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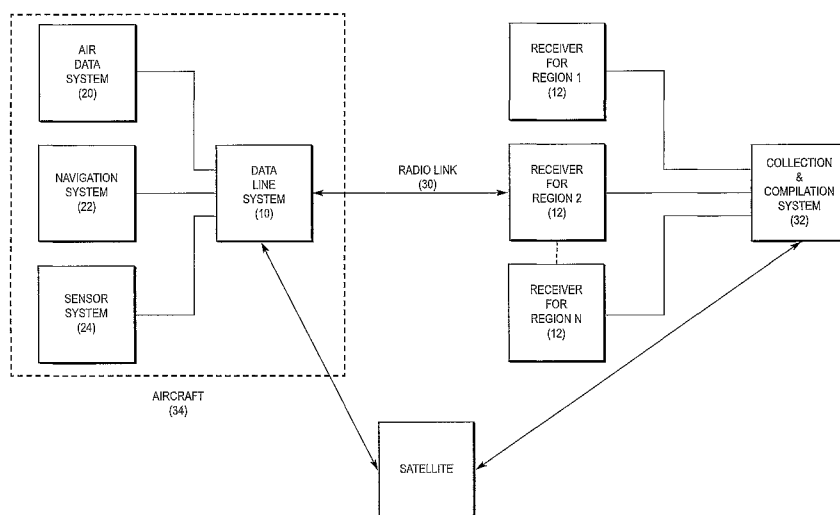
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(54) Title: METHOD AND APPARATUS FOR HIGH ALTITUDE ENVIRONMENTAL DATA COLLECTION



(57) Abstract: A system consisting of a collection of aircraft (34) equipped with specific chemical, radiological or particulate sensors (24) as well as a data link radio (30) and navigation sub system (22) flying their normal routes. The position, sensor output and air data is periodically communicated to the ground (12) via a data link radio (30) and collected. The data is used to make maps or models of the spatial distribution of the sensed quantity for a particular time period. Dynamic behavior can be discerned by considering time consecutive models. Predictions can be made using this data alone, or in conjunction with other data, and can be refined by comparisons (32) between the prediction and subsequent spatial distribution maps.

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METHOD AND APPARATUS FOR HIGH ALTITUDE ENVIRONMENTAL DATA COLLECTION

BACKGROUND OF THE INVENTION

Field of the Invention (Technical Field):

The present invention relates to data collection, compiling and distribution and more particularly to air component sensor data collected aboard at least one aircraft matched with location data and sent to at least one receiving site for distribution to end users.

Background Art:

Thematic maps and models, and the conditions they portray or predict, have historically been made using sensor platforms dedicated solely to these tasks. For example, in the realm of weather mapping and prediction, specialized aircraft, satellites, balloons and earthbound weather sensing stations all contribute to the generation of weather maps and to weather prediction. The situation is similar for thematic map and predictions generation where the sensed quantity is, for example, particulate, chemical, or radiological.

On any given day and at any given time, there are thousands of air transport aircraft in the air. Each of these aircraft is equipped with air data systems that measure temperature and pressure and compute such things as wind direction and speed. In addition, these aircraft come equipped with navigation systems sufficient to determine the aircraft position at a given point in time. Today, many air transport aircraft are equipped with data link capability, and this number of equipped aircraft is growing every day.

A system that collects from data link equipped aircraft, air data, position, altitude and time can be used to produce a data base that can be

used in the mapping and prediction of weather and climate. The contents of
this database can be used to populate a finite element weather analysis.
The collection of such weather related data using existing aircraft sensors
and the transmission to the ground has been taught by Bateman et al., in
U.S. Patent No. 6,043,756 and Gremmert et al., in U.S. Patent No.
6,501,392. Batemen and Gremmert teach the use of datalink radios to
downlink weather data from existing aircraft sensors. This information is
used to make weather maps and predictions. Weather and predictions
appropriate to an area are uplinked to aircraft flying in that area.

In the present invention, sensors specific to the detection of
particulate, chemical, biological or radiological air constituents are placed
aboard either commercial or military aircraft. The aircraft flight path is not
chosen for sensor detection purposes, so as the aircraft is performing its
normal duties. The data from these sensors, in addition to positional data,
time and air data system outputs, are communicated to the ground to a
collection system on a regular basis. The data can be used to create
thematic maps comprising the distribution of the air constituents and, since
the data is collected regularly, a dynamic picture of the movement of these
constituents can be created.

Currently, air transport aircraft fly vector airways between their
departure and arrival cities. These vector airways can be thought of as
highways in the sky. This implies that only a relatively small portion of the
earth's atmosphere is available to collect air data on. The populated land
masses, such as western Europe, the east and west coasts of North
America, and the pacific rim of Asia contain such a large number of vector
airways as to eliminate this constraint. In addition, the concept of free flight,
whereby an air transport aircraft can take the most direct available route, will
increase the coverage available for air data collection. The present invention
uses sensor packages to allow for the detection, mapping and modeling of
chemical, particulate, biological and radiological phenomena.

SUMMARY OF THE INVENTION (DISCLOSURE OF THE INVENTION)

2

4 The present invention comprises sensors specific to the detection of
particulate, chemical, biological or radiological air constituents, placed
aboard either commercial or military aircraft. As the aircraft fly in its normal
6 course, the data from these sensors, in addition to positional data, are
communicated to the ground to a collection system on a regular basis. The
8 data can be used to create thematic maps on the distribution of the air
constituents and, since the data is collected regularly, a dynamic picture of
10 the movement of these constituents can be created.

12 A primary object of this invention is to use existing and future aircraft
fleets to collect data on air components that are relevant to current or future
14 problems and to produce spatial models or maps of the distribution of these
components.

16

Another object of this invention is to periodically collect such data
18 which permits the creation of a time sequence of such thematic maps.

20 Yet another object of the present invention is to provide time
sequence models that can be used to make predictions or to refine
22 predictions produced by other means.

24 A primary advantage of this invention is that it allows for the collection
of data on the distribution of relevant air components at low cost, since the
26 sensors are aboard aircraft that are flying their normal flight plans.

28 Another advantage is that there is nearly constant coverage as these
aircraft are flying at all hours along the myriad of flight routes that crisscross
30 the globe.

32 It is also an advantage that higher aircraft density corresponds to
higher population density in that aircraft tend to group around large
34 population centers. Thus greater spatial and temporal resolution can be

achieved in the very regions that have the most to benefit from detailed
timely thematic maps.

Other objects, advantages and novel features, and further scope of
applicability of the present invention will be set forth in part in the detailed
description to follow, taken in conjunction with the accompanying drawings,
and in part will become apparent to those skilled in the art upon examination
of the following, or may be learned by practice of the invention. The objects
and advantages of the invention may be realized and attained by means of
the instrumentalities and combinations particularly pointed out in the
appended claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The accompanying drawings, which are incorporated into and form a
part of the specification, illustrate several embodiments of the present
invention and, together with the description, serve to explain the principles of
the invention. The drawings are only for the purpose of illustrating a
preferred embodiment of the invention and are not to be construed as
limiting the invention. In the drawings:

Fig. 1 shows the preferred embodiment of the invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS (BEST MODES FOR CARRYING OUT THE INVENTION)

The present invention is a method and apparatus for obtaining air
constituent sensor data from at least one aircraft, a means for compiling the
data, a transmission apparatus **30** for sending the compiled data along with
time and location data to a receiving station and a means for obtaining the
compiled data by users. Referring to Fig. 1, the airborne components of the
invention include an air data system **22**, navigation system **20**, sensor
system **24** and data link system **10**.

Data link system **10** is responsible for aircraft radio communications with the regional receivers **12** and for directly or indirectly receiving data from the navigation **20**, air data **22** and sensor **24** systems. All necessary formatting of the data in preparation for transmission is also done by data link system **10**.

Air data system **20** can either provide raw data, such as static and impact pressure and total temperature, and the like, or may provide derived quantities such as altitude, wind speed and direction, and true or computed airspeed.

Navigation system **22** includes all necessary navigational sensors such as gyros, accelerometers, radar altimeters, GPS receivers, LORAN receivers as well as such computing hardware and software as is needed to compute at least one estimate of present location. A three dimensional location is assumed, such as latitude, longitude and altitude. Navigation system **22** may compute more than one position estimate based on navigational sensors and software used.

Sensor system **24** is collection of one or more devices that can measure the degree to which a sensed quantity is present at the particular aircraft position at a particular time. Sensors envisioned by this invention include, but are not limited to, chemical sensor for specific compounds or for classes of compounds, spectrographic sensors, sensors for particulate matter, sensors for specific biological species or for classes of biological species and radiological sensors sensitive to either subatomic particles or nuclear electromagnetic radiation. Sensor system **24** may report raw sensor output such as scintillation counts, or spectra or may report derived quantities from the raw sensor output.

Referring again to Fig. 1, the ground based systems include regional receivers **12** and a collection and compilation system **32**. In this embodiment, the regional receiver **12** directly receives data from aircraft **34** in its region via a radio link **30**. Another embodiment involves the use of a

satellite, whereby the aircraft communicates with the satellite and the
satellite communicates with a ground station radio link **30** between aircraft
34 and regional receiver **12** may be bi-directional, but as a minimum, the
receiver **12** must be able to receive data, directly or indirectly, from passing
aircraft **34**. Each receiver **12** is capable of communicating with many
aircraft.

Collection and compilation system **32** collects the data, the time and
the aircraft position from all receivers **12** and creates one or more electronic
files. Collection and compilation system **32** would consist of communication
channels sufficient to handle the traffic from the regional receivers **12**,
sufficient computing power to create the needed electronic files and
sufficient memory to store the electronic files. The various parts of the
collection and compilation system **32** may be physically located together or
may be located in different sites (virtual). The preferred embodiment for the
electronic files is a database containing the data collected by the system, but
the invention is not restricted to the type or format of file created. Collection
and compilation system **32** is connected to receivers **12** via communication
channels. The present invention is not restricted to the type or format of
these communication channels. In the case of a virtual collection and
compilation system, parts of this system may be physically located with one
or more of the regional receivers. The collection and compilation system **32**
need not log all available data, but may be designed so as to collect specific
data for specific mapping or modeling application.

Industrial Applicability

The invention is further illustrated by the following non-limiting
example.

As an example, consider a fleet of commercial aircraft equipped with
sulfuric acid sensors. Again referring to Fig. 1, aircraft **34** are flying their
normal routes over the North American continent. Aircraft **34** are fitted with

chemical sensors **24**, specifically for detecting sulfuric acid. Sensors **24**,
2 collect sulfuric acid concentrations and communicate them, via data link
system **10**, to the ground, comprising regional receivers **12** and a collection
4 and compilation system **32**, on a periodic basis, for example, every thirty
seconds. This data is collected into a database and used to make a model,
6 or map, of sulfuric acid concentrations over the continent for a time, for
example between noon and one o'clock Pacific Standard Time. A similar
8 model or map can be made for the time between one and two o'clock.
These two maps can be compared and dynamic and stationary features
10 observed. For example, it may be that a stationary high concentration area
may exist downwind of a large coal burning power plant or it may be that the
12 concentration of the sulfuric acid changes significantly with wind velocity
around this same power plant. Since the winds aloft are measured by the air
14 data system on the aircraft at the time of sensor measurement, and since
models of wind direction and speed are produced regularly by various
16 weather services, a prediction of where the sulfuric acid concentrations will
be in the future can be estimated. In addition, since a new model of the
18 sulfuric acid concentration distribution is made periodically, the predictions
can be refined against the more recently made models.

20
Similar types of models could be made for chlorinated hydrocarbons,
22 or beta emitting particles. Of particular interest is the detection of weapons
of mass destruction, the sensors for which are undergoing a rapid
24 development at this time.

CLAIMS

What is claimed is:

1. A system for collecting air constituent information from a
2 sensor system disposed on at least one aircraft (34), the system comprising:
said at least one aircraft (34) comprising an air data system
4 (20), a navigation system (22), a data link system (10) and the sensor
system (24), the sensor system (24) comprising at least one sensor;
6 a means for collecting and compiling data (32) from said
sensor system (22), air data system data (20) and navigation system (22)
8 data; and
a transmitter (30) for transmitting the compiled data to at least
10 one receiving station (12).
2. The system of claim 1 wherein said at least one sensor
2 comprises of a member from the group consisting of a chemical sensor, a
particulate sensor and a radiological sensor.
3. The system of claim 1 wherein said navigation system (22)
2 comprises aircraft (34) position data and time data.
4. The system of claim 1 further comprising a means for creating
2 a thematic map from said compiled data.
5. The system of claim 5 wherein said means for creating a
2 thematic map comprises a means for creating a thematic map for a
predefined period of time.
6. The system of claim 1 further comprising a means for creating
2 a thematic map from said transmitted data from each receiving station from
said at least one receiving station.

2 7. The system of claim 7 wherein the means for creating a
thematic map comprises a means for creating a thematic map over a
4 predefined period of time.

 8. A method for collecting air constituent information collected
2 from a sensor system (24) disposed on at least one aircraft (34) comprising:
 a) providing at least one sensor comprising the sensor
4 system (24) on the at least one aircraft (34);
 b) collecting air constituent data from the sensor system
6 (34);
 c) compiling (32) the collected air constituent data with
8 data from a navigation system (22) and data from an air data system (20),
the navigation system (22) and the air data system on board the at least one
10 aircraft; and
 d) transmitting (30) the compiled data to at least one
12 receiving station (12).

 9. The method of claim 9 wherein the at least one sensor
2 comprises a member from the group consisting of a chemical sensor, a
particulate sensor and a radiological sensor.

 10. The method of claim 9 wherein the navigation system (22)
2 comprises aircraft (34) position data and time data.

 11. The method of claim 9 further comprising the step of creating a
2 thematic map from the compiled data.

 12. The method of claim 13 wherein the step of creating a thematic
2 map comprises creating a thematic map over a predefined period of time.

 13. The method of claim 9 further comprising the step of predicting
2 an air constituent quantity from the compiled data.

2 14. The method of claim 9 further comprising the step of creating a
thematic map from the transmitted data from each receiving station from the
at least one receiving station (12).

4

6 15. The method of claim 16 wherein the step of creating a thematic
map comprises creating the thematic map over a predefined period of time.

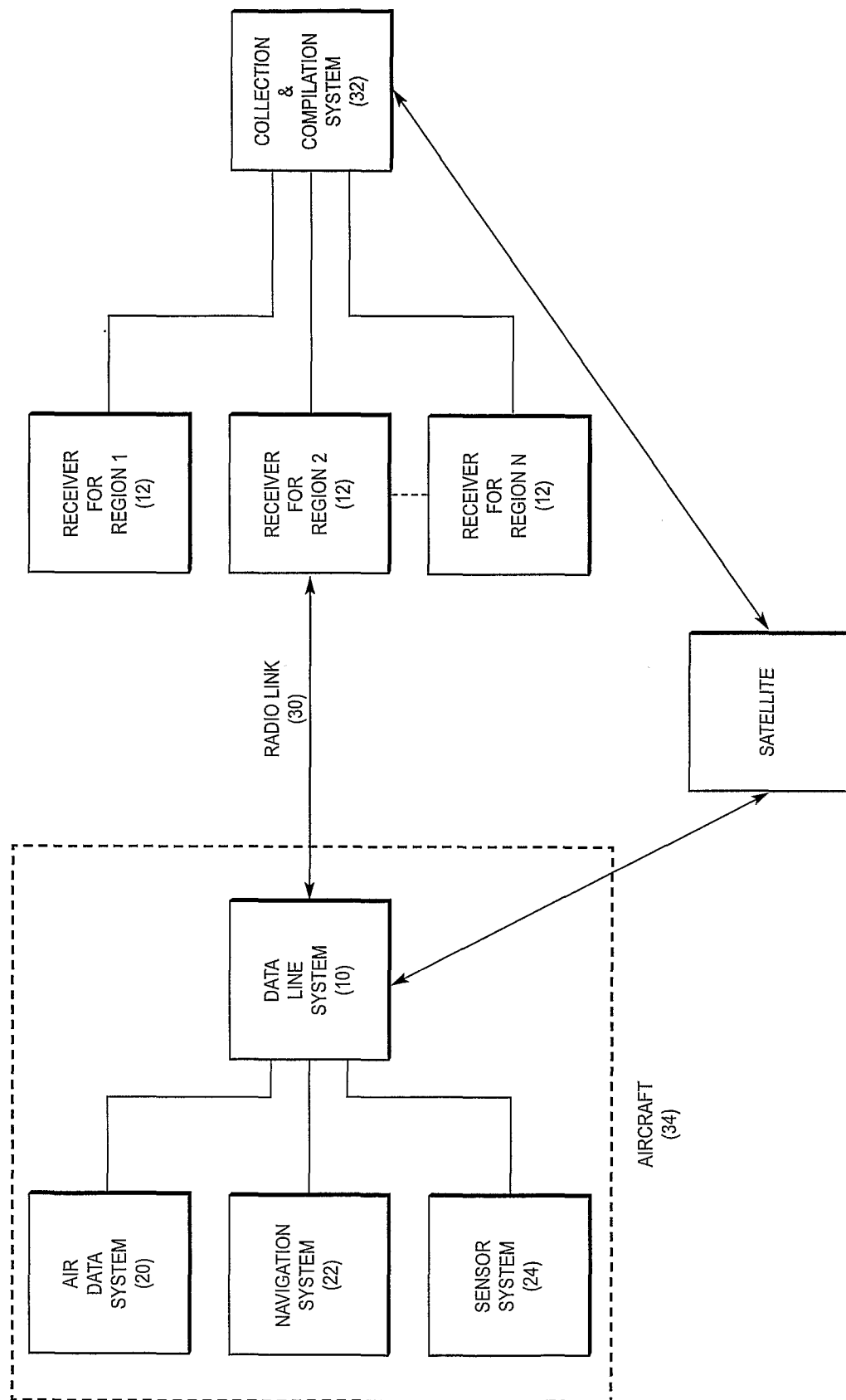


FIG-1

INTERNATIONAL SEARCH REPORT

International application No

PCT/US2006/026301

A. CLASSIFICATION OF SUBJECT MATTER
 INV. G01W1/00 G01N33/00

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

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

G01S G01W G06T G01N

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

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X	US 2004/189976 A1 (BURNS JOSEPH D [US] ET AL) 30 September 2004 (2004-09-30) the whole document	1-15
A	US 5 831 876 A (ORR WILSON W [US] ET AL) 3 November 1998 (1998-11-03) column 3, line 18 - line 26 column 3, line 34 - line 40 column 4, line 10 - line 20 column 9, line 26 - line 38	1-15
A	US 6 043 756 A (BATEMAN CHARLES D [US] ET AL) 28 March 2000 (2000-03-28) cited in the application the whole document	1, 3-8, 10-12, 14, 15



Further documents are listed in the continuation of Box C.



See patent family annex.

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- *O* document referring to an oral disclosure, use, exhibition or other means
- *P* document published prior to the international filing date but later than the priority date claimed

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- *Y* document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.
- * & * document member of the same patent family

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INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

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Patent document cited in search report		Publication date	Patent family member(s)	Publication date
US 2004189976	A1	30-09-2004	NONE	
US 5831876	A	03-11-1998	US 5815417 A	29-09-1998
			US 5835386 A	10-11-1998
			US 5808916 A	15-09-1998
			US 5818737 A	06-10-1998
US 6043756	A	28-03-2000	DE 69900498 D1	10-01-2002
			DE 69900498 T2	20-06-2002
			EP 1055136 A1	29-11-2000
			JP 2002536627 T	29-10-2002
			WO 9940457 A1	12-08-1999