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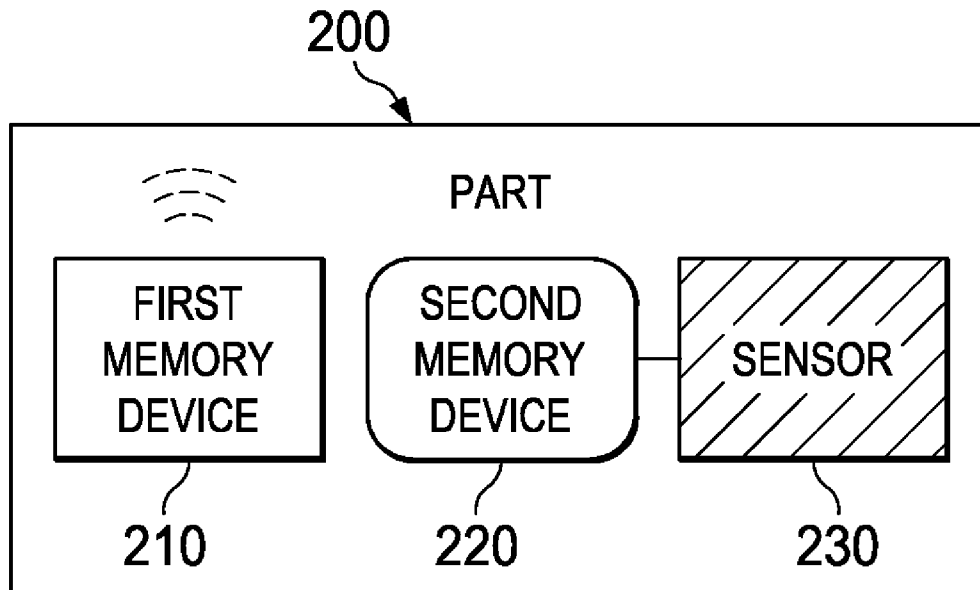
(19) **United States**(12) **Patent Application Publication**
Tucker(10) **Pub. No.: US 2014/0061382 A1**(43) **Pub. Date: Mar. 6, 2014**(54) **LONG AND SHORT RANGE STORAGE AND
TRANSMISSION SYSTEM ON AIRCRAFT
PARTS**(52) **U.S. Cl.**CPC **B64F 5/0036** (2013.01)USPC **244/1 R**(75) Inventor: **Brian E. Tucker**, Fort Worth, TX (US)

(57)

ABSTRACT(73) Assignee: **BELL HELICOPTER TEXTRON
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According to one embodiment, an aircraft part storage system includes a first storage device and a second storage device. The first storage device is configured to be coupled to an aircraft part and operable to store and transmit a first set of information about the aircraft part. The second storage device is configured to be coupled to the same aircraft part and operable to store and transmit a second set of information about the aircraft part. The second storage device has a larger storage capacity than the first storage device but a shorter transmission range than the first storage device.



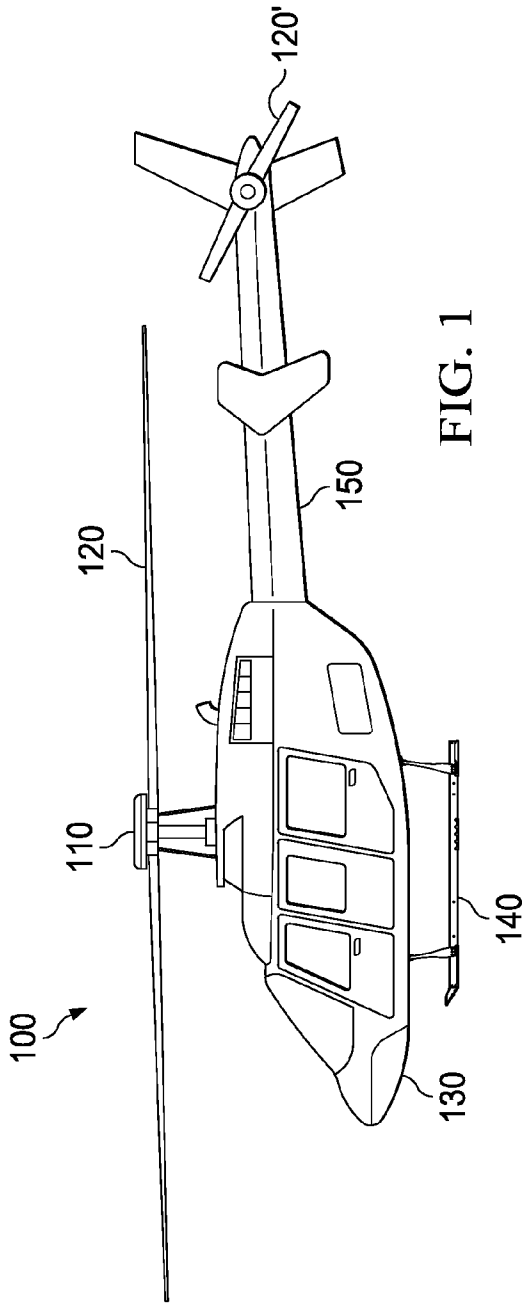
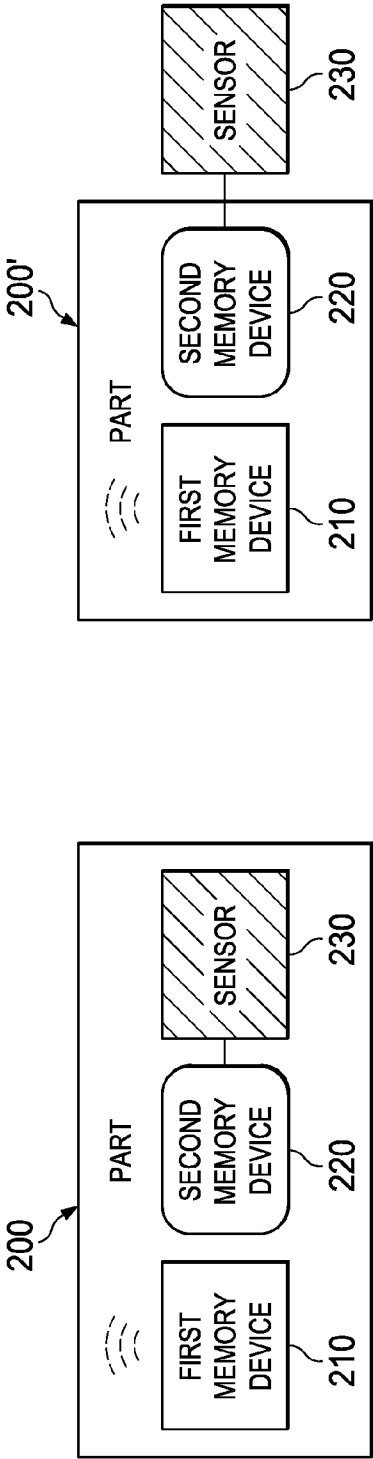
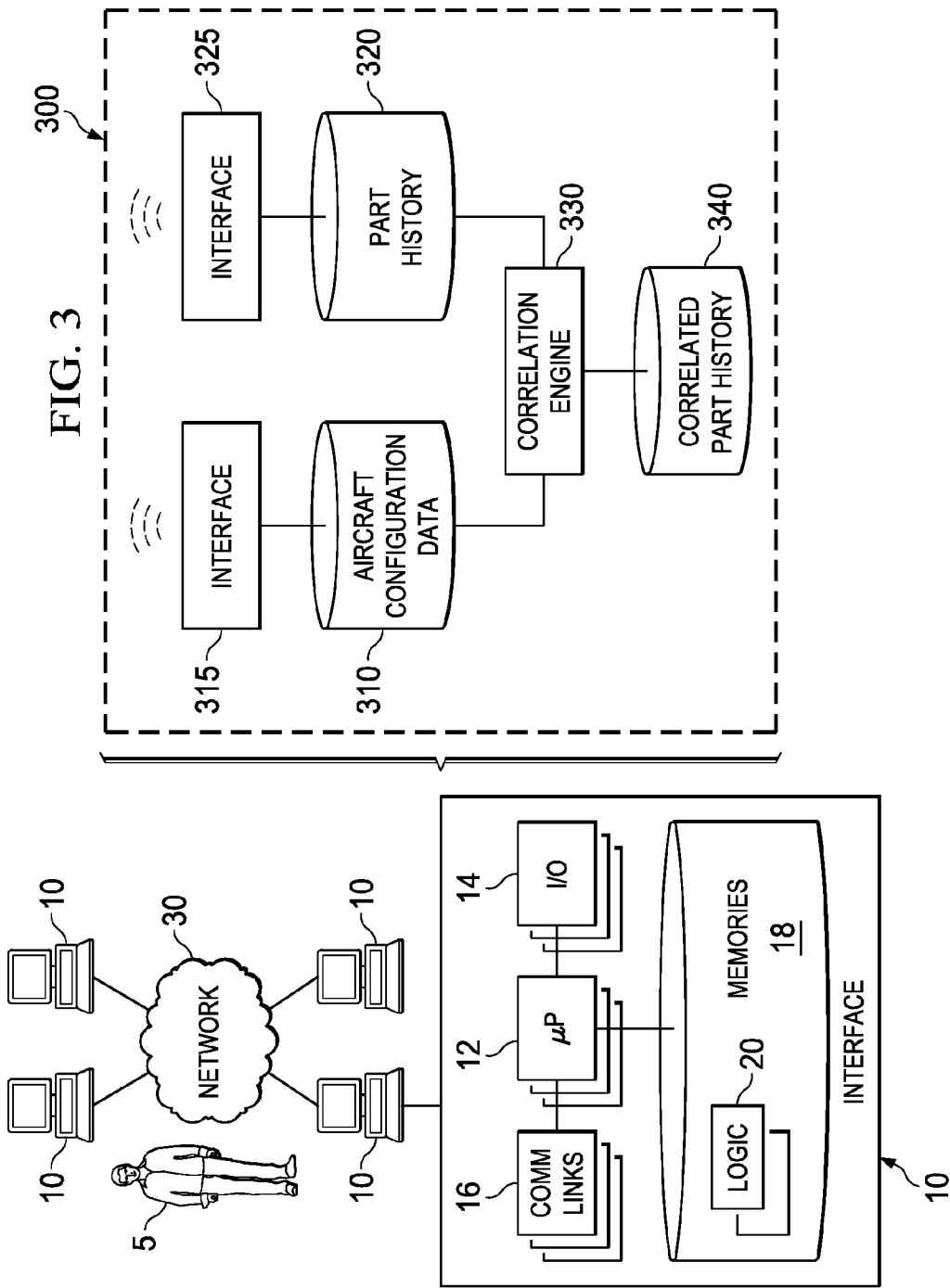


FIG. 1





LONG AND SHORT RANGE STORAGE AND TRANSMISSION SYSTEM ON AIRCRAFT PARTS

TECHNICAL FIELD

[0001] This invention relates generally to storage solutions on aircraft parts, and more particularly, to long and short range storage and transmission system on aircraft parts.

BACKGROUND

[0002] An aircraft, such as a rotorcraft, may be manufactured from a variety of parts. Some of these parts may be moved between aircraft. Some of these parts may also be serviced, maintained, and/or replaced during the life of the part.

SUMMARY

[0003] Particular embodiments of the present disclosure may provide one or more technical advantages. A technical advantage of one embodiment may include the capability to store and transmit aircraft configuration and part history information from a part on an aircraft. A technical advantage of one embodiment may include the capability to increase the transmission range for aircraft configuration information and increase the storage capacity for part history information. A technical advantage of one embodiment may include the capability to eliminate the need for access to the Internet or part databases when servicing an aircraft part.

[0004] Certain embodiments of the present disclosure may include some, all, or none of the above advantages. One or more other technical advantages may be readily apparent to those skilled in the art from the figures, descriptions, and claims included herein.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] To provide a more complete understanding of the present invention and the features and advantages thereof, reference is made to the following description taken in conjunction with the accompanying drawings, in which:

[0006] FIG. 1 shows a rotorcraft according to one example embodiment;

[0007] FIGS. 2A and 2B show parts associated with the rotorcraft of FIG. 1 according to one example embodiment; and

[0008] FIG. 3 shows an aircraft part information correlation system according to one example embodiment.

DETAILED DESCRIPTION OF THE DRAWINGS

[0009] FIG. 1 shows a rotorcraft 100 according to one example embodiment. Rotorcraft 100 features a rotor system 110, blades 120, a fuselage 130, a landing gear 140, and an empennage 150. Rotor system 110 may rotate blades 120. Rotor system 110 may include a control system for selectively controlling the pitch of each blade 120 in order to selectively control direction, thrust, and lift of rotorcraft 100. Fuselage 130 represents the body of rotorcraft 100 and may be coupled to rotor system 110 such that rotor system 110 and blades 120 may move fuselage 130 through the air. Landing gear 140 supports rotorcraft 100 when rotorcraft 100 is landing and/or when rotorcraft 100 is at rest on the ground. Empennage 150 represents the tail section of the aircraft and features components of a rotor system 110 and blades 120'.

Blades 120' may provide thrust in the same direction as the rotation of blades 120 so as to counter the torque effect created by rotor system 110 and blades 120. Teachings of certain embodiments relating to rotor systems described herein may apply to rotor system 110 and/or other rotor systems, such as other tilt rotor and helicopter rotor systems. It should also be appreciated that teachings regarding rotorcraft 100 may apply to aircraft and vehicles other than rotorcraft, such as airplanes and unmanned aircraft, to name a few examples.

[0010] An aircraft, such as a rotorcraft, may be manufactured from a variety of parts. Some of these parts may be moved between aircraft. Some of these parts may also be serviced, maintained, and/or replaced during the life of the part.

[0011] Workers may track aircraft part configurations by periodically recording which parts are installed on a particular aircraft. To perform this task, workers may inspect the aircraft and record a part number or serial number for each part installed. In some cases, such a task may be very resource intensive. For example, aircraft may include a large number of parts, and some of these parts may be not convenient to the workers (e.g., inside a small compartment or located high off the ground). Accordingly, teachings of certain embodiments recognize the capability to wirelessly transmit aircraft configuration information to workers.

[0012] Workers may also use maintenance information of an aircraft part when servicing, maintaining, and/or replacing the part. For example, workers may access maintenance information describing a history of the aircraft part (e.g., maintenance history, environmental history, service history, repair history) as well as service manuals indicating how the part should be inspected and maintained.

[0013] In some circumstances, such maintenance information may be stored in a database accessible by the workers. Such a database, however, may not always be accessible by the workers. For example, the aircraft may undergo repair in remote locations where database access is not available. Accordingly, teachings of certain embodiments recognize the ability to provide a storage medium with the aircraft part that is configured to store maintenance information about the part.

[0014] As stated above, aircraft configuration information may be transmitted wirelessly to workers. It may be possible, therefore, to also wirelessly transmit maintenance information to workers using the same wireless communication technique. Teachings of certain embodiments recognize, however, numerous problems associated with using the same communication technique to transmit both aircraft configuration information and maintenance information. For example, in general, transmitting larger amounts of information may necessarily require an increase in power consumption and/or a decrease in transmission range. Maintenance information may include much larger amounts of information than aircraft configuration information, and transmitting maintenance information with aircraft configuration information may increase the power consumption necessary to transmit the aircraft configuration information and/or reduce the transmission range of the aircraft configuration information.

[0015] Teachings of certain embodiments recognize, therefore, the ability to optimize the tradeoff between transmission range versus storage capacity by providing two storage and transmission devices: a long-range transmission device (having a limited amount of storage) and a short-range transmis-

sion device (having a greater amount of storage). In some embodiments, the long-range transmission device may store and transmit aircraft configuration information, whereas the short-range transmission device may store and transmit maintenance information. Unlike aircraft configuration information, the short-range transmission device may be appropriate for maintenance information because storage capacity may be a higher priority than transmission range (e.g., because maintenance information is used primarily by workers that have direct contact with the aircraft part when servicing or replacing the part).

[0016] FIG. 2A shows a part **200** according to one embodiment. Part **200** may represent an aircraft part associated with an aircraft such as rotorcraft **100** of FIG. 1. For example, part **200** may represent a rotor blade, an abrasion strip on a rotor blade, a bearing, or any number of other parts.

[0017] In the example of FIG. 2A, a first storage device **210** and a second storage device **220** are coupled to part **200**. In some embodiments, first storage device **210** and/or second storage device **220** may be coupled proximate to part **200** but not necessarily to part **200**. For example, if part **200** is a bearing, first storage device **210** and/or second storage device **220** may be coupled to a surface near part **200**.

[0018] First storage device **210** may be operable to store and transmit a first set of information identifying part **200**. Examples of first storage device **210** may include, but are not limited to, passive and active radio-frequency identification (RFID) tags. RFID is the use of a wireless non-contact system that uses radio-frequency electromagnetic fields to transfer data from a tag attached to or near an object. Passive RFID tags may not require a battery, but rather may be powered by the electromagnetic fields used to read them. Active RFID tags, on the other hand, may use a local power source and emit radio waves (electromagnetic radiation at radio frequencies). An RFID tag may contain electronically stored information which can be read at a distance. Unlike a bar code, the RFID tag does not necessarily need to be within line of sight of the reader and may even be embedded in the tracked object.

[0019] In some embodiments, the first set of information stored and transmitted by first storage device **210** may represent the aircraft configuration information from the previous example. For example, the first set of information identifying the aircraft part may include a part number unique to a category of aircraft parts and a serial number unique to the individual aircraft part. As stated above, the more information that is stored and transmitted may reduce the transmission range of first storage device **210**. Accordingly, teachings of certain embodiments recognize that limiting first storage device **210** to a small amount of information (e.g., only part number and serial number) may optimize the transmission range of first storage device **210**.

[0020] Second storage device **220** may be operable to store and transmit a second set of information about part **200**. Second storage device **210** may have a larger storage/transmission capacity than first storage device **210** but may also have a shorter transmission range. For example, one example of second storage device **220** may include, but is not limited to, a contact memory button (CMB) or flash memory device. CMBs are electronic devices that can receive, store, and/or transmit information when contacted with a touch probe. CMBs may have a larger storage/transmission capacity than RFID tags but may also have a shorter transmission range. For example, CMBs may store approximately four gigabytes of information, whereas an RFID tag may store approximately

512 bits of information. The CMBs, however, may have a 0 foot transmission range (i.e., transmits information only when contacted), whereas the 512-bit RFID tag may transmit information up to 20 feet.

[0021] Another example of second storage device **220** may include, but is not limited to, a higher-capacity RFID tags. For example, a higher-capacity RFID tag may store approximately 4000 or 8000 bytes of information. This higher-capacity RFID tag, however, may only have a transmission range of approximately 4 feet, which is substantially smaller than the 20 foot transmission range of a 512-bit RFID tag.

[0022] Second storage device **220** may store a myriad of information about part **200**. For example, storage device **200** may store information describing a history of part **200** (e.g., maintenance history, environmental history, service history, repair history) as well as service manuals indicating how the part should be inspected and maintained. For example, second storage device **220** may store a service manual indicating how part **200** should be inspected as well as information detailing the results of previous inspections of part **200**.

[0023] Teachings of certain embodiments also recognize that maintaining this second set of information with part **200** may make the second set of information more useful for workers. For example, storing maintenance records with the part makes such information more accessible as compared to storing such information in a database. Not only may it be more convenient to collect such information when the worker is physically working with the part, but the worker may not even have access to databases. The worker may not even have access to the internet, which could make it difficult for the worker to access service manuals for the part. Furthermore, different part models may be associated with different service manual versions, and storing the appropriate service manual locally with the part may help ensure that the worker uses the correct service manual when servicing the part. For example, different part models may have different damage limits, and it may be important for workers to access the correct service manual in order to apply the correct damage limit values when servicing the part.

[0024] In some embodiments, second storage device **220** may store environmental history of part **200**. In general, some aircraft parts may be subject to different environmental stresses. For example, rotorcraft **100** may operate in tropical environments where the air is more saturated with humidity. As another example, rotorcraft **100** may operate in marine environments where the air has higher levels of salinity, which may cause corrosion. As yet another example, rotorcraft **100** may operate in deserts where sand and other particulates may wear down rotorcraft components.

[0025] Such environmental stresses are not limited to when rotorcraft **100** is flying. For example, operation of rotorcraft **100** in a desert environment may include both flying rotorcraft **100** and parking rotorcraft **100** between flights. In this example, both flying and parking rotorcraft **100** may subject rotorcraft **100** to sand and other particulates.

[0026] Damage to part **200** may depend on the severity of exposure to environmental stresses. For example, damage may result from prolonged exposure from environmental stresses. In addition, damage may result from extreme exposure to environmental stresses, even if such exposure is short-lived. Furthermore, some parts **200** may be more susceptible to prolonged exposure to environmental stresses, whereas other parts may be more susceptible to extreme environmental stresses.

[0027] Aircraft parts may be designed to withstand expected environmental stresses. Different aircraft may fly in many different environments, however. Some aircraft may be exposed to more environmental stresses, whereas other aircraft may be exposed to less environmental stresses. Accordingly, teachings of certain embodiments recognize the capability to measure and store an environmental history of part 200.

[0028] In the example of FIG. 2A, part 200 features an environmental sensor 230. Environmental sensor 230 may measure aspects of the natural environment of which part 200 is subject to. Examples of environmental sensor 230 may include, but are not limited to, a humidity sensor, a salinity sensor, a corrosivity sensor, a particulate sensor, a pressure sensor, and a vibration sensor. Humidity sensors are operable to measure humidity in the atmosphere proximate to part 200. Salinity sensors are operable to measure salinity in the atmosphere proximate to part 200. Corrosivity sensors are operable to measure existence of corrosive substances proximate to part 200 or conditions favorable for corrosion part 200. Particulate sensors are operable to measure existence of particulates proximate to part 200. Particulate sensors may also measure the size and density of particulates, as well as other information. Pressure sensors may measure and determine information such as ambient air pressure (or pressure altitude) and dynamic air pressure (such that airspeed may be determined). Vibration sensors may measure vibration forces on part 200.

[0029] In the example of FIG. 2A, environmental sensor 230 is configured to communicate environmental history information directly to second storage device 220 (either wirelessly or through a wired connection). In this example, environmental sensor 230 may be configured to communicate environmental history information to second storage device 220 over an extended period of time (e.g., multiple flights or missions).

[0030] In some embodiments, however, environmental sensor 230 may be a “sacrificial” sensor. Sacrificial sensors are sensors that are permanently altered after performing one or more measurements such that the sacrificial sensor must be replaced before performing additional measurements. For example, some corrosivity sensors may detect corrosion of nearby parts by itself becoming corroded. In some embodiments, measurements from sacrificial sensors may be collected by a worker at the time of replacement, who may upload these measurements to second storage device 220. In some embodiments, these measurements may be associated with an approximate timestamp, indicating when the measurements are believed to have been taken. Alternatively, measurements may be associated with a known period of exposure based on an installation timestamp (indicating when the sensor was installed) and a removal timestamp.

[0031] In the example of FIG. 2A, environmental sensor 230 is coupled to part 200. In some embodiments, however, environmental sensor 230 may be coupled proximate to part 200 but not necessarily to part 200. For example, if part 200 is a bearing, environmental sensor 230 may be coupled to a surface near part 200. As another example, part 200 and environmental sensor 230 may be located in the same enclosed area, such as shown in FIG. 2B. For example, a humidity sensor may be located in areas within rotorcraft 100 where humidity may build up due to humidity in the air surrounding rotorcraft 100.

[0032] FIG. 3 shows aircraft part information correlation system 300 according to one example embodiment. In general, system 300 features an aircraft configuration data repository 310, a part history repository 320, a correlation engine 330, and a correlated part history repository 340. Aircraft configuration data repository 310 and part history repository 320 may receive information from first storage device 210 and second storage device 220 through interfaces 315 and 325, respectively. In one example embodiment, interface 315 is an RFID tag scanner, and interface 325 is a CMB reader.

[0033] Users 5 may access system 100 through computer systems 10. For example, in some embodiments, users 5 may access aircraft configuration data repository 310, part history repository 320, correlation engine 330, and correlated part history repository 340 through computer systems 10. Users 5 may include any individual, group of individuals, entity, machine, and/or mechanism that interacts with computer systems 10. Examples of users 5 include, but are not limited to, a pilot, service person, engineer, technician, contractor, agent, and/or employee. Users 5 may be associated with an organization. An organization may include any social arrangement that pursues collective goals. One example of an organization is a business. A business is an organization designed to provide goods or services, or both, to consumers, governmental entities, and/or other businesses.

[0034] Computer system 10 may include processors 12, input/output devices 14, communications links 16, and memory 18. In other embodiments, computer system 10 may include more, less, or other components. Computer system may be operable to perform one or more operations of various embodiments. Although the embodiment shown provides one example of computer system 10 that may be used with other embodiments, such other embodiments may utilize computers other than computer system 10. Additionally, embodiments may also employ multiple computer systems 10 or other computers networked together in one or more public and/or private computer networks, such as one or more networks 30.

[0035] Processors 12 represent devices operable to execute logic contained within a medium. Examples of processor 12 include one or more microprocessors, one or more applications, and/or other logic. Computer system 10 may include one or multiple processors 12.

[0036] Input/output devices 14 may include any device or interface operable to enable communication between computer system 10 and external components, including communication with a user or another system. Example input/output devices 14 may include, but are not limited to, a mouse, keyboard, display, and printer.

[0037] Network interfaces 16 are operable to facilitate communication between computer system 10 and another element of a network, such as other computer systems 10. Network interfaces 16 may connect to any number and combination of wireline and/or wireless networks suitable for data transmission, including transmission of communications. Network interfaces 16 may, for example, communicate audio and/or video signals, messages, internet protocol packets, frame relay frames, asynchronous transfer mode cells, and/or other suitable data between network addresses. Network interfaces 16 connect to a computer network or a variety of other communicative platforms including, but not limited to, a public switched telephone network (PSTN); a public or private data network; one or more intranets; a local area network (LAN); a metropolitan area network (MAN); a wide

area network (WAN); a wireline or wireless network; a local, regional, or global communication network; an optical network; a satellite network; a cellular network; an enterprise intranet; all or a portion of the Internet; other suitable network interfaces; or any combination of the preceding.

[0038] Memory **18** represents any suitable storage mechanism and may store any data for use by computer system **10**. Memory **18** may comprise one or more tangible, computer-readable, and/or computer-executable storage medium. Examples of memory **18** include computer memory (for example, Random Access Memory (RAM) or Read Only Memory (ROM)), mass storage media (for example, a hard disk), removable storage media (for example, a Compact Disk (CD) or a Digital Video Disk (DVD)), database and/or network storage (for example, a server), and/or other computer-readable medium.

[0039] In some embodiments, memory **18** stores logic **20**. Logic **20** facilitates operation of computer system **10**. Logic **20** may include hardware, software, and/or other logic. Logic **20** may be encoded in one or more tangible, non-transitory media and may perform operations when executed by a computer. Logic **20** may include a computer program, software, computer executable instructions, and/or instructions capable of being executed by computer system **10**. Example logic **20** may include any of the well-known OS2, UNIX, Mac-OS, Linux, and Windows Operating Systems or other operating systems. In particular embodiments, the operations of the embodiments may be performed by one or more computer readable media storing, embodied with, and/or encoded with a computer program and/or having a stored and/or an encoded computer program. Logic **20** may also be embedded within any other suitable medium without departing from the scope of the invention.

[0040] Various communications between computers **10** or components of computers **10** may occur across a network, such as network **30**. Network **30** may represent any number and combination of wireline and/or wireless networks suitable for data transmission. Network **30** may, for example, communicate internet protocol packets, frame relay frames, asynchronous transfer mode cells, and/or other suitable data between network addresses. Network **30** may include a public or private data network; one or more intranets; a local area network (LAN); a metropolitan area network (MAN); a wide area network (WAN); a wireline or wireless network; a local, regional, or global communication network; an optical network; a satellite network; a cellular network; an enterprise intranet; all or a portion of the Internet; other suitable communication links; or any combination of the preceding. Although the illustrated embodiment shows one network **30**, teachings of certain embodiments recognize that more or fewer networks may be used and that not all elements may communicate via a network. Teachings of certain embodiments also recognize that communications over a network is one example of a mechanism for communicating between parties, and any suitable mechanism may be used.

[0041] Aircraft configuration data repository **310** may store aircraft configuration information from first storage device **210**. For example, aircraft configuration data repository **310** may store, for a certain aircraft, the part and serial numbers for each part installed on the aircraft at a certain time. Aircraft configuration data repository **310** may store such information for multiple aircraft and over a period of time such that one may determine both how aircraft configurations have changed over time and how parts have moved over time. For

example, aircraft configuration data repository **310** may indicate, for a certain aircraft part, whether or not the aircraft part has been in service and, if so, each aircraft in which the part has been installed.

[0042] Part history repository **320** may store part information from second storage device **220**. For example, part history repository **320** may store, for a certain aircraft part, maintenance history, environmental history, service history, and repair history. In some embodiments, information stored in part history repository **320** may duplicate information stored by second storage device **220** proximate to part **200**.

[0043] Correlation engine **330** may correlate information between aircraft configuration data repository **310** and part history repository **320**. For example, part history repository **320** may include environmental history information for part **200** but may not indicate the aircraft associated with part **200** at the time the environmental history was recorded. Correlation engine **330** may identify the aircraft corresponding to part **200** during the environmental history by referring to aircraft configuration data repository **310**. In this manner, correlation engine **330** may take environmental history for part **200** and determine the environmental history of the corresponding aircraft. Such correlated part and aircraft history may be stored in correlated part history **340**.

[0044] Modifications, additions, or omissions may be made to the systems and apparatuses described herein without departing from the scope of the invention. The components of the systems and apparatuses may be integrated or separated. Moreover, the operations of the systems and apparatuses may be performed by more, fewer, or other components. The methods may include more, fewer, or other steps. Additionally, steps may be performed in any suitable order.

[0045] Although several embodiments have been illustrated and described in detail, it will be recognized that substitutions and alterations are possible without departing from the spirit and scope of the present invention, as defined by the appended claims.

[0046] To aid the Patent Office, and any readers of any patent issued on this application in interpreting the claims appended hereto, applicants wish to note that they do not intend any of the appended claims to invoke paragraph 6 of 35 U.S.C. §112 as it exists on the date of filing hereof unless the words “means for” or “step for” are explicitly used in the particular claim.

What is claimed is:

1. A rotorcraft, comprising:

a body;

a power train coupled to the body and comprising a power source and a drive shaft coupled to the power source;

a hub;

a rotor blade coupled to the hub;

an aircraft part; and

an aircraft part storage system comprising:

a first storage device coupled to the aircraft part and operable to store and transmit a first set of information identifying the aircraft part; and

a second storage device coupled to the same aircraft part and operable to store and transmit a second set of information about the aircraft part, the second storage device having a larger storage capacity than the first storage device but a shorter transmission range than the first storage device.

2. The rotorcraft of claim 1, wherein the first storage device comprises a radio-frequency identification tag.

3. The rotorcraft of claim 1, wherein the second storage device comprises a contact memory button.

4. The rotorcraft of claim 3, wherein the first set of information identifying the aircraft part comprises a part number unique to a category of parts.

5. The rotorcraft of claim 3, wherein the first set of information identifying the aircraft part comprises a serial number unique to the individual aircraft part.

6. The rotorcraft of claim 1, wherein the second set of information about the aircraft part comprises a maintenance history of the aircraft part.

7. The rotorcraft of claim 1, further comprising an environmental condition sensor coupled to the rotorcraft proximate to the aircraft part, the environmental condition sensor operable to measure at least one aspect of a natural environment of which the aircraft part is subject to.

8. The rotorcraft of claim 7, wherein the environmental condition sensor is configured to transmit environmental data to the second storage device for storage.

9. The rotorcraft of claim 7, wherein the environmental condition sensor is coupled to the aircraft part.

10. An aircraft part storage system comprising:

a first storage device configured to be coupled to an aircraft part and operable to store and transmit a first set of information about the aircraft part; and

a second storage device configured to be coupled to the same aircraft part and operable to store and transmit a second set of information about the aircraft part, the second storage device having a larger storage capacity than the first storage device but a shorter transmission range than the first storage device.

11. The aircraft part storage system of claim 10, wherein the first set of information about the aircraft part comprises information identifying the aircraft part.

12. The aircraft part storage system of claim 11, wherein the information identifying the aircraft part comprises a part number unique to a category of parts.

13. The aircraft part storage system of claim 11, wherein the information identifying the aircraft part comprises a serial number unique to the individual aircraft part.

14. The aircraft part storage system of claim 11, wherein the information identifying the aircraft part consists of a part number unique to a category of parts and a serial number unique to the individual aircraft part.

15. The aircraft part storage system of claim 10, wherein the second set of information about the aircraft part comprises a maintenance history of the aircraft part.

16. The aircraft part storage system of claim 10, wherein the second set of information about the aircraft part comprises maintenance information about the aircraft part.

17. The aircraft part storage system of claim 10, wherein the second set of information about the aircraft part comprises an environmental history of the aircraft part.

18. The aircraft part storage system of claim 10, wherein the first storage device comprises a radio-frequency identification tag.

19. The aircraft part storage system of claim 10, wherein the second storage device comprises a contact memory button.

20. The aircraft part storage system of claim 10, wherein the first storage device is operable to wirelessly transmit the first set of information.

21. The aircraft part storage system of claim 10, wherein the second storage device is operable to transmit the second set of information in response to physical contact.

22. The aircraft part storage system of claim 10, further comprising an environmental condition sensor coupled to the aircraft part, the environmental condition sensor operable to measure at least one aspect of a natural environment of which the aircraft part is subject to.

23. The aircraft part storage system of claim 22, wherein the environmental condition sensor is configured to transmit environmental data to the second storage device for storage.

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