The invention is an autonomous anomaly response unit comprising: a signal coupler in communication with a selected avionics sensor in the aircraft avionics system, the signal coupler functioning to acquire from the selected avionics sensor a monitored sensor signal configured in a first signal format; a signal processor for receiving the monitored sensor signal and cross-formattting the monitored sensor signal into a second signal format; a parameter check for evaluating the selected sensor reading such that a monitor trigger signal is issued in response to detection of an anomaly in the selected sensor reading; and a response module configured to issue an emergency response alarm in response to receiving the monitor trigger signal.
Fig. 3
RECEIVE MESSAGE IN FIRST DIGITAL FORMAT

IDENTIFY INTENDED RECIPIENT

DETERMINE DESTINATION AND SECOND FORMAT

FORMAT COMMUNICATION FOR DELIVERY OF MESSAGE

COMMUNICATE MESSAGE

Fig. 4
Fig. 5
Fig. 10
<table>
<thead>
<tr>
<th>Aircrafts Device</th>
<th>Triggering Event</th>
<th>Emergency Response</th>
</tr>
</thead>
<tbody>
<tr>
<td>Digital Gyroscope</td>
<td>Adverse pitch, yaw, or roll</td>
<td>Aircraft Tracking System</td>
</tr>
<tr>
<td>Digital Accelerometer</td>
<td>Adverse acceleration</td>
<td>Alarm</td>
</tr>
<tr>
<td>ADS-B</td>
<td>Power failure/interruption</td>
<td>Emergency Location Transmitter</td>
</tr>
<tr>
<td>Differential Pressure Sensor</td>
<td>Pressure Anomaly</td>
<td>Emergency Location Transmitter</td>
</tr>
<tr>
<td>Temperature Sensor</td>
<td>Temperature Anomaly</td>
<td>Alarm</td>
</tr>
<tr>
<td>Open Cockpit Door Sensor</td>
<td>Door open</td>
<td>Alarm</td>
</tr>
<tr>
<td>Radar System</td>
<td>Transceiver failure</td>
<td>Aircraft Tracking System</td>
</tr>
<tr>
<td>Altimeter</td>
<td>Drop in altitude</td>
<td>Emergency Location Transmitter</td>
</tr>
<tr>
<td>Transponder</td>
<td>Power failure/interruption</td>
<td>Emergency Location Transmitter</td>
</tr>
<tr>
<td>Smoke Detector</td>
<td>Smoke</td>
<td>Alarm</td>
</tr>
<tr>
<td>Engine Speed Sensor</td>
<td>Engine stall</td>
<td>Emergency Location Transmitter</td>
</tr>
</tbody>
</table>

**Fig. 12**
Fig. 14
(Prior Art)
Fig. 15
GLOBAL AERONATIONAL DISTRESS SAFETY SYSTEM CONTROLLER/TRANSMITTER

EMERGENCY LOCATOR TRANSMITTER

Fig. 16
Fig. 17
GADSS CONTROLLER RECEIVES AIRCRAFT-SPECIFIC OPERATING PARAMETER OVER SATELLITE

GADSS CONTROLLER SYNCHRONIZES PARAMETERS WITH SYSTEM MONITORING INTERFACE

GADSS CONTROLLER MONITORS AVIONICS AND INTERNAL GADSS TRIGGERING PARAMETERS

WHEN GADSS CONTROLLER PARAMETER IS BREACHED

GADSS TRANSCEIVER TRIGGERED AND 60 SECOND TRACKING OF AIRCRAFT BEGINS BY GNSS

GADSS CONTROLLER TRIGGERED THE AIRCRAFTS ELT TO CONCURRENTLY TRACK THE AIRCRAFT INFLIGHT

GADSS TRANSCEIVER SENDS BURST MESSAGE TO AUTHORITIES

GADSS GROUND CONTROL TRACKING AIRCRAFT REDUNDANTLY BY TWO SEPARATE AVIONICS: GADSS/ELT DURING FLIGHT

Fig. 20
Fig. 25
Fig. 26
(1) Time;
(2) Pressure altitude;
(3) Indicated airspeed;
(4) Heading—primary flight crew reference (if selectable, record discrete, true or magnetic);
(5) Normal acceleration (Vertical);
(6) Pitch attitude;
(7) Roll attitude;
(8) Manual radio transmitter keying, or CVR/DFDR synchronization reference;
(9) Thrust/power of each engine—primary flight crew reference;
(10) Autopilot engagement status;
(11) Longitudinal acceleration;
(12) Pitch control input;
(13) Lateral control input;
(14) Rudder pedal input; (15) Primary pitch control surface position;
(16) Primary lateral control surface position
(17) Primary yaw control surface position;
(18) Lateral acceleration;
(19) Pitch trim surface position or parameters
(20) Trailing edge flap or cockpit flap control selection
(21) Leading edge flap or cockpit flap control selection
(22) Each Thrust reverser position (or equivalent for propeller airplane);
(23) Ground spoiler position or speed brake selection

Fig. 28A
(24) Outside or total air temperature

(25) Automatic Flight Control System (AFCS) modes and engagement status, including Auto-throttle;

(26) Radio altitude

(27) Localizer deviation, MLS Azimuth;

(28) Glideslope deviation, MLS Elevation;

(29) Marker beacon passage;

(30) Master warning;

(31) Air/ground sensor (primary airplane system reference nose or main gear);

(32) Angle of attack

(33) Hydraulic pressure low (each system); Ground speed

(34) Ground proximity warning system;

(35) Landing gear position or landing gear cockpit control selection;

(36) Drift angle

(37) Wind speed and direction

(38) Latitude and longitude

(39) Stick shaker/pusher

(40) Windshear

(41) Throttle/power lever position;

(42) Additional engine parameters

(43) Traffic alert and collision avoidance system;

(44) DME 1 and 2 distances;

(45) Nav 1 and 2 selected frequency;

Fig. 28B
(46) Selected barometric setting
(47) Selected altitude
(48) Selected speed
(49) Selected mach
(50) Selected vertical speed
(51) Selected heading
(52) Selected flight path
(53) Selected decision height
(54) EFIS display format;
(55) Multi-function/engine/alerts display format;
(56) Thrust command
(57) Thrust target
(58) Fuel quantity in CG trim tank
(59) Primary Navigation System Reference;
(60) Icing
(61) Engine warning each engine vibration
(62) Engine warning each engine over temp.
(63) Engine warning each engine oil pressure low
(64) Engine warning each engine over speed
(65) Yaw trim surface position;
(66) Roll trim surface position;
(67) Brake pressure;
(68) Brake pedal application (left and right);

Fig. 28C
(69) Yaw or sideslip angle
(70) Engine bleed valve position
(71) De-icing or anti-icing system selection
(72) Computed center of gravity
(73) AC electrical bus status;
(74) DC electrical bus status;
(75) Hydraulic pressure (each system);
(76) Loss of cabin pressure;
(77) Computer failure;
(78) Heads-up display
(79) Para-visual display
(80) Cockpit trim control input position--pitch;
(81) Cockpit trim control input position--roll;
(82) Cockpit trim control input position--yaw;
(83) Trailing edge flap and cockpit flap control position;
(84) Leading edge flap and cockpit flap control position;
(85) Ground spoiler position and speed brake selection; and
(86) All cockpit flight control input forces (control wheel, control column, rudder pedal)
(87) Cockpit trigger
(88) Cabin trigger
(89) Crash trigger
(90) Remote control trigger

Fig. 28D
(91) Inflight Triggered GADSS
(92) Remotely Triggered GADSS
(93) Remotely controlled
(94) Manually triggered
(95) ADS-B Triggered GADSS
(96) Reset Sensor over the air(over satellite)
(97) Flight plan deviation trigger
(98) Power trigger
(99) Data trigger
(100) Over The Air to GADSS to ELT
(101) Aircraft Digital Orientation Alert Device
(102) Abnormal Aircraft Orientation Software
(103) Programmable Digital Aircraft Disorientation Indictor
(104) Unusual aircraft physical position, direction or location
(105) Weather condition trigger
(106) EICAS Triggered GADSS
(107) Transponder Triggered
(108) FDR triggered GADSS
(109) TAWS triggered GADSS
(110) ACARS Triggered
(111) GPS Trigger
(112) GADSS triggers ELT
(113) ELT triggers GADSS

Fig. 28E
AUTONOMOUS DISTRESSED AIRCRAFT TRACKING SYSTEM

FIELD OF THE INVENTION

[0001] The present invention relates to a system and method for automatically tracking an aircraft placed in a distressed state by the occurrence of one or more anomalies in flight operational conditions.

BACKGROUND OF THE INVENTION

[0002] Nowadays, commercial aircraft remain top priority targets for terrorist groups. In 2015, more than 8 million people traveled by aircraft on a daily basis; which equates to 3.3 billion passengers annually, a number equal to forty four percent of the world’s population. Despite strenuous efforts by governments to harden commercial aviation in the post-9/11 era, the number of terrorist plots uncovered annually illustrates that al-Qaeda, its affiliates, and numerous other Islamist extremist groups maintain a high level of interest in attacking aviation. Terrorists know that any terrorism targeting commercial aircraft impacts the world’s economy on many levels and for long periods of time. These groups direct their hostility onto what are referred to as “symbolic targets.” Terrorism is a form of intimidation, which often inflicts wide-spread chaos. Understandably, aircraft, both large and small, are attractive terrorist targets for mass destruction.

[0003] As has been observed, the first stage of such terrorist acts is to take over the aircraft through the aircraft avionics. One method is to disarm key avionics, including the aircraft’s transponder. This method was used in all four aircraft during the infamous 9/11 attacks on America in 2001. During the 9/11 attacks, one of the government’s top assets, NORAD, could not locate any of the hi-jacked aircraft until it was too late. That series of four coordinated terrorist attacks by the Islamic terrorist groups on the morning of September 11, 2001, resulted in thousands of deaths. The attacks caused $10 billion in property and infrastructure damage, and over $3 trillion in total costs.

[0004] In 2014, a similar terrorist incident occurred with Malaysian Air flight 370, as well as several other lesser-known terrorist incidents. Key avionics systems, such as the Aircraft Communication and Addressing and Reporting System (ACARS) and/or the Transponder were turned off or tampered with while the aircraft were in-flight. These terrorist actions caused the aircraft to essentially vanish from primary radar, and to fly undetected for hours as “vehicles of mass destruction.”

[0005] The Malaysian authorities had reported that ground control lost contact with Flight 370 about two hours after takeoff. As with the four planes on 9/11, the transponder was inexplicably turned off, and the plane veered wildly off course. Yet, the crew had sent no distress signal—an action that would have taken only a few seconds to perform. Authorities report that Flight 370 flew hundreds of miles off-course, heading west instead of north, before disappearing. It is suggested that flight 370 was a deliberate act by someone on board who turned off or disabled the transponder, enabling the aircraft to disappear from radar, never to be found.

[0006] Today, opportunities still exist for terrorist to take control of an aircraft’s avionics. This vulnerability enables any aircraft to become the next Malaysian Air 370 or 9/11 hi-jacked aircraft. Given the breadth and complexity of the threats to commercial aviation, technology that is tamper-proof, inaccessible, self-powered and remotely-controlled for real-time notification and aircraft tracking is a high priority for United Nations governed International Civil Aviation Organization (ICAO), Homeland Security and the general public.

[0007] It is critical that the aforementioned anti-terroristic/tamper-proof technologies be designed and deployed to leverage existing avionics in commercial aircraft. The upside benefit of these developments is to offer easier market entry and faster expedited implementation. What is needed is an application and teachings that can address this missing part of aviation security, and which functions to ensure that commercial aviation remains both secure and commercially viable.

BRIEF SUMMARY OF THE INVENTION

[0008] In one aspect of the present invention, an autonomous anomaly response unit suitable for monitoring an aircraft avionics system and initiating an emergency response if the aircraft operational state escalates to a distressed stage, the anomaly response unit comprising: a signal coupler in communication with a selected avionics sensor in the aircraft avionics system, the signal coupler functioning to acquire from the selected avionics sensor a monitored sensor signal configured in a first signal format; a signal processor for receiving the monitored sensor signal and cross-formatting the monitored sensor signal into a selected sensor reading configured in a second signal format; a parameter check for evaluating the selected sensor reading such that a monitor trigger signal is issued in response to detection of an anomaly in the selected sensor reading; and a response module configured to issue an emergency response alarm in response to receiving the monitor trigger signal.

[0009] In another aspect of the present invention, a method of remotely tracking a distressed aircraft comprises the steps of: coupling to a selected avionics sensor in the aircraft avionics system so as to acquire from the selected avionics sensor a monitored sensor signal configured in a first signal format; cross-formatting the monitored sensor signal into a selected sensor reading configured in a second signal format; evaluating the selected sensor reading against a predetermined sensor operating range of parameter values; if the selected sensor reading lies outside the predetermined sensor operating range of parameter values, sending a monitor trigger signal to a response module, issuing an emergency response alarm from the response module in response to the monitor trigger signal; and communicating with a pre-established group of ground-based personnel.

[0010] In still another aspect of the present invention, an autonomous communication system for remotely tracking a distressed aircraft comprises: an aircraft tracking system for automatically determining current aircraft location; an avionics monitoring system in communication with an avionics system in the aircraft, the avionics monitoring system including a signal coupler in communication with a selected avionics sensor in the aircraft avionics system, the signal coupler functioning to acquire from the selected avionics sensor a monitored sensor signal configured in a first signal format; a signal processor for receiving the monitored sensor signal and cross-formatting the monitored sensor signal into a selected sensor reading configured in a second signal format;
format; a parameter check for evaluating the selected sensor reading such that a monitor trigger signal is issued in response to detection of an anomaly in the selected sensor reading; and a response module configured to issue an emergency response alarm in response to receiving the monitor trigger signal; a transmitter for transmitting an emergency message in response to receiving the emergency response alarm; a transmitter for transmitting an emergency homing transmission in response to receiving the emergency response alarm; and a satellite communication system for sending the emergency message and homing transmission to ground based personnel.

[0011] The additional features and advantage of the disclosed invention is set forth in the detailed description which follows, and will be apparent to those skilled in the art from the description or recognized by practicing the invention as described, together with the claims and appended drawings.

BRIEF DESCRIPTIONS OF THE DRAWINGS

[0012] The foregoing aspects, uses, and advantages of the present invention will be more fully appreciated as the same becomes better understood from the following detailed description of the present invention when viewed in conjunction with the accompanying figures, in which:

[0013] FIG. 1 is a diagrammatic illustration of an aircraft communication system suitable for message exchange, in accordance with the present invention;

[0014] FIG. 2 is a diagrammatic illustration of the aircraft communication system of FIG. 1 showing an aircraft tracking system in the aircraft;

[0015] FIG. 3 shows functional components of an illustrative computing arrangement in the aircraft communication system of FIG. 1;

[0016] FIG. 4 is a flow diagram of an illustrative process for processing information regarding a recipient of a message;

[0017] FIG. 5 is a flow diagram of an illustrative process for processing requests to communicate a message in the aircraft communication system of FIG. 1;

[0018] FIG. 6 depicts an illustrative user interface for entering a message in the aircraft communication system of FIG. 1;

[0019] FIG. 7 depicts an illustrative user interface for entering a message regarding an emergency situation;

[0020] FIG. 8 is a diagrammatic illustration of an automatic aircraft emergency communication system, in accordance with the present invention;

[0021] FIG. 9 is a functional block diagram of an avionics monitoring system as used in the automatic aircraft emergency communication system of FIG. 8;

[0022] FIG. 10 is a functional block diagram of the avionics monitoring system of FIG. 9 showing the monitoring of a programmable aircraft attitude sensor;

[0023] FIG. 11 is a flow diagram illustrating operation of the avionics monitoring system of FIG. 9;

[0024] FIG. 12 is a listing of various sensor signals that can be monitored by the avionics monitoring system of FIG. 9;

[0025] FIG. 13 is an illustration of an aircraft showing a flight data acquisition unit used to acquire various data related to the operational status of the aircraft, in accordance with the present state of the art;

[0026] FIG. 14 is a simplified diagram showing data transfer from a flight data acquisition unit to a flight data recorder, in accordance with the present state of the art;

[0027] FIG. 15 is a simplified block diagram of an anomaly response unit, in accordance with the present invention;

[0028] FIG. 16 is a simplified block diagram of the anomaly response unit of FIG. 15 coupled to a global aeronautical distress safety system controller/transmitter and an emergency locator transmitter, in accordance with the present invention;

[0029] FIG. 17 is a simplified block diagram of a satellite emergency communication system, in accordance with the present invention;

[0030] FIG. 18 is a diagram illustrating the use of a manual switch for optionally initiating operation of the emergency locator transmitter, in accordance with an aspect of the present invention;

[0031] FIG. 19 is a physical embodiment of the anomaly response unit of FIG. 15 enclosed in a housing;

[0032] FIG. 20 is a flow diagram illustrating operating principles of the anomaly response unit of FIG. 15;

[0033] FIG. 21 shows a satellite emergency communication system configured to enable a crew member to use a mobile communication device to communicate with government security personnel on the ground;

[0034] FIG. 21 is satellite emergency communication system configured to enable a crew member to use audio devices to communicate with control towers and air traffic controllers;

[0035] FIG. 23 shows a satellite emergency communication system which can record and store verbal communications between an aircraft crew member and air traffic controllers;

[0036] FIG. 24 is an illustration of communication continuity between a crew member, an air traffic controller, and a ground-based official;

[0037] FIG. 25 is flow diagram illustrating the operation of the aircraft tracking system of FIGS. 2 and 8;

[0038] FIG. 26 is a flow diagram showing that the aircraft tracking system of FIG. 2 can be activated when the aircraft experiences a change in a programmable aircraft attitude sensor reading that exceeds a pre-determined threshold;

[0039] FIG. 27 is a functional block diagram of an autonomous distressed aircraft tracking system showing the monitoring of a plurality of aircraft sensors and automatic emergency notification via a smart ELT system and a smart GADSS system; and

[0040] FIGS. 28A-28E are a listing of triggering sensors and events that function to automatically activate an appropriate emergency response in the autonomous distressed aircraft tracking system of FIG. 27.

DETAILED DESCRIPTION OF THE INVENTION

[0041] The following detailed description is of the best currently contemplated modes of carrying out the invention. The description is not to be taken in a limiting sense, but is made merely for the purpose of illustrating the general principles of the invention.

[0042] A user of a conventional communication technology generally accesses any one of several technologies to communicate with other users of the same communication technology. For example, text messaging is used to com-
municate a text message to a recipient who is also using text messaging. Similarly, an email program is used to communicate an email to an intended recipient who is also using email. Thus, although there are numerous communication technologies and devices available to consumers, the technologies are used independently of each other. According to existing systems and methods, a user of a web interface does not communicate with a recipient that is using instant messaging. Similarly, a recipient of an instant message does not respond to a sender who is using an email interface.

[0043] The present application discloses systems and methods for performing cross-format messaging and signaling such that users are able to send a communication or message in a first message or signal format and have the communication or message received by the recipient in a second message or signal format. For example, a user may enter the text of a message into a web interface, wherein the message is then delivered to the recipient as a text message. Similarly, a user may enter an instant message using a phone, and have the message delivered to the intended recipient as an e-mail or as a real-time audio/video communication or recording. Of particular interest is a method which automatically contacts ground-based personnel, and maintains a current location of an in-flight aircraft.

[0044] FIG. 1 illustrates an exemplary aircraft communication system 100 suitable for signal and message exchange of different formats. A message service 120 offers a number of different functions including transmitting messages to a recipient in a message format other than the message format in which the message was initially created. A user may employ a first communication device, such as any one of a desktop computer 110, a laptop computer 112, a mobile phone 114, a mobile communication device 116, or a computer tablet 118 to create messages which may be transmitted to a second communication device, such as another one of the desktop computer 110, the laptop computer 112, the mobile phone 114, the mobile communication device 116, or the computer tablet 118, through the message service 120 via a communications network 130. In general, the message service 120 provides for two-way, emergency communication services using communication devices, communication systems, and communication networks, as well known in the relevant art. While only five communication devices are illustrated in FIG. 1, it should be understood that the message service 120 may be simultaneously accessed by a greater number of communication devices than shown.

[0045] In an exemplary environment, the message service 120 has the capability to receive a message in a first message format and to appropriately cross-format the received message for subsequent transmission in a second message format. For example, the message service 120 may receive a message formatted as text that was input through a web page, and cross-format the message for transmission to the intended recipient as an instant message. The cross-format messaging functionality as described herein is performed on one or more computing servers 122 which communicate with one or more data stores 124, accessed locally or remotely. The data stores 124 maintain data regarding individual users of the system and the messages that they send and receive. The computing servers 122 provide functionality as described below to receive messages, identify an appropriate format for a message, and transmit the message so as to be received in the appropriate format. Any number of computing servers 122 and data stores 124 may be used to provide a cross-format service as described herein.

[0046] The message service 120 is accessible via a communications network 130. The communications network 130 may be any type of network that is suitable for providing communications among the communication devices 110, 112, 114, 116, 118, and the message service 120. Moreover, the communications network 130 may include a combination of discrete networks, one or more of which may use different communication technologies. For example, the communications network 130 may comprise local area networks (LANs), wide area networks (WAN's), cellular networks, a satellite communication network, or combinations thereof.

[0047] The communications network 130 may comprise wireless, wireline, or combination thereof. In an exemplary embodiment, the communications network 130 may comprise the Internet, and may additionally include any peripheral networks adapted to communicate with the Internet. The communications network 130 may enable an individual using the laptop 112, or an equivalent mobile communication device, in an aircraft 140 to communicate with the server(s) 122 via: (i) a first communication link 132 from the laptop 112 to the communications network 130, and (ii) a second communication link 134 from the communications network 130 to the message service 120. In response to the realization of one or more predefined flight criteria, an emergency communication system 142 in the aircraft 140 may automatically communicate with one or more ground-based communication devices, servers, and personnel, preferably via a two-way transmission link 146 to a communication satellite 144, and alternatively through the first communication link 132 and the communications network 130, as described in greater detail below.

[0048] The aircraft communication system 100 is capable of functioning by using a plurality of network topologies such as client/server, peer-to-peer, or hybrid architectures. The “client” may be a member of a class or group that uses the services of another class or group to which the client is not related. Thus, in computing, a client is a process (i.e., roughly a set of instructions or tasks) that requests a service provided by another program. The client process utilizes the requested service without having to “know” any working details about the other program or about the service itself. In a client/server architecture, particularly a networked system, a client is usually a computing device, such as one of communication devices 110, 112, 114, 116, 118 that accesses shared network resources provided by another computer (e.g., a server). A server, such as the server 122, is typically a remote computer system accessible over a remote network such as the Internet. The client process may be active in a first computer system, and the server process may be active in a second computer system, communicating with one another over communications medium, and allowing multiple clients to take advantage of the information-gathering capabilities of the common server.

[0049] Clients and servers communicate with one another utilizing the functionality provided by a protocol layer. For example, Hypertext-Transfer Protocol (HTTP) is a common protocol that is used in conjunction with the World Wide Web (WWW) or, simply, the “Web.” Typically, a computer network address such as a Uniform Resource Locator (URL) or an Internet Protocol (IP) address is used to identify the server or client computers to each other. Communication
among computing devices is provided over a communications medium. In particular, the client and server may be coupled to one another via TCP/IP connections for high-capacity communication.

FIG. 2 is a generalized functional diagram showing the aircraft 140 with an aircraft tracking system 152 on board, in accordance with the present invention. The aircraft tracking system 152 can determine and monitor the position of the aircraft 140 by acquiring signals transmitted by three or more Global Positioning System (GPS) satellites 154 via a GPS communication link 156, as is well-known in the art. Moreover, the aircraft tracking system 152 can maintain continuous communication with ground base facilities and personnel by means of a Short Burst Data (SBD) communication link 164 to an Iridium communication network 160. In an exemplary embodiment, the Iridium communication network 160 includes an Iridium satellite 162 that operates to establish a two-way communication link 166 to an Iridium base station 168. The Iridium base station 168 may communicate with an aircraft tracking system server 172 via two-way communication links 174, 176 and the Internet 170.

FIG. 3 depicts a block diagram of exemplary logical components of a message service 200 for performing cross-format message communication, where the message may be text, audio, video, or any sort of an electronic signal. The message service 200 includes a user database 210 for use in text messages, for example. The user database 210 stores information about the various users of the message service 200. In an illustrative embodiment, the user database 210 may include identifying information about a particular user such as, for example, a user identifier, a password, a name, one or more email addresses, and a mobile phone number, as well as a list of contacts that have been grouped together into a distribution list for a message to be transmitted to ground-based recipients. A message database 212 stores information about messages that have been communicated from or received by users of the message service 200. For example, the information may comprise a message identifier, an identifier for the sender, a recipient of the message, and a date and time the message was sent or received.

A message processor 214 operates to receive messages, to determine the proper message format intended for receipt of the messages, and to forward messages as described below. A message monitor 216 may operate with the message processor 214 to identify when scheduled messages are to be delivered and to initiate the forwarding of such messages. A user interface service 218 operates to provide a user interface for creating and receiving messages and signals. In an exemplary embodiment, for example, the user interface service 218 generates data for creating a web page through which users may enter message text, schedule the delivery of the message text, and review messages forwarded by other users.

FIG. 4 is a flowchart 230 of an example process for communicating electronic messages. At step 232, the message processor 214 receives a message that is to be communicated. The message is received in a first message format which may be, for example, text entered into a Web page, an email, a text message, an instant message, a sort messaging service message, a digital voice recording, an electronic signal, a real-time audio/video communication or recording, for example. In an exemplary embodiment, the message may be received as an electronic digital signal providing data or other relevant information. In connection with receiving a message, the message processor 214 may also update the message.

At step 234, the message processor 214 identifies the intended recipient of the message. For example, the message may be intended for receipt by an individual identified in a contact list, or may be intended for receipt by emergency personnel. The message processor 214 identifies the intended recipient by, for example, parsing information received with the message and querying the user database 210. For example, the message may identify an intended recipient using an identifier. The message processor 214 queries the user database 210 in order to identify the contact associated with the identifier. In an exemplary embodiment, a message may also be intended for receipt by a group of individuals or a distribution list or government agencies. At step 234, the message processor 214 also identifies the individuals or groups in the distribution list by querying the user database 210.

At step 236, the message processor 214 determines the destination for the message and the appropriate message format. For example, an intended recipient or electronic device may have a particular format in which it has been determined that the message should be received, and in which the intended recipient or electronic device has identified the means by which the recipient or device should receive the message or signal. The recipient may have established that he wishes to receive messages as an instant message on a wireless phone that has a particular phone number. The message processor 214 may query the user database 210 to identify the intended recipient's format and destination for the message, signal, or data. For example, the message processor 214 may identify from information in the user database 210 that, for the intended recipient, messages are preferably forwarded for delivery as a text message or as digital data to a wireless device with a particular associated number. In another example, the message processor 214 may identify from information in the user database 210 that the intended recipient is to receive messages in multiple locations and in multiple formats. For example, the message processor 214 may identify that the message is to be received as a text message on a particular mobile device and as an email at a particular email address. In scenarios where the intended recipient is a plurality of individuals, the message processor 214 identifies at least one destination and format for each of the individuals.

At step 238, the message processor 214 formats the message for communication to the intended recipient. For example, if the message format that the intended recipient is to receive is an email, the message processor 214 creates an email addressed to a designated email address. In an alternate scenario, a message that was originally entered as text in a web page may be formatted as a voice rendering that is generated automatically by software from the input text. In some scenarios, an anomaly in the avionics system may produce a signal which automatically initiates communication with ground-based emergency personnel or air traffic control personnel, for example. In still another scenario, if the format that the intended recipient is to receive is an instant message on a device with a particular phone number, the message processor 214 formats a communication that will ultimately be directed to the phone number.
Any methodology that is suitable for formatting the message to be communicated to and received by the intended recipient may be employed, as described in greater detail below. For example, in one exemplary embodiment, the message service 200 may rely upon a simple object access protocol (SOAP) object to communicate with services at which intended recipients are accessible. In such a scenario, formatting a message for communication to the intended recipient may comprise formatting a SOAP envelope that contains the message text in the body of the SOAP envelope and the intended recipient in the header of the SOAP envelope. Such a scenario may be adapted to communicate numerous messages between the message service 200 and other services in a single SOAP envelope and thereby expedite and simplify the communication of messages.

In an exemplary embodiment, the message service 200 may communicate messages via an SMS gateway. At step 238, the message service 200 may format messages for communication via the SMS gateway. The SMS gateway may be adapted to send a text message with or without using a mobile (cell) phone. The SMS gateway may offer SMS transit by either transforming messages to mobile network traffic from other media or by allowing transmission or receipt of SMS messages with or without the use of a mobile phone. A typical use of an SMS gateway is forwarding a simple message to a mobile phone recipient.

Alternatively, the message service 200 may communicate messages using a short message peer to peer (SMPP) protocol and, accordingly, formats messages to be communicated using the SMPP protocol. The SMPP protocol is adapted to provide a flexible data communications interface for transfer of short message data between a message center, such as a short message service center, GSM unstructured supplementary services data (USSD) server or other type of message center and a SMS application system, such as a WAP proxy server, or other messaging gateway.

The message service 200 may format messages in order to conform to the formats required by the particular service through which intended recipients may be contacted. For example, in order to comply with the communication format of a particular mobile service provider, the message processor 214 may format an electronic message such as, for example, an email, directed to a particular address of the mobile service provider. The message may be specially formatted and addressed to a particular address so that upon receipt, the mobile service forwards the contents of the message to the designated mobile device as a text message. For example, the address may comprise the phone number and an internet domain that is operated or controlled by the mobile service provider (e.g., phone_number@phoneco.com).

In some scenarios, a user may have identified a particular phone number, but not designated the mobile service provider that provides service for a phone with the designated number. In such a scenario, the message processor 214 may format separate messages to server domains for each of the potential service providers. Thus, the message processor 214 may format messages directed to the same phone number address but at multiple different service providers “phoneco1.com,” “phoneco2.com,” “phoneco3.com,” etc., where phoneco1.com, phoneco2.com, and phoneco3.com are domains established by the respective mobile service carriers to receive messages, e.g., emails, the content of which are to be communicated as a text message real-time audio/video communication or pre-recorded message or other message format.

At step 240, the message processor 214 communicates the message toward the intended recipient. For example, the message processor 214 may communicate an email to an identified email address. In another scenario, the message processor 214 may initiate a cell phone call to a particular phone number where the message is to be delivered as a voice recording. Where a message is intended to be delivered as a text in a web page, the message is formatted as text. Still further, where one or more emails have been formatted for communication to a particular mail domain of a mobile service provider designated for receiving emails that contain text for delivery as an instant message or text message, the message processor 214 communicates the one or more emails. In addition to communicating the message, the message processor 214 updates the user database 210 and the message database 212 to identify that the message has been transmitted and received.

As described above, when a mobile device number is known, but the mobile service operator is not, the message processor 214 may format emails for communication to a plurality of mobile service operators. Each of the emails comprises the same known number incorporated into each of the email addresses. Of course, only one of the mobile service operators, in fact, provides service to the identified phone number. When the email arrives at that particular service operator, the message is formatted as a text message or instant message and delivered to the intended recipient. Meanwhile, the emails to those mobile service operators that do not provide service to the identified number will not be delivered at all.

After a message has been communicated, the sender may wish to modify the previously sent message in some manner. For example, the sender may wish to erase, remove, overwrite, encrypt, whitenout or text color match the previously sent message. In such a scenario, receiving a message at step 232 may comprise receiving a request to modify the previously sent message. At step 234, the recipient of the previously sent message is identified. At step 236, the destination is identified as the destination of the previously stored message. For example, it is determined whether the previously sent message was delivered to a particular electronic device or, perhaps, still located at the message service 200.

The message service 200 also identifies the particular modification that has been requested. For example, the message service 200 determines whether it is desired to erase, remove, overwrite, encrypt, and/or whitenout or color match all or a portion of a previously sent message. At step 238, the message service 200 formats a communication to the intended recipient that is consistent with the desired action. For example, the communication may include instructions or an indication to erase, remove, overwrite, and/or encrypt a previously communicated message. The particular format of the communication and instructions may vary depending upon the location of the previously communicated message. For example, if the previously communicated message exists within the message service 200, the format of the communication may be different than if the previously communicated message was communicated to an external system such as, for example, a mobile phone.
At step 240, the message comprising instructions to modify the previously forwarded message are communicated.

FIG. 6 illustrates a flow diagram 250 for a process that may occur when a response is received from a mobile service provider, where it was previously not known which service provider provided service for a particular number. At step 252, a response message is received in connection with a message that was transmitted to a plurality of different phone service providers because the exact service provider was not known. At step 254, the message processor 214 identifies the mobile device number and the service provider associated with the response communication. The message processor 214 identifies that the particular phone service provider provided the service for the number and stores information identifying the service provider as corresponding to the mobile number, at step 256. Thereafter, when messages are communicated to the particular number, the message can be directed to the identified service provider.

Transmitting information for generating a user interface may include the transmission of information for creating multiple pages that are used to create messages. FIG. 6 shows a user interface screen 260 that can be created from information provided to the user by the user interface 218 and the message processor 214. The user interface screen 260 may include a text input area 262 for inputting the content of the message. Text libraries panels 264 contain predefined text entries that can be selected for addition to the content of the text input area 262. The content of the text libraries can be customized by the particular individual.

The user interface screen 260 may include one or more buttons 266 that are used to access a particular functionality. The button(s) 266 may provide access to one or more of: (i) an address book containing contact information for the particular user’s contacts; (ii) a groups list containing a list of groups of individuals that the user has defined; (iii) a capability to send the message presently specified in text input area 610; (iv) a message event calendar; (v) a calendar of personal reminders; (vi) an inbox of received messages; (vii) an outbox of sent messages; (viii) a repository of deleted messages; and (ix) various message related functions.

The capability to communicate messages while in-transit may be particularly useful in order to address in-flight emergencies. For example, a passenger on a commercial airliner that is experiencing an emergency situation may prepare a message regarding the emergency using a Web based interface. The message may be communicated in another format, such as for example a phone call, email, electronic signals, short message or ‘live,’ real-time audio/video communication or recording, to emergency and law enforcement personnel. The passenger may communicate information about the flight, including for example, the airline, the flight number, the destination location, and the current location. The passenger may record a personalized audio and/or video message using the client device and include it in or attach it as a file to the message. The current location may be gathered by any suitable means, including, for example, by a geo-location positioning system, by an on-board aircraft tracking system, by triangulation techniques, or any other methodology. In a scenario wherein air-to-ground communication with the plane relies upon cell towers, the current location information communicated with a message may comprise information identifying a particular cell tower, or location of a cell tower, from which the communication originated.

In a scenario wherein air-to-ground communication relies upon air-to-satellite communication, the current location information may comprise latitude and longitude information derived from the satellite positioning system (GPS), a search and rescue satellite system, or an iridium communication network, may be used to derive the location of an aircraft. The information about the emergency situation and the information regarding the flight may be transmitted to the message service 200. The message service 200 can forward the message to the appropriate authorities by any appropriate means. For example, the message service 200 may communicate an email, by VOIP, by voice, audio and/or video recording, and/or instant message to any and all of: (i) the Federal Bureau of Investigation (FBI), (ii) the Central Intelligence Agency (CIA), (iii) the Federal Aviation Authority (FAA), (iv) the Federal Emergency Management Association (FEMA), (v) the Office of Homeland Security, (vi) National Security Administration (NSA), (vii) Transportation Safety Administration (TSA), North American Aerospace Defense Command (NAADC), and (viii) local police and safety/emergency response personnel. One or more of these agencies may respond to the message. The response message is received at message service 200 and transmitted to the user via the web page that was used to create the initial message.

FIG. 7 depicts an illustrative user interface 280 suitable for use with the message service 200 by an individual on the aircraft 140 when providing notice of an aircraft emergency situation. The message processor 214 of FIG. 3 may format the user interface 280 of FIG. 7 so as to include a passenger information panel 282, a flight information panel 284, and a message panel 286. The passenger information panel 282 is used to identify information about the individual on board the aircraft 140, shown in FIG. 2. The identifying information may include any information suitable to identify the individual such as, for example, name; age; address; state; zip code; mobile phone number; home phone number; email address; driver’s license; all or portion of a social security number; emergency contact name; and emergency contact phone number. This information may be automatically populated to the extent available in the user database 210 of FIG. 3.

The flight information panel 284, in FIG. 7, is used to display information about the particular flight, including any data that would assist authorities in identifying the particular flight. In the example shown, the flight information panel 284 includes fields for entering: the destination of the flight, the origin of the flight, the airline, the flight number, and a category of emergency or problem with the flight. The user may enter the information manually, and/or the message processor 214 and user interface processor 218, shown in FIG. 3, may retrieve relevant information from the user database 210 for populating the fields in the user interface 280, shown in FIG. 7.

The message panel 286 may be accessed by the user to enter messages relevant to the emergency information and to review responsive messages. The user prepares the message and presses a send button 288. The message history may be shown in the message panel 286. In an exemplary embodiment, the message that is communicated...
out for a message may include information about the person sending the message and about the flight. For example, in addition to any text of the message that was entered by the operator, the communication may also comprise one or more of: the sender's name; age; social security number; home
address; phone number; email address; doctor's name and
contact information; an emergency contact; and details
regarding the flight. Each message that is transmitted may
include all of the information displayed on the passenger
information panel 282 and the flight information panel 284.

It can be appreciated that the message flow to and from the
user in the user interface 280 proceeds through a message
service, such as the message service 200 of FIG. 3, and
provides for formatting the messages as appropriate for the
intended recipient.

[0074] FIG. 8 illustrates an automatic aircraft emergency
communication system 300 which functions to automat-
ically establish, under an emergency situation, communica-
tions between the aircraft 140 and a plurality of ground-
based recipients such as, for example, government security
personnel 302, 304, 306, and 308, similar to the emergency
communication system 142 in FIG. 1, above. It should
be understood that the number of ground-based personnel
contacted by the automatic aircraft emergency system 300
in FIG. 8 is not limited to the four examples of government
security personnel shown in the illustration, but may be as
many as one hundred individuals or more. Emergency
messages may be generated on the aircraft 140 and trans-
mitted, for example, (i) manually by a member of a flight
crew using a mobile communication device 312 via the first
communication link 132, (ii) manually by a passenger using
a computer tablet 314 via the first communication link 132,
or (iii) automatically by an avionics monitoring system 320
via a search and rescue satellite 310 in response to a
determination that the flight status of an aircraft has esca-
lated to a distressed state. The automatic aircraft emergency
communication system 300 may also establish communica-
tions between the aircraft 140 and one or more control
towers 316, and/or between the aircraft 140 and one or more
air traffic controllers 318.

[0075] On board the aircraft 140, the passengers may use
a Wi-Fi communication access point or other methodology
that is provided within the aircraft 140 for communication.
Alternatively, passenger communication may be provided
via VHF, satellite, or other technology. The automatic air-
craft emergency system 300 may further enable communica-
tions from passengers on the aircraft 140 to persons
located on different planes or anywhere else that communi-
cation access is provided. In other words, communication
may be, for example, from "plane-to-ground" or "plane-to-
plane."

[0076] The emergency messages may be transmitted to an
emergency system server 290, for example, via the first
communication link 132, where the messages are converted
into any suitable message format for use at any of the
numerous government platforms receiving the emergency
message, as described above. Accordingly, the emergency
system server 290 may convert a single emergency message
or signal into multiple different message and signal formats,
as described above, in order to satisfy the formatting require-
ments of the particular recipient or device. The emergency
messages may be communicated simultaneously to the gov-
ernment security personnel 302, 304, 306, 308, the control
towers 312, and the air traffic controllers 314.

[0077] As described above, the aircraft tracking system
152 may be automatically activated in flight by the avionics
monitoring system 320 upon detection of a flight anomaly in
the aircraft operating parameters 140, or in response to a
signal indicating the presence of the flight anomaly. The
avionics monitoring system 320 utilizes a specialized user
interface, described below, that monitors aircraft avionics,
instrumentation, gauges and devices for technical limitations
or reading anomalies during a flight. If the avionics moni-
toring system 320 detects a technical limitation or problem,
thus identifying an in-flight emergency, the avionics moni-
toring system 320 will initiate the aircraft tracking system
152 that automatically tracks, records, and reports the geo-
location and GPS location of the aircraft 140 to the plurality
of ground-based government security personnel 312, 314,
316, and 318 in specified and designated time intervals.

[0078] In an exemplary embodiment, the escalation of an
aircraft into a distressed state results in placing the aircraft
tracking system 152 into a transmission mode concurrently
with the establishment of communications with the ground-
based personnel. It can be appreciated by one skilled in
the art that the ability of the automatic aircraft emergency
communication system 300 to transmit timely aircraft loca-
tion provided by the aircraft tracking system 152 serves to
greatly improve the probability of finding the aircraft 140 if
a downing of the aircraft or diversion from a planned flight
path has occurred.

[0079] FIG. 9 is a simplified functional block diagram
illustrating the major components of the avionics monitoring
system 320. In an exemplary embodiment, the avionics
monitoring system 320 functions to monitor one or more
selected avionics components, gauges, instruments, and
aircraft sensors for use in the automatic aircraft emergency
communication system 300, shown in FIG. 8, to issue an
emergency signal. For clarity of illustration, a single selected
avionics sensor 322 is used to represent any one of
these avionics components, gauges, instruments, and aircraft
sensors that can be selected for monitoring, to evaluate
aircraft operating parameters for determining as to whether
an emergency response alarm 348 should be issued. Addi-
tionally, for clarity of illustration, a single avionics system
sensor 326 is used to represent the avionics components,
 gauges, instruments, and aircraft sensors that are active and
functional during flight, but are not actively monitored by
the avionics monitoring system 320. It should be understood
that one or more of the monitored sensors may comprise a
programmable aircraft orientation alert device and software,
as described in greater detail below.

[0080] When the aircraft 140 is airborne, the selected
avionics sensor 322 provides an avionics sensor signal 324
to a signal coupler 332 in an anomaly response unit (ARU)
330. The sensor signal 324 is also sent to a Flight Data
Acquisition Unit (FDAU) 356 in the aircraft avionics system
350, in accordance with standard flight operation procedure.
A sensor signal 328 is sent only to the FDAU 356, as
the avionics system sensor 326 is not being monitored by the
anomaly response unit 330. The FDAU 356 processes the
avionics sensor signals 324, 328 into flight data 354 for
storage in a flight data recorder (FDR) 358, also in accor-
dance with standard flight operation procedure.

[0081] The signal coupler 332 is a signal isolation device
designed to detect or to acquire the avionics sensor signal
324 without affecting the characteristics of the avionics
sensor signal 324 as transmitted to the FDAU 356.
signal coupler 332 further functions to provide the acquired avionics sensor signal 324, here designated as a corresponding, monitored sensor signal 342, to a signal processor 334, where the outputted monitored sensor signal 342 is the same, or substantially the same, as the inputted avionics sensor signal 324. The monitored sensor signal 342 is then cross-formatted by the signal processor 334 into a cross-formatted sensor reading 344, which is in a message format or a signal format suitable for evaluation by a parameter check module 336.

[0082] For example, the monitored sensor signal 342 may comprise an analog signal, a logic signal, or a digital signal, and the cross-formatted sensor signal 344 may comprise a signal in a different message or signal format. It should be understood that certain types of operational signals produced by particular avionics components, aircraft gauges, in-flight instruments, and aircraft sensors, for examples, may be in the same signal format compatible for input to the parameter check module 336 and may thus not require the cross-formating operation by the signal processor 334.

[0083] The parameter check module 336 functions to compare the cross-formatted sensor reading 344 to an acceptable operating parameter value or range of parameter values. The cross-formatted sensor reading 344 is used in the parameter check module 336 to determine whether the cross-formatted sensor reading 344 lies: (i) above a specified minimum value, (ii) below a specified maximum value, or (ii) within acceptable upper and lower operating limits. If the cross-formatted sensor reading 344 is an anomalous reading, and falls outside the specified value range, the cross-formatted sensor reading 344 will fail a parameter value check. Accordingly, a monitor trigger signal 346 may be generated, in response to the failure, and be sent to a response module 338. When the trigger signal 346 is sent because an anomalous sensor reading has been detected, the response module 338 may issue an emergency response alarm 348 to activate one or more of: (i) the aircraft tracking system 152, (ii) an emergency locator transmitter, (iii) an alarm, or (iv) a global aeronautical distress safety system, for example, as described in greater detail below.

[0084] It can be appreciated by one skilled in the art that the particular message or signal format of the emergency response alarm 348 will conform to the input requirements of the one or more of the receiving components, that is, the aircraft tracking system 152, the emergency locator transmitter, the alarm, or the global aeronautical distress safety system. In an exemplary embodiment, a manually-initiated trigger signal 340 can be physically sent by a member of the aircraft crew, or a passenger with appropriate authority, for example. Inputting the manually-initiated trigger signal 340 to the response module 338 will similarly produce the emergency response alarm 348. In an exemplary embodiment, the anomaly response unit 330 can issue the emergency response alarm 348 in response to deriving an anomalous sensor reading from a flight data acquisition unit (FDAU) 356 or from a flight data recorder (FDR) 358, both located in the aircraft avionics unit 350. In standard operating procedure, the flight data acquisition unit 356 provides flight data 354 to the flight data recorder 358.

[0085] Referring now to an alternative functional block diagram shown in FIG. 10, operation of the avionics monitoring system 320 can be more explicitly illustrated by using as an example, a programmable aircraft attitude sensor 362, which provides a reading related to the yaw of the aircraft 140. A programmable aircraft attitude sensor enables values of the X-, Y- or Z-axis to be entered into the sensor and, when certain X, Y or Z values are exceeded, this flight situation acts to trigger an event. In a typical application of the disclosed method, the aircraft attitude sensor 362 would be only one of a plurality of actively monitored sensors in the aircraft avionics system 350. For clarity of description, the monitoring procedure will be explained for just the aircraft attitude sensor 362, but the disclosed method is applicable to any of the plurality of sensors found in the avionics system 350 of the aircraft 140.

[0086] During normal flight operations, an attitude sensor signal 364 is sent to the flight data acquisition unit 356, as shown in the diagram. In the example shown, the anomaly response unit 330 also includes an ARU controller 372 and an ARU database 374 used for storing aircraft operating parameters. The ARU controller 372 functions to continuously monitor selected signals in the aircraft avionics system 350. The ARU controller accomplishes this task by controlling operations of the signal coupler 332, the signal processor 334, the parameter check module 336, and the response module 338, as described in flow diagram 390 of FIG. 11.

[0087] The ARU controller 372 begins a monitoring sequence by directing the signal coupler 332 to acquire the next sensor signal in a predetermined series of sensor signals, the attitude sensor signal 364 in this example, at step 392. The signal format of the attitude sensor signal 364 may be identified by the ARU controller 372 by accessing the ARU database 374, at step 394, so as to produce a monitored attitude signal 392. The monitored attitude signal 392 may be substantially the same signal as the attitude sensor signal 364. The monitored attitude signal 392 is sent to the signal processor 334. The ARU controller 372 provides the monitored attitude signal 392 cross-format information to the signal processor 334, at step 396, and instructs the signal processor 334 to perform a cross-formatting operation on the monitored attitude signal 392, if necessary, at step 398. This operation yields a cross-formatted attitude sensor reading 384.

[0088] The cross-formatted attitude sensor reading 384 is then provided to the parameter check module 336. The ARU controller 372 may access the ARU database 374 to retrieve acceptable aircraft operating parameters for the aircraft attitude sensor 362, at step 400. The acceptable aircraft operating parameters are provided to the parameter check module 336 for comparison to the cross-formatted attitude sensor reading 384. For example, an acceptable aircraft operating parameter (psi) range for the aircraft attitude sensor 362 may be plus or minus sixteen degrees (i.e., −16° to +16°). If the cross-formatted attitude sensor reading 384 lies outside this range, at decision block 402, the ARU controller 372 proceeds to step 404, an attitude monitor trigger signal 386 is sent to the response module 338, and an appropriate response requirement is provided to the response module 338.

[0089] In an exemplary embodiment, at step 406, the response requirement when the attitude monitor trigger signal 386 is received is to issue an attitude emergency response alarm 388 to activate the aircraft tracking system 152. The appropriate response requirement to be initiated by the response module 338 may depend on (i) which monitored sensor signal is not within specification, and (ii) the degree to which the selected sensor signal is out of specification.
[0090] On the other hand if, at decision block 402 in FIG. 11, the cross-formatted attitude sensor reading 384 lies within the acceptable operating range, the ARU controller 372 continues the monitoring process from step 394 with another selected sensor signal. Preferably, the anomaly response unit 330 also includes a programmable link 376 by which both the operating methodology of the ARU controller 372, and the flight operational data in the ARU database 374 can be updated from, for example, the emergency system server 290 (in FIG. 8), from a ground-based facility (not shown), or from an authorized user on board the aircraft 140.

[0091] FIG. 12 shows a table listing 410 of exemplary avionics components, aircraft gauges, in-flight instruments, and other aircraft inflight sensors, that can be selected for use in the automatic aircraft emergency communication system 300. It should be understood that the table listing 410 is only a partial listing, and that any aircraft avionics component that produces a signal or a measurement or a reading can be used, or adapted for use, in the aircraft emergency communication systems disclosed herein. The avionics devices in the table listing 410 can provide sensor signals to the flight data acquisition unit 356, and are typically included in the flight data 354 sent to the flight data recorder 358, in accordance with standard aircraft flight operational procedures.

[0092] Such devices may include, for example, a digital gyroscope, a digital accelerometer, an automatic dependent surveillance broadcast (ADS-B) device, a differential pressure sensor, a temperature sensor, an open cockpit door sensor, a radar system, an altimeter, a transponder, a smoke detector, an engine sensor, or a programmable aircraft orientation alert device and software. The ARU controller 372 in the anomaly response unit 330 functions to determine which of the sensor signals produced by avionics devices, such as the avionics devices in the table listing 410, are to be monitored. The anomaly response unit 330 may also function to determine the sensor signal selection and sampling rate at which the signal monitoring procedure illustrated in the flow diagram 390 is executed.

[0093] As shown in FIG. 13, the flight data acquisition unit 356 typically obtains data related to the operational status of the landing gear 414, engine speed 416, wing flap position 418, aileron position 422, and rudder position 424, among other aircraft systems. These data are provided to the flight data recorder 358, usually located in an aft section of the aircraft 140. It can be appreciated by one skilled in the art that avionics sensor signals to be monitored can be readily acquired from the FDAU 356 and the FDR 358, as shown in greater detail in FIG. 14.

[0094] The FDAU 356 may be housed in two AIMS cabinets 432, 434, a configuration currently adopted by some aircraft designs. The flight data 354 may be sent to a data acquisition section 436 via a high speed data bus (ARINC 717) 438. The data acquisition section 436 processes the flight data 354 and sends processed data 442 to a microprocessor 444 where the processed data 442 is further processed and then stored in a crash-survivable memory 446. Processed data 448 generated by the microprocessor 444 may be sent to a front panel (not shown). The FDR 358 also monitors the flight data 354 and sends fault data 448 to the FDAU 356.

[0095] Referring now to FIG. 15, there is shown a functional block diagram of an exemplary embodiment of an anomaly response unit 460, in accordance with the present invention. The monitored sensor signal 324, shown in FIG. 9, may be provided to a controller 470, shown in FIG. 15, via an input/output module 462. The controller 470 functions to condition the monitored sensor signal 324 and issue the emergency response alarm 348 via an internal response module 338 to an alarm 464. The emergency response alarm 348 may also be transmitted via an optical coupler 466 to a remote device (not shown), or to the iridium satellite 162 (shown in FIG. 2) via a satellite modem 468. In an alternative operating mode, the controller 470 may issue the emergency response alarm 348 to the search and rescue satellite 310 and/or the government security personnel 302, 304, 306, 308 shown in FIG. 8, for example. As an optional feature, the controller 470 may issue a response signal 472 to initiate emergency procedures. For example, the flight crew may be notified of the potential problem by energizing an indicator light (not shown) on the aircraft instrument panel.

[0096] In an exemplary embodiment, shown in FIG. 16, an aircraft emergency response system 480 may include the anomaly response unit 460, a global aeronautical distress safety system (GADSS) controller/transmitter 482, and the emergency locator transmitter 484. The anomaly response unit 460 may transmit the emergency response alarm 348 to the global aeronautical distress system controller/transmitter 482, wherein the GADSS controller/transmitter 482 may, in turn, transmit a GADSS emergency response signal 486 to the emergency locator transmitter 484. The GADSS has been established to enable emergency units and personnel to locate an aircraft accident site with a greater degree of accuracy, in a shorter timeframe, and executed with a higher confidence level than is achieved with most current aircraft emergency response systems.

[0097] As shown in a satellite emergency communication system 490 in FIG. 17, the GADSS controller/transmitter 482 may repeatedly transmit, via a GNSS antenna 496, a GADSS emergency message at predefined time intervals (e.g., every sixty seconds, every fifteen seconds, or every second) to an appropriate satellite, such as a Global Navigation Satellite System (GNSS) satellite 492 to a ground and tracking reporting service 494, for example. The current location coordinates of the aircraft 140 may be included in the GADSS emergency message, and/or may be transmitted by the ELT 484 to the search and rescue satellite 310 via an ELT antenna 498.

[0098] As shown in FIG. 18, a satellite emergency communication system 510 may include a manual switch 512 activated by the manual trigger signal 340 sent by a crew member on the aircraft 140, to initiate transmission of emergency messages. As described above, the anomaly response unit 330, 460 in conjunction with the avionics sensor signals 324 monitored signals received from the avionics system 350, generates the emergency response alarm 348 when it is determined that the aircraft 140 is in a distressed state. The GADSS emergency response signal 486 is provided to the manual switch 512 for routing to the ELT 484 via a switch harness cable 516, if manual operation is initiated. The GADSS emergency response signal 486 can also be sent to the ELT 484 manually via the manual switch 512. For automatic operation, a GADSS harness cable 518 is provided to route the GADSS emergency response signal 486 directly to the ELT 484 from the GADSS controller/transmitter 482.
FIG. 19 shows an exemplary physical embodiment of an anomaly response module 560 configured with either the anomaly response unit 330 or the anomaly response unit 460 enclosed in a housing 562. The anomaly response module 560 may be installed into the communication path transmitting flight data 354 along the high speed data bus 438, shown in FIG. 14, so as to acquire the avionics sensor signals to be monitored. Accordingly, the anomaly response module 560 may include a first electrical connector 564 for attachment to the flight data recorder 358 and a second electrical connector 566 for attachment to the flight data acquisition unit 356. In accordance with the present invention, the anomaly response module 560 may further include a third electrical connector 568 for one or more of: (i) providing electrical power to the enclosed anomaly response unit 330, 460, (ii) providing the programmable link 376 (shown in FIG. 10), (iii) enabling transmission of the emergency response alarm 348 (shown in FIG. 9), and (iv) enabling transmission of the attitude emergency response alarm 388 (shown in FIG. 10).

Operation of the satellite emergency communication systems 480, 490 incorporating the anomaly response unit 330, 460 can be explained with reference to a flow diagram 520, shown in FIG. 20. In an exemplary embodiment, the ARU controller 372 (shown in FIG. 10) or the controller 464 (shown in FIG. 15), may receive specific or updated monitored parameters within which the aircraft 140 is expected to operate under normal flight conditions, at step 522 in FIG. 20. The controller 372, 464 may then synchronize these new or specific parameters with a system monitoring interface, such as the anomaly response unit 460 shown in FIG. 15. The controller 372, 464 then functions to evaluate the monitor sensor signals 324 and the aircraft avionics system 350, shown in FIG. 9, against internal GADSS triggering parameters resident in the avionics monitoring system 320, at step 526.

In the event that one or more of the internal GADSS triggering parameters is breached, at step 528, the GADSS controller/transmitter 482 will, at step 530, begin one of a pre-defined sixty-second period, fifteen-second period, or one-second period tracking (for example) of the aircraft 140 by the aircraft tracking system 152, shown in FIG. 8. The ELT 484 may be similarly activated by the GADSS controller/transmitter 482 to continue tracking the airborne aircraft 140, at step 532. The GADSS controller/transmitter 482 will issue a series of burst messages to ground-based authorities, at step 534, via the ground tracking and reporting service 494, shown in FIG. 17. As can be appreciated by one skilled in the relevant art, the satellite emergency communication systems 480, 490 provide for redundant tracking of the distressed aircraft 140 by simultaneously operating the GADSS controller/transmitter 482 and the ELT 484 during flight, at step 536.

FIG. 21 illustrates a satellite emergency communication system configuration 540 in which a crew member can use the cockpit-based mobile communication device 312 on board the aircraft 140 to communicate with the government security personnel 304 via the anomaly response unit 460. The input from the mobile communication device 312 may be received by the input/output module 462, and the transmission to the government security personnel 304 may be made via the satellite modem 466.

FIG. 22 illustrates a satellite emergency communication system configuration 550 in which a crew member on board the aircraft 140 can use a headset 552 or a microphone 554 to verbally communicate with the control tower 316 and the air traffic controllers 318 via the anomaly response unit 460. The audio input from the headset 552 or the microphone 554 may be received by the input/output module 462, and the transmission to the control tower 316 and the air traffic controllers 318 may be made via the satellite modem 466.

FIG. 23 illustrates a satellite emergency communication system configuration 568 in which a crew member on board the aircraft 140 can use the mobile communication device 312, the headset 552, or the microphone 554 to verbally communicate with the air traffic controllers 318 via the anomaly response unit 460. The audio input from the headset 552 or from the microphone 554 may be received by the input/output module 462, and the transmission to the air traffic controllers 318 may be made via the satellite modem 466. In an exemplary embodiment, the anomaly response unit may include a voice-to-text converter 476 for producing and storing text versions of the conversations between the crew member and the air traffic controllers 318. The stored text may be displayed by the satellite emergency communication system configuration 568 when the message is communicated to the air traffic controllers 318.

As can be appreciated by one skilled in the art, voice communication accessed, converted, and stored via the voice-to-text converter 476 provides an important feature that supplements the use of the cockpit voice recorder 412, shown in FIG. 13. Advantageously, the text produced by the voice-to-text converter 476 is available for immediate retrieval by the air traffic controllers 318, for example, whereas the data acquired by the cockpit voice recorder 412 may not be available until the aircraft 140 has landed. The ability to record messages and cockpit conversations, both as audio via a cockpit voice recorder 412, and as text via the voice-to-text converter 476, may find use in any of numerous situations, including a scenario where an interruption takes place during air-to-ground communication. Information that was not communicated due to the interruption is thus not lost, and may be accessed when the communication link is reestablished via the satellite modem 466, and retrieved from the cockpit conversation data stored in the voice-to-text converter 476.

FIG. 24 illustrates a communication scenario in which a message input maybe made by any of numerous different message or signal formats, including voice real-time audio/video communication or recording. A voice input may be formatted as necessary by any of the emergency communication systems 142, 300, 480, 490, 510, 540, 550, and 560 described above, for use by the appropriate recipient(s). The message or signal format for an individual recipient may be determined by referring to the information about the individual when registered in the system. For example, for an individual whose profiles indicate that he receives messages using text, the voice input may be converted to text prior to receipt by the text-message individual. For other individuals whose profiles indicate they are may receive voice communications, the voice message from the pilot is received as such. Accordingly, communication continuity can be maintained in a satellite emergency communication system configuration 570 between a crew member 572, an air traffic controller 574, and optionally, the ground-based official 304, shown in FIG. 24.
FIG. 25 shows a flow diagram that illustrates operation of the aircraft tracking system 152, shown above in FIGS. 2 and 8. The anomaly response unit 330, 460, for example, may receive operational data from the selected avionics sensor 322 in FIG. 9, at step 582, and can compare the data with a related threshold profile 584 to determine if the capacity of the threshold profile 584 has been exceeded, at step 586, resulting in an anomalous sensor reading. This adverse condition initiates the aircraft tracking system satellite alert sequence 520 in FIG. 20, at step 588. Execution of the satellite alert sequence 520 may include one or more of: (i) automatic activation of the ELT 484, at step 590; (ii) activation of an Automatic Dependent Surveillance Broadcast (ADS-B) indicator (not shown), at step 592; and (iii) activation of an underwater locator beacon (ULB), not shown, at step 594.

In an exemplary embodiment for an emergency communication system operating in accordance with a flow diagram 600, in FIG. 26, the aircraft tracking system 152 of FIG. 8 can be activated when the aircraft 140 experiences a change in attitude that exceeds a pre-determined threshold, such as, for example, a limit of plus or minus sixteen degrees. The particular parameters for the programmable aircraft attitude sensor 362, shown in the aircraft avionics system 320 in FIG. 10, may be set from a ground-based facility for updating the ARU database 374, at step 602. The aircraft attitude sensor 362 is monitored for any unusual change in attitude, at step 604, and the monitored value is compared to the corresponding attitude parameter stored in the ARU database 374, at step 606. If the attitude change in the aircraft 140 has exceeded the current database threshold of plus or minus sixteen degrees, for example, at decision block 608, the aircraft tracking system 152 may be activated, at step 610. In either case, the results of the monitoring action may be stored in the ARU database 374, at step 612.

There is shown in FIG. 27 a functional block diagram of an exemplary autonomous distressed aircraft tracking system 620. The autonomous distressed aircraft tracking system 620 includes either or both an advanced Emergency Location Transmitter (smart ELT) 622 and an advanced Global Aeronautical Distress Safety System (smart GADSS) 624, wherein the smart ELT 622 and the smart GADSS 624 can be activated by a programmable autonomous response unit controller 642 in a programmable autonomous response unit 630. The programmable autonomous response unit 630 monitors the aircraft avionics 350 for an anomaly during flight and, when an anomaly is detected, an emergency message is issued. The programmable autonomous response unit 630 is similar in operation to the anomaly response unit 330 described above in FIG. 10.

Referring now to FIG. 27, a triggering sensor 626 provides an avionics sensor signal 628 to a signal coupler 632. The signal coupler 632 functions to provide the acquired avionics sensor signal 628 to a signal processor 634. The acquired avionics sensor signal 628 is then cross- reformatted by the signal processor 634 suitable for evaluation by a parameter check module 636. A monitor trigger signal may be generated in response to an anomaly, and sent to a response module 638. The programmable PARU controller is in communication with a programmable autonomous response unit database 644 to input or retrieve flight operational parameters.

Upon transmittal of the emergency distress signal 648, either or both the smart ELT 624 and the smart GADSS 622 transmit a search and rescue (SAR) alert to a COSPAS-SARSAT satellite 652, a underwater locator beacon, and, concurrently, an aircraft tracking signal to the GNSS satellite 492 so as to provide for two separate but redundant alert notifications and distressed aircraft tracking signals, with an elapsed time of one minute or less before appropriate authorities receive notification, informing of an aircraft avionics malfunction or emergency.

Depending on the severity of the emergency alert, the autonomous distressed aircraft tracking system 620 can determine who may manually or automatically activate and deactivate an emergency response by utilizing, for example: instrumentation or avionics in the aircraft 140 (shown above) or over communication methodologies on the ground or in the aircraft 140, and/or bi-directionally through the existing ELT antenna 498, from a ground station, or from within the aircraft 140. That is, updates or modification to parameters for a sensor, such as an attitude sensor, may be made “over the air,” via “ground to air” communication, or via a ground based web interface. The emergency response may also be controlled by an Aircraft Communications Addressing and Reporting System (ACARS) or a Non-radar Position Reporting Points System.

The autonomous emergency response signal can be generated as a consequence of an avionics failure, an instrument failure, or by some other failure of equipment to operate properly. As can be appreciated by one skilled in the art, such failures include, for example, electrical problems, power failure, fuse tripping or malfunction and or tampered with (turning off a device when it is not protocol). This control can be executed via: a remote control or remotely; wired or wirelessly; through a transceiver or transmitter, Wi-Fi, satellite, aircraft equipment using a hand held device; by an aircraft-based pilot telemetry system; a computer server; data recorder; instrument and or sensor information.

Any of these preceding methods can function to send one or timed series of Smart ELT GPS-based 406 MHz emergency messages and notifications and/or live or recorded audio/video to the COSPAS SARSAT satellite 652, Rescue Personnel, Air Traffic Control Personnel, Airline or Aircraft Personnel or government authorities, so as to provide a location for the Smart ELT 624 and, accordingly, the current location of the aircraft 140.

The smart ELT 624 and the smart GADSS 622 may operate with, or independently of, any of standard equipment found in the aircraft 140 including, but not limited to, the onboard ELT 484, the onboard Flight Data Recorder 358, the onboard cockpit voice recorder 412, an onboard Automatic Dependent Surveillance Broadcast System (ADS-B), an onboard Automatic Dependent Surveillance Contract System (ADS-C), an onboard Terrain Awareness Warning System (TAWS), a programmable digital gyroscope, a programmable axis sensor, a programmable axis indicator, or any avionics or appropriate instrumentation.

The smart ELT 624 may include a newly-designed Emergency Location Transmitter or integrated with similar flight equipment, deployment or configuration, or a system including the smart ELT 624 in the form of hardware, hardware/software or software only developments. Additionally, the smart ELT 624 and the smart GADSS 622 can be independently powered; and may be attached or integrated into any onboard avionics device such as, for
example, a symbol generator, the flight data acquisition unit 356, the FDR 358, the CVR, the TAWS, the ADS-B, the ADS-C, a transponder, the ELT 484, or an appropriate aircraft performance and/or flight data monitoring system.

[0117] The existing Automatic Dependent Surveillance Broadcast System, the Automatic Dependent Surveillance Contract System, the Terrain Awareness Warning System, an Engine Indication and Crew Alerting System (EICAS or CAS), a circuit breaker, or other electrical device, avionics, or instrumentation may have added hardware, hardware/software, or software only developments to convert the devices into a smart ADS-B, a smart ADS-C, a smart TAWS, or a smart CAS which may work with or independent of, the Smart ELT 624, and may transmit, act as a transceiver, send emergency messages, notifications and or live or recorded audio/video and or activate the Smart ELT 624, as well as perform added monitoring and notification functions, with or independent of, the Smart ELT 624. It should be understood that onboard avionics typically includes one or more of the symbol generator, Flight Data Acquisition Unit, FDR, CVR, TAWS, GPWS, ADS-B, ADS-C, transponder, ELT, and aircraft performance and/or flight data monitoring system described above.

[0118] The smart ELT 624 may be activated and controlled: manually, automatically, wired or wirelessly, remotely, through a remote control unit, by a software interface, through instrumentation or avionics; through a headset, by voice commands or voice recognition software, through a ground or aircraft sensor, by aircraft personnel on/off the aircraft, through flight data information, aircraft equipment or avionics. FIG. 28 provides an exemplary listing of triggering sensors in events that may function to automatically activate the appropriate response.

[0119] It is to be understood that the description herein is only exemplary of the invention, and is intended to provide an overview for the understanding of the nature and character of the disclosed aircraft emergency communication systems. The accompanying drawings are included to provide a further understanding of various features and embodiments of the method and devices of the invention which, together with their description serve to explain the principles and operation of the invention.

What is claimed is:

1. An autonomous anomaly response unit suitable for monitoring an aircraft avionics system and initiating an emergency response if the aircraft operational state escalates to a distressed stage, said anomaly response unit comprising:
a signal coupler in communication with a selected avionics sensor in the aircraft avionics system, said signal coupler functioning to acquire from said selected avionics sensor a monitored sensor signal configured in a first signal format;
a signal processor for receiving said monitored sensor signal and cross-formatting said monitored sensor signal into a selected sensor reading configured in a second signal format;
a parameter check for evaluating said selected sensor reading such that a monitor trigger signal is issued in response to detection of an anomaly in said selected sensor reading; and
a response module configured to issue an emergency response alarm in response to receiving said monitor trigger signal.

2. The anomaly response unit of claim 1 wherein said anomaly response unit communicates with a flight data acquisition unit in the aircraft so as to access and acquire said monitored sensor signal.

3. The anomaly response unit of claim 1 wherein said emergency response alarm functions to initiate an aircraft tracking system in the aircraft.

4. The anomaly response unit of claim 1 wherein said emergency response alarm functions to send an emergency response signal to initiate an emergency location transmitter in the aircraft, said emergency location transmitter functioning to transmit aircraft coordinates via a search and rescue satellite.

5. The anomaly response unit of claim 1 wherein said emergency response alarm functions to send an emergency response signal to a global aeronautical distress safety system and to transmit an emergency message via a global navigation satellite system to authorities.

6. The anomaly response unit of claim 1 wherein said emergency response alarm functions to send an emergency response signal to a global aeronautical distress safety system and to transmit the distressed aircraft position via a global navigation satellite system to authorities.

7. The anomaly response unit of claim 1 wherein said emergency response alarm functions to send an emergency response signal to a global aeronautical distress safety system and to continuously transmits and reports the distressed aircraft position in predetermined time increments via a global navigation satellite system to authorities.

8. The anomaly response unit of claim 1 wherein said emergency response alarm functions to send an emergency response signal to a global aeronautical distress safety system and to continuously transmits and reports the distressed aircraft position in predetermined time increments via a global navigation satellite system to authorities and concurrently activates the aircraft’s emergency location transmitter which transmits a separate and distinct transmission emergency signal to the Search and Rescue personnel via the Search and Rescue satellite constellation.

9. The anomaly response unit of claim 1 wherein said emergency response alarm is issued by said response module in responsive to a manual trigger emergency response alarm sent by one of a aircraft crew member, an authorized passenger, or a ground-based authority.

10. The anomaly response unit of claim 1 wherein said anomaly response unit further comprises an anomaly response unit controller and a programmable link, said anomaly response controller functioning to receive anomaly response unit flight operation data and operating parameter updates via said programmable link, said anomaly response unit controller further functioning to store aircraft operating parameters in an anomaly response unit database.

11. The anomaly response unit of claim 1 wherein said selected sensor reading comprises an aircraft attitude sensor reading.

12. The anomaly response unit of claim 1 wherein said selected sensor reading comprises a reading derived from a sensor signal produced by one of a digital gyroscope, a digital accelerometer, an automatic dependent surveillance broadcast (ADS-B) device, a terrain awareness warning sensor, a differential pressure sensor, a temperature sensor, an open cockpit door sensor, a flight plan sensor, a radar system, an altimeter, a transponder, a smoke detector, and an engine sensor.
13. A method of remotely tracking a distressed aircraft, said method comprising the steps of:
   coupling to a selected avionics sensor in the aircraft avionics system so as to acquire from said selected avionics sensor a monitored sensor signal configured in a first signal format;
   cross-formatting said monitored sensor signal into a selected sensor reading configured in a second signal format;
   evaluating said selected sensor reading against a predetermined sensor operating range of parameter values; if said selected sensor reading lies outside said predetermined sensor operating range of parameter values, sending a monitor trigger signal to a response module; issuing an emergency response alarm from said response module in response to said monitor trigger signal; and communicating with a pre-established group of ground-based personnel.

14. The method of claim 13 further comprising the step of initiating an aircraft tracking system in response to said step of issuing said emergency response alarm, said aircraft tracking system configured to automatically track, record, and report a geo-location and a GPS location of the aircraft to a plurality of ground-based government security personnel.

15. The method of claim 13 further comprising the steps of: (i) initiating operation of at least one of an emergency location transmitter and a global aeronautical distress safety system in the aircraft, and (ii) transmitting an emergency message via a global navigation satellite system.

16. The method of claim 13 further comprising the step of reporting, at a predetermined rate of transmission, a geo-location and a GPS location of the aircraft to a plurality of ground-based government security personnel.

17. The method of claim 13 wherein said monitored sensor signal comprises a reading derived from a sensor signal produced by one of a digital gyroscope, a digital accelerometer, an automatic dependent surveillance broadcast (ADS-B) device, a terrain awareness warning sensor, a differential pressure sensor, a temperature sensor, an open cockpit door sensor, a flight plan sensor, a radar system, an altimeter, a transponder, a smoke detector, and an engine sensor.

18. The method of claim 13 wherein said step of coupling to a selected avionics sensor in the aircraft avionics system comprises the step of installing an anomaly response unit in a communication path between a flight data acquisition unit in the aircraft and a flight data recorder in the aircraft, said anomaly response unit including a signal coupler.

19. An autonomous communication system for remotely tracking a distressed aircraft, said system comprising:
   an aircraft tracking system for automatically determining current aircraft location;
   an avionics monitoring system in communication with an avionics system in the aircraft, said avionics monitoring system including
   a signal coupler in communication with a selected avionics sensor in the aircraft avionics system, said signal coupler functioning to acquire from said selected avionics sensor a monitored sensor signal configured in a first signal format;
   a signal processor for receiving said monitored sensor signal and cross-formatting said monitored sensor signal into a selected sensor reading configured in a second signal format;
   a parameter check for evaluating said selected sensor reading such that a monitor trigger signal is issued in response to detection of an anomaly in said selected sensor reading;
   a response module configured to issue an emergency response alarm in response to receiving said monitor trigger signal;
   a transmitter for transmitting an emergency message in response to receiving said emergency response alarm;
   a transmitter for transmitting an emergency homing transmission in response to receiving said emergency response alarm; and
   a satellite communication system for sending said emergency message and homing transmission to ground based personnel.

20. The communication system of claim 19 wherein said response module issues said emergency response alarm to at least one of an emergency location transmitter, a global aeronautical distress safety system transmitter, a global navigation satellite system, a search and rescue satellite, an indium communication satellite, and said aircraft tracking system.