(12) **UK Patent Application** (19) **GB** (11) **2617065** (13) **A**

(43) Date of A Publication **04.10.2023**

(21) Application No: **2204263.4**

(22) Date of Filing: **25.03.2022**

(71) Applicant(s):
Airbus Operations Limited
UK IP Dept., Pegasus House, Aerospace Avenue, Filton, BRISTOL, BS34 7PA, United Kingdom

Airbus Opérations (S.A.S.)
316, Route de Bayonne, 31060 Toulouse, Cedex 09, France (including Overseas Departments and Territori es)

(72) Inventor(s):
Vincent Nicolas
Jamie McGirr

(74) Agent and/or Address for Service:
EIP
Fairfax House, 15 Fulwood Place, LONDON, WC1V 6HU, United Kingdom

(51) INT CL:
B64F 5/50 (2017.01) ***B60T 17/20*** (2006.01)
B60T 17/22 (2006.01) ***B64C 25/34*** (2006.01)
B64C 25/42 (2006.01)

(56) Documents Cited:
EP 3363697 A2 **EP 2940675 A2**
US 20150254990 A1

(58) Field of Search:
INT CL **B64C**

(54) Title of the Invention: **Monitoring friction associated with a plurality of aircraft wheels**
Abstract Title: **Monitoring friction associated with a plurality of aircraft wheels**

(57) Disclosed is a method 200 of monitoring friction in aircraft wheels of an aircraft comprising, for each aircraft wheel, obtaining wheel speed data 202, and determining deceleration 204 of the aircraft wheel during a time interval, and determining a value indicative of friction 206 associated with the aircraft wheel. The method additionally provides a signal indicative of a level of friction 208. Also disclosed is an aircraft system having a controller for achieving the method and data carrier comprising machine readable instructions for the operation of the controller. Friction may occur through interaction between a first 14 and second 16 hydraulic brake and first 34 and second 36 wheel, and/or through interaction between the first and second wheels and bearing assemblies 38, 40. Monitoring such friction may enable the impact of the friction on components of the aircraft system 10 , to be monitored, and may enable appropriate maintenance action to be taken to prevent the level of friction becoming excessively high.

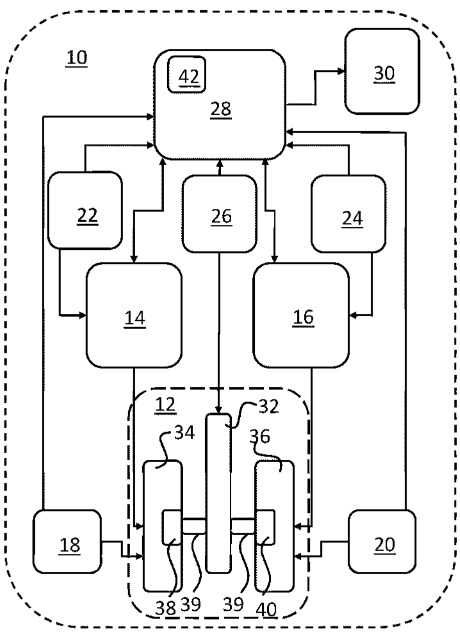

Fig. 1

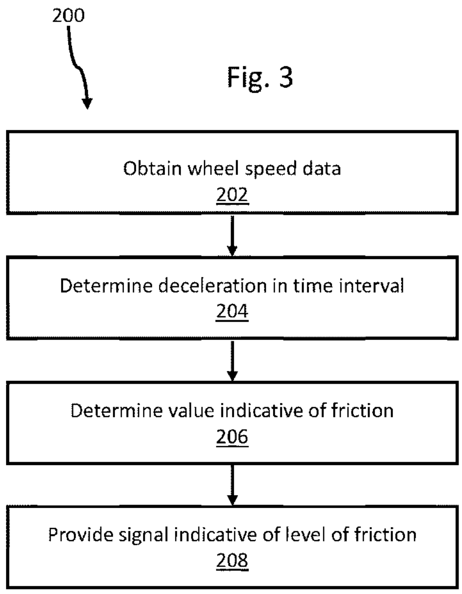

Fig. 3

GB 2617065 A

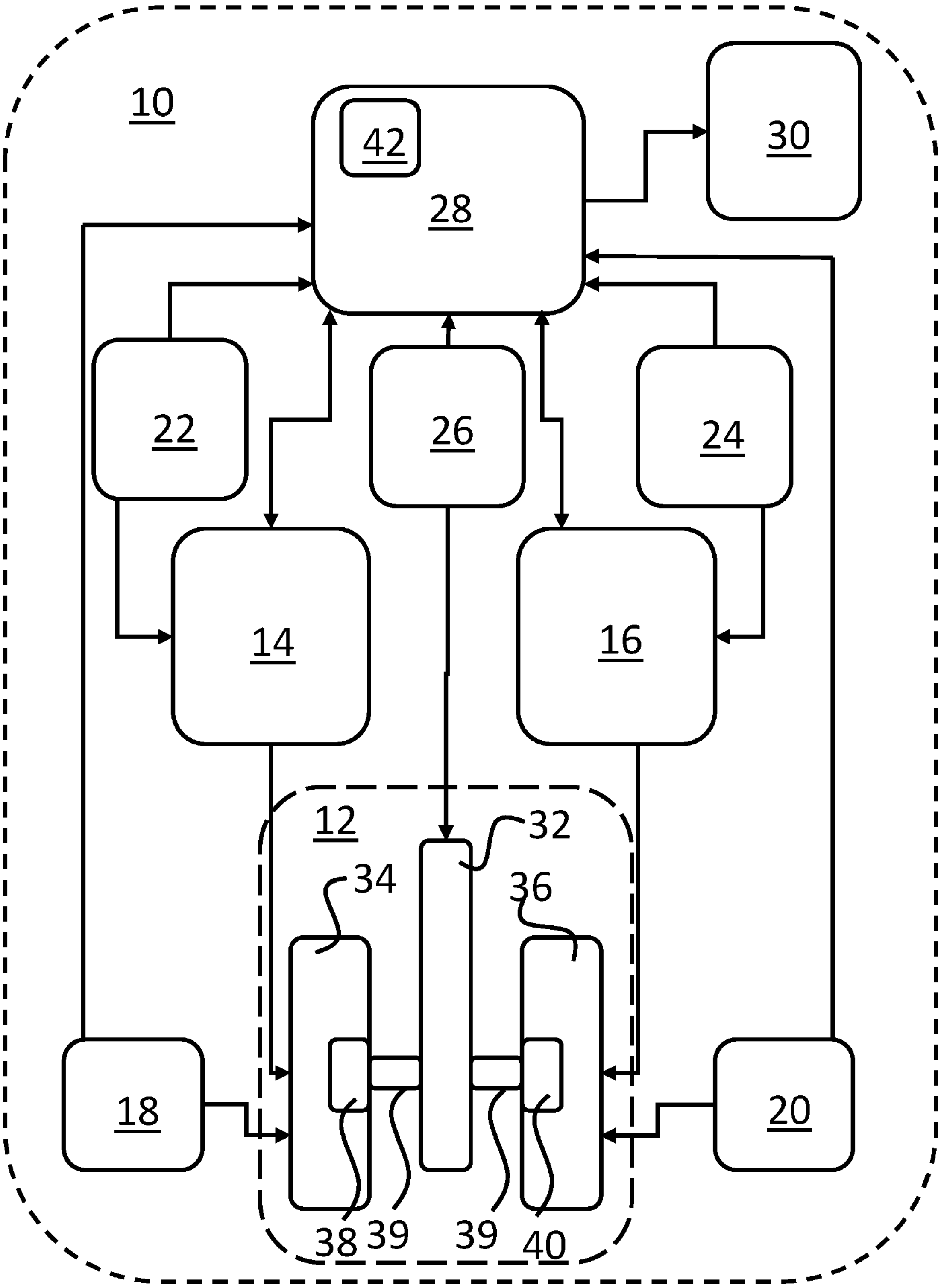

Fig. 1

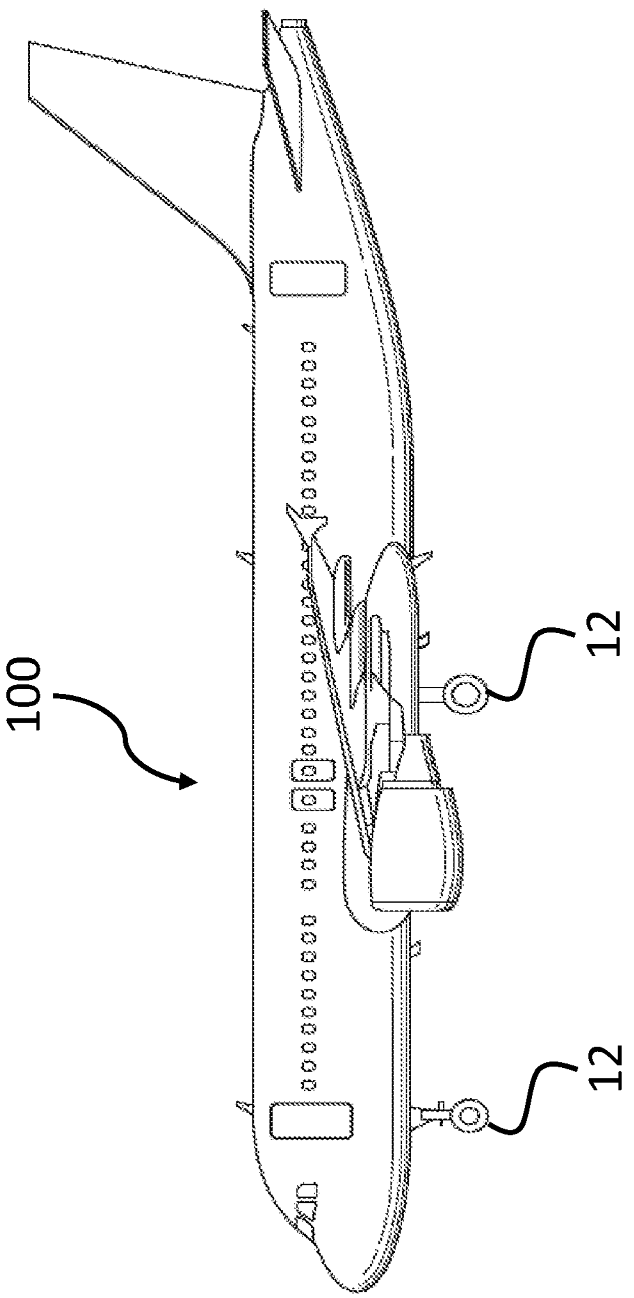

Fig. 2

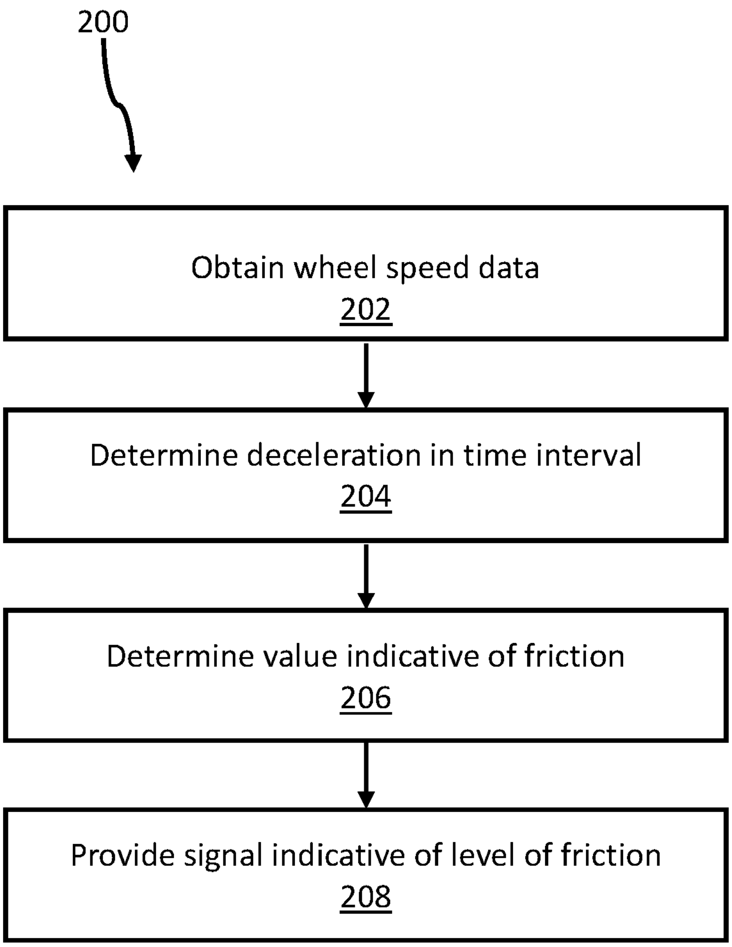
200
Obtain wheel speed data
202
Determine deceleration in time interval
204
Determine value indicative of friction
206
Provide signal indicative of level of friction
208

Fig. 3

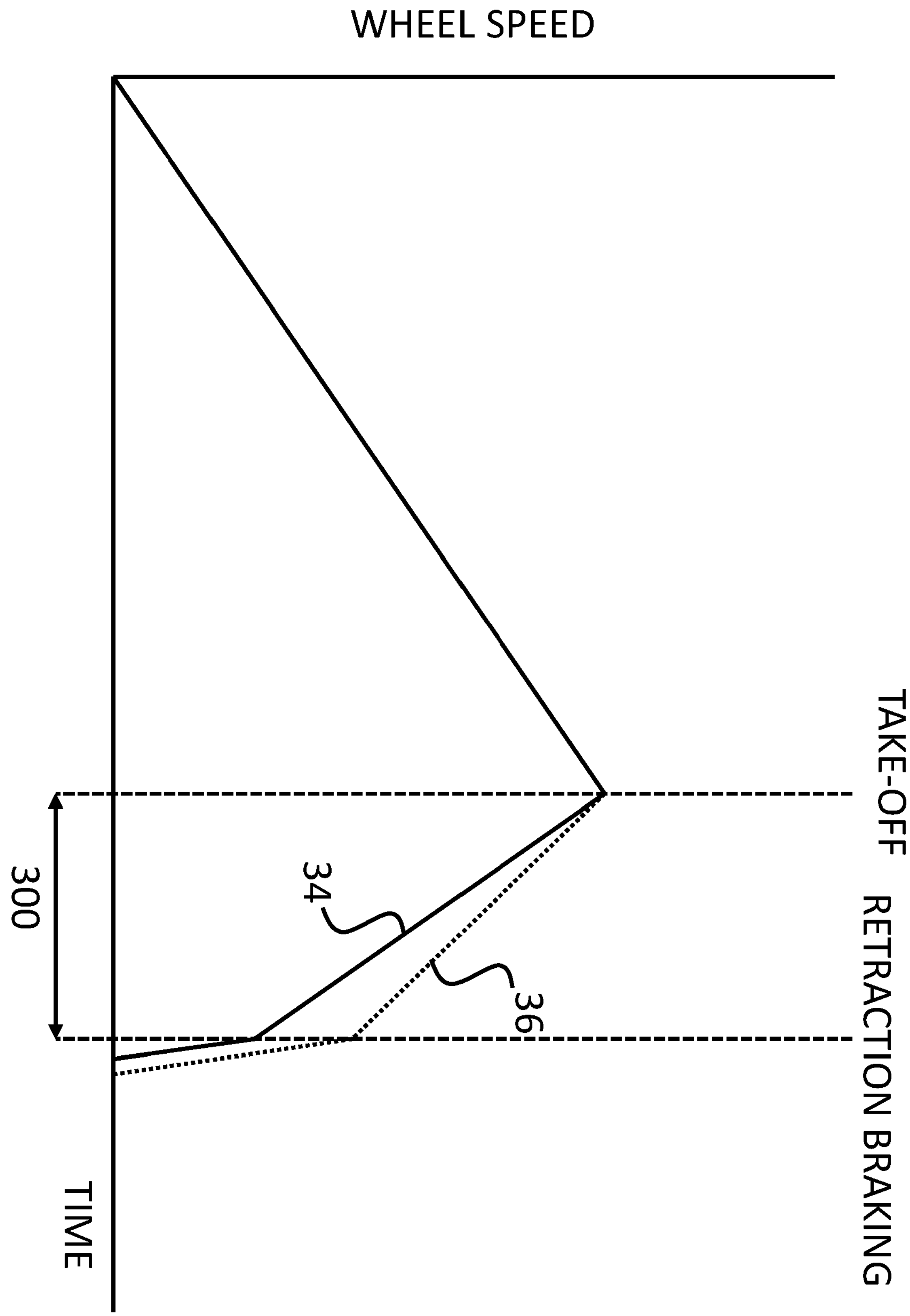

FIG 4

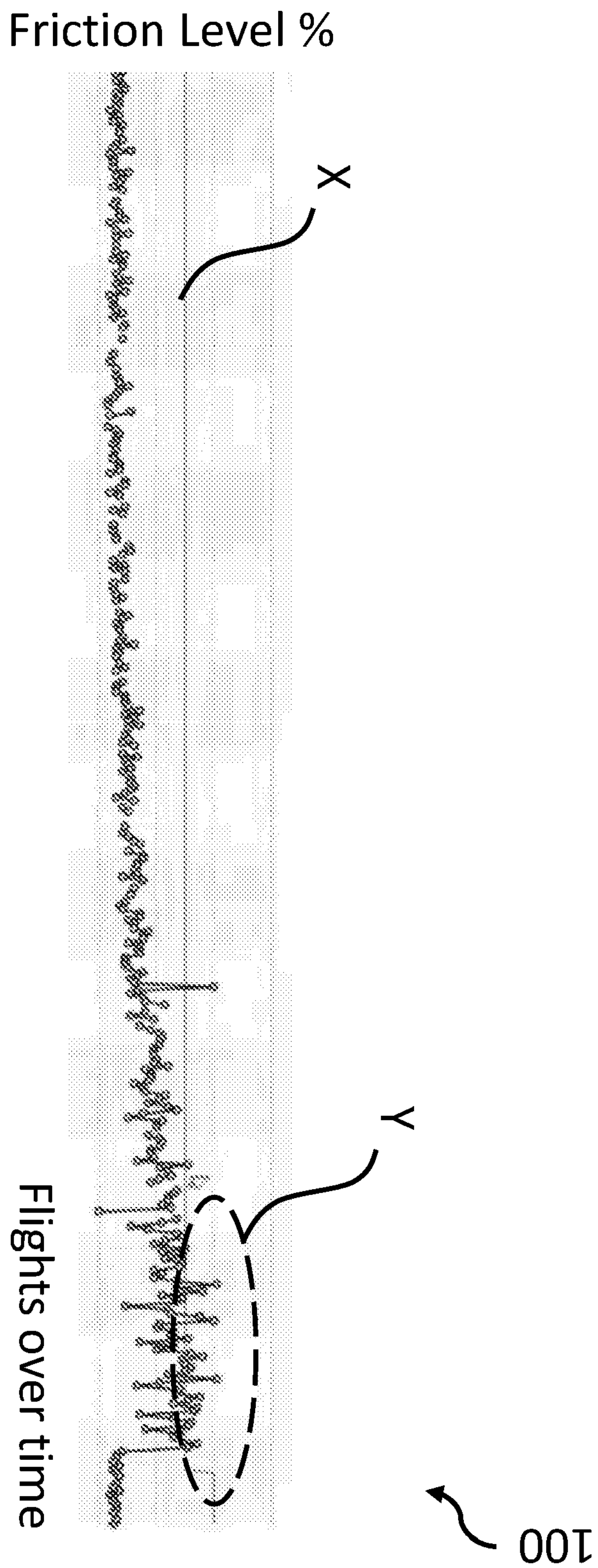

FIG 5

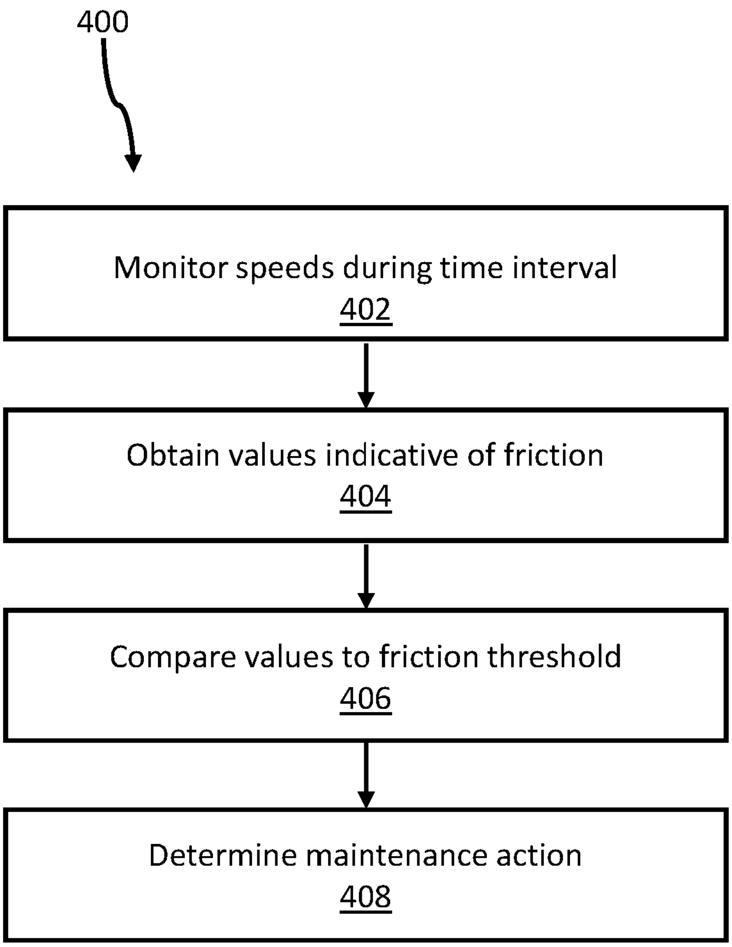
400
Monitor speeds during time interval
402
Obtain values indicative of friction
404
Compare values to friction threshold
406
Determine maintenance action
408

Fig. 6

MONITORING FRICTION ASSOCIATED WITH A PLURALITY OF AIRCRAFT WHEELS

TECHNICAL FIELD

[0001] The present invention relates to a method of monitoring friction associated with a plurality of aircraft wheels of an aircraft.

BACKGROUND

[0002] Aircraft typically comprise one or more landing gear assemblies to support the aircraft when it is not flying, thereby allowing the aircraft to take-off, land and taxi. Some landing gear assemblies may comprise wheels that rotate to enable the aircraft to travel along a surface.

SUMMARY

[0003] A first aspect of the present invention provides a method of monitoring friction associated with a plurality of aircraft wheels of an aircraft, the method comprising, for each of the plurality of aircraft wheels: obtaining wheel speed data associated with the aircraft wheel; determining, based at least in part on the wheel speed data, deceleration of the aircraft wheel during a time interval; determining, based at least in part on the determined deceleration, a value indicative of friction associated with the aircraft wheel; and providing, based at least in part on the determined value, a signal indicative of a level of friction associated with the aircraft wheel.

[0004] By monitoring friction associated with each of the plurality of aircraft wheels, and providing a signal indicative of the level of friction associated with the aircraft wheel, one or more of aircraft crew, ground staff, and maintenance personnel may be informed of the level of friction associated with the aircraft wheel, which may enable appropriate maintenance action to be taken, if required, to ensure the level of friction remains within normal operating parameters.

[0005] Optionally, the determining the value indicative of friction associated with the aircraft wheel comprises utilising at least one of historic wheel data, simulated wheel data, and experimental wheel data.

[0006] Optionally, the determining the value indicative of friction associated with the aircraft wheel comprises performing feature scaling on the determined deceleration, the feature scaling based at least in part on minimum and maximum deceleration values obtained from at least one of historic wheel data, simulated wheel data, and experimental wheel data.

[0007] Optionally, the performing feature scaling comprises performing a min-max scaling using the determined deceleration, and the maximum and minimum deceleration values.

[0008] Optionally, the time interval comprises a start point determined by take-off of an aircraft comprising the aircraft wheel, and an end point determined by retraction of a landing gear comprising the aircraft wheel.

[0009] Optionally, the end point of the time interval occurs prior to retraction braking of the aircraft wheel. Optionally, the end point of the time interval occurs in response to a signal indicating performance of retraction braking is about to take place. Retraction braking may comprise braking of a wheel prior to or during retraction of a landing gear that comprises the wheel.

[0010] Optionally, take-off of the aircraft is determined using at least one of a weight-on-wheels sensor, a proximity sensor, and a wheel speed sensor.

[0011] Optionally, the method comprises comparing the determined value to a friction threshold, and providing the signal where the determined value exceeds the friction threshold, for example by more than a pre-determined amount.

[0012] Optionally, the method comprises, for each of a plurality of flights of an aircraft comprising the aircraft wheel: obtaining wheel speed data associated with the aircraft wheel; determining, based at least in part on the wheel speed data, deceleration of the aircraft wheel during a time interval; determining, based at least in part on the determined deceleration, the value indicative of friction associated with the aircraft wheel; and providing, based at least in part on the determined value, the signal indicative of a level of friction associated with the aircraft wheel.

[0013] Optionally, the method comprises, for each of the plurality of flights, comparing the determined value to a friction threshold, and where the determined value exceeds the friction threshold for more than a threshold number of flights, determining an altered level of friction associated with the aircraft wheel. An altered level of friction associated with the wheel may comprise an increased level of friction relative to an expected level of friction to occur in normal operating conditions of the wheel.

[0014] Optionally, determining the altered level of friction associated with the aircraft wheel takes place where the determined value exceeds the friction threshold for more than a threshold number of flights within a window. Optionally the window comprises a pre-determined time period, or a pre-determined number of past flights.

[0015] Optionally, determining the altered level of friction associated with the aircraft wheel takes place where the determined value exceeds the friction threshold for 5 or more flights within the last 20 flights.

[0016] Optionally, the determining deceleration of the aircraft wheel during the time interval comprises performing a linear regression on the obtained wheel speed data.

[0017] Optionally, the signal is provided to one or more of aircraft crew, ground staff, and a maintenance system.

[0018] Optionally, the signal is provided by one or more of a visual indicator and an aural indicator. Optionally, the signal is provided by a plot of level of friction per flight.

[0019] Optionally, the method comprises storing the value in memory, and providing the signal comprises reading the stored value from the memory.

[0020] Optionally, the method comprises scheduling maintenance on the basis of the signal, for example automatically in response to the signal via one or more maintenance scheduling systems.

[0021] A second aspect of the present invention provides an aircraft system comprising: a plurality of aircraft wheels; and one or more controllers configured to, for each aircraft wheel, perform a friction monitoring method comprising: obtaining wheel speed data associated with the aircraft wheel; determining, based at least in part on the wheel speed data, deceleration of the aircraft wheel during a time interval; determining, based at least in part on the determined deceleration, a value indicative of friction associated with the aircraft wheel; and providing, based at least in part on the determined value, a signal indicative of a level of friction associated with the aircraft wheel.

[0022] Optionally, the aircraft system comprises a plurality of brakes associated with corresponding ones of the plurality of aircraft wheels, and the one or more controllers are configured to perform the friction monitoring method where pressures associated with the plurality of brakes are below a pressure threshold.

[0023] Optionally, the aircraft system comprises a wheel speed sensor for obtaining the wheel speed data. Optionally, the wheel speed sensor comprises a tachometer. Optionally, the aircraft comprises a plurality of wheel speed sensors, for example one wheel speed sensor per wheel.

[0024] Optionally, the time interval comprises a start point determined by take-off of an aircraft comprising the aircraft wheel, and an end point determined by retraction of a landing gear comprising the aircraft wheel, and the aircraft system comprises a weight-on-wheels sensor for determining the take-off of the aircraft.

[0025] Optionally, the aircraft system comprises a display located remotely from an aircraft comprising the plurality of aircraft wheels, and the one or more controllers are configured to cause, based at least in part on the signal, the display to indicate the level of friction associated with the aircraft wheel.

[0026] A third aspect of the present invention provides an aircraft comprising an aircraft system according to the second aspect of the present invention.

[0027] A fourth aspect of the present invention provides a data carrier comprising machine readable instructions for the operation of one or more processors of a controller of an aircraft system comprising a plurality of aircraft wheels to, for each aircraft wheel, perform a friction monitoring method comprising: obtaining wheel speed data associated with the aircraft wheel; determining, based at least in part on the wheel speed data, deceleration of the aircraft wheel during a time interval; determining, based at least in part on the determined deceleration, a value indicative of friction associated with the aircraft wheel; and providing, based at least in part on the determined value, a signal indicative of a level of friction associated with the aircraft wheel.

[0028] A fifth aspect of the present invention provides a method of determining performance of a maintenance action for a wheel of an aircraft, the method comprising: for each of a plurality of flights of the aircraft, monitoring a speed of the wheel during a time interval post take-off of the aircraft, and utilising the monitored speed to obtain a value indicative of friction associated with the wheel; comparing each of the values of the plurality of flights to a friction threshold; and where the number of values that exceed the friction threshold is greater than a numerical threshold within a given window, determining that the maintenance action is required.

[0029] A sixth aspect of the present invention provides an aircraft system comprising a wheel of an aircraft, and one or more controllers configured to: for each of a plurality of flights of the aircraft, monitor a speed of the wheel during a time interval post take-off of the aircraft, and utilise the monitored speed to obtain a value indicative of friction associated with the wheel; compare each of the values of the plurality of flights to a friction threshold; and where the number of values that exceed the friction threshold is greater than a numerical threshold within a given window, determine that a maintenance action is required.

[0030] A seventh aspect of the present invention provides an aircraft comprising an aircraft system according to the sixth aspect of the present invention.

[0031] An eighth aspect of the present invention provides a data carrier comprising machine readable instructions for the operation of one or more processors of a controller of an aircraft system comprising a wheel of an aircraft to: for each of a plurality of flights of the aircraft, monitor a speed of the wheel during a time interval post take-off of the aircraft, and utilise the monitored speed to obtain a value indicative of friction associated with the wheel; compare each of the values of the plurality of flights to a friction threshold; and where the number of values that exceed the friction threshold is greater than a numerical threshold within a given window, determine that a maintenance action is required.

BRIEF DESCRIPTION OF THE DRAWINGS

[0032] Embodiments of the invention will now be described, by way of example only, with reference to the accompanying drawings, in which:

[0033] Figure 1 shows a schematic view of an aircraft system;

[0034] Figure 2 shows a schematic view of an aircraft comprising the aircraft system of Figure 1;

[0035] Figure 3 shows a flow diagram of a first method according to the present disclosure;

[0036] Figure 4 shows a plot of wheel speed over time;

[0037] Figure 5 shows a plot of friction values for a number of flights; and

[0038] Figure 6 shows a flow diagram of a second method according to the present disclosure.

DETAILED DESCRIPTION

[0039] An aircraft system 10 is illustrated schematically in Figure 1, and comprises a landing gear assembly 12, first 14 and second 16 hydraulic brakes, first 18 and second 20 tachometers, first 22 and second 24 pressure sensors, a weight-on-wheels sensor 26, a controller 28, and an indicator 30. It will be appreciated that in practice at least some of the components of the aircraft system 10 may be considered part of the landing gear assembly 12.

[0040] The landing gear assembly 12 comprises a strut 32, and first 34 and second 36 wheels rotatably mounted to the strut 32 by corresponding first 38 and second 40 bearing assemblies and an axle 39. The first 38 and second 40 bearing assemblies comprise rolling bearings. The landing gear assembly 12 is retractably mounted to the body of an aircraft 100 in use. The aircraft 100 is illustrated schematically in Figure 2.

[0041] The first 14 and second 16 hydraulic brakes are configured to selectively apply a braking response to the respective first 34 and second 36 wheels. The first 22 and second 24 pressure sensors are configured to sense pressure applied to the first 34 and second 36 wheels by the first 14 and second 16 hydraulic brakes. The weight-on wheels sensor 26 is utilised to determine whether the first 34 and second 36 wheels are on the ground or not, and as such the weight-on-wheels sensor 26 is utilised to determine when take-off of the aircraft 100 has occurred.

[0042] The controller 28 comprises one or more processors 42, and is configured to send and/or receive data to and/or from the first 14 and second 16 hydraulic brakes, the first 18 and second 20 tachometers, the first 22 and second 24 pressure sensors, and the weight-on-wheels sensor 26. The controller 28 may be disposed locally on-board the aircraft 100, or may be located remotely off-board the aircraft 100.

[0043] The indicator 30 is configured to receive one or more signals from the controller 28, and provide an indication, based on the received signals, to an operator such as aircraft crew, ground staff, and/or maintenance personnel. The indicator 30 may be located on-board the aircraft 100, or may be located remotely off-board the aircraft 100. The indicator may comprise a visual indicator, such as a display, or an audible indicator, such as an audio transducer.

[0044] In use, friction may occur as a result of the interaction between the first 14 and second 16 hydraulic brakes and the respective first 34 and second 36 wheels, and/or friction may occur as a result of the interaction between the first 34 and second 36 wheels and the respective first 38 and second 40 bearing assemblies. Monitoring such friction may enable the impact of the friction on components of the aircraft system 10, or indeed other components of the aircraft 100, to be monitored, and may enable appropriate maintenance action to be taken to prevent the level of friction becoming excessively high.

[0045] A method 200 of monitoring friction associated with the first 34 and second 36 wheels is illustrated schematically in Figure 3. The method 200 comprises, for each of a plurality of aircraft wheels, obtaining 202 wheel speed data associated with the aircraft wheel, and determining 204, based at least in part on the wheel speed data, deceleration of the aircraft wheel during a time interval. The method 200 comprises determining 206, based at least in part on the determined deceleration, a value indicative of friction associated with the aircraft wheel, and providing 208, based at least in part on the determined value, a signal indicative of a level of friction associated with the aircraft wheel.

[0046] By monitoring friction associated with each of the plurality of aircraft wheels, and providing a signal indicative of the level of friction associated with the aircraft wheel, one or more of aircraft crew, ground staff, and maintenance personnel may be informed of the level of friction associated with the aircraft wheel, which may enable appropriate maintenance action to be taken, if required, to ensure the level of friction remains within normal operating parameters.

[0047] More specifically, it has been recognised that an appropriate time in which to monitor friction associated with aircraft wheels may be a period shortly after take-off of the aircraft, in which the wheels should be free to rotate before braking prior to or during retraction of landing gear occurs. Excessive friction in this period may then be indicative of altered frictional conditions associated with the wheel, for example as a result of unintentional braking and/or bearing friction.

[0048] Thus, in the aircraft system 10, the weight-on-wheels sensor 26 is utilised to determine take-off of the aircraft 100, and the first tachometer 18 is configured to monitor the wheel speed of the first wheel 34 during a time interval that starts with take-off of the aircraft 100, and ends with retraction braking being applied to the first wheel 34 by the first hydraulic brake 14. Such a time interval 300 is illustrated schematically in the plot of Figure 4. During the time interval 300, there should be no residual pressure applied to the first wheel 34 by the first hydraulic brake, and the first pressure sensor 22 is utilised to ensure that this is the case.

[0049] Wheel speed data obtained from the first tachometer 18 during the time interval 300 is sent to the controller 28, and the controller 28 determines deceleration of the first wheel 34 during the time interval 300. The deceleration is determined using a linear regression method to fit the wheel speed data.

[0050] Once the controller 28 has determined the deceleration of the first wheel 34 during the time interval 300, the controller 28 uses the deceleration to determine a value indicative of friction associated with the first wheel 34 during the time interval 300. Such a value is determined by applying a min-max scaling of the determined deceleration to obtain a value between 0 and 100, with the minimum and maximum values for the scaling determined best on historic best- and worst-case deceleration values obtained from historic flight data. Such best- and worst-case deceleration values are here indicative of minimum and maximum friction levels historically associated with wheels on a similar aircraft. Use of a value between 0 and 100 may provide a readily understandable scale for the value, which may facilitate ease of comparison of the value to determine altered levels of friction as will be discussed in more detail hereafter.

[0051] An exemplary min-max scaling may be provided by an equation of the form:

$$x' = \frac{\left(x - min(x)\right) * 100}{\max(x) - \min\,(x)}$$

where x' is the value to be determined, x is the determined deceleration, min(x) is the historic minimum deceleration value, and max(x) is the historic maximum deceleration value. Whilst historic best- and worst-case deceleration values, i.e. minimum and maximum historic deceleration values, have been utilised here, it will be appreciated that other best- and worst-case deceleration values may be utilised, for example those obtained by simulation and/or experimental data.

[0052] When the value indicative of friction associated with the first wheel 34 during the time interval 300 has been obtained, the value is stored in memory. The memory may form part of the controller, or the memory may comprise a standalone unit located elsewhere on the aircraft 100, and/or may be located remotely from the aircraft 100. Such storing of the value in memory, and/or reading of the value from the memory, can be thought of as providing a signal indicative of a level of friction associated with the first aircraft wheel 34.

[0053] This process is repeated over a number of flights of the aircraft 100 with each value for a given flight either stored in memory of the controller 28, stored in a wider memory of the aircraft 100, or transmitted to and stored in a remote memory location. Each stored value is compared to a friction threshold which is indicative of a normal level of friction associated with the first wheel 34, for example with values above the friction threshold comprising values which indicate relatively high levels of friction. The friction threshold may be chosen to be lower than a value which would cause an in-flight altered operating condition warning to be provided. Where a pre-determined number of values exceed the friction threshold within a pre-determined flight window, an indication of an altered level of friction associated with the first wheel 34 is provided.

[0054] Examples of stored values are indicated in the graph of Figure 5, with each point corresponding to a value indicative of friction associated with the first wheel 34 for a given flight. Here, the friction threshold is illustrated as X. In some examples, X is in the region of 20 to 50%, for example around 30%. Where stored values for a pre-determined number of flights, say a number of flights between two and ten flights within a flight window of the last twenty flights, exceed the friction threshold X, an indication of an altered level of friction associated with the first aircraft wheel 34 is provided. Such a situation is illustrated in the circled region Y of the plot of Figure 5.

[0055] As will be appreciated, the indication may take many forms. For example, where the controller 28 stores the values in local memory of the aircraft 100, when a value is determined that causes the above-mentioned criteria to be met, the indicator 30 may provide a visual indication to flight crew of the aircraft 100, in the form of an illuminated light or an on-screen message, that an altered level of friction associated with the first wheel 34 has been determined. In such a circumstance, the flight crew of the aircraft 100 may record the indication in a log and/or flag the indication to on-ground maintenance personnel such that the first wheel 34, and/or the first hydraulic brake 14 and/or the first bearing assembly 38 can be examined and replaced as required.

[0056] In some examples, the comparison steps may be performed by the controller 28, with the indication of an altered level of friction associated with the first wheel 34 being transmitted from the controller 28 to the indicator 30 for display by the indicator 30. For example, comparative and/or computational steps may be performed by the controller 28, with the remote indicator 30 being used to display the indication to on-ground maintenance personnel. The indication in such examples may comprise an illuminated light or an on-screen message, or a visual representation such as the plot of Figure 5.

[0057] In some examples, where the controller 28 transmits the values storage in remote memory, and the indicator 30 is located remotely from the aircraft 100, comparative and/or computational steps may be performed remotely from the aircraft 100 based on data transmitted by the controller 28, with the indicator 30 communicating the indication of an altered level of friction associated with the first wheel 34 to on-ground maintenance personnel. The indication in such examples may comprise an illuminated light or an on-screen message, or a visual representation such as the plot of Figure 5.

[0058] Whilst visual forms of indication have been described above, it will be appreciated that other forms of indication, for example aural indications, are also envisaged. Furthermore, it will be appreciated that the raw data values of the values indicative of friction associated with the first aircraft wheel 34, may be considered an indication of an altered level of friction associated with the first aircraft wheel 34, given that an altered level of friction may be derived from the raw data values.

[0059] In response to the indication by the indicator 30, a maintenance action can be scheduled by one or more of aircraft personnel, ground staff, or maintenance crew, as appropriate.

[0060] In some examples, rather than providing the indication via the indicator 30, a maintenance action may be automatically scheduled, for example by the controller 28, based on a signal representing the value indicating friction associated with the first aircraft wheel 34.

[0061] The steps described above in respect of the first wheel 34 can similarly be applied in respect of the second wheel 36, enabling a full picture of friction associated with each of the first 34 and second 36 wheels to be obtained. It will be appreciated that such methods can be extended to any number of wheels in practice. The wheel speed data for the first 34 and second 36 wheels is indicated schematically in Figure 4, where it can be seen that the first wheel 34 experiences greater deceleration over the time interval 300, and hence is experiencing a greater level of friction.

[0062] A further method 400 in accordance with the above is illustrated schematically in the flow diagram of Figure 6. The method 400 comprises, for each of a plurality of flights of the aircraft, monitoring 402 a speed of the wheel during a time interval post take-off of the aircraft, and utilising 404 the monitored speed to obtain a value indicative of friction associated with the wheel. The method 400 comprises comparing 406 each of the values of the plurality of flights to a friction threshold, and where the number of values that exceed the friction threshold is greater than a numerical threshold within a given flight window, determining 408 that a maintenance action is required.

[0063] Whilst described above in relation to monitoring over a plurality of flights, it will also be appreciated that the method 100 of Figure 3 can also be utilised to provide an indication of a level of friction associated with a given wheel for a single flight, for example with the indicator 30 being used to provide an immediate indication where a value exceeds the friction threshold by more than a pre-determined amount. In such examples, the level of friction associated with the given wheel may be deemed to be sufficiently high that an immediate indication needs to be provided to one or more of aircraft personnel, ground staff and/or maintenance crew.

[0064] It is to noted that the term “or” as used herein is to be interpreted to mean “and/or”, unless expressly stated otherwise.

CLAIMS:

1. A method of monitoring friction associated with a plurality of aircraft wheels of an aircraft, the method comprising, for each of the plurality of aircraft wheels:

obtaining wheel speed data associated with the aircraft wheel;

determining, based at least in part on the wheel speed data, deceleration of the aircraft wheel during a time interval;

determining, based at least in part on the determined deceleration, a value indicative of friction associated with the aircraft wheel; and

providing, based at least in part on the determined value, a signal indicative of a level of friction associated with the aircraft wheel.

2. The method according to Claim 1, wherein the determining the value indicative of friction associated with the aircraft wheel comprises utilising at least one of historic wheel data, simulated wheel data, and experimental wheel data.

3. The method according to Claim 1 or Claim 2, wherein the determining the value indicative of friction associated with the aircraft wheel comprises performing feature scaling on the determined deceleration, the feature scaling based at least in part on minimum and maximum deceleration values obtained from at least one of historic wheel data, simulated wheel data, and experimental wheel data.

4. The method according to Claim 3, wherein the performing feature scaling comprises performing a min-max scaling using the determined deceleration, and the maximum and minimum deceleration values.

5. The method according to any preceding claim, wherein the time interval comprises a start point determined by take-off of an aircraft comprising the aircraft wheel, and an end point determined by retraction of a landing gear comprising the aircraft wheel.

6. The method according to Claim 5, wherein the end point of the time interval occurs prior to retraction braking of the aircraft wheel.

7. The method according to Claim 5 or Claim 6, wherein the take-off of the aircraft is determined using at least one of a weight-on-wheels sensor, a proximity sensor, and a wheel speed sensor.

8. The method according to any preceding claim, wherein the method comprises comparing the determined value to a friction threshold, and providing the signal where the determined value exceeds the friction threshold .

9. The method according to any preceding claim, wherein the method comprises, for each of a plurality of flights of an aircraft comprising the aircraft wheel:

obtaining wheel speed data associated with the aircraft wheel;

determining, based at least in part on the wheel speed data, deceleration of the aircraft wheel during a time interval;

determining, based at least in part on the determined deceleration, the value indicative of friction associated with the aircraft wheel; and

providing, based at least in part on the determined value, the signal indicative of a level of friction associated with the aircraft wheel.

10. The method according to Claim 9, wherein the method comprises, for each of the plurality of flights, comparing the determined value to a friction threshold, and where the determined value exceeds the friction threshold for more than a threshold number of flights, determining an altered level of friction associated with the aircraft wheel.

11. The method according to Claim 10, wherein the determining the altered level of friction associated with the aircraft wheel takes place where the determined value exceeds the friction threshold for more than the threshold number of flights within a window.

12. The method according to any preceding claim, wherein the determining deceleration of the aircraft wheel during the time interval comprises performing a linear regression on the obtained wheel speed data.

13. The method according to any preceding claim, wherein the signal is provided to one or more of aircraft crew, ground staff, and a maintenance system.

14. The method according to any preceding claim, wherein the method comprises scheduling maintenance on the basis of the signal.

15. An aircraft system comprising:

a plurality of aircraft wheels; and

one or more controllers configured to, for each aircraft wheel, perform a friction monitoring method comprising:

obtaining wheel speed data associated with the aircraft wheel;

determining, based at least in part on the wheel speed data, deceleration of the aircraft wheel during a time interval;

determining, based at least in part on the determined deceleration, a value indicative of friction associated with the aircraft wheel; and

providing, based at least in part on the determined value, a signal indicative of a level of friction associated with the aircraft wheel.

16. An aircraft system as claimed in Claim 15, wherein the aircraft system comprises a plurality of brakes associated with corresponding ones of the plurality of aircraft wheels, and the one or more controllers are configured to perform the friction monitoring method where pressures associated with the plurality of brakes are below a pressure threshold.

17. An aircraft system as claimed in Claim 15 or Claim 16, wherein the aircraft system comprises a wheel speed sensor for obtaining the wheel speed data.

18. An aircraft system as claimed in any of Claims 15 to 17, wherein the time interval comprises a start point determined by take-off of an aircraft comprising the aircraft wheel, and an end point determined by retraction of a landing gear comprising the aircraft wheel, and the aircraft system comprises a weight-on-wheels sensor for determining the take-off of the aircraft.

19. An aircraft system as claimed in any of Claims 15 to 18, wherein the aircraft system comprises a display located remotely from an aircraft comprising the plurality of aircraft wheels, and the one or more controllers are configured to cause, based at least in part on the signal, the display to indicate the level of friction associated with the aircraft wheel.

20. An aircraft comprising an aircraft system as claimed in any of Claims 15 to 18.

21. A data carrier comprising machine readable instructions for the operation of one or more processors of a controller of an aircraft system comprising a plurality of aircraft wheels to, for each aircraft wheel, perform a friction monitoring method comprising:

obtaining wheel speed data associated with the aircraft wheel;

determining, based at least in part on the wheel speed data, deceleration of the aircraft wheel during a time interval;

determining, based at least in part on the determined deceleration, a value indicative of friction associated with the aircraft wheel; and

providing, based at least in part on the determined value, a signal indicative of a level of friction associated with the aircraft wheel.

Intellectual Property Office

Application No:	GB2204263.4	**Examiner:**	Mr Sean O'Connor
Claims searched:	1-21	**Date of search:**	22 September 2022

Patents Act 1977: Search Report under Section 17

Documents considered to be relevant:

Category	Relevant to claims	Identity of document and passage or figure of particular relevance
X	1, 15, 21 at least	EP 3363697 A2 (GOODRICH) See paragraph [0023].
X	1, 15, 21 at least	US 2015/254990 A1 (RABY) See figure 1 and paragraphs [0035]-[0036].
X	1, 15, 21 at least	EP 2940675 A2 (GOODRICH) See paragraphs [0045]-[0047].

Categories:

X	Document indicating lack of novelty or inventive step	A	Document indicating technological background and/or state of the art.
Y	Document indicating lack of inventive step if combined with one or more other documents of same category.	P	Document published on or after the declared priority date but before the filing date of this invention.
&	Member of the same patent family	E	Patent document published on or after, but with priority date earlier than, the filing date of this application.

Field of Search:

Search of GB, EP, WO & US patent documents classified in the following areas of the UKC^{X} :

Worldwide search of patent documents classified in the following areas of the IPC

B64C

The following online and other databases have been used in the preparation of this search report

WPI, EPODOC

International Classification:

Subclass	Subgroup	Valid From
B64F	0005/50	01/01/2017
B60T	0017/20	01/01/2006
B60T	0017/22	01/01/2006
B64C	0025/34	01/01/2006
B64C	0025/42	01/01/2006