



- (51) International Patent Classification:
G06F 19/00 (2011.01)
- (21) International Application Number:
PCT/US2013/078540
- (22) International Filing Date:
31 December 2013 (31.12.2013)
- (25) Filing Language:
English
- (26) Publication Language:
English
- (30) Priority Data:
61/748,046 31 December 2012 (31.12.2012) US
61/747,899 31 December 2012 (31.12.2012) US
61/747,905 31 December 2012 (31.12.2012) US
61/747,885 31 December 2012 (31.12.2012) US
61/748,009 31 December 2012 (31.12.2012) US
61/773,726 6 March 2013 (06.03.2013) US
61/919,796 22 December 2013 (22.12.2013) US

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(81) Designated States (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JP, KE, KG, KN, KP, KR, KZ, LA, LC, LK, LR, LS, LT, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

(84) Designated States (unless otherwise indicated, for every kind of regional protection available): ARIPO (BW, GH, GM, KE, LR, LS, MW, MZ, NA, RW, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian (AM, AZ, BY, KG, KZ, RU, TJ, TM), European (AL, AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HR, HU, IE, IS, IT, LT, LU, LV, MC, MK, MT, NL, NO, PL, PT, RO, RS, SE, SI, SK, SM, TR), OAPI (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, KM, ML, MR, NE, SN, TD, TG).

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Published:
— with international search report (Art. 21(3))

[Continued on next page]

(54) Title: DYNAMIC AIRCRAFT THREAT CONTROLLER MANAGER APPARATUSES, METHODS AND SYSTEMS

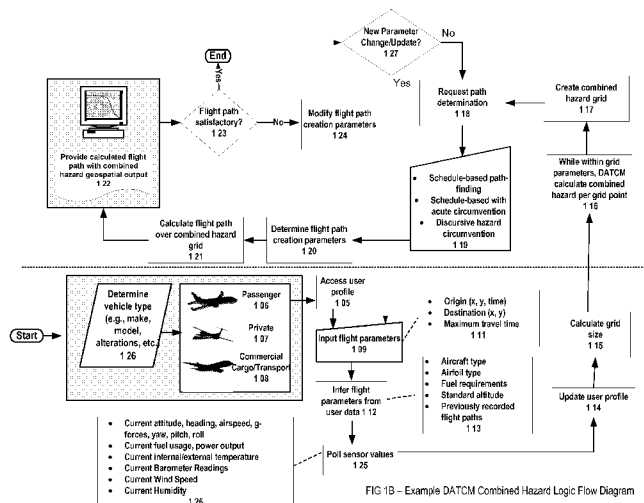


FIG 1B - Example DATCM Combined Hazard Logic Flow Diagram

(57) Abstract: The dynamic aircraft threat controller manager apparatuses, methods and systems ("DATCM") transforms flight profile information, terrain, weather/atmospheric data and flight parameter data via DATCM components into comprehensive hazard avoidance optimized flight plans. Comprehensive hazard avoidance includes synergistic comprehensive turbulence and airfoil-specific icing data. In one implementation, the DATCM comprises a processor and a memory disposed in communication with the processor and storing processor-issuable instructions to receive anticipated flight plan parameter data, obtain weather data based on the flight plan parameter data, obtain atmospheric data based on the flight plan parameter data, and determine a plurality of four-dimensional grid points based on the flight plan parameter data. The DATCM may then determine comprehensive hazards mappings. With (near) real-time comprehensive hazard information and/or predictive turbulence/icing forecast specific to airfoil type and/or profile parameters, the DATCM may allow aircraft to avoid areas where comprehensive hazard is greater than a predetermined threshold and/or avoid areas where turbulence/icing may occur.

WO 2014/106268 A1

- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

DYNAMIC AIRCRAFT THREAT CONTROLLER MANAGER APPARATUSES, METHODS AND SYSTEMS

1 [0001] This application for letters patent document discloses and describes inventive
2 aspects that include various novel innovations (hereinafter “disclosure”) and contains material
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PRIORITY CLAIM

9
10 [0002] This application is a non-provisional of and claims priority under 35 U.S.C. § 119
11 to: United States provisional patent application serial no. 61/748,046, filed December 31, 2012,
12 entitled “Dynamic Airfoil Platform Manager Apparatuses, Methods and Systems,” attorney
13 docket no. SCHN-007/00US 318573-2010; United States provisional patent application serial
14 no. 61/747,899, filed December 31, 2012, entitled “Airfoil Icing Platform Apparatuses, Methods
15 and Systems,” attorney docket no. SCHN-006/00US 318573-2006; United States provisional
16 patent application serial no. 61/773,726, filed March 6, 2013, entitled “Airfoil Icing Platform
17 Apparatuses, Methods and Systems,” attorney docket no. SCHN-006/01US 318573-2011;
18 United States provisional patent application serial no. 61/747,905, filed December 31, 2012,
19 entitled “Dynamic Turbulence Platform Apparatuses, Methods and Systems,” attorney docket
20 no. SCHN-005/00US 318573-2005; United States provisional patent application serial no.
21 61/747,885, filed December 31, 2012, entitled “Dynamic Turbulence Engine Apparatuses,
22 Methods and Systems,” attorney docket no. SCHN-008/00US 318573-2008; United States
23 provisional patent application serial no. 61/748,009, filed December 31, 2012, entitled
24 “Dynamic Turbulence Manager Apparatuses, Methods and Systems,” attorney docket no.
25 SCHN-009/00US 318573-2009; and United States provisional patent application serial no.
26 61/919,796, filed December 22, 2013, entitled “Dynamic Storm Environment Engine
27 Apparatuses, Methods and Systems,” attorney docket no. SCHN-015/00US 318573-2029. The

1 entire contents of the aforementioned applications are expressly incorporated by reference
2 herein.

3 **BACKGROUND**

4 **[0003]** A variety of weather monitoring systems, including ground-based and satellite-
5 based observations, are used to provide weather reports and forecasts, which may be utilized to
6 arrange outings and plan for trips.

7 **BRIEF DESCRIPTION OF THE DRAWINGS**

8 **[0004]** The accompanying appendices and/or drawings illustrate various non-limiting,
9 example, inventive aspects in accordance with the present disclosure:

10 **[0005]** FIGURE 1A demonstrates an example user interface wherein comprehensive
11 hazard prediction is integrated into an existing and/or future flight planning tool, allowing users
12 to alter flight path creation to account for projected comprehensive hazard in some
13 embodiments of the DATCM;

14 **[0006]** FIGURE 1B shows a logic flow diagram illustrating an example of an DATCM
15 integrating comprehensive hazard modeling into flight path creation, facilitating user preference
16 in flight planning variation in some embodiments of the DATCM;

17 **[0007]** FIGURE 2 shows a data flow diagram illustrating an example of a DATCM
18 functionality;

19 **[0008]** FIGURE 3 shows an example data flow diagram of various output media
20 provided by the DATCM and the use of its data in multiple intermediate and end stage
21 applications in some embodiments of the DATCM;

22 **[0009]** FIGURE 4 provides an overview of an aspect of the DATCM;

23 **[0010]** FIGURE 5 shows a data flow diagram illustrating an example of a DATCM
24 accepting inputs and data requests, utilizing internal data repositories for data request execution
25 and outputting both predictive and (near) real-time data in some embodiments of the DATCM;

1 [0011] FIGURE 6 shows a data flow diagram illustrating an example of an DATCM
2 initializing internal data repositories for input while accepting inputs and data requests and
3 outputting both predictive and (near) real-time data in some embodiments of the DATCM;

4 [0012] FIGURE 7 demonstrates a logic flow diagram illustrating example DATCM data
5 requests, creating an aircraft profile, accepting input and outputting grid point percent power
6 increase (PPI) in some embodiments of the DATCM;

7 [0013] FIGURE 8 demonstrates a logic flow diagram illustrating example DATCM data
8 requests, accessing an aircraft profile, accepting input and outputting grid point percent power
9 increase (PPI) in some embodiments of the DATCM;

10 [0014] FIGURE 9 demonstrates an example user interface where icing prediction is
11 integrated into an existing and/or future flight planning tool, allowing users to alter flight path
12 creation to account for projected icing in some embodiments of the DATCM;

13 [0015] FIGURE 9A shows a logic flow diagram illustrating an example of an DATCM
14 integrating icing modeling into flight path creation, facilitating user preference in flight
15 planning variation in some embodiments of the DATCM;

16 [0016] FIGURES 10-14 show various example and/or visual input/output component
17 aspects of the DATCM;

18 [0017] FIGURE 15 illustrates aspects of ice accumulation and resultant PPI values with
19 respect to a Beechcraft King Air airfoil, in one implementation of the DATCM;

20 [0018] FIGURE 16 illustrates aspects of ice accumulation and resultant PPI values with
21 respect to a Boeing 737 airfoil, in one implementation of the DATCM;

22 [0019] FIGURE 17 shows an example percent power increase (“PPI”) component
23 installation and usage scenario, in one implementation of the DATCM;

24 [0020] FIGURES 18A-F show an example PPI component hardware component, in one
25 implementation of the DATCM;

26 [0021] FIGURE 19A provides an example logic flow for an embodiment of the DATCM,
27 illustrating aspects of a real-time flight alerting and planning component of the DATCM;

1 [0022] FIGURE 19B provides an overview diagram illustrating example enhanced
2 turbulence regions affecting aircraft and an example output of integrated turbulence output in
3 some embodiments of the DATCM;

4 [0023] FIGURE 20 shows a data flow diagram illustrating an example of a DATCM
5 accepting inputs and data requests and outputting both predictive and (near) real-time data in
6 some embodiments of the DATCM.

7 [0024] FIGURE 21 shows a data flow diagram illustrating an example of a DATCM
8 utilizing both external and internal data repositories for input while accepting inputs and data
9 requests and outputting both predictive and (near) real-time data in some embodiments of the
10 DATCM;

11 [0025] FIGURE 22A demonstrates a logic flow diagram illustrating example DATCM
12 turbulence computational integration component, accepting input and outputting grid point
13 enhanced turbulence data in some embodiments of the DATCM;

14 [0026] FIGURE 22B provides example output from an enhanced above-storm turbulence
15 determination;

16 [0027] FIGURE 23 demonstrates an example user interface where turbulence prediction
17 is integrated into an existing and/or future flight planning tool, allowing users to alter flight path
18 creation to account for projected turbulence in some embodiments of the DATCM;

19 [0028] FIGURE 24 shows a logic flow diagram illustrating an example of a DATCM
20 integrating turbulence modeling into flight path creation, facilitating user preference in flight
21 planning variation in some embodiments of the DATCM;

22 [0029] FIGURE 25 shows an overview diagram illustrating an example of a vertical air
23 region and the overlay of turbulent areas affecting aircraft at various altitudes and times, where
24 overlapping regions illustrate enhanced turbulence in some embodiments of the DATCM;

25 [0030] FIGURE 26 shows example grid outputs of the mathematical models both pre and
26 post integration, illustrating how enhanced turbulence is more than graphical intersection and
27 represents both cumulative and heightened turbulence in overlay zones in some embodiments of
28 the DATCM;

1 [0031] FIGURE 27 shows an example data flow diagram of various output media
2 provided by the DATCM and the use of its data in multiple intermediate and end stage
3 applications in some embodiments of the DATCM;

4 [0032] FIGURES 28A-29D show various example and/or visual input/output component
5 aspects of the DATCM;

6 [0033] FIGURE 30 provides an exemplary flow diagram for an embodiment of a
7 VVSTORMSE component of the DATCM;

8 [0034] FIGURES 30A-30F illustrate exemplary data displays for embodiments of the
9 DATCM and/or components/subcomponents thereof;

10 [0035] FIGURE 31 provides an exemplary logic flow diagram illustrating EDR
11 determination and masking for an embodiment of the DATCM and/or an associated
12 VVSTORMSE component/subcomponent;

13 [0036] FIGURE 32 provides an exemplary logic flow diagram illustrating aspects of a
14 VVSTORMSE component operation for an embodiment of the DATCM;

15 [0037] FIGURE 33 provides a logic flow diagram illustrating an embodiment of an
16 integration component;

17 [0038] FIGURE 34 provides an illustrative overview of features of an implementation of
18 the DATCM;

19 [0039] FIGURE 35 provides an exemplary illustration of geostationary operational
20 environmental satellite convective initiation data according to one embodiment;

21 [0040] FIGURE 36 illustrates an example convective cloud mask for an embodiment;

22 [0041] FIGURE 37 provides an exemplary output of an overshooting top mask for an
23 embodiment;

24 [0042] FIGURES 38A-39D illustrate exemplary turbulence forecasts according to some
25 embodiments;

26 [0043] FIGURE 40 provides an exemplary schematic drawing illustrating regions of
27 turbulence in an embodiment;

1 [0044] FIGURE 41 provides an exemplary cross-sectional view of a flight path and
2 regions of turbulence in an embodiment;

3 [0045] FIGURE 42 provides an exemplary flow diagram illustrating an integrated
4 turbulence forecast process according to some embodiments;

5 [0046] FIGURE 43 provides a table containing an in-flight time sequence of turbulence
6 forecasts according to some embodiments;

7 [0047] FIGURE 44 provides an exemplary view of an output file generated by the
8 DATCM in some embodiments;

9 [0048] FIGURES 45A and 45B depict an example set of observation data points and
10 their overlay onto mapped forecast data, respectively, according to some embodiments; and

11 [0049] FIGURE 46 shows a block diagram illustrating embodiments of a DATCM
12 controller;

13 [0050] The leading number of each reference number within the drawings indicates the
14 figure in which that reference number is introduced and/or detailed. As such, a detailed
15 discussion of reference number 101 would be found and/or introduced in Figure 1. Reference
16 number 201 is introduced in Figure 2, etc.

DETAILED DESCRIPTION

DYNAMIC AIRCRAFT THREAT CONTROLLER MANAGER (DATCM)

[0051] In some embodiments, the DYNAMIC AIRCRAFT THREAT CONTROLLER MANAGER (“DATCM”) as disclosed herein transforms flight profile information, terrain, weather/atmospheric data and flight parameter data via DATCM components into comprehensive hazard avoidance optimized flight plans. Comprehensive hazard avoidance includes synergistic comprehensive turbulence and airfoil-specific icing data. In one implementation, the DATCM comprises a processor and a memory disposed in communication with the processor and storing processor-issuable instructions to receive anticipated flight plan parameter data, obtain weather data based on the flight plan parameter data, obtain atmospheric data based on the flight plan parameter data, and determine a plurality of four-dimensional grid points based on the flight plan parameter data. The DATCM may then determine comprehensive hazard mappings. With (near) real-time comprehensive hazard information and/or predictive turbulence/icing forecast specific to airfoil type and/or profile parameters, the DATCM may allow aircraft to avoid areas where the comprehensive hazard is greater than a predetermined threshold and/or avoid areas where turbulence and/or icing may occur.

[0052] Figure 1A shows an example of how the DATCM provides and/or may be incorporated into flight planning tools, such as AviationSentry Online®. The DATCM may be included with online services, with desktop services, with mobile applications, and/or the like. In the embodiment shown in Figure 1A, a flight planning tool has an interface 101 representative of an online flight planning service with user profile information. As an interactive element 102, the DATCM may allow users to factor comprehensive turbulence and icing (“comprehensive hazard”) predictions into flight path creation. The DATCM may allow users to consider several ways of incorporating comprehensive hazard prediction into their flight path considering their flight requirements 103. In this example, the DATCM may offer shortest path generation where comprehensive hazards may not be a considering factor in flight path creation, comprehensive hazard circumvention where comprehensive hazard avoidance is a serious flight consideration, some comprehensive hazard circumvention with emphasis on

1 shortest path generation where comprehensive hazard avoidance warrants some consideration,
2 but may not be a primary goal and/or the like. The DATCM may then generate a regional
3 comprehensive hazard forecast within the specified flight path region 104 and suggest flight
4 path alterations with respect to the level of comprehensive hazard circumvention desired. The
5 comprehensive hazard determination is made based on a variety of factors and may be tailored
6 to the aircraft airfoil, purpose (e.g., passenger vs. cargo flights), etc. When determining
7 comprehensive hazards, the DATCM may output a color-coded map overlay where black may
8 represent no significant comprehensive hazard, green may represent mild comprehensive
9 hazard, yellow may represent moderate comprehensive hazard, and red may represent severe
10 comprehensive hazard.

11 **[0053]** Figure 1B shows one example of an expanded logic flow diagram of flight path
12 considerations when the DATCM is part of an integrated flight planning tool. In one
13 embodiment of the disclosure, e.g., at 126, a vehicle type (e.g, make, model, classification,
14 modifications, service history, and/or like information) may be determined. The vehicle type
15 may, for example, be categorized as a Passenger aircraft 106, a Private aircraft 107, or a
16 Commercial Cargo/Transport aircraft; it may also include model number, sub-type, and
17 alteration information to the vehicle. The flight planning service may access/input user profile
18 information 105 which may include such information type of aircraft and/or flight service such
19 as passenger 106, private 107 and/or commercial cargo/transport 108, the consideration of
20 which may influence comprehensive hazard avoidance (i.e., commercial cargo transport may
21 prioritize shortest path with minimal evasion while passenger may emphasize discursive icing
22 circumvention over speed or directness). The DATCM may request additional user profile
23 information for flight path construction 109. In some embodiments of the disclosure, such
24 information may include the origin grid point and departure time of the flight, the destination
25 grid point, and/or the maximum travel time the flight can utilize in constructing its path 111. In
26 some embodiments of the disclosure, the DATCM may infer user information from previously
27 stored user profile data and/or prior flight path generation 112. In some embodiments, this
28 information may include the aircraft type, aircraft airfoil parameters, aircraft fuel requirements,
29 standard flying altitude, previous planned flight paths, and/or the like 113. Sensor values may
30 then be polled, at 125 (e.g., a polling of the myriad sensors that vary according to the airframe
31 type), providing sensor data such as attitude, altitude, heading, airspeed, g-forces, yaw, pitch,

1 roll, fuel consumption rate, current fuel capacity/fuel remaining for the flight, number of
2 passengers, weight, tire pressure, fire sensor, engine status, fluid levels, hours flown, barometric
3 pressure, water content of the atmosphere and/or clouds, icing on wings, CO₂, oxygen, power
4 output, temperatures of the aircraft's interior volume and exterior surface(s), wind speed,
5 humidity, and/or the like, for example as shown at 126. In some embodiments, user profile,
6 polled sensor information, and flight creation information that is both input and/or inferred by
7 the DATCM, may be used to update the user profile data for future DATCM use 114. In some
8 embodiments of the disclosure, the DATCM may use other stored profile information where
9 similar parameters resulted in successful flight path creation. In addition, in some embodiments,
10 user profile data corresponding to a particular pilot may include the pilot's preference(s) with
11 regard to fuel mixture, flight path, amount of turbulence, etc.). In some embodiments of the
12 disclosure, the DATCM may use additional input, such as those from sources external to the
13 flight planning tool, such as historical flight plan data and/or the like. The DATCM may then
14 calculate the grid size of the region 115 over which the DATCM may consider flight path
15 creation, using input such as the origin, destination, maximum flight time, polled sensor values
16 125, and/or facilities of the aircraft and/or type of flight. In some embodiments of the
17 disclosure, two dimensional grid space may be considered for initial path planning purposes. In
18 some embodiments of the disclosure, three or four dimensional grid space may be considered
19 for path planning purposes. In some embodiments of the disclosure, two dimensional grid space
20 may be considered for initial path planning purposes, which may then be integrated with
21 additional dimensional information as necessary to accurately determine available grid space
22 inside which the flight path may still meet flight path parameters.

23 **[0054]** In some embodiments of the disclosure, this initial input component may then be
24 followed by DATCM comprehensive hazard calculation 116 of the generated geospatial grid
25 region, some examples of which are described in later figures. The DATCM may create a
26 comprehensive hazard overlay to the generated grid region 118 and may request additional
27 information about the desired parameters of the flight path through this grid region 118. In some
28 embodiments of the disclosure, these parameters may include schedule-based path-finding
29 (shortest path immediacy), schedule-based but with circumvention of acute comprehensive
30 hazard (shortest path avoiding high hazard icing and/or turbulence areas), discursive
31 comprehensive hazard circumvention (navigating out of turbulent/high icing areas), and/or any

1 combination of or intermediate stage to these parameters 119. The DATCM may then use
2 available input as described in the input component to determine all flight path creation
3 parameters 120. The DATCM may then create a flight path over the comprehensive hazard grid
4 region 121, considering flight path creation parameters 119. The DATCM may then provide the
5 user the proposed flight path as a terminal overlay, standard or high definition map overlay
6 and/or the like 122, as is applicable to the flight planning tool. If the flight path is satisfactory
7 123, the user may then exit the flight path planning component of the DATCM as an
8 incorporated flight planning tool option. The polled sensor data discussed above with respect to
9 125 may also be employed in the calculations at 120, 121, and 122. In some embodiments of the
10 disclosure, the DATCM may allow the user to export the determined flight path to other media,
11 save the flight path to the user profile, share the flight path with additional users, and/or the like.
12 In some embodiments of the disclosure, if the proposed flight path is not satisfactory 123, the
13 DATCM may allow the user to modify flight path creation parameters 124. At 127, the
14 DATCM may evaluate whether a new parameter change or update is required. If so, the process
15 may loop back to the input flight parameters step 109 before proceeding. If no new parameter
16 changes/updates are required, the process may proceed to request a path determination at 118
17 and proceed as described above with regard to 119, 120, 121, 122 and 123. In some embodiments
18 of the disclosure, the user may reenter a flight path creation component specified earlier. In
19 some embodiments of the disclosure, users may be allowed to visually manipulate flight path
20 options using the proposed flight path comprehensive hazard grid overlay. In some
21 embodiments of the disclosure, the user may be able to reenter flight path creation, visually
22 manipulate the proposed flight path and/or combine these methods in any intermediate path
23 modification.

24 **[0055]** In some embodiments, the DATCM transforms atmospheric and terrain data, via
25 DATCM components, into comprehensive four-dimensional comprehensive hazard displays and
26 interfaces. In one implementation, the DATCM comprises a processor and a memory disposed
27 in communication with the processor and storing processor-issuable instructions to determine a
28 plurality of four-dimensional grid points for a specified temporal geographic space-time area
29 and obtain corresponding terrain and atmospheric data. Then, for each point of the plurality of
30 four-dimensional grid point, the DATCM determines airfoil-specific icing attributes and non-
31 dimensional mountain wave amplitude and mountain top wave drag, upper level non-

1 dimensional gravity wave amplitude, and a buoyant turbulent kinetic energy. The DATCM may
2 also determine a boundary layer eddy dissipation rate, storm velocity and eddy dissipation rate
3 from updrafts, maximum updraft speed at grid point equilibrium level, storm divergence while
4 the updraft speed is above the equilibrium level and identifying storm top, storm overshoot and
5 storm drag. The DATCM determines Doppler speed, eddy dissipation rate above the storm top,
6 eddy dissipation rate from downdrafts. Then, the DATCM determines the turbulent kinetic
7 energy and/or the total eddy dissipation rate for each grid point and provides a four-dimensional
8 grid map overlay with comprehensive hazard data for the specified temporal geographic space-
9 time area.

10 **[0056]** As illustrated in Figure 2, in some embodiments of the disclosure, the DATCM
11 201 may be available to aircraft 202, air traffic controllers 203, flight planning tools and
12 software 217, third party applications 216 where comprehensive hazard feed incorporation is
13 contributing, and the like. In some embodiments of the disclosure, PIREPS and sensor data of
14 aircraft in real-time comprehensive hazard conditions 204 may be sent to the DATCM to be
15 incorporated into the DATCM aggregate data analysis. In some embodiments, the sensor data
16 may take an industry-standard format, for example according to a wireless sensor network
17 (WSN) standard such as ZigBee, 802.15.4, or 6LoWPAN. Alternatively, the sensor data input
18 204 may take the following XML formatted form:

```
19 <sensor_data>
20     <position_data>
21         <time>10:03:10 UCT</time>
22         <GPS_coord>00907612</GPS_coord>
23         <heading>180 degrees</heading>
24     </position_data>
25     <airspeed>500 knots</airspeed>
26     <ground_speed>575 mph</ground_speed>
27     <wind_velocity>20 kts</wind_velocity>
28     <nose_temperature> -100 degrees F </nose_temperature>
29     <relative_humidity>65 </relative_humidity>
30     <hazard_report_1>
31         <GPS_coord_hazard1>00924867</GPS_coord_hazard1>
32         <hazard_radius>1.4 miles</hazard_radius>
33         <type>tornado</type>
34         <source_xmn>UHF</source_xmn>
35         <source>NOAA</source>
```

```

1         </hazard_report_1>
2         <hazard_report_2>
3             <GPS_coord_hazard1>01124527</GPS_coord_hazard1>
4             <hazard_radius>15 miles</hazard_radius>
5             <type>strong turbulence above 50,000 feet</type>
6             <source_xmn>vHF</source_xmn>
7             <source>ATC Denver</source>
8         </hazard_report_2>
9         ...
10    </sensor_data>
11
```

12 **[0057]** Similarly in some embodiments of the disclosure, additional/other sources of
13 input may be weather stations 220 and satellites 221 which may provide numerical weather
14 forecast data 206 to the DATCM. Such weather information may be obtained from a variety of
15 sources, including the National Weather Service, NOAA, and/or the like, and may in some
16 embodiments be substantially in the form of a HTTP(S) POST message including XML-
17 formatted data, is provided below:

```

18    POST /weather_forecast_.php HTTP/1.1
19    Host: www.NOAA.gov/wx
20    Content-Type: Application/XML
21    Content-Length: 484
22    <?XML version = "1.0" encoding = "UTF-8"?>
23    <local_weather_alerts_report>
24        <request_ID>45DSKFSWFG5</request_ID>
25        <GPS_coord_requestor>00907612</GPS_coord_requestor>
26        <timestamp>yyyy-mm-dd hh:mm:ss</timestamp>
27        <request_coverage_period>24 hours</request_coverage_period>
28        <weather_detail_24hour>
29            <humidity>64%</humidity>
30            <wind_speed>W 8 mph</wind_speed>
31            <barometer>30.12 in (1019.2 mb)</barometer>
32            <dewpoint>20 degrees F (-7 degrees C)</dewpoint>
33            <visibility>8.00 mi</visibility>
34            <wind_chill>24 degrees F (-4 degrees C)</wind_chill>
35            <alert_status>frost advisory</alert_status>
36        </weather_detail_24hour>
37    </local_weather_alert_report>
```

38 **[0058]**

1 [0059] In some embodiments of the DATCM, additional/other sources of input may be
2 topological data 218 which may provide terrain characteristic data 205 to the DATCM. A variety
3 of sources may be used to supply the terrain characteristic data, including GPS/satellite terrain
4 mapping services like Terraserver, TopoZone, MapTech, Google Earth, NOAA Global Relief
5 Images, etc. Alternatively or in addition, topographical imaging may also be conducted by the
6 aircraft itself during the flight and transmitted to/processed by the DATCM. In some
7 embodiments of the DATCM, the receipt of this input may occur prior to requests to the
8 DATCM for comprehensive hazard forecasting. In some embodiments of the DATCM, the
9 receipt of this input may be ongoing during requests to the DATCM for comprehensive hazard
10 forecasting. In some embodiments of the DATCM, receipts of input may be both before requests
11 to the DATCM for comprehensive hazard forecasting and ongoing during forecasting requests.
12 In some embodiments, an aircraft 202 may request (near) real-time localized comprehensive
13 hazard data 207, an air traffic control system 203 may request predictive regional comprehensive
14 hazard data as an updating feed 209 and/or a (near) real-time regional comprehensive hazard data
15 request 211, and/or a flight-planning tool or software may request predictive comprehensive
16 hazard within a flight path region or along a flight path course 213. A hazard data feed may, in
17 some embodiments, be substantially in the form of a HTTP(S) POST message including XML-
18 formatted data, is provided below:

```
19 POST /hazards.php HTTP/1.1
20 Host: www.NOAA.gov/wx
21 Content-Type: Application/XML
22 Content-Length: 484
23 <?XML version = "1.0" encoding = "UTF-8"?>
24 <hazard_data_feed>
25     <requestor_ID>45DSKFSWFG5</requestor_ID>
26     <request_type_realtime>TRUE</request_type_realtime>
27     <request_type_predictive>FALSE</request_type_predictive>
28     <GPS_coord_requestor>00907612</GPS_coord_requestor>
29     <heading_requestor>208.13 degrees</heading_requestor>
30     <timestamp>2013-12-31 16:51:22</timestamp>
31     <last_updated>2013-12-31 15:51:22</last_updated>
32     <hazard_display_type>map</hazard_display_type>
33     <hazard_info_001>
34     <coord_001>47BSKFSWFG5<coord_001>
35     <turb_hazard_info_001>9</turb_hazard_info_001>
```

```
1      <icing_hazard_info_001>12.1</icing_hazard_info_001>
2      </hazard_info_001>
3      <hazard_info_002>
4      <coord_002>47LCMFSWFG5<coord_002>
5      <turb_hazard_info_002>8.8</turb_hazard_info_002>
6      <icing_hazard_info_002>12.0</icing_hazard_info_002>
7      </hazard_info_002>
8      ...
9
10     <hazard_info_00N>
11     <coord_00N>47LCMFSWFG5<coord_00N>
12     <turb_hazard_info_00N>4.3</turb_hazard_info_00N>
13     <icing_hazard_info_00N>11.0</icing_hazard_info_00N>
14     </hazard_info_00N>
15 </hazard_data_feed>
16
```

17 **[0060]** In some embodiments, the DATCM may direct such requests through a
18 comprehensive hazard Integration Mechanism component 210 where DATCM components
19 such as Airfoil Icing Platform (AIP) component, MWAVE component, INTTURB component,
20 VVSTORMSE component, and VVTURB2 component process input into percentage power
21 increase (PPI) and eddy dissipation rate (EDR) values and render them for terminal 230,
22 standard/high-definition 231, and/or displays of the like. In some embodiments, the DATCM
23 may return a real-time/near real-time comprehensive hazard map 208 terminal display to an
24 aircraft, a predictive and updating regional data feed 212 (e.g., see data displays in Figures 30A-
25 30F) to an air traffic controller, a predictive flight path comprehensive hazard 214 display to a
26 flight-planning tool/software, a comprehensive hazard data feed 215 to a third party application
27 displaying comprehensive hazard data, and/or the like.

28 **[0061]** Figure 3 demonstrates one example of how DATCM Integration Mechanism
29 component(s) may incorporate external data feeds and may provide various partners, third party
30 software applications/tools, end users, integrators, internal and external flight planning services,
31 and/or the like with integrated turbulence output in the form of comma-separated value (CSV),
32 geometric vector data files, gridded binary (GRIB) format, data feeds, and/or the like. In one
33 embodiment, the DATCM receives Global Forecast System (GFS) data 301 from the National
34 Oceanic and Atmospheric Administration (NOAA) as input. In one embodiment, the DTP

1 receives Rapid Refresh (RAP) 302 data from the NOAA as input. In one embodiment, the
2 DATCM receives GFS, RAP, and/or similar information as input. In some embodiments the
3 DATCM produces one or more GRIB2 file(s) 303 and/or record outputs that may be appended
4 in GRIB format for use in file distribution by DATCM partners 304. In some embodiments,
5 DATCM partners may distribute DATCM output through various communication networks 305
6 such as local area networks (LAN) and/or external networks such as the internet which may
7 provide DATCM partners, third party applications/tools 306, and/or end users 307 with
8 DATCM output. In some embodiments of the DATCM, such output may be in propagated
9 GRIB files as provided to DATCM partners. In some embodiments of the DATCM, such
10 output may be converted to a visual form for display on a web browser, smart phone
11 application, software package and/or the like. In some embodiments of the DATCM, electronic
12 messaging 307 such as email, SMS text, push notifications, and/or the like may be employed to
13 alert end users of important data updates from the DATCM, DATCM partners, and/or other
14 parties providing DATCM output data.

15 **[0062]** In some embodiments, the DATCM may provide a file or data stream as output,
16 in which values of the DATCM during component production, including but not limited to EDR
17 finalization, may be recorded or provided. One example of a DATCM CSV output file is
18 provided below, showing an in-flight time sequence of forecasted turbulence:

Flight PHX-MSP dd mm yyyy Leave:0413Z Arrive:0646Z
Turbulence Forecast (EDR*100)

Time	Latitude	Longitude	Altitude (kft)	MWAVE	COMTURB	VVTURB	INTTURB	VVENTURB	FINAL	Explanation
415	33.5	-111.8	50	0	0	0	0	1	1	
425	34.5	-111.5	250	0	0	0	0	26	26	Near-storm turbulence
435	35.4	-110.3	370	0	0	0	0	1	1	
445	36.2	-109	370	0	0	1	25	1	25	Mountain wave and free gravity wave amplitudes combine
455	36.9	-107.7	370	0	0	0	0	0	0	
505	37.3	-106	370	0	0	0	0	34	34	Storm top turbulence
515	38.1	-104.7	370	0	0	1	35	1	35	Mountain wave and free gravity wave amplitudes combine
525	38.9	-103.5	370	0	0	1	0	1	1	
535	39.9	-102.3	370	0	45	0	45	0	45	
545	40.9	-101	370	0	0	1	0	1	1	
555	41.8	-99.7	370	0	51	1	51	1	51	
605	42.6	-98.5	370	0	34	0	34	0	34	
615	43.5	-97	370	0	30	1	30	1	30	
625	44.4	-95.3	390	0	18	43	18	43	43	
635	44.7	-94	100	0	0	24	0	24	24	
645	44.8	-93.2	20	0	19	0	19	51	51	Near-storm turbulence

1

2 [0063] In some embodiments of the DATCM, a file or feed (e.g., a CSV file) output from
 3 the DATCM may be provided as input to a geometric vector data generator 307, which may
 4 provide additional data output options. In some embodiments of the DATCM, the geometric
 5 vector data generator may output geometric vector data files to a file server 330 which may
 6 provide the data output to an alert server 320 which may provide the output a communications
 7 networks 305 to such partners, third parties, software applications, end users and/or the like as
 8 described. In some embodiments of the DATCM, the geometric vector data generator may
 9 output geometric vector data files, such as shapefiles, for storage in GIS database(s) 308. In
 10 some embodiments of the DATCM, Web Mapping Services (WMS) and/or Web Feature
 11 Services (WFS) 309 may obtain the geometric vector data files from GIS database(s) and
 12 provide geographic service integrators 311 with DATCM output data through various
 13 communication networks 305 as described. In some embodiments of the DATCM, file server(s)
 14 308 and/or WMS may incorporate the DATCM output data into a DATCM integrated server
 15 340 with application, data, and/or network components. A DATCM integrated server may
 16 employ such output data from DATCM components in proprietary software tools, web services,
 17 mobile applications and/or the like. In one embodiment of the DATCM, a DATCM integrated

1 server may employ DATCM component output for use in flight planning tools 312, such as
2 AviationSentry Online®.

3 **[0064]** Icing forecasting methods may focus on general categories of aircraft, such as
4 aircraft size, and real-time icing information rely primarily on pilot reports (PIREPS), other
5 subjective/observational data, and local sensors for determining icing airspace regions. The
6 DATCM as disclosed herein utilizes unique predictive mathematical calculation/determination
7 components of icing per unique airfoil type and utilizes these predictive mechanisms to generate
8 a comprehensive forecasting map display and/or overlay that is not merely a generalized icing
9 projection for aircraft of a broad-spectrum type, but is the computational specification of icing
10 to any airfoil known to the DATCM, providing an accurate representation of icing over a
11 specified spatial/temporal area.

12 **[0065]** In some embodiments, DATCM transforms flight profiles, atmospheric data, and
13 terrain data, via DATCM components, into comprehensive turbulence alerts and optimized
14 flight path adjustments. In one implementation, the DATCM comprises a processor and a
15 memory disposed in communication with the processor and storing processor-issuable
16 instructions to receive a flight profile for an aircraft, the flight profile including an at least one
17 initial route. The DATCM identifies an initial predicted comprehensive turbulence for the at
18 least one initial route and determines a real-time comprehensive turbulence for the at least one
19 initial route. The DATCM may then determine turbulence threshold compliance based on the
20 real-time comprehensive turbulence and at least one of the flight profile and the initial predicted
21 comprehensive turbulence, and may generate a turbulence exception if the real-time
22 comprehensive turbulence exceeds threshold turbulence parameters. The turbulence exception
23 may comprise an alert for the aircraft and/or determining an at least one adjusted route for the
24 aircraft based on the updated/real-time comprehensive turbulence data.

25 **[0066]** Turbulence forecasting methods may focus on discrete areas of turbulence, such
26 as clear air turbulence (CAT) or thunderstorm regions, and rely primarily on pilot reports
27 (PIREPS) and other subjective/observational data for determining turbulent airspace regions.
28 The DATCM as disclosed herein utilizes unique predictive mathematical components and
29 calculations of turbulence in four-dimensional space-time and utilizes these predictive devices
30 to generate a comprehensive forecasting and/or nowcasting map display and/or overlay that is

1 not merely the visual combination of disparate turbulence projections and/or observation, but is
2 the computational multi-hazard integration of enhanced turbulent regions, providing an
3 accurate, real-time/near real-time, multi-dimensional representation of turbulence over a
4 specified spatial/temporal area, reactive to new weather developments. In some embodiments,
5 the DATCM identifies areas where there is lower turbulence, even though there are radar
6 echoes. With this enhanced granularity, the DATCM enables flight following and/or path
7 determining and real-time (and/or near real-time) response to changing weather conditions.

8 **[0067]** Thunderstorms may create some of the most intense turbulence and icing
9 conditions. Avoidance of such conditions may be preferred, particularly for passenger aircraft.
10 Experienced forecasters use many subjective and objective tools to attempt to forecast
11 convection locations over large time ranges. DATCM provides for accurate, granular, and time-
12 specific convection and turbulence forecasts.

13 **[0068]** In some embodiments, DATCM objectively analyzes numerical forecast data
14 based on, for example, a conditionally unstable environmental lapse rate, sufficient heat and
15 moisture for a parcel to have a level of free convection (LFC), and a process to lift that parcel to
16 its LFC. DATCM determines weightings and/or balances each factor and combines them to
17 determine the appropriate level for the environment and for thunderstorm generation prediction.
18 For example, vertical velocities that may lift parcels are typically small in numerical models,
19 and rather than merely inferring higher speeds, DATCM may inflate velocities to values
20 observed in real storm environments. If a parcel at any grid point reaches its LFC, then DATCM
21 continues to track the parcel's vertical velocity as it rises buoyantly.

22 **[0069]** Icing determination may rely on sensors located on an aircraft to determine when
23 icing has occurred. This method fails to give advance warning to aircraft personnel to potential
24 icing hazards and may not give sufficient notice for course correction to improve icing
25 conditions. In some scenarios, an aircraft advancing into icing conditions may lose altitude
26 and/or be forced to terminate a specific flight plan without adequate notification of impending
27 icing conditions. Icing forecasts may rely on weather conditions alone to determine if icing may
28 occur and may apply only a generalized aircraft type to forecasting methods, an example of
29 which might be that a small aircraft may experience more significant icing than a larger aircraft
30 or require a greater power increase in icing conditions. However, airfoils, generally defined as

1 curved surface structures that provide aircraft with positive lift to drag ratios, under identical
2 weather conditions may ice differently, without respective to other aspects of aircraft
3 construction and/or size 401. In one example, a medium size propeller plane (e.g., see 402 in
4 Figure 4) may form ice encasing the endpoint of its airfoil requiring a PPI of 0.3548. In this
5 example under duplicate weather conditions, a large passenger aircraft (e.g., 403 in Figure 4)
6 may experience only slight icing of its airfoil, requiring a much smaller PPI of 0.0051. Lastly,
7 in this example, under these replicated weather conditions, a small private aircraft (e.g., 404 in
8 Figure 4) may experience larger ice formation on its airfoils than the passenger aircraft and
9 require a PPI of 0.0880, which is greater than that of the passenger aircraft, but less than that of
10 the medium-sized propeller aircraft. By way of example, the terms "small", "medium", and
11 "large" have been employed to describe diverse aircraft generalized in Figure 4. The AIP
12 component of the DATCM, however, may be indeterminate of aircraft size, purpose, and/or the
13 like. In this embodiment, the DATCM uses airfoil type to determine how, where, under what
14 conditions, and/or the like of icing occurrence. In some embodiments, the DATCM may
15 associate aircraft with their known airfoil types. In some embodiments, the DATCM may
16 maintain information exclusive to airfoils. In some embodiments, the AIP may use aircraft type
17 reciprocally with airfoil type.

18 **[0070]** In some embodiments of the disclosure, e.g., as depicted in Figure 5, the DATCM
19 501 may maintain a data repository 510 of aircraft PPI. In some embodiments, the data
20 repository may be organized by aircraft type. In some embodiments, the data repository may be
21 organized by airfoil type. In some embodiments, data tables of aircraft and airfoil types may be
22 linked by information keys, associating aircraft and airfoil types. In other embodiments, the
23 aircraft and/or airfoil parameters for use by the DATCM may be stored with respect to a PPI
24 module, such as that disclosed with respect to Figure 46 (e.g., PPI Component 4649; DATCM
25 data store 4619, Weather 4619h, Aircraft 4619i, Airfoil 4619j; and/or the like); Figures 18A-F
26 (e.g., an example PPI hardware module); and/or the like. The PPI component and/or data
27 repository may be internally searchable to the DATCM by a database query language and/or
28 platform. In some embodiments, the DATCM may allow external sources to query the data
29 repository. In this embodiment, aircraft types are independently input 502 to the PPI data
30 repository, which is maintained internally to the DATCM. Weather data and/or information
31 obtained from sources such as the Global Forecasting System (GFS) and Rapid Refresh (RAP)

1 may be made available to the DATCM through satellite transmission 570, weather station input
2 580, and/or the like. In some embodiments, the DATCM may reduce weather data to
3 determinate icing factors. In some embodiments, the DATCM may request specific numerical
4 weather input that is icing condition related. In some embodiments of the DATCM, weather
5 input is continuous and/or updated at systematic intervals. In the example of Figure 5, airline
6 operations 530 may request both predictive and (near) real-time icing data 508 from the
7 DATCM. In this example, the operational request contains the aircraft type(s) for which icing
8 conditions should be predicted. In some embodiments, the DATCM may contain user profile
9 information under which a user, having created a profile with the DATCM, may provide
10 identifying information other than aircraft type. In some embodiments, the DATCM may store
11 user information in a profile data repository 590 and access aircraft type(s) and/or other user
12 information based on identifying input data. The DATCM may then submit operational data,
13 such as airfoil type and location, localized and real-time weather data, such as temperature,
14 cloud liquid water, and median droplet size, and/or the like 504 to the PPI data repository 510
15 which may then return PPI(s) 505 needed for requested aircraft and/or conditions. The DATCM
16 may return 509 this output to the airline operations as requested. In one example, commercial
17 and/or private airline services 540 may request predictive and/or (near) real-time localized icing
18 information. In some embodiments, this request may contain aircraft type and other user
19 information. In some embodiments, this request may contain identifying information to access
20 user profile data stored in a DATCM profile data repository. The DATCM may submit the
21 relevant operational and weather data to the PPI data repository and receive PPI(s) as described,
22 returning output to the requestor 540. In some embodiments, in-house and/or third party flight
23 planning tools 550 may request 511 predictive icing conditions over a region for one or more
24 aircraft types. In some embodiments, the flight planning tools may have and/or share user
25 profile information of a profile data repository with the AIP in making this request. In some
26 embodiments, the DATCM may return a PPI grid overlay for the requested region 512. In some
27 embodiments, the DATCM may return a flight path over PPI grid overlay for the requested
28 region, according to flight path request parameters, as described in Figures 9-9A. In some
29 embodiments, the DATCM may return multiple paths and/or PPI grid overlays for the requested
30 regions. In another example, air traffic controllers 560 may request predictive localized icing
31 data 513 for its common regional aircraft from the DATCM. As in other examples, this request

1 may provide all necessary input data singly and/or with identifying information with which the
2 DATCM may access stored profile information from a profile data repository. The DATCM
3 may submit the necessary inputs and return a regional icing grid overlay 514 and/or PPI(s) for
4 all aircraft type which may have been named in the data request or which may be part of an
5 accessed profile. In some embodiments, the DATCM may use request data to maintain and/or
6 update a profile data repository to assist in future data requests from sources for which a profile
7 has been created. In some embodiments, the DATCM may use request data to create user
8 profile data for sources for which no profile data previously existed.

9 **[0071]** Figure 6 shows an alternate embodiment of DATCM data flow in which data
10 requests are received from like sources 630, 640, 650, 660, such as in Figure 5 and which
11 aircraft/airfoil type 602, aircraft specific icing 605, location/region, weather data such as
12 temperature, cloud liquid water, median droplet size 604, and/or the like is input to the
13 DATCM. In this embodiment, a PPI data repository 610 may store aircraft/airfoil type in the
14 manner(s) described in Figure 5, and may be used as an input source to the DATCM. In this
15 embodiment, data requests such as 606, 608, 611, and/or 613 are fulfilled through the DATCM,
16 with data requests providing either input singly and/or with identifying user information to
17 access profile data from a profile repository 690, as may be maintained by the DATCM as
18 described in Figure 5. In some embodiments of the disclosure, the data repositories storing PPI,
19 aircraft/airfoil type, and/or user profile information may be separate from, but accessible to, the
20 DATCM. As in Figure 5, the DATCM may provide similar outputs 607, 609, 612, 614 to
21 requesting parties. The DATCM may maintain/update its profile data repository with
22 information from processed requests.

23 **[0072]** In Figure 7, one embodiment of the DATCM's PPI calculation component is put
24 forth. In this embodiment, an icing request is initiated to the DATCM 701. The DATCM may
25 request the aircraft type(s) 702. In some embodiments, the DATCM may use provided
26 identifying user information as part of a user profile maintained by the DATCM to determine
27 aircraft type(s). In this embodiment, the DATCM maintains a PPI data repository, which may
28 be internal or external to the DATCM, of aircraft types and/or airfoil types which may be
29 maintained in separate tables or repository with information keys linking types. In all
30 subsequent aspects of the diagram, reference aircraft and/or airfoil may be singular or plural, i.e.
31 the DATCM may be considered to process multiple types in each request or the DATCM may

1 process a single type in a request. The DATCM may query the PPI data repository 703 to
2 determine if the aircraft type is already known to the system. If the aircraft type is not stored in
3 the PPI 704, the DATCM may assign an aircraft type 705 by creating a new or finding an
4 existing matching record in the PPI that conforms to the aircraft specifications. If the aircraft is
5 not associated with a known airfoil type 706, the DATCM may request that an airfoil type be
6 associated with the aircraft 707 and request an airfoil identification. If the airfoil type identified
7 is not in system 708, the DATCM may issue an insufficient data notice 709 and request the
8 parameters of the airfoil type 710. If the input parameters of the airfoil match a known airfoil
9 type, the input airfoil is recorded as the existing airfoil type 712. If the input parameters of the
10 airfoil do not match an existing type, the DATCM may create a new record in the PPI data
11 repository with the input airfoil parameters 713. If the aircraft type is known and/or the airfoil
12 type is known, and/or the DATCM has input new aircraft/airfoil types in the PPI, the DATCM
13 may request gridpoints and time to calculate icing data 714. The DATCM may execute a query
14 on its icing component for the requested points and time 715. The DATCM may then
15 determine, e.g., at 716, the PPI necessary for input aircraft under the defined conditions, as
16 predicted by the DATCM. The following non-discursive PPI calculation/determination
17 embodiment, presented substantially in the form of a Fortran code fragment, shows one
18 embodiment of a methodology for such processing:

```
19      C
20      C* Get grid file user input.
21      C
22          WRITE ( 6, 1002 )
23          READ ( 5, 999 ) gdfile
24          WRITE ( 6, 1003 )
25          READ ( 5, 999 ) gdout
26          WRITE ( 6, 1004 )
27          READ ( 5, 999 ) fhour
28          WRITE ( 6, 1005 )
29          READ ( 5, 999 ) acft
30      C
31      C* Fill aircraft performance loss table depending on aircraft type.
32      C
33          IF ( acft .eq. 'be20 ' ) THEN
34              DO m = 1,14
```

```
1          DO n = 1,10
2              apltbl (m,n) = be20(m,n)
3          END DO
4      END DO
5  ELSE
6      DO m = 1,14
7          DO n = 1,10
8              apltbl (m,n) = be20(m,n)
9          END DO
10         END DO
11     END IF
12     C
13     C* Get grid file user input.
14     C
15     WRITE ( 6, 1002 )
16     READ ( 5, 999 ) gdfile
17     WRITE ( 6, 1003 )
18     READ ( 5, 999 ) gdout
19     WRITE ( 6, 1004 )
20     READ ( 5, 999 ) fhour
21     WRITE ( 6, 1005 )
22
23     C
24     C* Find levels.
25     C
26     CALL DG_GLEV ( 1, time, ivcord, LLMXLV,
27         + iflev, nlev, iret )
28     DO j = 1, nlev
29         rlevel (j) = FLOAT ( iflev (1,j) )
30     END DO
31     CALL LV_SORT ( ivcord, nlev, rlevel, iret )
32     C
33     DO j = 1, nlev
34         CALL ST_INCH ( INT(rlevel(j)), glevel, iret )
35     C
36     C* Read icing parameter grids.
37     C
38     gvcord = 'HGHT'
39     gfunc = 'TMPC'
40     CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, t,
41         + igx, igy, time, level, ivcord, parm, iret )
42     gfunc = 'CWTR'
43     CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, cwtr,
44         + igx, igy, time, level, ivcord, parm, iret )
```

24

```
1      gfunc = 'MVD'
2      CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, mvd,
3          + igx, igy, time, level, ivcord, parm, irect )
4          maxpts = igx*igy
5
6      C
7      C* Compute aircraft performance loss.
8      C
9      DO i = 1, maxpts
10         IF ( t(i) .eq. RMISSD .or. cwtr(i) .eq. RMISSD ) THEN
11             apl(i) = RMISSD
12         ELSE IF ( (t(i) .ge. 0.0) .or. (t(i) .le. -40.0) .or.
13             + (cwtr(i) .le. 0.0) ) THEN
14             apl(i) = 0.0
15         ELSE
16             C
17             C* Bi-linearly interpolate aircraft icing values.
18             C
19             IF ( cwtr(i) .le. .001 ) THEN
20                 rcol = cwtr(i)/.0001
21                 icol = rcol
22                 c = rcol - FLOAT(icol)
23                 oc = 1. - c
24             ELSE IF ( cwtr(i) .le. .002 ) THEN
25                 rcol = 10. + (cwtr(i) - .001)/.00025
26                 icol = rcol
27                 c = rcol - FLOAT(icol)
28                 oc = 1.0 - c
29             ELSE
30                 icol = 14
31             END IF
32             IF ( t(i) .gt. -2.0 ) THEN
33                 r = -t(i)/2.0
34                 apl(i) = apltbl(1,icol)*r*oc + apltbl(1,icol+1)*r*c
35             ELSE IF ( t(i) .gt. -4.0 ) THEN
36                 irow = 1
37                 r = (-t(i) - 2.0)/2.0
38                 or = 1. - r
39                 IF ( icol .eq. 14 ) THEN
40                     apl(i) = apltbl(1,14)*or + apltbl(2,14)*r
```

25

```

1           ELSE
2             apl(i) = apltbl(irow,icol)*oc*or
3             + + apltbl(irow,icol+1)*c*or
4             + + apltbl(irow+1,icol)*oc*r
5             + + apltbl(irow+1,icol+1)*c*r
6           END IF
7         ELSE
8           rrow = (-t(i)/4.0) + 1.0
9           irow = rrow
10          r = rrow - FLOAT(irow)
11          or = 1.0 - r
12          IF ( icol .eq. 14 ) THEN
13            apl(i) = apltbl(irow,14)*or + apltbl(irow+1,14)*r
14          ELSE
15            apl(i) = apltbl(irow,icol)*oc*or
16            + + apltbl(irow,icol+1)*c*or
17            + + apltbl(irow+1,icol)*oc*r
18            + + apltbl(irow+1,icol+1)*c*r
19          END IF
20        END IF
21      END IF
22    END DO
23  C
24  C* Output PPI
25  C
26  ifl(1) = INT(rlevel(j))
27  ifl(2) = -1
28  parm = 'apl'
29  CALL DG_NWDT ( apl, time, ifl, ivcord, parm,ighdr,
30  + gpack, .true., iret )
31  IF ( iret .eq. 0 ) write (6,*) time(1), parm, ' at ',
32  + ifl(1), ' grid write successful'
33  END DO
34  CALL DG_NTIM ( .false., .false., time, nxttm, ier )

```

35 [0073]

36 [0074] Figure 8 shows an alternate embodiment of DATCM's PPI determination
37 component. In all subsequent aspects of the diagram, reference aircraft and/or airfoil may be

1 singular or plural, i.e. the DATCM may be considered process multiple types in each request or
2 the DATCM may process a single type in a request. As in Figure 7, the component processes
3 the initial request 801 and aircraft type 802 and queries a PPI data repository 803. In this
4 embodiment, if the requested aircraft type is not known to the DATCM, the DATCM may use
5 an airfoil based on the aircraft size in which the largest PPI may eventually be generated 805.
6 In this embodiment, the DATCM may assign this airfoil, e.g., at 806, to the aircraft for icing
7 calculation purposes. The PPI calculation proceeds through requesting gridpoints and time 807,
8 querying the AIP weather component 808, and determining the PPI for the given airfoil 809, as
9 shown in Figure 7. The requested PPI(s) are then output to the initiator of the request.

10 **[0075]** Figure 9 shows an example of how the DATCM may be incorporated into
11 existing and/or prospective flight planning tools, such as AviationSentry Online®. The
12 DATCM may be included with online services, with desktop services, with mobile applications,
13 and/or the like. In this embodiment of the disclosure, a flight planning tool has an interface 901
14 representative of an online flight planning service with user profile information. As an
15 interactive element 602, the DATCM may allow users to factor icing prediction into flight path
16 creation. The DATCM may allow users to consider several ways of incorporating icing
17 prediction into their flight path considering their flight requirements 903. In this example, the
18 DATCM may offer shortest path generation where icing may not be a considering factor in
19 flight path creation, icing circumvention where icing avoidance is a serious flight consideration,
20 some icing circumvention with emphasis on shortest path generation where icing avoidance
21 warrants some consideration, but may not be a primary goal and/or the like. The DATCM may
22 then generate a regional icing forecast within the specified flight path region 904 and suggest
23 flight path alterations with respect to the level of icing circumvention desired. In this
24 embodiment, the DATCM outputs a color-coded map overlay where black may represent no
25 necessary PPI, green may represent mild PPI, yellow may represent moderate necessary PPI,
26 and red may represent severe necessary PPI.

27 **[0076]** Figure 9A shows one example of an expanded logic flow diagram of flight path
28 considerations when the DATCM is part of an integrated flight planning tool. In one
29 embodiment of the disclosure, the flight planning service may access/input user profile
30 information 905 which may include such information as the type of aircraft and/or flight service
31 such as passenger 906, private 907 and/or commercial cargo/transport 908, the consideration of

1 which may influence icing avoidance (i.e. commercial cargo transport may prioritize shortest
2 path with minimal evasion while passenger may emphasize discursive icing circumvention over
3 speed or directness). The DATCM may request additional user profile information for flight
4 path construction 909. In some embodiments of the disclosure, such information may include
5 the origin grid point and departure time of the flight, the destination grid point, and/or the
6 maximum travel time the flight can utilize in constructing its path 911. In some embodiments
7 of the disclosure, the DATCM may infer user information from previously stored user profile
8 data and/or prior flight path generation 912. In some embodiments, this information may
9 include the aircraft type, its fuel requirements, its standard flying altitude, previous planned
10 flight paths, and/or the like 913. In some embodiments, user profile and flight creation
11 information that is both input and/or inferred by the DATCM may be used to update the user
12 profile data for future DATCM use 914. In some embodiments of the disclosure, the DATCM
13 may use other stored profile information where similar parameters resulted in successful flight
14 path creation. In some embodiments of the disclosure, the DATCM may use additional input,
15 such as those from sources external to the flight planning tool, such as historical flight plan data
16 and/or the like. The DATCM may then calculate the grid size of the region 915 over which the
17 DATCM may consider flight path creation, using input such as the origin, destination,
18 maximum flight time, and/or facilities of the aircraft and/or type of flight. In some
19 embodiments of the disclosure, two dimensional grid space may be considered for initial path
20 planning purposes. In some embodiments of the disclosure, three dimensional grid space may
21 be considered for path planning purposes. In some embodiments of the disclosure, two
22 dimensional grid space may be considered for initial path planning purposes, which may then be
23 integrated with additional dimensional information as necessary to accurately determine
24 available grid space inside which the flight path may still meet flight path parameters.

25 **[0077]** In some embodiments of the disclosure, this initial input component may then be
26 followed by DATCM PPI calculation 916 of the generated geospatial grid region, some
27 examples of which have been described in Figures 2, 3, 4 and 5. The DATCM may create a PPI
28 overlay to the generated grid region 918 and may request additional information about the
29 desired parameters of the flight path through this grid region 918. In some embodiments of the
30 disclosure, these parameters may include schedule-based path-finding (shortest path
31 immediacy), schedule-based but with circumvention of acute icing (shortest path avoiding high

1 hazard icing areas), discursive icing circumvention (navigating out of icing areas), and/or any
2 combination of or intermediate stage to these parameters 919. The DATCM may then use
3 available input as described in the input component to determine all flight path creation
4 parameters 920. The DATCM may then create a flight path over the PPI grid region 921,
5 considering flight path creation parameters 919. The DATCM may then provide the user the
6 proposed flight path as a terminal overlay, standard or high definition map overlay and/or the
7 like 922, as is applicable to the flight planning tool. If the flight path is satisfactory 923, the
8 user may then exit the flight path planning component of the DATCM as an incorporated flight
9 planning tool option. In some embodiments of the disclosure, the DATCM may allow the user
10 to export the determined flight path to other media, save the flight path to the user profile, share
11 the flight path with additional users, and/or the like. In some embodiments of the disclosure, if
12 the proposed flight path is not satisfactory 923, the DATCM may allow the user to modify flight
13 path creation parameters 924. In some embodiments of the disclosure, the user may re-enter a
14 flight path creation component as specified earlier. In some embodiments of the disclosure,
15 users may be allowed to visually manipulate flight path options using the proposed flight path
16 PPI grid overlay. In some embodiments of the disclosure, the user may be able to reenter flight
17 path creation, visually manipulate the proposed flight path and/or combine these methods in any
18 intermediate path modification.

19 **[0078]** Figure 10 shows an example four-hour Rapid Refresh data (RUC2 format)
20 numerical temperature forecast at 4572 m (FL150) over the Washington state region, which the
21 DATCM may use as an input for PPI calculation.

22 **[0079]** Figure 11 shows one example of cloud liquid water forecast 801 at FL150, as
23 computed by the DATCM using the data of Figure 10.

24 **[0080]** Figure 12 shows one example of a median droplet diameter forecast 901 at
25 FL150, as computed by the DATCM using the data of Figure 10.

26 **[0081]** Figure 13 shows one example of a color-coded PPI map grid overlay 1301 as
27 calculated and generated by the DATCM for the Beechcraft Super King 200 aircraft, if it were
28 to fly in the icing conditions described in Figures 10-12. In this example, PPI is the percent
29 power increase necessary to overcome performance loss after five minutes exposure to the

1 shown icing conditions, where black indicates less than 1% PPI, green indicates less than 10%
2 PPI, yellow indicates less than 60% PPI, and red indicates greater than 60% PPI.

3 **[0082]** Figure 14 shows one example of a color-coded PPI map grid overlay 1401 as
4 calculated and generated by the DATCM for a larger aircraft than was shown in Figure 13, if it
5 were to fly in the icing conditions described in Figures 10-12. In this example, PPI is the
6 percent power increase necessary to overcome performance loss after five minutes exposure to
7 the shown icing conditions, where black indicates less than 1% PPI, green indicates less than
8 10% PPI, yellow indicates less than 60% PPI, and red indicates greater than 60% PPI.

9 **[0083]** In some embodiments, the DATCM server may issue PHP/SQL commands to
10 query a database table (such as FIGURE 46, Profile 4619c) for profile data. An example profile
11 data query, substantially in the form of PHP/SQL commands, is provided below:

```
12 <?PHP
13 header('Content-Type: text/plain');
14
15 // access database server
16 mysql_connect("254.93.179.112", $DBserver, $password);
17
18 // select database table to search
19 mysql_select_db("DATCM_DB.SQL");
20
21 //create query
22 $query = "SELECT field1 field2 field3 FROM ProfileTable WHERE user LIKE
23     '% ' $prof";
24
25 // perform the search query
26 $result = mysql_query($query);
27
28 // close database access
29 mysql_close("DATCM_DB.SQL");
30 ?>
```

31 **[0084]**

32 **[0085]** The DATCM server may store the profile data in a DATCM database. For
33 example, the DATCM server may issue PHP/SQL commands to store the data to a database

1 table (such as FIGURE 46, Profile 4619c). An example profile data store command,
2 substantially in the form of PHP/SQL commands, is provided below:

```
3 <?PHP
4 header('Content-Type: text/plain');
5
6 // access database server
7 mysql_connect("254.92.185.103", $DBserver, $password);
8
9 // select database to append
10 mysql_select("DATCM_DB.SQL");
11
12 // add data to table in database
13 mysql_query("INSERT INTO ProfileTable
14             (fieldname1, fieldname2, fieldname3)
15             VALUES ($fieldvar1, $fieldvar2, $fieldvar3)");
16
17 // close connection to database
18 mysql_close("DATCM_DB.SQL");
19 ?>
20
```

21 **[0086]** Various embodiments of the DATCM may be used to provide real-time, pre-flight
22 and/or in-flight icing reporting, planning and response. The integrated, unified icing system
23 provided by the DATCM may be used in flight equipment and/or ground equipment. The
24 DATCM may provide weather/aviation decision support (e.g., via graphical displays) and/or
25 provide alerts/triggers. Although it is discussed in terms of re-routing in time of increased icing,
26 in some embodiments, the DATCM may identify more efficient paths based on real-time
27 updates where there is decreased icing over a shorter physical distance, and may update a flight
28 plan accordingly. The DATCM identifies 4D areas for flight hazards, and a user may choose or
29 set their profile based on particular hazards (e.g., a passenger airline would have a different
30 hazard/icing profile than an air freight company, and a large airliner would have a different
31 profile from a small plane or helicopter). Various cost calculations and risk calculations may
32 also be used in determining alerts and/or flight paths. In some embodiments, real-time feedback
33 may come from plane-mounted instrument sensors and provide updates to predicted icing. Such
34 information may be used to refine mechanisms for icing determination. Although examples

1 were discussed in the context of jet airliners, it is to be understood that the DATCM may be
2 utilized for low-level services, such as helicopters, unmanned aerial vehicles, as well as high
3 speed and/or military aircraft, and may even have potential ground applications, especially in
4 mountainous terrain. The DATCM may work with air traffic control, particularly in
5 management of routing. In some embodiments, the DATCM may receive input from and render
6 output directly to avionics systems to guide planes.

7 **[0087]** Many pilots view aircraft icing as one of the most dangerous in-flight hazards.
8 Prior to the DATCM, icing forecasts have been one-size-fits-all. Different aircraft accumulate
9 ice differently even in the same meteorological environment, and thus a generic icing forecast
10 may not be useful to a pilot. The DATCM addresses this situation by providing a universal and
11 objective quantitative metric for aircraft performance loss and applying it to ice accumulation
12 for specific airfoils. In some embodiments, an icing component, module or program, such as
13 NASA LEWICE, may be used to generate the accumulations and a computational fluid
14 dynamics (CFD) component, module or program to analyze the resulting performance losses,
15 and the DATCM generates aircraft-specific icing forecasts.

16 **[0088]** In some embodiments, ice accumulation on aircraft surfaces may depend on many
17 aerodynamic (e.g., body shape, body size, angle attack, exposure time, and flight speed) and
18 meteorological variables (e.g., air temperature, liquid water content (LWC), and median volume
19 droplet (MVD) size). In some embodiments, the DATCM, utilizing one or more various
20 thermodynamic analysis (TdA) components, modules, and/or programs (e.g., LEWICE 3.2.2
21 software) may evaluate the thermodynamics of supercooled droplets as they impinge on a body
22 given aerodynamic, flight, and atmospheric inputs and compute the resulting ice shape(s).
23 Using computation fluid dynamics (CFD) component(s), the DATCM may analyze
24 aerodynamic performance changes. In some embodiments, a CFD component may solve
25 equations of motion for the resulting airflow. In some embodiments, the Percent Power
26 Increase (PPI) metric may be determined and/or computed from CFD results, providing an
27 elegant way to quantify the post-icing performance change. For additional detail, see McCann,
28 D.W. and P.R. Kennedy, 2000: Percent power increase. Proc. 9th Conf. on Aviation, Range, and
29 Aerospace Meteorology, Amer. Meteor. Soc., Boston MA, 266-269, the entirety of which is
30 hereby incorporated by reference.

1 [0089] For example, in some implementations, lift and drag are functions of the aircraft's
2 speed (V)

3 [0090]
$$Lift = C_L A \frac{\rho V^2}{2}$$

4 [0091]
$$Drag = C_D A \frac{\rho V^2}{2}$$

5 [0092] where ρ is the air density, A is the aircraft component's cross sectional area, and
6 C_L and C_D are coefficients of lift and drag respectively. In this example, in order to maintain
7 speed and altitude, the new thrust (power) is

8 [0093]
$$Thrust_{iced} = Thrust_{clean} \frac{C_{L:clean}}{C_{L:iced}} \frac{C_{D:iced}}{C_{D:clean}}$$

9 [0094] where the subscripts *clean* and *iced* indicate conditions before and after ice
10 accumulation. Thus

11 [0095]
$$PPI \times .01 = \frac{Thrust_{iced}}{Thrust_{clean}} - 1 = \frac{C_{L:clean}}{C_{L:iced}} \frac{C_{D:iced}}{C_{D:clean}} - 1$$

12 [0096] In some implementations of the DATCM, this elegant relationship may be utilized
13 to determine performance loss with ice accumulation on any airfoil. For example, Figures 15
14 and 16 show ice accumulation and resulting PPI values on a Beechcraft King Air airfoil and a
15 Boeing 737 airfoil, respectively. Figure 15 shows ice (red) accumulation, e.g., 1501, on a
16 Beechcraft King Air airfoil using the inputs, e.g., 1502, in the figure. The resulting performance
17 change is also shown, e.g., 1503. Figure 16 shows ice (red) accumulation, e.g., 1601, on a
18 Boeing 737 airfoil using the inputs, e.g., 1602, in the figure. The resulting performance change
19 is also shown, e.g., 1603.

20 [0097] In some embodiments of the DATCM, aircraft-specific icing forecasting may be a
21 two element process. The DATCM creates numerous ice accumulation simulations modifying
22 the meteorological variables for each aerodynamic configuration. The combinations of air
23 temperature, LWC, and MVD are may be limited by choosing representative values for each
24 variable. For example, supercooled liquid water exists only in a finite range of air temperatures
25 (0C to -40C). With temperatures less than about -20C ice shapes are similar because

1 supercooled drops freeze quickly. Similarly, cloud liquid water amounts rarely exceed 2 g m^{-3} .
2 While most icing occurs with small droplet sizes, supercooled large drops pose a significant
3 icing threat, so the DATCM may test ice shapes over a fairly large droplet size range. Properly
4 implemented parameters provide significant ranges of variables to analyze. The DATCM may
5 select/recvie representative values to ensure sufficient granularity yet limit the time necessary
6 to create a PPI profile or determine a PPI value given a particular input set. A TdA component
7 may create an ice shape for the chosen meteorological and aerodynamic configuration. In some
8 implementations, a CFD component may analyze the resulting ice shape for the airfoil's
9 performance. Various implementations may do hundreds or thousands of iterations to converge
10 on a suitable solution. The DATCM may be configured to create PPI profiles for as many
11 aircraft as desired, or even for every available aircraft. Initially, PPI profiles may be generated
12 for popular aircraft, both in terms of ownership and in terms of airfoil shapes and sizes used by
13 manufacturers.

14 **[0098]** In some embodiments, aircraft-specific icing forecasts can be implemented with
15 any forecast of air temperature, LWC, and MVD. Forecast air temperature may be determined
16 or computed by numerical weather forecast (NWF) components or mechanisms. For example, a
17 VVICE module may be utilized that post-processes any numerical mechanism for the LWC and
18 MVD. The VVICE module parameterizes vertical motions then uses straight-forward cloud
19 physics relationships to create the cloud parameters (additional detail may be found in McCann,
20 D.W., 2006: Parameterizing convective vertical motions for aircraft icing forecasts. Proc.12th
21 Conf. on Aviation, Range, and Aerospace Meteorology, Amer. Meteor. Soc., Boston MA., the
22 entirety of which is hereby incorporated by reference).

23 **[0099]** In some embodiments, to produce an aircraft-specific forecast, the DATCM
24 makes a three-dimensional lookup table for every aircraft type for which a PPI profile was
25 created. A user may specify an aircraft type, and the DATCM interpolates the appropriate PPI
26 profile table at every grid point, horizontally, vertically, and in time. If the selected aircraft type
27 is not in the DATCM database, the DATCM may be configured with relatively more flexible
28 tables based on aircraft size. Thus, the DATCM can create horizontal maps at the user's
29 requested altitude, cross sections along the user's requested flight path, and/or other useful
30 displays.

1 [00100] By providing aircraft-specific icing forecasts, the DATCM may remove much of
2 the ambiguity inherent in previous one-size-fits-all icing forecasts. In particular, there may be a
3 unique situation in which a particular aircraft may be more vulnerable to icing than a traditional
4 forecast indicates. By providing icing hazards in quantitative terms, the DATCM forecasts give
5 more detail than previously available and pilots may utilize to the Percent Power Increase
6 metric directly since increasing power is one of the ways a pilot can combat the effects of icing.

7 [00101] Moreover, by being aircraft-specific, the DATCM forecasts may create goodwill
8 with users. Knowing the icing forecasts are tailored to their aircraft type, users can better utilize
9 and rely on forecasts as meaningful to them. This also creates less doubt about how to interpret
10 the forecasts.

11 [00102] Figure 17 illustrates an example PPI component installation. In one embodiment,
12 an aircraft 1701 may have installed a DATCM containing a PPI component 1702 for the
13 determination of an instantaneous percent-power-increase value for a given input set. The PPI
14 component may be configured, as in the current example, as an integrated hardware component
15 containing one or more hardware logic circuits for determining a PPI value. In alternative
16 embodiments, portions (or, in some cases, substantially all) of the PPI value determination may
17 be performed by the DATCM utilizing software commands substituted for one or more of the
18 PPI component integrated hardware logic circuits. An example PPI component and
19 configuration is disclosed herein and particularly with respect to Figure 7, Figure 8 and Figures
20 18A-F.

21 [00103] In one configuration, airplane 1701 may provide an electrical signal to
22 `airfoilDesign_IN` terminal 1703 representing the aircraft or airfoil design on which the
23 PPI value determination is to be made. For example, if the current aircraft in which the PPI
24 component is installed is a Boeing 737, the aircraft flight control software may signal a value of
25 "101" on `airfoilDesign_IN`, that value representing the current aircraft type. The value
26 "101" may be expressed as three electrical voltages ("high-low-high") across three
27 `airfoilDesign_IN` hardware input pins. By utilizing three input pins, the
28 `airfoilDesign_IN` input may be used to represent at least 7 different aircraft
29 configurations (e.g., "000", "001", "010", "100", "110", "101", "111"). By way of further
30 examples, in one embodiment "110" may represent a Beechcraft Super King 200 aircraft, "111"

1 may represent a default medium-body airframe, etc. In alternative embodiments, additional
2 hardware input pins or other serial communication input may be utilized to allow the PPI
3 component to determine instantaneous PPI values for a limitless number of aircraft and/or
4 airfoil designs.

5 **[00104]** In one embodiment, aircraft 1701 may provide the PPI component 1702 with
6 input, using `currentCWTR_IN` terminal 1704, representing the current atmospheric water
7 droplet density. The value provided may be electrical signals representing an integer value. For
8 example, if the aircraft water density sensor determines that the current water density about the
9 aircraft is .002, the aircraft may signal the integer value of “2” (representing $.002 * 1000$) to
10 `currentCWTR_IN`. In one embodiment, the value “2” may be represented as a 16-bit value
11 (e.g., “0000 0000 0000 0010”) signaled as 16 high-or-low voltages across an equivalent number
12 of hardware input pins. Additionally, airplane 1701 may similarly signal a current ambient
13 temperature value for the temperature about the plane to PPI input
14 `currentTemperature_IN` terminal 1705.

15 **[00105]** As disclosed herein, the PPI component configuration discussed with respect to
16 Figure 17 may be utilized to determine an instantaneous PPI value for a current airframe and
17 ambient condition inputs. However, other PPI component configurations may be utilized in
18 association with the other embodiments of the DATCM discussed herein. For example, if the
19 PPI component is configured to provide a PPI value for a point in space an aircraft will
20 encounter after 10-minutes of further flight time (e.g., a future point/time), then the values
21 provided to `currentCWTR_IN` and `currentTemperature_IN` may be estimated values
22 for that time/location. In further embodiments, the discrete PPI value determinations by the PPI
23 component may be utilized to perform an optimized flight-path determination. For example, the
24 PPI component may be repeatedly utilized to determine PPI values for all points in a 3-D space.
25 In an alternate embodiment, the PPI component may have multiple input/output terminals
26 and/or accept an array of inputs and provide an array of outputs on one or more input/output
27 terminals. As such, the PPI component embodiment described herein may be utilized with the
28 other components of the DATCM to perform any or all of the embodiments of the DATCM
29 described herein.

1 [00106] Additionally, it should be noted that the signal inputs/outputs disclosed herein are
2 representative of example PPI component inputs/outputs. For example, a PPI input for aircraft
3 type may be represented as a single aircraft designator, an airfoil designator, an aircraft airfoil
4 configuration (e.g., a representation of airfoil geometry such as, for example, a height and angle
5 of curvature), a default designator (e.g., “medium aircraft”), and/or the like. Further, the
6 percent-power-increase output value determination may be made by the PPI component on the
7 basis of inputs other than those illustrated herein without departing from the disclosure. For
8 example, the PPI component may utilize the instantaneous or expected aircraft altitude in lieu of
9 temperature, may utilize a cloud density forecast in lieu of water droplet density, and/or the like.

10 [00107] Figure 18A shows an example PPI hardware component. In one embodiment, an
11 aircraft flight planning system and/or the like may provide electrical inputs to the PPI
12 component. Thereafter, the one or more electrical inputs may be processed by the logic circuits
13 (for example, integrated ASIC’s, FPGA’s, and/or the like) to produce a percent-power-increase
14 value representing the PPI for the given aircraft and input parameters. In one embodiment, the
15 flight planning system may provide an atmospheric water droplet density value
16 `currentCWTR_IN 1801a`, an airfoil or aircraft design or state value `airfoilDesign_IN`
17 `1801b`, a temperature value `currentTemperature_IN 1801c`, and/or the like and receive as
18 output electrical signals representing a determined PPI value, e.g., `ppi_OUT 1801g`.

19 [00108] In one embodiment, the atmospheric water droplet density is provided to a
20 `ppi_ivertical` PPI sub-component 1801d, which is described herein with respect to Figure
21 18C and the temperature value is provided to a `ppi_ihorizontal` PPI sub-component
22 1801e, which is described herein with respect to Figure 18B. In one embodiment, the output
23 from both the `ppi_ivertical` and `ppi_ihorizontal` PPI sub-components as well as
24 one or more of the original input signals are provided to a `ppi_apl` PPI sub-component 1801f,
25 which is described herein with respect to Figure 18D. In one embodiment, the `ppi_apl` PPI
26 sub-component may provide a calculated PPI value to the PPI component, which may be output
27 on `ppi_OUT` terminal 1801g.

28 [00109] In one embodiment, a PPI hardware component, represented substantially in the
29 form of VHDL hardware description statements suitable for configuring an FPGA to operate as
30 an integrated hardware logic circuit performing the features described herein, is:

```
1  library IEEE;
2  use IEEE.STD_LOGIC_1164.ALL;
3  use IEEE.NUMERIC_STD.ALL;
4
5  entity PPI_Component is
6      Port ( airfoilDesign_IN : in STD_LOGIC_VECTOR(2 downto 0);
7            currentCWTR_IN : in STD_LOGIC_VECTOR(15 downto 0);
8            currentTemperature_IN : in STD_LOGIC_VECTOR(15 downto 0);
9            ppi_OUT : out STD_LOGIC_VECTOR(15 downto 0)
10           );
11 end PPI_Component;
12
13 architecture PPI of PPI_Component is
14
15     --sub-component to determine vertical (icol) offset
16     --assumes cwtr values are multiplied by 1,000 (so .001 is input as "1")
17     component ppi_ivertical is
18         port(cwtr : in signed;
19              invert : inout integer;
20              c : inout signed;
21              oc : inout signed
22             );
23     end component;
24     signal invert : integer;
25     signal c, oc : signed(15 downto 0);
26
27     --sub-component to determine horizontal (irow) offset
28     --assumes temp is inverse of value input
29     --(so -32deg is input as "32")
30     component ppi_ihorizontal is
31         port(temperature : in signed;
32              ihoriz : inout integer;
33              r : inout signed;
34              orv : inout signed
35             );
```

38

```
1  end component;
2  signal ihoriz : integer;
3  signal r, orv : signed(15 downto 0);
4
5  --sub-component to determine customized airframe PPI
6  component ppi_apl is
7      port(  temperature : in signed;
8            airfoilDesign : in signed;
9            ihoriz : integer;
10           iverit : integer;
11           c : in signed;
12           oc : in signed;
13           r : in signed;
14           orv : in signed;
15           aplv : inout signed
16           );
17  end component;
18  signal aplv : signed(15 downto 0);
19
20
21  begin
22
23      --sub-components
24      CPNT_ppi_iveritcal : ppi_iveritcal port
25          map (signed(currentCWTR_IN), iverit, c, oc);
26      CPNT_ppi_ihorizontal : ppi_ihorizontal port
27          map (signed(currentTemperature_IN), ihoriz, r, orv);
28      CPNT_ppi_apl : ppi_apl port
29          map (signed(currentTemperature_IN),
30             signed(airfoilDesign_IN), ihoriz, iverit, c, oc, r, orv, aplv);
31
32      --output PPI
33      process(airfoilDesign_IN)
34      begin
35          ppi_OUT <= std_logic_vector(aplv);
```

```
1     end process;  
2  
3     end PPI;  
4
```

5 **[00110]** Figure 18B represents a `ppi_ihorizontal` PPI sub-component. The sub-
6 component takes input temperature 1802b and outputs a horizontal offset value for PPI
7 determination, e.g., 1802a and one or more coefficient values for use by the `ppi_apl` PPI sub-
8 component, e.g., 1802c, 1802d. Within the `ppi_ihorizontal` sub-component, the input
9 value signal crosses a plurality of logic gates as represented herein and described below. In one
10 embodiment, a `ppi_ihorizontal` PPI sub-component, represented substantially in the form
11 of VHDL hardware description statements suitable for configuring an FPGA to operate as an
12 integrated hardware logic circuit performing the features described herein, is:

```
13     library IEEE;  
14     use IEEE.STD_LOGIC_1164.ALL;  
15     use IEEE.NUMERIC_STD.ALL;  
16  
17     entity ppi_ihorizontal is  
18         Port ( temperature : in signed;  
19             ihoriz : inout integer;  
20             r : inout signed;  
21             orv : inout signed  
22             );  
23     end ppi_ihorizontal;  
24  
25     architecture Behavioral of ppi_ihorizontal is  
26  
27     begin  
28         process(temperature)  
29         begin  
30             if (temperature > to_signed(2,16)) then  
31                 ihoriz <= 1;  
32                 r <= resize(temperature / to_signed(2,16),16);  
33             else
```

```

1      if (temperature > to_signed(4,16)) then
2          ihoriz <= 1;
3          r <= resize((temperature -
4              to_signed(2,16)) / to_signed(2,16),16);
5          orv <= to_signed(1,16) - r;
6      else
7          ihoriz <= to_integer((signed(temperature) / to_signed(4,16)));
8          r <= to_signed(0,16);
9          orv <= to_signed(1,16);
10         end if;
11     end if;
12 end process;
13 end Behavioral;

```

15 **[00111]** Figure 18C represents a `ppi_ivertical` PPI sub-component. The sub-
16 component takes input atmospheric water droplet density 1803a and outputs a vertical offset
17 value for PPI determination, e.g., 1803d and one or more coefficient values for use by the
18 `ppi_apl` PPI sub-component, e.g., 1803b, 1803c. Within the `ppi_ivertical` sub-
19 component, the input value signal crosses a plurality of logic gates as represented herein and
20 described below. In one embodiment, a `ppi_ivertical` PPI sub-component, represented
21 substantially in the form of VHDL hardware description statements suitable for configuring an
22 FPGA to operate as an integrated hardware logic circuit performing the features described
23 herein, is:

```

24 library IEEE;
25 use IEEE.STD_LOGIC_1164.ALL;
26 use IEEE.NUMERIC_STD.ALL;
27
28 entity ppi_ivertical is
29     Port ( cwtr : in signed;
30           invert : inout integer;
31           c : inout signed;
32           oc : inout signed
33           );

```

```
1  end ppi_ivertical;
2
3  architecture Behavioral of ppi_ivertical is
4
5  signal rcol : signed(15 downto 0);
6
7  begin
8    process(cwtr)
9    begin
10     if (cwtr <= to_signed(1,16)) then
11       rcol <= resize(cwtr * to_signed(10,16),16);
12       ivert <= to_integer(rcol);
13       c <= rcol - ivert;
14       oc <= to_signed(1,16) - c;
15     else
16       if (cwtr <= to_signed(2,16)) then
17         rcol <= resize(to_signed(10,16) +
18           ((cwtr - to_signed(1,16)) * to_signed(4,16)),16);
19         ivert <= to_integer(rcol);
20       else
21         ivert <= 14;
22       end if;
23     end if;
24   end process;
25 end Behavioral;
26
```

27 **[00112]** Figure 18D represents a ppi_apl PPI sub-component. The sub-component
28 takes inputs airfoil design, temperature, and the output from ppi_ihorizontal and
29 ppi_ivertical, e.g., 1804a, and provides output representing an instantaneous PPI value,
30 e.g., 1804e. Within the ppi_apl sub-component, the input value signal crosses a plurality of
31 logic gates as represented herein and described below and which may route the inputs to one or
32 more of a plurality of airframe specific customization modules, e.g., airFrame_boeing747
33 1804b, airFrame_defaultMed 1804c, airframe_bCKingAir 1804d. An example

1 airframe specific customization module is described herein with respect to Figures 18E-F.
2 Although three airframe customization modules have been illustrated herein, other embodiments
3 may contain only one airframe customization module (e.g., in the case of a “hard” installation
4 that will only be used with respect to one airframe). Furthermore, in other embodiments the
5 airframe customization modules may be provided as a “snap in” module that may be connected
6 to the PPI component after manufacture. In still other embodiments, the airframe customization
7 module’s capabilities may be performed by a local data/logic store (such as, for example, that
8 disclosed with respect to Figure 46) , a remote data/logic store (for example, by transmitting an
9 in-flight wireless signal to a remote airframe customization module configured to respond to
10 remote queries), or via a specially configured general purpose computing platform (such as, for
11 example, that disclosed herein and particularly with respect to Figure 4 and Figure 5, which
12 describe alternate PPI component configurations). In one embodiment, a `ppi_apl` PPI sub-
13 component, represented substantially in the form of VHDL hardware description statements
14 suitable for configuring an FPGA to operate as an integrated hardware logic circuit performing
15 the features described herein, is:

```
16 library IEEE;  
17 use IEEE.STD_LOGIC_1164.ALL;  
18 use IEEE.NUMERIC_STD.ALL;  
19  
20 entity ppi_apl is  
21     Port ( temperature : in signed;  
22           airfoilDesign : in signed;  
23           ihoriz : in integer;  
24           invert : in integer;  
25           c : in signed;  
26           oc : in signed;  
27           r : in signed;  
28           orv : in signed;  
29           aplv : inout signed  
30           );  
31 end ppi_apl;  
32  
33 architecture Behavioral of ppi_apl is
```

```
1
2 component airFrame_bCKingAir is
3     port(  temperature : in signed;
4           ihoriz      : in integer;
5           invert      : in integer;
6           airFrame_val : inout signed
7     );
8 end component;
9 signal airFrame_bCKingAir_val : signed(15 downto 0);
10
11 component airFrame_boeing747 is
12     port(  temperature : in signed;
13           ihoriz      : in integer;
14           invert      : in integer;
15           airFrame_val : inout signed
16     );
17 end component;
18 signal airFrame_boeing747_val : signed(15 downto 0);
19
20 component airFrame_defaultMed is
21     port(  temperature : in signed;
22           ihoriz      : in integer;
23           invert      : in integer;
24           airFrame_val : inout signed
25     );
26 end component;
27 signal airFrame_defaultMed_val : signed(15 downto 0);
28
29 begin
30     --airframe customization modules
31     CPNT_airFrame_bCKingAir : airFrame_bCKingAir port
32         map (temperature,ihoriz,invert,airFrame_bCKingAir_val);
33     CPNT_airFrame_boeing747 : airFrame_boeing747 port
34         map (temperature,ihoriz,invert,airFrame_boeing747_val);
35     CPNT_airFrame_defaultMed : airFrame_defaultMed port
```

```
1      map (temperature,ihoriz,ivert,airFrame_defaultMed_val);
2
3      process(ihoriz, ivert, c, oc, r, orv)
4      begin
5          if (airfoilDesign = 1) then
6              aplv <= resize(airFrame_bCKingAir_val * r,16);
7          else
8              if (airfoilDesign = 2) then
9                  aplv <= resize(airFrame_boeing747_val * orv,16);
10             else
11                 aplv <= resize(airFrame_defaultMed_val,16);
12             end if;
13         end if;
14     end process;
15 end Behavioral;
16
```

17 **[00113]** Figure 18E represents a PPI sub-component aircraft customization module. The
18 aircraft customization module takes as input horizontal/vertical offset values, e.g., 1805a,
19 1805b, and temperature 1805c and outputs an airframe customization value 1805e for use in
20 determining airframe specific PPI. Within the sub-component, the input value signal crosses a
21 plurality of logic gates as represented herein and described below. Furthermore, the aircraft
22 customization module may contain non-volatile memory such as ROMs 1805d for storing
23 airframe specific customization parameters. The aircraft customization module represented
24 herein is for a Beechcraft Super King 200 aircraft. However, similarly configured
25 customization modules may be used for other aircraft or airframes. In one embodiment, a PPI
26 sub-component aircraft customization module, represented substantially in the form of VHDL
27 hardware description statements suitable for configuring an FPGA to operate as an integrated
28 hardware logic circuit performing the features described herein, is:

```
29 library IEEE;
30 use IEEE.STD_LOGIC_1164.ALL;
31 use IEEE.NUMERIC_STD.ALL;
32
33 entity airFrame_bCKingAir is
```

45

```
1      Port ( temperature : in signed;
2            ihoriz : in integer;
3            ivert : in integer;
4            airFrame_val : inout signed
5            );
6  end airFrame_bCKingAir;
7
8  architecture Behavioral of airFrame_bCKingAir is
9
10 --airfoil customization params
11 type airfoilDesignParams is array (1 to 10, 1 to 7) of integer;
12 shared variable airfoil_p1: airfoilDesignParams :=(
13     (0,0,0,0,0,0,0),
14     (62,110,160,164,172,176,184),
15     (31,62,157,228,369,440,448),
16     (21,42,83,117,289,376,548),
17     (16,31,62,78,156,250,438),
18     (12,25,50,62,88,100,297),
19     (10,21,42,52,73,83,141),
20     (8,18,36,45,62,71,89),
21     (8,16,31,39,55,62,78),
22     (7,14,28,35,49,56,69)
23 );
24 shared variable airfoil_p2: airfoilDesignParams :=(
25     (0,0,0,0,0,0,0),
26     (188,196,200,208,212,220,224),
27     (452,460,464,472,476,484,488),
28     (634,724,728,736,740,748,752),
29     (531,719,812,1000,1004,1012,1016),
30     (395,592,690,887,985,1182,1280),
31     (242,445,546,749,851,1053,1154),
32     (98,286,390,597,701,908,1011),
33     (86,121,226,437,542,752,850),
34     (76,90,97,270,377,590,696)
35 );
```

```
1
2  signal INT_ihoriz, INT_ivert : integer :=0;
3
4  begin
5      process(ihoriz, ivert)
6          begin
7
8              --determine horiz and vert offset values
9              if (temperature > to_signed(2,16)) then
10                 INT_ihoriz <= ihoriz;
11                 INT_ivert <= ivert + 1;
12             else
13                 INT_ihoriz <= ihoriz + 1;
14                 INT_ivert <= ivert;
15             end if;
16
17             --return correct offset value
18             if (INT_ivert <= 7) then
19                 airFrame_val <= to_signed(airfoil_p1(INT_ihoriz,INT_ivert),16);
20             else
21                 airFrame_val <= to_signed(airfoil_p2(INT_ihoriz,INT_ivert-7),16);
22             end if;
23
24         end process;
25     end Behavioral;
26
```

27 **[00114]** Figure 18F is an alternate representation of the Beechcraft Super King 200
28 airframe customization module described with respect to Figure 18E. However, in this
29 representation each of the internal input wires carrying component signals representing the input
30 values have been broken out to further the reader's understanding. For example, the input for
31 temperature has been represented herein as 16 wires each capable of providing a single "1" or
32 "0" (e.g., high/low voltage) input. The aircraft customization module takes as input
33 horizontal/vertical offset values, e.g., 1806a, 1806b, and temperature 1806c, utilizes the
34 described logic gates and ROMs 1806d, and outputs an airframe customization value 1806e for

1 use in determining airframe specific PPI, as further described herein and particularly above with
2 respect to Figure 18E.

3 **[00115]** Figure 19A provides an example logic flow for aspects of a real-time flight
4 alerting and planning component for one embodiment of the DATCM. As discussed in greater
5 detail below, the DATCM may provide a variety of flight planning and/or flight following tools.
6 Additionally or alternatively, the DATCM may provide flight plan adjustments/modifications
7 and/or alerts if weather/turbulence determinations change, for example, if an airplane were on a
8 particular course that, based on real-time turbulence determinations, had become potentially
9 dangerous. The DATCM can also provide enhanced granularity for all flight-level altitudes in
10 order to identify the optimal path for avoiding hazards, and/or choosing the least dangerous
11 hazard to encounter.

12 **[00116]** As shown in Figure 19A, the DATCM alerting component receives (and/or
13 retrieves via response to a database query) current aircraft position 1902 (e.g., flight profile data
14 1900 from a flight profile database), and may also receive the previously predicted turbulence
15 for that route (or for an anticipated route if the actual flight plan is not provided). The DATCM
16 then determines real-time turbulence for the planned route 1904 and compares the predicted
17 turbulence to the real-time turbulence 1906. If the newly determined real-time turbulence does
18 not deviate notably 1908 from the previously predicted/anticipated turbulence, then the process
19 cycles, e.g., for a certain period (1 min, 2 min, 5 min, 10 min, etc.) or for some other measure
20 such as location of one or more aircraft, weather events, and/or the like. If the newly determined
21 real-time turbulence is a notable deviation or significant difference from the previously
22 predicted turbulence 1908, then the turbulence is updated 1910 and the process continues. Note
23 that the threshold difference or deviation may be set by the DATCM or DATCM
24 user/subscriber, and in some embodiments may be any numerical change, while in other
25 embodiments may be a change or certain magnitude or percentage.

26 **[00117]** When the turbulence is updated, the DATCM determines if there is a known or
27 determinable turbulence threshold 1912 for the flight/aircraft. For example, a commercial
28 passenger aircraft that subscribes to the DATCM may have set a particular turbulence threshold
29 in the profile, reflecting that passenger aircraft may wish to avoid significant turbulence for
30 safety and comfort reasons, while a cargo aircraft may have a much higher threshold and be

1 willing to undertake more turbulence to save time and/or money. The threshold may also be
2 predicted/determined based on the airframe and/or airfoil type, the user, the flight plan, fuel
3 resources, alternative routes, etc. For flights/aircraft that the turbulence threshold either is not
4 known or is not determinable 1912, the DATCM may have a default (i.e., safety) threshold
5 1914, and if that default threshold is exceeded 1914, may issue an alert or notification 1920 to
6 the aircraft (and/or ground control).

7 **[00118]** If the flight turbulence threshold is known 1912 (i.e., the flight has a subscription
8 or is otherwise registered with the DATCM), the DATCM determines whether the turbulence
9 exceeds the specified threshold 1916, and if so, determines if the flight's route can be adjusted
10 or updated 1918 by the DATCM (e.g., using the flight path component discussed in greater
11 detail later with regard to Figure 20 and Figure 21) to find the optimal path based on the desired
12 turbulence profile/threshold and various flight parameters, such as fuel reserves, destination,
13 aircraft type, etc. If the DATCM is unable or not configured to provide an alternative or
14 adjusted flight plan 1918, an alert or notification 1920 is generated/issued. If the DATCM can
15 adjust or update the flight's route 1918, the adjusted/modified route is determined 1922 and the
16 flight plan is adjusted accordingly 1924, and updated 1900. Note that, in some embodiments, an
17 adjusted or modified flight plan (or a selection of plans) may be provided for approval or
18 selection 1922a.

19 **[00119]** The term "turbulence" as a haphazard secondary motion caused by the eddies of a
20 fluid system has often been treated as a singular event in casual connotation, caused by passage
21 through an entropic weather system or by proximity to shifting air flow patterns. This definition
22 is commonly perpetuated by many turbulence forecast platforms that focus on a specific type of
23 turbulence, such as CAT, without accounting for additional turbulence factors, nor how multi-
24 hazards conflagrate into not just a series of turbulence events, but an enhanced system which
25 continues to flux. In Figure 19B, wind 1952, thunderstorms 1954, and gravity waves 1953 (the
26 interaction of media, such as the ocean and the atmosphere caused by energy transfer, on which
27 gravity acts as a restoring force) can all be turbulence contributors to a region of three-
28 dimensional space over a specified time. An aircraft 1951 traveling through this region may
29 experience multiple turbulence hazards 1955. A turbulence forecast display that indicates only
30 CAT with gravity wave interference may display a low hazard area into which an aircraft may
31 be moving. Similarly a weather prediction display may also fail to factor in the additional risk of

1 CAT. In one embodiment of the disclosed DATCM, a CAT calculation component producing
2 color-coded terminal display of turbulence hazard over a specified area (where clear may
3 indicate no turbulence, green may indicate low turbulence hazard, yellow may indicate medium
4 turbulence hazard, and red may indicate high turbulence hazard) 1956 may be integrated
5 mathematically with a mountain wave forecasting component which produces a similar color-
6 coded terminal display 1957, resulting in an integrated display where the resulting hazard
7 matrix 1958 may not be an overlay of the individual turbulence predictions, but an enhanced
8 turbulence forecast where individual areas of low or no hazard turbulence may now indicated
9 high hazard turbulence 1959. In some embodiments, multiple turbulence overlay displays may
10 be available showing individuated turbulence forecasts without enhancement. In some
11 embodiments of the disclosure, only enhanced turbulence forecast displays may be available. In
12 some embodiments of the disclosure, users may be able to switch between individuated
13 turbulence forecasts and enhanced turbulence forecasts.

14 **[00120]** In some embodiments, the DATCM transforms atmospheric and terrain data, via
15 DATCM components, into comprehensive four-dimensional turbulence displays and interfaces.
16 In one implementation, the DATCM comprises a processor and a memory disposed in
17 communication with the processor and storing processor-issuable instructions to determine a
18 plurality of four-dimensional grid points for a specified temporal geographic space-time area
19 and obtain corresponding terrain and atmospheric data. Then, for each point of the plurality of
20 four-dimensional grid point, the DATCM determines a non-dimensional mountain wave
21 amplitude and mountain top wave drag, an upper level non-dimensional gravity wave
22 amplitude, and a buoyant turbulent kinetic energy. The DATCM may also determine a
23 boundary layer eddy dissipation rate, storm velocity and eddy dissipation rate from updrafts,
24 maximum updraft speed at grid point equilibrium level, storm divergence while the updraft
25 speed is above the equilibrium level and identifying storm top, storm overshoot and storm drag.
26 The DATCM determines Doppler speed, eddy dissipation rate above the storm top, eddy
27 dissipation rate from downdrafts. Then, the DATCM determines the turbulent kinetic energy
28 and/or the total eddy dissipation rate for each grid point and provides a four-dimensional grid
29 map overlay with comprehensive turbulence data for the specified temporal geographic space-
30 time area.

1 [00121] In some embodiments of the disclosure, the DATCM 2001 may be available to
2 aircraft 2002, air traffic controllers 2003, flight planning tools and software 2017, third party
3 applications 2005 where turbulence feed incorporation is contributing, and the like. Figure 20
4 illustrates that in some embodiments of the disclosure, PIREPS and sensor data of aircraft in
5 real-time turbulence conditions 2004 may send data to the DATCM to be incorporated into the
6 DATCM aggregate data analysis. Similarly, in some embodiments of the disclosure,
7 additional/other sources of input may be weather stations 2020, satellites 2021 and/or other
8 sources/sensors, which may provide radar data, lightning data, satellite data, and/or numerical
9 weather forecast data 2006 to the DATCM. In some embodiments of the DATCM,
10 additional/other sources of input may be topological data 2018 which may provide terrain
11 characteristic data 2005a to the DATCM. In some embodiments of the DATCM, the receipt of
12 this input may occur prior to requests to the DATCM for turbulence forecasting. In some
13 embodiments of the DATCM, the receipt of this input may be ongoing during requests to the
14 DATCM for dynamic turbulence forecasting and/or nowcasting. In some embodiments of the
15 DATCM, receipts of input may be both before requests to the DATCM for turbulence
16 forecasting and ongoing during forecasting requests and nowcasting. In some embodiments, an
17 aircraft 2002 may request (near) real-time localized turbulence data 2007, an air traffic control
18 system 2003 may request predictive regional turbulence data as an updating feed 2009 and/or a
19 (near) real-time regional turbulence data request 2011, a flight-planning tool or software may
20 request predictive turbulence within a flight path region or along a flight path course 2013. In
21 some embodiments, the DATCM may direct such requests through a turbulence Integration
22 Mechanism component 2010 where DATCM components such as Airfoil Icing Platform (AIP)
23 component, MWAVE component, INTTURB component, and VVTURB2 component process
24 input into eddy dissipation rate (EDR) values and render them for terminal 2030, standard/high-
25 definition 2031, and/or displays of the like. In some embodiments, the Integration Mechanism
26 component 2010 may also include or utilize a VVSTORMSE component, which may be utilized
27 in flight planning, flight following, and/or the like. In some implementations, a VVSTORMSE
28 component may subsume and/or replace a VVTURB2 component. In some embodiments, the
29 DATCM may return a real-time/near real-time turbulence map 2008 terminal display to an
30 aircraft, a predictive and updating regional data feed 2012 to an air traffic controller, a

1 predictive flight path turbulence 2014 display to a flight-planning tool/software, a turbulence
2 data feed 2015 to a third party application displaying turbulence data, and/or the like.

3 **[00122]** Figure 21 shows an alternate embodiment of DATCM data flow in which input is
4 gathered through like sources 2104, 2120, 2121, 2108, such as in Figure 20 and these inputs
5 may be stored in various current and historical databases systems 2140 which in some
6 embodiments of the disclosure may be integrated with the DATCM. In some embodiments of
7 the disclosure, the database systems storing turbulence input may be separate from, but
8 accessible to, the DATCM. Similarly, in some embodiments of the disclosure, additional/other
9 sources of input may be weather stations 2120, satellites 2121 and/or other sources/sensors,
10 which may provide radar data, lightning data, satellite data, and/or numerical weather forecast
11 data 2106 stored in various current and historical databases systems 2140 and/or the DATCM.
12 Similar parties 2102, 2103, 2104, to those discussed above with reference to Figure 20 may
13 request data from the DATCM which may access the database systems for input values in
14 addition to directing the requests through its Integration Mechanism component 2110. In some
15 embodiments, such data is provided via data streams and/or data feeds. In some embodiments,
16 the Integration Mechanism component 2110 may also include or utilize a VVSTORMSE
17 component, which may be utilized in flight planning, flight following, and/or the like. As in
18 Figure 20, the DATCM may return these requests with turbulence forecasts in a variety of
19 formats to requesting parties.

20 **[00123]** In Figure 22A, one embodiment of the DATCM's integration component is put
21 forth. Beginning with turbulence data input 2201 as derived from such sources as user
22 application input 2201a, weather 2201b, terrain 2201c, PIREPs/aircraft sensors 2201d, and/or
23 the like, which may provide the DATCM with four-dimensional grid points (three-dimensional
24 space plus time), temperature, winds, humidity, topography, current turbulent conditions,
25 historical conditions, and/or the like, the DATCM may first process the input through a
26 mountain wave turbulence calculation component (MWAVE). The system computes the non-
27 dimensional mountain wave amplitude ($\hat{a}mv$) 2202 and computes the mountain top wave drag
28 2203. The following code fragment shows one embodiment of a methodology for such
29 processing:

30

31 C

```

1 C* a is the non-dimensional wave amplitude (at mountain top)
2 C
3   a (i,m,n) = stab0*h(m,n)/spd0
4   h0 (m,n) = a(i,m,n)
5 C
6 C* ddrct is the wind and mountain top wind direction difference
7 C
8   ddrct = ABS(drct-drct0(m,n))
9   IF ( (ddrct .lt. 90.0) .or. (ddrct .gt. 270.0) ) THEN
10 C
11 C* a above the mountain top is adjusted for stability, wind,
12 C* and density changes.
13 C
14   a (i,m,n) = stab*h(m,n)/spd/COS(ddrct*DTR) *
15   + SQRT(pnu0(m,n)/(pmodel*stab*spd))
16 ELSE
17   a (i,m,n) = 0.0
18 END IF
19 C
20 C* maximum a is 2.5
21 C
22   IF ( a(i,m,n) .gt. 2.5 ) a(i,m,n) = 2.5
23 C
24 C* Find max 'a' below h0max.
25 C
26   IF (ll .lt. nlyrs) THEN
27     amax0 = a(ll,m,n) - (zsdg(ll,m,n)-h0max)/
28     + (zsdg(ll,m,n)-zsdg(ll+1,m,n)) *
29     + (a(ll,m,n)-a(ll+1,m,n))
30     lll = ll
31     DO i = ll,1,-1
32       IF ( (a (i,m,n) .ne. RMISSD) and.
33       + (a(i,m,n) .gt. amax0) ) THEN
34         lll = i-1
35         amax0 = a(i,m,n)
36       END IF
37     END DO
38 C

```

```

1 C* 'a' is increased at all levels below max 'a'.
2 C
3     DO i = lll,1,-1
4         IF (a (i,m,n) .ne. RMISSD) THEN
5             a (i,m,n) = amax0
6             enhc (i,m,n) = 1.0
7         END IF
8     END DO
9 END IF
10 C
11 C* Find .75 vertical wavelength (and 1.75, 2.75, 3.75).
12 C
13     zrefl = (nn + .75)*lambda(m,n) + elv(m,n)
14     ll = 1
15     DO i = 1,nlyrs
16         IF ( zsdg(i,m,n) .lt. zrefl ) ll = i
17     END DO
18     IF (ll .lt. nlyrs) THEN
19         ar = a(ll,m,n) - (zsdg(ll,m,n)-zrefl)/
20             + (zsdg(ll,m,n)-zsdg(ll+1,m,n))*
21             + (a(ll,m,n)-a(ll+1,m,n))
22 C
23 C* Find .50 vertical wavelength (and 1.50, 2.50, 3.75).
24 C
25     zhalf = (nn + .50)*lambda(m,n) + elv(m,n)
26     lll = 1
27     DO i = 1,ll
28         IF ( zsdg(i,m,n) .lt. zhalf ) lll = i
29     END DO
30     ahalf = a(lll,m,n) - (zsdg(lll,m,n)-zhalf)/
31             + (zsdg(lll,m,n)-zsdg(lll+1,m,n))*
32             + (a(lll,m,n)-a(lll+1,m,n))
33 C
34 C* 'a' is increased by reflected 'a' if layered
35 C* favorably.
36 C
37     IF ( ( ahalf .lt. ar ).and.( ahalf .lt. 0.85 ) ) THEN
38         rcoeff = (ar-ahalf)**2/(ar+ahalf)**2

```

```

1   refl = rcoeff*ar
2   havrfl = .true.
3   DO i = 11,1,-1
4       IF ( (a(i,m,n) .ne. RMISSD) .and.
5           + (havrfl) ) THEN
6           arfl = a(i,m,n) + refl
7           a (i,m,n) = arfl
8           IF ( a(i,m,n) .gt. 2.5 ) a(i,m,n) = 2.5
9           enhc (i,m,n) = 1.0
10          END IF
11      END DO

```

12 C

13 C* Compute mountain top wave drag

14 C

```

15   drag (m,n) = PI/4.0*h(m,n)*pnu0(m,n)

```

16

17 **[00124]** In some embodiments of the DATCM, output obtained from the MWAVE
18 calculation component may then be directed into an integrated turbulence calculation
19 component (INTTURB), which will compute upper level non-dimensional gravity wave
20 amplitude (\hat{a}_l) 2204, and sum \hat{a}_m and \hat{a}_l into (\hat{a}) to determine buoyant turbulent kinetic
21 energy (TKEbuoy) 2205. If \hat{a} is greater than 1 2206, then $TKE_{buoy} = TKE_{mv} + TKE_{ul-buoy}$
22 2207. Otherwise, $TKE_{buoy} = 0$ 2208. If \hat{a} greater than \hat{a}_{min} 2209, then $TKE = TKE_{ul-wshr}$
23 2210. The boundary layer eddy dissipation rate (EDR) is computed 2211 and if EDR_{bl} is
24 greater than zero and \hat{a}_m is not enhanced 2212, then the $EDR = EDR_{bl}$ 2213, else the EDR is
25 the $TKE^{1/3}$ 2214.

26 **[00125]** The following code fragment shows one embodiment of a methodology for
27 processing of the INTTURB calculation:

28 C* Non-dimensional L-F amplitude is square root of L-F radiation

29 C* divided by constant. Constant is for 20km resolution grids

30 C* and is proportionally scaled to resolution of current grid.

31 C

```

32   ahatlf = SQRT(ABS(lfrad)/cc*gdd/20000.)

```

33 C

34 C

35 C* ahat is sum of lf and mw ahats

```
1 C
2   ahat = ahatlf + ahatmw(i)
3 C
4 C* Maximum ahat = 2.5
5 C
6   IF ( ahat .gt. 2.5 ) ahat = 2.5
7   IF ( ahat .gt. 1.0 ) THEN
8 C
9 C* mountain wave tke is proportional to drag.
10 C
11   tkemw = drag(i)*.0004
12 C
13 C* Reduce mw drag above this level
14 C
15   IF ( nhnc(i) .eq. 0.0 )
16     + drag(i) = drag(i)*((2.5-ahat)/1.5)
17     tkebuoy = kh*(ahat-1.0)*bvsq(i) + km*wshrsq(i)
18     + + tkemw
19   IF (ahat .lt. 1.0) THEN tkebuoy = 0.0
20   tke = km*wshrsq(i)*(1.0 + SQRT(rich)*ahat)**2
21     + -kh*bvsq(i)
22 C
23 C* Compute layer stability and wind shear
24 C
25   thtamn = ( thta + sfcthta )/2.0
26   bvsq = GRAVITY*thtadf/zdf/thtamn
27   udf = u - sfcu
28   vdf = v - sfcv
29   wshrsq = ( udf*udf + vdf*vdf )/zdf/zdf
30 C
31 C* Compute tke with equation
32 C
33   tke = km*wshrsq - kh*bvsq
34 C
35 C* If the < 0, we've reach top of boundary layer. Set topbl = T
36 C
37   IF ( tke .lt. 0.0 ) THEN
38     edrbl = 0.0
```

```

1      topbl = .true.
2      ELSE
3          edrbl = tke**.333
4      END IF

```

5

6 **[00126]** In some embodiments of the DATCM, output obtained from the MWAVE and

7 INTTURB calculation components may then be processed through a vertical velocity turbulence

8 with perimeter turbulence integration calculation component (VVTURB2). The storm velocity

9 is computed 2215, as is the EDR from computed updrafts 2216. The maximum updraft speed at

10 the grid point equilibrium level (EL) is computed 2217. While the updraft speed is above the

11 EL, the storm's divergence is calculated 2218, after which the storm top is identified 2219.

12 Storm overshoot (the storm top minus the storm EL) and storm drag (the overshoot squared

13 multiplied by the stability between the EL and storm up squared) are calculated 2220. The

14 magnitude of the wind velocity minus the storm velocity is calculated (known as the Doppler

15 speed) 2221. The EDR above the storm top is computed 2222. If there is turbulence within a set

16 distance or radius, by way of example thirty kilometers, of the storm 2223, then the EDR near

17 the storm is also computed 2224. Otherwise, only the EDR from downdrafts is additionally

18 computed 2225. Finally, all EDRs computed from INTURB and VVTURB2 calculation

19 components are summed and converted to turbulent kinetic energy (TKE) 2226.

20 **[00127]** The following code fragment shows one embodiment of a methodology for

21 processing of the VVTURB2 calculation:

```

22 C
23 C* Compute mean wind near freezing level (estimate of
24 C* storm velocity)
25 C
26     nlyrs = nlev - 1
27     DO j = 1, nlyrs
28         CALL ST_INCH ( INT(rlevel(j)), clvl1, iret )
29         CALL ST_INCH ( INT(rlevel(j+1)), clvl2, iret )
30         pbar = (rlevel(j) + rlevel(j+1))/2.0
31         IF ( pbar .gt. 400. ) THEN
32             glevel = clvl2//':'//clvl1
33             gvcord = 'PRES'
34             gfunc = 'LAV(TMPC)'

```

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```
1      CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, t,
2      + igx, igy, time, level, ivcord, parm, iret )
3      gvcord = 'PRES'
4      gfunc = 'UR(VLAV(WIND))'
5      CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, u,
6      + igx, igy, time, level, ivcord, parm, iret )
7      ierr = iret + ierr
8      gvcord = 'PRES'
9      gfunc = 'VR(VLAV(WIND))'
10     CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, v,
11     + igx, igy, time, level, ivcord, parm, iret )
12 C
13 C* Find weighted average of winds in all layers in which
14 C* -5C < t < 5C, weighting layer closer to 0C the highest.
15 C
16     DO i = 1, maxpts
17         tabs = ABS(t(i))
18         IF ( tabs .lt. 5.0 ) THEN
19             ufrzl(i) = ufrzl(i) + (5.0 - tabs)*u(i)
20             vfrzl(i) = vfrzl(i) + (5.0 - tabs)*v(i)
21             tsum(i) = tsum(i) + (5.0 - tabs )
22         END IF
23     END DO
24 END IF
25 END DO
26 C* Compute edr from mean vertical velocity
27 C
28 IF ( wmean .gt. 10.0 ) THEN
29     edr (i) = (.035+.0016*(wmean-10.0))**.333
30 ELSE
31     edr (i) = (.0035*wmean)**.333
32 END IF
33 ELSE
34     edr (i) = 0.0
35 END IF
36 IF (wwnd(i) .gt. maxvv(i)) THEN
37     havtop(i) = .false.
38     maxvv(i) = wwnd(i)
```

```
1      el(i) = z(i)
2      iii = 0
3 C
4 C* Divergence above EL is deceleration of the updraft divided by
5 C* thickness.
6 C
7      ELSE IF ( .not. havtop(i) ) THEN
8          divhi(i) = (vvbase(i)-wwnd(i))/tkns(i)
9          bvsqtop(i) = bvsqtop(i) + bvsq(i)
10         iii = iii + 1
11     ELSE
12         divhi(i) = 0.0
13     END IF
14 C
15 C* Define storm top
16 C
17     IF ( (maxvv(i) .gt. 1.0) .and. (wwnd(i) .lt. .1)
18 + .and. (.not. havtop(i)) ) THEN
19         havtop(i) = .true.
20         stmtop(i) = z(i) - tkns(i)/2.0
21         + - tkns(i)*vvbase(i)*vvbase(i)/wsq
22         ovshoot (i) = stmtop(i) - el (i)
23     IF ( iii .ne. 0 ) THEN
24         bvsqtop(i) = bvsqtop(i)/iii
25     ELSE
26         bvsqtop(i) = 0.0
27     END IF
28 C
29 C* Compute storm overshooting drag and storm top relative wind
30 C* (relative to freezing level wind)
31 C
32     drag (i) = ovshoot(i)*ovshoot(i)*bvsqtop(i)
33     dopu = u(i) - ufrzl(i)
34     dopv = v(i) - vfrzl(i)
35     dopspd = SQRT(dopu*dopu + dopv*dopv)
36     pnu0(i) = dden(i)*SQRT(bvsq(i))*dopspd
37     IF ( (wsq .le. 0.0) .and. havtop(i) ) THEN
38         stab = SQRT(bvsq(i))
```

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```

1      dopu = u(i) - ufrzl(i)
2      dopv = v(i) - vfrzl(i)
3      dopspd = SQRT(dopu*dopu + dopv*dopv)
4 C
5 C* Compute EDR above storm top as a function of drag
6 C
7      IF (ahat .ge. 1.0) THEN
8          edrtop = (drag(i)*.0004)**.333
9          edr(i) = MAX(edr(i), edrtop)
10         drag(i) = drag(i)*((2.5-ahat)/1.5)
11     END IF
12 C
13 C* Compute turbulence near storms if grid distance low enough.
14 C
15     DO i = 1,maxpts
16         IF (edr(i) .ne. RMISSD) THEN
17             gdd = (gdx(i)+gdy(i))/2.0
18             IF ( gdd .lt. 30000. .and. .not.havtop(i)) THEN
19 C
20 C* Compute tke near storm using Term 2C of L-F radiation
21 C* using same method as in ULTURB.
22 C
23             IF ( MOD(i,igx) .eq. 1 ) THEN
24                 ddivdx = (divhi(i+1)-divhi(i))/gdx(i)
25             ELSE IF ( MOD(i,igx) .eq. 0 ) THEN
26                 ddivdx = (divhi(i)-divhi(i-1))/gdx(i)
27             ELSE
28                 ddivdx = (divhi(i+1)-divhi(i-1))/2.0/gdx(i)
29             END IF
30             IF ( i .le. igx ) THEN
31                 ddivdy = (divhi(i+igx)-divhi(i))/gdy(i)
32             ELSE IF ( i .gt. (maxpts-igx) ) THEN
33                 ddivdy = (divhi(i)-divhi(i-igx))/gdy(i)
34             ELSE
35                 ddivdy = (divhi(i+igx)-divhi(i-igx))/2.0/gdy(i)
36             END IF
37             crsdiv = -ff(i)*(u(i)*ddivdy - v(i)*ddivdx)
38             ahat = SQRT(ABS(crsdiv)/cc)

```

60

```

1         IF ( ahat .gt. 2.5 ) ahat = 2.5
2         rich = bvsq(i)/wshrsq(i)
3         IF ( rich .lt. 0.0 ) rich = 0.0
4         IF ( rich .lt. 0.25 ) THEN
5             amin = 0.0
6         ELSE
7             amin = 2.0 - 1.0/SQRT(rich)
8         END IF
9         IF ( ahat .gt. 1.0 ) THEN
10            tkebuoy = kh*(ahat-1.0)*bvsq(i) + km*wshrsq(i)
11        ELSE
12            tkebuoy = 0.0
13        END IF
14        IF ( amin .ge. ahat ) THEN
15            tke = tkebuoy
16        ELSE
17            tke = km*wshrsq(i)*(1.0 + SQRT(rich)*ahat)**2
18                + - kh*bvsq(i)
19        END IF
20        IF ( tke .lt. 0.0 ) tke = 0.0
21        edrnear = tke**.333
22        edr(i) = MAX(edr(i),edrnear)
23    END IF
24 END IF
25 END DO
26 C
27 C* Compute downdraft velocities (a function of the windex
28 C and how far below the freezing level) and downdraft edr
29 C
30     fl = 304.8
31     DO WHILE ( fl .le. 6097. )
32         CALL ST_INCH ( INT(fl), glevel, iret )
33         gvcord = 'HGHT'
34         gfunc = 'EDR+2'
35         CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, edr,
36             + igx, igy, time, klevel, kvcord, parm, iret )
37         DO i = 1, maxpts
38             IF ( maxvv(i) .gt. 10. ) THEN

```

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```

1         IF ( fl .gt. sfcz(i) ) THEN
2             wdown = windex(i)*(frz1z(i)-fl)/frz1z(i)
3             IF ( wdown .gt. 10.0 ) THEN
4                 edrdown = (.035+.0016*(wdown-10.0))**.333
5             ELSE IF ( wdown .gt. 0.0 ) THEN
6                 edrdown = (.0035*wdown)**.333
7             ELSE
8                 edrdown = 0.0
9             END IF
10            edr (i) = MAX (edr(i), edrdown)
11        END IF
12    END IF
13 END DO
14

```

15 **[00128]** The following code fragment shows an additional or alternative embodiment of
16 enhanced code to address above-storm turbulence for some embodiments, an example image
17 resulting for which is shown in Figure 22B:

```

18 C* Compute turbulence above storm top.
19 C
20         IF ( (wsq .le. 0.0) .and. havtop(i) ) THEN
21             stab = SQRT(bvsq(i))
22             dopu = u(i) - ufrz1z(i)
23             dopv = v(i) - vfrz1z(i)
24             dopspd = SQRT(dopu*dopu + dopv*dopv)
25             pnu = dden(i)*stab*dopspd
26             IF ( dopspd .eq. 0.0 ) THEN
27                 ahat = 2.5
28             ELSE
29                 ahat = ovshoot(i)*stab/dopspd*SQRT(pnu0(i)/pnu)
30             END IF
31             IF (ahat .gt. 2.5) ahat = 2.5
32             IF (ahat .ge. 1.0) THEN
33                 edrtop = (drag(i)*.0004)**.333
34                 edr(i) = MAX(edr(i), edrtop)
35                 drag(i) = drag(i)*((2.5-ahat)/1.5)
36             END IF
37         END IF

```

1 END DO

2 C

3

4 **[00129]** Figure 23 shows an example of how the DATCM may be incorporated into
5 existing and/or prospect flight planning tools. The DATCM may be included with online
6 services, with desktop services, with mobile applications, and/or the like. In this embodiment of
7 the disclosure, a flight planning tool has an interface 2301 representative of an online flight
8 planning service with user profile information. As an interactive element 2302, the DATCM
9 may allow users to factor integrated turbulence prediction into flight path creation. The
10 DATCM may allow users to consider several ways of incorporating turbulence prediction into
11 their flight path considering their flight requirements 2303. In this example, the DATCM may
12 offer shortest path generation where turbulence may not be a considering factor in flight path
13 creation, turbulence circumvention where turbulence avoidance is a serious flight consideration,
14 some turbulence circumvention with emphasis on shortest path generation where turbulence
15 avoidance warrants some consideration, but may not be a primary goal and/or the like. The
16 DATCM may then generate an enhanced, integrated turbulence forecast within the specified
17 flight path region 2304 and suggest flight path alterations with respect to the level of turbulence
18 circumvention desired.

19 **[00130]** Figure 24 shows one example of an expanded logic flow diagram of flight path
20 considerations when the DATCM is part of an integrated flight planning tool. In one
21 embodiment of the disclosure, the flight planning service may access/input user profile
22 information 2400 which may include such information type of aircraft and/or flight service such
23 as passenger 2401, private 2402 and/or commercial cargo/transport 2403, the consideration of
24 which may influence turbulence avoidance (i.e. commercial cargo transport may prioritize
25 shortest path with minimal evasion while passenger may emphasize turbulence circumvention
26 over speed or directness). The DATCM may request additional user profile information for
27 flight path construction 2404. In some embodiments of the disclosure, such information may
28 include the origin grid point and departure time of the flight, the destination grid point, and/or
29 the maximum travel time the flight can utilize in constructing its path 2405. In some
30 embodiments of the disclosure, the DATCM may infer user information from previously stored
31 user profile data and/or prior flight path generation 2406. In some embodiments, this
32 information may include the aircraft type, its fuel requirements, its standard flying altitude,

1 previous planned flight paths, and/or the like 2408. In some embodiments, user profile and
2 flight creation information that is both input and/or inferred by the DATCM may be used to
3 update the user profile data for future DATCM use 2408. In some embodiments of the
4 disclosure, the DATCM may use other stored profile information where similar parameters
5 resulted in successful flight path creation. In some embodiments of the disclosure, the DATCM
6 may use additional input, such as those from sources external to the flight planning tool, such as
7 historical flight plan data and/or the like. The DATCM may then calculate the grid size of the
8 region 2409 over which the DATCM may consider flight path creation, using input such as the
9 origin, destination, maximum flight time, and/or facilities of the aircraft and/or type of flight. In
10 some embodiments of the disclosure, two dimensional grid space may be considered for initial
11 path planning purposes. In some embodiments of the disclosure, three dimensional grid space
12 may be considered for path planning purposes. In some embodiments of the disclosure, two
13 dimensional grid space may be considered for initial path planning purposes, which may then be
14 integrated with additional dimensional information as necessary to accurately determine
15 available grid space inside which the flight path may still meet flight path parameters.

16 **[00131]** In some embodiments of the disclosure, this initial input component may then be
17 followed by DATCM computational turbulence integration 2410 of the generated geospatial
18 grid region, some examples of which have been described in Figures 2, 3, and 4. The DATCM
19 may create an overlay to the generated grid region 2411 and may request additional information
20 about the desired parameters of the flight path through this grid region 2412. In some
21 embodiments of the disclosure, these parameters may include schedule-based path-finding
22 (shortest path immediacy), schedule-based but with circumvention of acute turbulence (shortest
23 path avoiding high hazard turbulence areas), turbulence circumvention (navigating out of
24 turbulence areas), and/or any combination of or intermediate stage to these parameters. The
25 DATCM may then use available input as described in the input component to determine all
26 flight path creation parameters 2414. The DATCM may then create a flight path over the
27 integrated turbulence grid region 2415, considering flight path creation parameters 2413. The
28 DATCM may then display the proposed flight path to the user as a terminal overlay, standard or
29 high definition map overlay and/or the like 2416, as is applicable to the flight planning tool. If
30 the flight path is satisfactory 2417, the user may then exit the flight path planning component of
31 the DATCM as an incorporated flight planning tool option, In some embodiments of the

1 disclosure, the DATCM may allow the user to export the determined flight path to other media,
2 save the flight path to the user profile, share the flight path with additional users, and/or the like.
3 In some embodiments of the disclosure, if the proposed flight path is not satisfactory 2417, the
4 DATCM may allow the user to modify flight path creation parameters 2418. In some
5 embodiments of the disclosure, the user may reenter a flight path creation component as
6 specified earlier 2412. In some embodiments of the disclosure, users may be allowed to visually
7 manipulate flight path options using the proposed flight path turbulence grid overlay. In some
8 embodiments of the disclosure, the user may be able to reenter flight path creation, visually
9 manipulate the proposed flight path and/or combine these methods in any intermediate path
10 modification.

11 **[00132]** Figure 25 shows an example of a vertical slice dissection of a proposed flight path
12 through which an aircraft may pass through multiple turbulence types and where an aircraft may
13 experience enhanced turbulence integration as calculated by the DATCM. In this example, the
14 aircraft experiences no turbulence at either origin A 2501 or destination B 2507, but as the
15 aircraft rises through the atmosphere along the projected flight path, it may begin to encounter
16 turbulence regions. In this example, between 20 and 30 kilofeet (kft), the aircraft at position
17 2520 has encountered a thunderstorm region 2502. As the aircraft moves directionally forward
18 along its flight path, it reaches the upper level 2504 where CAT may be pronounced. In this
19 example, the aircraft at position 2530 is in an enhanced thunderstorm and upper level CAT
20 region where integrated turbulence as calculated by the DATCM may show greater turbulence
21 hazard than either turbulence regions, separately or combined in a conventional summation. In
22 this example, at position 2540 the aircraft has moved into an enhanced upper level and
23 mountain wave turbulence region 2505 which, as calculated by the DATCM, may show greater
24 turbulence hazard than either turbulence regions, separately or combined in a conventional
25 summation. At position 2550, the aircraft descends in a mountain turbulence region where
26 mountain and gravity wave turbulence may be pronounced. At position 2560, the aircraft has
27 arrived at its destination, having experienced multi-hazard turbulence events in both singular
28 and overlap turbulence regions.

29 **[00133]** Figure 26 shows an example grid output of one embodiment of the DATCM,
30 where computational integration components may produce staged map overlays of each
31 component of the DATCM turbulence calculation process. In some embodiments of the

1 DATCM, the DATCM may show an initial MWAVE grid output 2601, incorporating MWAVE
2 turbulence calculations into a singular, non-enhanced turbulence map overlay. In one
3 embodiment of the DATCM, the map overlay may be color-coded to indicate areas of
4 turbulence hazard where clear represents no turbulence, green represents light turbulence
5 hazard, yellow represents moderate turbulence hazard, and red represents severe turbulence
6 hazard. In some embodiments of the disclosure, the DATCM may output a forecast as a four-
7 dimensional grid of EDR values in multiple file formats, such as GRIB2 and/or geometric
8 vector data such as Geographic Information System (GIS) shapefiles, for use in any GIS
9 display, software, integrator, and/or the like. In one embodiment of the disclosure, the DATCM
10 may display the results of the integration of its MWAVE and INTTURB components 2602, with
11 enhanced turbulence regions. In some embodiments of the DATCM, the output may be a color-
12 coded map overlay, export files for use in geospatial display systems, and/or the like. In one
13 embodiment of the disclosure, the DATCM may then display the integration of its INTTURB
14 component with its VVTURB2 component 2603. In some embodiments of the DATCM, the
15 output may be a color-coded map overlay, export files for use in geospatial display systems,
16 and/or the like. In one embodiment of the disclosure, the DATCM may display a finalized
17 output of full computational turbulence integration component 2604, as described in Figures 2,
18 3, and 4. In some embodiments of the DATCM, the output may be a color-coded map overlay,
19 export files for use in geospatial display systems, and/or the like. In some embodiments of the
20 disclosure, these outputs may be available as separate data feeds, software/tool options, export
21 files and/or the like. In some embodiments of the disclosure, these outputs may be available
22 internally to the DATCM and only integrated outputs available externally in the form of data
23 feeds, software/tool options, export files, and/or the like.

24 **[00134]** Figure 27 demonstrates, in a manner similar to that depicted in Figure 3, a further
25 example of how DATCM Integration Mechanism component(s) may incorporate external data
26 feeds and may provide various partners, third party software applications/tools, end users,
27 integrators, internal and external flight planning services, and/or the like with integrated
28 turbulence output in the form of comma-separated value (CSV), geometric vector data files,
29 gridded binary (GRIB) format, data feeds, and/or the like. In one embodiment, the DATCM
30 receives and/or requests global calculation data for a variety of weather and/or geographic
31 mechanisms 2701, including but not limited to global mechanisms 2701a and/or regional

1 mechanisms 2701b. In some embodiments, Global Forecast System (GFS) information 2702a
2 from the National Oceanic and Atmospheric Administration (NOAA) is utilized as input. In
3 some embodiments, the DATCM receives Rapid Refresh (RAP) 2702b information from the
4 NOAA as input. In some embodiments, the DATCM receives GEM 2702c (Global
5 Environmental Multiscale Model) as input. In some embodiments, the DATCM receives
6 ECMWF 2702d information as input. In one embodiment, the DATCM receives GFS, RAP,
7 GEM, ECMWF, and/or similar information as input. Some embodiments of the DATCM are
8 model agnostic. In some embodiments the DATCM produces one or more GRIB2 file(s) 2703
9 and/or record outputs that may be appended in GRIB format for use in file distribution by
10 DATCM partners 2704. In some embodiments, DATCM partners may distribute DATCM
11 output through various communication networks 2705 such as local area networks (LAN)
12 and/or external networks such as the internet which may provide DATCM partners, third party
13 applications/tools 2706, and/or end users 2707 with DATCM output. In some embodiments of
14 the DATCM, such output may be in propagated GRIB files as provided to DATCM partners. In
15 some embodiments of the DATCM, such output may be converted to a visual form for display
16 on a web browser, smart phone application, software package and/or the like. In some
17 embodiments of the DATCM, electronic messaging 2707 such as email, SMS text, push
18 notifications, and/or the like may be employed to alert end users of important data updates from
19 the DATCM, DATCM partners, and/or other parties providing DATCM output data.

20 **[00135]** In some embodiments, the DATCM may provide a file or data stream as output,
21 in which values of the DATCM during component production, including but not limited to EDR
22 finalization, may be recorded or provided. One example of a DATCM CSV output file is
23 provided below, showing an in-flight time sequence of forecasted turbulence:

Flight PHX-MSP dd mm yyyy Leave:0413Z Arrive:0645Z
Turbulence Forecast (EDR*100)

Time	Latitude	Longitude	Altitude (kft)	MWAVE	COMTURB	VVTURB	INTTURB	VVINTTURB	FINAL	Explanation
415	33.5	-111.8	50	0	0	0	0	1	1	
425	34.6	-111.6	250	0	0	0	0	26	26	Near-storm turbulence
435	35.4	-110.3	370	0	0	0	0	1	1	
445	36.2	-109	370	0	0	1	25	1	25	Mountain wave and free gravity wave amplitudes combine
455	36.9	-107.7	370	0	0	0	0	0	0	
505	37.3	-106	370	0	0	0	0	34	34	Storm top turbulence
515	38.1	-104.7	370	0	0	1	35	1	35	Mountain wave and free gravity wave amplitudes combine
525	38.9	-103.6	370	0	0	1	0	1	1	
535	39.9	-102.3	370	0	45	0	45	0	45	
545	40.9	-101	370	0	0	1	0	1	1	
555	41.8	-99.7	370	0	51	1	51	1	51	
605	42.6	-98.5	370	0	34	0	34	0	34	
615	43.5	-97	370	0	30	1	30	1	30	
625	44.4	-95.3	250	0	18	43	18	43	43	
635	44.7	-94	100	0	0	24	0	24	24	
645	44.8	-93.2	20	0	19	0	19	51	51	Near-storm turbulence

1
2

3 **[00136]** In some embodiments of the DATCM, a file or feed (e.g., a CSV file) output from
 4 the DATCM may be provided as input to a geometric vector data generator 2707, which may
 5 provide additional data output options. In some embodiments of the DATCM, the geometric
 6 vector data generator may output geometric vector data files to a file server 2730 which may
 7 provide the data output to an alert server 2720 which may provide the output a communications
 8 networks 2705 to such partners, third parties, software applications, end users and/or the like as
 9 described. In some embodiments of the DATCM, the geometric vector data generator may
 10 output geometric vector data files, such as shapefiles, for storage in GIS database(s) 2708. In
 11 some embodiments of the DATCM, Web Mapping Services (WMS) and/or Web Feature
 12 Services (WFS) 2709 may obtain the geometric vector data files from GIS database(s) and
 13 provide geographic service integrators 2711 with DATCM output data through various
 14 communication networks 2705 as described. In some embodiments of the DATCM, file
 15 server(s) 2708 and/or WMS may incorporate the DATCM output data into a DATCM integrated
 16 server 2740 with application, data, and/or network components. A DATCM integrated server
 17 may employ such output data from DATCM components in proprietary software tools, web
 18 services, mobile applications and/or the like. In one embodiment of the DATCM, a DATCM

1 integrated server may employ DATCM component output for use in flight planning tools 2712,
2 such as AviationSentry Online®.

3 **[00137]** Figure 28A shows an example terrain height map 2801 in meters over the
4 Colorado area in the 0.25 deg latitude/longitude grid world terrain database. In this embodiment
5 of the DATCM, black areas are regions where the terrain is relatively flat.

6 **[00138]** Figure 28B shows two examples of asymmetry in computed terrain height as
7 described in 28A along x and y directions. In one embodiment of the DATCM, asymmetry is
8 computed as the negative height change in the east (x) direction 2802. In one embodiment of the
9 DATCM, asymmetry is computed as the negative height change in the north (y) direction 2803.

10 **[00139]** Figure 29A shows one example of a 3-hour RAP forecast 2901 showing
11 Streamlines and isotachs (kts) of the forecast flow at 250mb (near FL350).

12 **[00140]** Figure 29B shows one example of Lighthill-Ford radiation 2902 computed at
13 10668 m (FL350) for the forecast flow shown in Figure 29A. Lighthill-Ford radiation is the
14 gravity wave diagnostic in ULTURB, a computational component of the DATCM, in one
15 embodiment of the DATCM.

16 **[00141]** Figure 29C shows one example of ULTURB turbulence forecast 2903 in EDR
17 values for the forecast flow described in Figure 29A. ULTURB, a computational component of
18 the DATCM in one embodiment, combines the gravity wave diagnostic described in Figure
19 29B, the Richardson number, and the vertical wind shear.

20 **[00142]** Figure 29D provides an example of output generated by the DATCM, a 4D grid
21 of EDR values, which may be made available in several forms including, by way of non-
22 limiting example, GRIB2 format and GIS shapefiles. As discussed above, EDR value is the
23 Eddy Dissipation Rate and is defined as the rate at which kinetic energy from turbulence is
24 absorbed by breaking down the eddies smaller and smaller until all the energy is converted to
25 heat by viscous forces. EDR is expressed as kinetic energy per unit mass per second in units of
26 velocity squared per second (m^2/s^3). The EDR is the cube root of the turbulent kinetic energy
27 (TKE). When adding the EDR values together from VVTURB2 and INTTURB, the values may
28 be converted back to TKE, added together, and converted back to EDR (take the cube root of
29 the sum).

1 [00143] Figure 29D also illustrates various interface features that may be used to navigate
 2 the four-dimensional grid, such as a time slider 2910 to move through various calculated time
 3 grids, an elevation slider 2912 to view various elevations, and a detail widget, to adjust the
 4 granularity/detail of the displayed turbulence interface.

5 [00144] In some embodiments, the DATCM server may issue PHP/SQL commands to
 6 query a database table (such as FIGURE 46, Profile 4619c) for profile data. An example profile
 7 data query, substantially in the form of PHP/SQL commands, is provided below:

```

8 <?PHP
9 header('Content-Type: text/plain');
10 mysql_connect("254.93.179.112", $DBserver, $password); // access database
11     server
12 mysql_select_db("DATCM_DB.SQL"); // select database table to search
13 //create query
14 $query = "SELECT field1 field2 field3 FROM ProfileTable WHERE user LIKE
15     '% ' $prof";
16 $result = mysql_query($query); // perform the search query
17 mysql_close("DATCM_DB.SQL"); // close database access
18 ?>
19
```

20 [00145] The DATCM server may store the profile data in a DATCM database. For
 21 example, the DATCM server may issue PHP/SQL commands to store the data to a database
 22 table (such as FIGURE 46, Profile 4619c). An example profile data store command,
 23 substantially in the form of PHP/SQL commands, is provided below:

```

24 <?PHP
25 header('Content-Type: text/plain');
26 mysql_connect("254.92.185.103", $DBserver, $password); // access database
27     server
28 mysql_select("DATCM_DB.SQL"); // select database to append
29 mysql_query("INSERT INTO ProfileTable (fieldname1, fieldname2,
30     fieldname3)
31     VALUES ($fieldvar1, $fieldvar2, $fieldvar3)"); // add data to table in
32     database
33 mysql_close("DATCM_DB.SQL"); // close connection to database
34 ?>
35
```

1 [00146] Various embodiments of the DATCM may be used to provide real-time, pre-flight
2 and/or in-flight turbulence reporting, planning and response. The integrated, unified turbulence
3 system provided by the DATCM may be used in flight equipment and/or ground equipment.
4 The DATCM may provide weather/aviation decision support (e.g., via graphical displays)
5 and/or provide alerts/triggers. Although it is discussed in terms of re-routing in time of
6 increased turbulence, in some embodiments, the DATCM may identify more efficient paths
7 based on real-time updates where there is decreased turbulence over a shorter physical distance,
8 and may update a flight plan accordingly. The DATCM identifies 4D areas for flight hazards,
9 and a user may choose or set their profile based on particular hazards (e.g., a passenger airline
10 would have a different hazard/turbulence profile than an air freight company, and a large
11 airliner would have a different profile from a small plane or helicopter). Various cost
12 calculations and risk calculations may also be used in determining alerts and/or flight paths. In
13 some embodiments, real-time feedback may come from plane-mounted instrument sensors and
14 provide updates to predicted turbulence. Such information may be used to refine mechanisms
15 for turbulence determination. Although examples were discussed in the context of jet airliners, it
16 is to be understood that the DATCM may be utilized for low-level services, such as helicopters,
17 unmanned aerial vehicles, as well as high speed and/or military aircraft, and may even have
18 potential ground applications, especially in mountainous terrain. The DATCM may work with
19 air traffic control, particularly in management of routing. In some embodiments, the DATCM
20 may input directly in avionics systems to guide planes.

21 [00147] Prior to the DATCM, forecasts of turbulence, if even available, were generally
22 qualitative (e.g., light/heavy), independent of aircraft type, and did not include all sources of
23 turbulence (e.g., they specifically exclude thunderstorms) or interactions of turbulence, thus
24 making them unusable for most practical applications such as flight planning. The integrated
25 turbulence forecast of the DATCM is unique because it dynamically determines the location and
26 level at which each comprehensive turbulence determination is made, based on the
27 meteorological conditions at that point in space and time. In some embodiments, the result is a
28 single, integrated forecast that includes all sources of turbulence, and is produced in quantitative
29 units, such as Eddy Dissipation Rate (EDR), thus making it suitable for practical uses, such as
30 flight planning applications, and allows for categorical flexibility specific to an aircraft.

1 **[00148]** In some embodiments, the DATCM integrates three DATCM turbulence
2 mechanisms, ULTURB, BLTURB, and MWAVE into one component/program called
3 INTTURB. In some additional or alternative embodiments, the DATCM integrates VVTURB
4 with ULTURB and BLTURB into a component/program called VVINTTURB. Output from all
5 components may in EDR, an aircraft-independent metric of turbulence intensity. The DATCM
6 may assign an EDR value at each grid point and at each flight level. Observations of turbulence
7 may also be used for further tuning of the forecast where and when they are available. In some
8 embodiments, the DATCM may utilize a VVSTORMSE component, as discussed below.

9 **[00149]** Embodiments of the DATCM may be configured to determine warnings for
10 relatively reduced volumes/areas/sizes of airspace, substantially more granular and detailed
11 than, for example, traditional convective SIGMETs. A Convective SIGMET is typically issued
12 as a text message for convection over the continental United States, for example, for an area of
13 thunderstorms affecting an area of 3,000 square miles or greater. The DATCM and/or
14 VVSTORMSE may provide granularity by reducing the size of the analyzed area by 10%, 15%,
15 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%, 65%, 70%, 75%, 80%, 85%, 90%, and/or
16 95%. Depending on the embodiment, the area granularity may be of the following, or within a
17 range of any of the following: 0.05 km², 0.1 km², 0.2 km², 0.3 km², 0.4 km², 0.5 km², 0.6 km²,
18 0.7 km², 0.8 km², 0.9 km², 1 km², 2 km², 3 km², 4 km², 5 km², 6 km², 7 km², 8 km², 9 km², 10
19 km², 11 km², 12 km², 13 km², 14 km², 15 km², 16 km², 17 km², 18 km², 19 km², 20 km², 21
20 km², 22 km², 23 km², 24 km², 25 km², 26 km², 27 km², 28 km², 29 km², 30 km², 31 km², 32
21 km², 33 km², 34 km², 35 km², 36 km², 37 km², 38 km², 39 km², 40 km², 41 km², 42 km², 43
22 km², 44 km², 45 km², 46 km², 47 km², 48 km², 49 km², 50 km², 55 km², 60 km², 65 km², 70
23 km², 75 km², 80 km², 85 km², 90 km², 95 km², 100 km², 105 km², 110 km², 115 km², 120 km²,
24 125 km², 130 km², 135 km², 140 km², 145 km², 150 km², 155 km², 160 km², 165 km², 170 km²,
25 175 km², 180 km², 185 km², 190 km², 195 km², 200 km², 205 km², 210 km², 215 km², 220 km²,
26 225 km², 230 km², 235 km², 240 km², 245 km², 250 km², 255 km², 260 km², 265 km², 270 km²,
27 275 km², 280 km², 285 km², 290 km², 295 km², 300 km², 305 km², 310 km², 315 km², 320 km²,
28 325 km², 330 km², 335 km², 340 km², 345 km², 350 km², 355 km², 360 km², 365 km², 370 km²,
29 375 km², 380 km², 385 km², 390 km², 395 km², 400 km², 425 km², 450 km², 475 km², 500 km²,
30 525 km², 550 km², 575 km², 600 km², 625 km², 650 km², 675 km², 700 km², 725 km², 750 km²,
31 775 km², 800 km², 825 km², 850 km², 875 km², 900 km², 925 km², 950 km², 975 km², 1000

1 km², 1100 km², 1200 km², 1300 km², 1400 km², 1500 km², 1600 km², 1700 km², 1800 km²,
2 1900 km², 2000 km², 2100 km², 2200 km², 2300 km², 2400 km², 2500 km², 2600 km², 2700
3 km², 2800 km², 2900 km², 3000 km², 3100 km², 3200 km², 3300 km², 3400 km², 3500 km²,
4 3600 km², 3700 km², 3800 km², 3900 km², 4000 km², 4100 km², 4200 km², 4300 km², 4400
5 km², 4500 km², 4600 km², 4700 km², 4800 km², 4900 km², 5000 km², 5500 km², 6000 km²,
6 6500 km², 7000 km², 7500 km². The area granulariy may be in the range of any two of the
7 previous areas, such as by way of non-limiting example, between 0.1 km² and 1000 km², 10
8 km² and 200 km², 100 km² and 5000 km², 800 km² and 5500 km², 900 km² and 4500 km²,
9 and/or the like. The shape of the area may be, by way of non-limiting example, square,
10 rectangular, parallelogram, n-gon, irregular, and/or the like.

11 **[00150]** The DATCM and/or VVSTORMSE may provide granularity by reducing the size
12 of the analyzed airspace volumes by 15%, 20%, 25%, 30%, 35%, 40%, 45%, 50%, 55%, 60%,
13 65%, 70%, 75%, 80%, 85%, 90%, and/or 95%. Depending on the embodiment, the volume
14 granularity may be of the following or within a range of the any of the following: 0.1 km³, 0.2
15 km³, 0.3 km³, 0.4 km³, 0.5 km³, 0.6 km³, 0.7 km³, 0.8 km³, 0.9 km³, 1 km³, 2 km³, 3 km³, 4 km³,
16 5 km³, 6 km³, 7 km³, 8 km³, 9 km³, 10 km³, 11 km³, 12 km³, 13 km³, 14 km³, 15 km³, 16 km³,
17 17 km³, 18 km³, 19 km³, 20 km³, 21 km³, 22 km³, 23 km³, 24 km³, 25 km³, 26 km³, 27 km³, 28
18 km³, 29 km³, 30 km³, 31 km³, 32 km³, 33 km³, 34 km³, 35 km³, 36 km³, 37 km³, 38 km³, 39
19 km³, 40 km³, 41 km³, 42 km³, 43 km³, 44 km³, 45 km³, 46 km³, 47 km³, 48 km³, 49 km³, 50
20 km³, 55 km³, 60 km³, 65 km³, 70 km³, 75 km³, 80 km³, 85 km³, 90 km³, 95 km³, 100 km³, 105
21 km³, 110 km³, 115 km³, 120 km³, 125 km³, 130 km³, 135 km³, 140 km³, 145 km³, 150 km³, 155
22 km³, 160 km³, 165 km³, 170 km³, 175 km³, 180 km³, 185 km³, 190 km³, 195 km³, 200 km³, 205
23 km³, 210 km³, 215 km³, 220 km³, 225 km³, 230 km³, 235 km³, 240 km³, 245 km³, 250 km³, 255
24 km³, 260 km³, 265 km³, 270 km³, 275 km³, 280 km³, 285 km³, 290 km³, 295 km³, 300 km³, 305
25 km³, 310 km³, 315 km³, 320 km³, 325 km³, 330 km³, 335 km³, 340 km³, 345 km³, 350 km³, 355
26 km³, 360 km³, 365 km³, 370 km³, 375 km³, 380 km³, 385 km³, 390 km³, 395 km³, 400 km³, 425
27 km³, 450 km³, 475 km³, 500 km³, 525 km³, 550 km³, 575 km³, 600 km³, 625 km³, 650 km³, 675
28 km³, 700 km³, 725 km³, 750 km³, 775 km³, 800 km³, 825 km³, 850 km³, 875 km³, 900 km³, 925
29 km³, 950 km³, 975 km³, 1000 km³, 1100 km³, 1200 km³, 1300 km³, 1400 km³, 1500 km³, 1600
30 km³, 1700 km³, 1800 km³, 1900 km³, 2000 km³, 2100 km³, 2200 km³, 2300 km³, 2400 km³,
31 2500 km³, 2600 km³, 2700 km³, 2800 km³, 2900 km³, 3000 km³, 3100 km³, 3200 km³, 3300

1 km³, 3400 km³, 3500 km³, 3600 km³, 3700 km³, 3800 km³, 3900 km³, 4000 km³, 4100 km³,
2 4200 km³, 4300 km³, 4400 km³, 4500 km³, 4600 km³, 4700 km³, 4800 km³, 4900 km³, 5000
3 km³, 5500 km³, 6000 km³, 6500 km³, 7000 km³, 7500 km³, 8000 km³, 8500 km³, 9000 km³,
4 9500 km³, 10000 km³. The volume granularly may be in the range of any two of the previous,
5 such as by way of non-limiting example, between 0.1 km³ and 10000 km³, 10 km³ and 200 km³,
6 100 km³ and 5000 km³, 800 km³ and 5500 km³, 900 km³ and 4500 km³, and/or the like. The
7 shape of the volume may be, by way of non-limiting example, cuboid, parallelepiped,
8 polygonal, irregular, and/or the like.

9 **[00151]** With reduced airspace volumes, such implementations of the DATCM issue
10 fewer aircraft alerts, resulting in increased compliance with and/or adherence to warnings. In
11 some embodiments, the DATCM avoids over-forecasting of alerts, including avoidance of over-
12 forecasting convective turbulence. Some aircraft-flight-following operations warn aircraft of
13 impending turbulence based on text messages issued by the National Weather Service. These
14 messages may coarsely outline the threat volume often resulting in alerting aircraft not in the
15 direct path of the turbulence. While non-convective turbulence is determined from numerical
16 weather forecast mechanisms, as it cannot generally be directly observed, the DATCM may
17 accurately infer convective turbulence from observations from radar, satellite, or lightning.

18 **[00152]** For example, rather than alerting the entire atmospheric volume from the surface
19 to very high altitudes (based on assumption that all altitudes are affected whenever, for
20 example, radar reflectivity reaches a certain threshold or whenever lightning is observed), the
21 DATCM can provide alerts with enhanced granularity. The DATCM can predict/identify
22 regions of relatively lower convective turbulence (primarily correlated to storm updraft and
23 downdraft strength) from the storm-supporting environment.

24 **[00153]** In some embodiments of the DATCM, a VVSTORMSE component may have a
25 plurality of subcomponents. In one exemplary embodiment, illustrated in Figure 30, the
26 VVSTORMSE component receives 3002 and analyzes a numerical weather forecast 3004 for
27 areas of atmospheric potential instability. It assigns a turbulence-intensity at each altitude 3006
28 based on the updraft or downdraft magnitude that the environment can support and assigns a
29 turbulence intensity (see discussion of Figure 30A below). An exemplary implementation for
30 one embodiment is illustrated in the below code fragment:

```
1 C
2 C*   Lift most unstable parcel to find potential instability
3 C*       (if parcel has an LFC).
4 C* Wwndvertical velocity ('+' is up and '-' is down)
5 C* Edr eddy dissipation rate
6 C* Plclpressure at the lifted condensation level (the pressure when
7 C* Lifted air becomes saturated)
8 C* Pbarpressure level being analyzed
9 C* Thteequivalent potential temperature
10 C* Thtapotential temperature
11 C* Pthteparcel equivalent potential temperature
12 C* Pctdil percent dilution to dilute parcel with environmental air
13 C* Tknslayer thickness
14 C* Ff Coriolis parameter
15 C* Vortabsolute vorticity
16 C* Avorgabsolute geostrophic vorticity
17 C* Pcltparcel temperature (PR_TMST is function that computes it)
18 C* Tenvenvironmental temperature (degK)
19 C* Pcldif temperature difference between parcel and environment
20 C* Wsq square of vertical acceleration
21 C* Vvsq square of vertical velocity
22 C* Vvbase vertical velocity at layer base
23 C* Wmeanmean upward vertical velocity in layer
24 C* Fl Flight level (m)
25 C* Windex maximum downward vertical velocity (at surface)
26 C* Maxvv maximum upward vertical velocity
27 C* Frzmsl freezing level above sea level
28 C* Frzllz freezing level above ground elevation
29 C* Sfcz surface elevation
30 C* Wdown downward vertical velocity at flight level
31 C* Edrdownedr from wdown
32 C* Edrlow edr from wmean
33 C
34     DO i = 1, maxpts
35         zsum = zsum + z(i) + tkns(i)/2.
36         IF (sfcp (i) .lt. rlevel (j+1)) THEN
37             wwnd (i) = RMISSD
38     edr (i) = RMISSD
```

```
1      ELSE
2  IF ( plcl(i) .gt. pbar ) THEN
3    IF ( thte(i) .eq. RMISSD ) thte(i) = thta(i)
4    IF ( pthte(i) .gt. thte(i) ) THEN
5      pctdil = tkns(i)/10000.0
6      pthte(i) = (1.0-pctdil)*pthte(i) + pctdil*thte(i)
7      END IF
8    IF ( ff(i) .gt. 0.0 ) THEN
9      vort = MAX ( avorg ( i), ff ( i) )
10   ELSE
11     vort = MIN ( avorg ( i), ff ( i) )
12     END IF
13   pclt = PR_TMST(pthte(i),pbar,0.0)
14   tenv = t(i) + 273.16
15   pcldif = pclt - tenv
16   IF ( pcldif .gt. 20.0 ) THEN
17     wsq = 0.0
18   ELSE
19     IF ( ABS(ff(i)) .lt. .00005 ) THEN
20       wsq = 2.0*tkns(i)*GRAVITY*pcldif/tenv
21     ELSE
22       wsq = 2.0*tkns(i)*GRAVITY*pcldif/tenv +
23       + 0.5*ff(i)/vort*gwshrsq(i)
24     END IF
25   END IF
26   IF ( (wsq .gt. 0.0) .and. (.not. abvlfc(i)) ) THEN
27     abvlfc ( i) = .true.
28   END IF
29 ELSE
30   wsq = 0.0
31   END IF
32   vvsq = vvbbase(i)*vvbase(i) + wsq
33   IF ( vvsq .lt. 0.0 ) THEN
34     wwnd(i) = 0.0
35   ELSE
36     wwnd(i) = SQRT (vvsq)
37   END IF
38   wmean = (vvbase(i)+wwnd(i))/2.
```

```

1 C
2 C* Compute EDR from updraft speed (wmean).
3 C
4 IF ( wmean .gt. 10.0 ) THEN
5   edr(i) = (.06 + .009*(wmean-10.0))**.333
6 ELSE
7   edr(i) = (.006*wmean)**.333
8 END IF
9 C
10 C* Compute downdraft velocities and downdraft edr
11 C
12     jj = 1
13   fl = 304.8
14   DO WHILE ( fl .le. 6097. )
15     DO i = 1, maxpts
16       IF (edrlow(jj,i) .ne. RMISSD .or. windex(i) .ne. RMISSD)
17         +
18           THEN
19           edrdown = 0.0
20           IF ( maxvv(i) .gt. 10. ) THEN
21             frzmsl = frzlz(i) + sfcz(i)
22             IF ( fl .gt. sfcz(i) .and. fl .lt. frzmsl ) THEN
23               wdown = windex(i)*(frzmsl-fl)/frzlz(i)
24             IF ( wdown .gt. 10.0 ) THEN
25               edrdown = (.06+.009*(wdown-10.0))**.333
26             ELSE IF ( wdown .gt. 0.0 ) THEN
27               edrdown = (.006*wdown)**.333
28             END IF
29           END IF
30         edr (i) = MAX (edrlow(jj,i), edrdown)
31       ELSE
32         edr(i) = RMISSD
33       END IF
34     END DO
35

```

36 **[00154]** Then the DATCM/ VVSTORMSE component (or subcomponent/program) masks
37 the potential turbulence forecast with convective observations and/or future derived

1 observations 3008. The following provides an example code fragment addressing this aspect for
2 some embodiments of the DATCM/VVSTORMSE component(s)/subcomponent(s):

```
3 C
4 C* Open radar file and read echo tops.
5 C* Gdrfileradar echo top filename
6 C* Etop echo top (computed by DG_GRID)
7 C* Gdefileedr filename
8 C* El equilibrium level
9 C* Edr potential edr at flight level
10 C
11 CALL DG_NFIL ( gdrfile, '', iret )
12 IF ( iret .ne. 0 ) THEN
13   write (6,*) 'Unable to process radar file input'
14   STOP
15 END IF
16 CALL DG_NDTM ( fhrdr, iret )
17 grdnam = ' '
18 gpack = 'NONE'
19 CALL DG_NTIM ( .false., .false., time, nexttm, ier )
20 CALL TG_DUAL ( time, timfnd, ier )
21 gvcord = 'NONE'
22   glevel = '0'
23 gfunc = 'QUO(NET,.003048)'
24 CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, etop,
25   + igx, igy, time, level, ivcord, parm, iret )
26 C
27 C* Open edr file and read edr data.
28 C
29 CALL DG_NFIL ( gdefile, gdout, iret )
30 IF ( iret .ne. 0 ) THEN
31   write (6,*) 'Unable to process edr file input'
32   STOP
33 END IF
34 CALL DG_NDTM ( fhedr, iret )
35 grdnam = ' '
36 gpack = 'NONE'
37 CALL DG_NTIM ( .false., .false., time, nexttm, ier )
```

```
1 CALL TG_DUAL ( time, timfnd, ier )
2 gvcord = 'NONE'
3     glevel = '0'
4 gfunc = 'EQLV'
5 CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, el,
6     + igx, igy, time, level, ivcord, parm, iret )
7     maxpts = igx*igy
8 C*
9 gvcord = 'HGHT'
10 CALL LV_CORD ( gvcord, sparm, ivcord, iret )
11 C
12 C* Find levels.
13 C
14 CALL DG_GLEV ( 1, time, ivcord, LLMXLV,
15     + iflev, nlev, iret )
16 DO j = 1, nlev
17     rlevel (j) = FLOAT ( iflev (1,j) )
18 END DO
19 CALL LV_SORT ( ivcord, nlev, rlevel, iret )
20 C
21 C
22 DO j = 1, nlev
23     CALL ST_INCH ( INT(rlevel(j)), glevel, iret )
24 C
25 C*   Read edr grid.
26 C
27 gvcord = 'HGHT'
28 gfunc = 'EDR'
29 CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, edr,
30     + igx, igy, time, level, ivcord, parm, iret )
31 C
32 C*       Mask edr data with echo tops > el.
33 C
34     DO i = 1, maxpts
35         IF ( etop(i) .eq. RMISSD .or. el(i) .eq. RMISSD ) THEN
36             edr(i) = RMISSD
37         ELSE IF ( etop(i) .lt. el(i) ) THEN
38             edr(i) = 0.0
```

```
1           END IF
2           END DO
```

3
4 **[00155]** Observations may be, by way of non-limiting example, radar, satellite, and/or lightning data and the future derived observations may be numerically predicted future projections of radar, satellite, and/or lightning; and/or the like. Observations may be received and/or imported as data files representing data such as is shown in Figures 30B and 30D. In the case of radar data, only those radar areas whose tops exceed the equilibrium level (EL) – the level at which storm updrafts begin to decelerate (e.g., calculated as discussed previously) – mask the VVSTORMSE potential turbulence area at each altitude. Figure 30F illustrates determined equilibrium levels for this example. Whenever storm tops exceed the EL, the storms have reached their full potential to produce turbulence. A non-limiting example of masking is illustrated by the example code fragment below:

```
14 C
15 C*           Mask edr data with echo tops > el.
16 C
17   DO i = 1, maxpts
18       IF ( etop(i) .eq. RMISSD .or. el(i) .eq. RMISSD ) THEN
19           edr(i) = RMISSD
20       ELSE IF ( etop(i) .lt. el(i) ) THEN
21           edr(i) = 0.0
22       END IF
23   END DO
```

24
25 **[00156]** Similarly, in some implementations, satellite derived convective cloud nowcasts may be applied to additionally or alternatively mask off convectively induced turbulence areas. Lightning density data above a specified threshold(s) or parameter(s) may also be used as a mask in some embodiments. In some embodiments of the DATCM, the VVSTORMSE is configured to discern more detail about the turbulence threat than a simple binary (yes/no) answer that a radar-only or a lightning-only decision method would make. The innovative combination of observations and forecasts enabled by DATCM and/or VVSTORMSE provide storm observations in proper context, and reducing or eliminating the need for user-interpretation.

1 [00157] In one implementation of the DATCM, VVSTORMSE finds a parcel based on
2 specified parameters, such as the most unstable parcel below the 500 mb level, at each grid
3 point. Then it lifts this parcel to find its level of free convection (LFC) if there is one. If it has an
4 LFC, then VVSTORMSE determines the upward vertical velocity that the parcel would have.
5 VVSTORMSE determines the turbulence potential in eddy dissipation rate (EDR) from the
6 potential vertical velocity, the maximum vertical velocity defining the equilibrium level (EL),
7 the level at which the parcel begins to decelerate. Then VVSTORMSE determines a potential
8 downward vertical velocity and the potential EDR from potential downward motion. In such an
9 implementation, VVSTORMSE determines potential EDR grids at flight levels at specified
10 intervals, such as every 1000 ft from the surface to the numerical calculation's highest level,
11 such as is shown in the exemplary code fragment below:

```
12 C
13 C*           Open radar file and read echo tops.
14 C
15 CALL DG_NFIL ( gdrfile, '', iret )
16 IF ( iret .ne. 0 ) THEN
17     write (6,*) 'Unable to process radar file input'
18     STOP
19 END IF
20 CALL DG_NDTM ( fhrdr, iret )
21 grdnam = ' '
22 gpack = 'NONE'
23 CALL DG_NTIM ( .false., .false., time, nxttm, ier )
24 CALL TG_DUAL ( time, timfnd, ier )
25 gvcord = 'NONE'
26     glevel = '0'
27 gfunc = 'QUO(NET,.003048)'
28 CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, etop,
29     +         igx, igy, time, level, ivcord, parm, iret )
30 C
31 C*           Open edr file and read edr data.
32 C
33 CALL DG_NFIL ( gdefile, gdout, iret )
34 IF ( iret .ne. 0 ) THEN
35     write (6,*) 'Unable to process edr file input'
```

```
1      STOP
2      END IF
3      CALL DG_NDTM ( fhedr, irect )
4      grdnam = ' '
5      gpack = 'NONE'
6      CALL DG_NTIM ( .false., .false., time, nxttm, irect )
7      CALL TG_DUAL ( time, timfnd, irect )
8      gvcord = 'NONE'
9          glevel = '0'
10     gfunc = 'EQLV'
11     CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, el,
12         +         igx, igy, time, level, ivcord, parm, irect )
13         maxpts = igx*igy
14     C*
15     gvcord = 'HGHT'
16     CALL LV_CORD ( gvcord, sparm, ivcord, irect )
17     C
18     C*         Find levels.
19     C
20     CALL DG_GLEV ( 1, time, ivcord, LLMXLV,
21         +         iflev, nlev, irect )
22     DO j = 1, nlev
23         rlevel (j) = FLOAT ( iflev (1,j) )
24     END DO
25     CALL LV_SORT ( ivcord, nlev, rlevel, irect )
26     C
27     C
28     DO j = 1, nlev
29         CALL ST_INCH ( INT(rlevel(j)), glevel, irect )
30     C
31     C*         Read edr grid.
32     C
33     gvcord = 'HGHT'
34     gfunc = 'EDR'
35     CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, edr,
36         +         igx, igy, time, level, ivcord, parm, irect )
37     C
38     C*         Mask edr data with echo tops > el.
```

```

1      C
2          DO i = 1, maxpts
3              IF ( etop(i) .eq. RMISSD .or. el(i) .eq. RMISSD ) THEN
4                  edr(i) = RMISSD
5              ELSE IF ( etop(i) .lt. el(i) ) THEN
6                  edr(i) = 0.0
7              END IF
8          END DO

```

9

10 **[00158]** For example, Figure 30A provides an example VVSTORMSE component output
 11 of turbulence potential for one such grid at FL250 from the one-hour rapid refresh forecast
 12 verifying at 1500 UTC. The figure shows widespread potential for strong turbulence (e.g., EDR
 13 > .55).

14 **[00159]** VVSTORMSE and/or a second VVSTORMSE component/subcomponent and/or
 15 program may then mask the potential turbulence forecast with convective observations and
 16 future-derived observations, including radar echo tops, lightning strikes, and satellite data,
 17 including but not limited to satellite overshoot detection data. Depending on the
 18 implementation, observations may be radar, satellite, lightning data, and/or the like, and the
 19 future-derived observations may be numerically predicted future projections of radar, satellite,
 20 lightning, and/or the like. In some embodiments, for radar data, only those radar areas whose
 21 tops exceed the EL mask of the VVSTORMSE potential turbulence area(s) at each altitude are
 22 utilized. In some implementations, when storm tops exceed the EL, the storms may be specified
 23 as having reached their full potential to produce turbulence.

24 **[00160]** Figure 30B shows observed radar top data at 1500 UTC (radar echo tops in 1000s
 25 of feet). The VVSTORMSE component identifies active convective tops, i.e., tops above the
 26 equilibrium level. Note that the equilibrium level may vary from location to location, and may
 27 not be a set particular value for a region (i.e., it varies across the map), for example, as
 28 illustrated in Figure 30F. The tops identified as active convective tops may then be used to mask
 29 the turbulence potential. The following code fragment illustrates an example embodiment of a
 30 methodology for masking:

```

31      C
32      C*          Open radar file and read echo tops.
33      C

```

```
1  CALL DG_NFIL ( gdrfile, '', ired )
2  IF ( ired .ne. 0 ) THEN
3      write (6,*) 'Unable to process radar file input'
4      STOP
5  END IF
6  CALL DG_NDTM ( fhrdr, ired )
7  grdnam = ' '
8  gpack = 'NONE'
9  CALL DG_NTIM ( .false., .false., time, nexttm, ired )
10 CALL TG_DUAL ( time, timfnd, ired )
11 gvcord = 'NONE'
12     glevel = '0'
13 gfunc = 'QUO(NET,.003048)'
14 CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, etop,
15 +           igx, igy, time, level, ivcord, parm, ired )
16 C
17 C*           Open edr file and read edr data.
18 C
19 CALL DG_NFIL ( gdefile, gdout, ired )
20 IF ( ired .ne. 0 ) THEN
21     write (6,*) 'Unable to process edr file input'
22     STOP
23 END IF
24 CALL DG_NDTM ( fhedr, ired )
25 grdnam = ' '
26 gpack = 'NONE'
27 CALL DG_NTIM ( .false., .false., time, nexttm, ired )
28 CALL TG_DUAL ( time, timfnd, ired )
29 gvcord = 'NONE'
30     glevel = '0'
31 gfunc = 'EQLV'
32 CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, el,
33 +           igx, igy, time, level, ivcord, parm, ired )
34     maxpts = igx*igy
35 C*
36 gvcord = 'HGHT'
37 CALL LV_CORD ( gvcord, sparm, ivcord, ired )
38 C
```

```

1      C*           Find levels.
2      C
3      CALL DG_GLEV ( 1, time, ivcord, LLMXLV,
4          +         iflev, nlev, irect )
5      DO j = 1, nlev
6          rlevel (j) = FLOAT ( iflev (1,j) )
7      END DO
8      CALL LV_SORT ( ivcord, nlev, rlevel, irect )
9      C
10     C
11     DO j = 1, nlev
12         CALL ST_INCH ( INT(rlevel(j)), glevel, irect )
13     C
14     C*           Read edr grid.
15     C
16     gvcord = 'HGHT'
17     gfunc = 'EDR'
18     CALL DG_GRID ( timfnd, glevel, gvcord, gfunc, pfunc, edr,
19         +         igx, igy, time, level, ivcord, parm, irect )
20     C
21     C*           Mask edr data with echo tops > el.
22     C
23     DO i = 1, maxpts
24         IF ( etop(i) .eq. RMISSD .or. el(i) .eq. RMISSD ) THEN
25             edr(i) = RMISSD
26         ELSE IF ( etop(i) .lt. el(i) ) THEN
27             edr(i) = 0.0
28         END IF
29     END DO

```

31 **[00161]** Figure 30C shows the subsequent mask – that is, the FL250 EDR resulting from
32 masking the data shown in Figure 30A with the data of Figure 30B. The results are grids of the
33 areas of active convective turbulence. As can be seen, there are areas of strong convection
34 across southeastern Missouri and northern Iowa. There is some convection over northeastern
35 Iowa, but the VVSTORMSE component identifies that that turbulence is relatively weaker. As
36 such, the DATCM may be able to facilitate aircraft navigation over the turbulence in
37 northeastern Iowa, even though there are radar echoes in that area.

1 [00162] In some embodiments, lightning flash density data within identified
2 parameters/above a specified threshold may be used as a mask, as illustrated in Figures 30D and
3 30E. Figure 30D illustrates lightning flash density per 100 km² in the 10 minutes prior to 1500
4 UTC, although other parameters, factors and/or measures may be utilized, depending on the
5 embodiment, for example, lightning data may be determined and/or received and/or processed
6 on a regional, national and/or global scale. In the figure, the lightning flash density appears to be
7 highest over central Illinois. Lightning flash density information may be derived from a variety
8 of sources, including stationary sensors, mobile sensors, satellites, and/or the like. Real-time or
9 near real-time lightning flash or strike data may also be provided via a feed, such as
10 SCHNEIDER ELECTRIC MXVISION WEATHERSENTRY and/or NATIONAL
11 LIGHTNING DETECTION NETWORK data. In some embodiments, the DATCM may utilize
12 real-time lightning detection data and/or data directed to advance warning of impending
13 lightning, including quantifiable parameters such as the time and location of recent strikes and
14 dynamics, such as rate of movement, direction and intensity of the associated storm. In some
15 embodiments, lightning grid data, such as illustrated in Figure 30D, is generated by creating an
16 initial grid of zeros where lightning point data is placed on the grid by rounding the
17 latitude/longitude pairs to the nearest grid point which creates a grid of lightning density, which
18 may then be provided as input to the VVSTORMSE component. In some embodiments,
19 lightning data is generated by creating an initial 3-Dimensional grid of zeros where lightning
20 point data is placed on the 3D grid by rounding the latitude/longitude/altitude triples to the
21 nearest 3D grid point which creates a three dimensional grid of lightning density, which may
22 then be provided as input to the VVSTORMSE component.

23 [00163] Figure 30E illustrates FL250 EDR derived by masking the data of Figure 30A
24 with the Figure 30D lightning density data greater than zero. Note that the areas identified in
25 Figure 30C and 30E are similar, but are not the same. Depending on the embodiment and/or
26 implementation, the DATCM may utilize echo top data, lightning data, or a combination or
27 hybrid to mask the convective turbulence and identify warning areas or zones. In some
28 embodiments, different masking data may be weighted differently (e.g., storm top data 0.30 and
29 lightning flash data 0.70), and in some implementations, the weighting may be configured to be
30 adjusted dynamically, for example, based on real-time weather and/or geo-location data.

1 [00164] Note that not all highlighted areas in Figures 30C and 30E are for severe
2 turbulence (colored red). In some embodiments, DATCM/VVSTORMSE has the ability to
3 discern more detail about the turbulence threat than a simple binary (e.g., yes/no) answer that a
4 radar-only or a lightning-only decision method would provide. The unique combination of
5 observations and forecasts of DATCM/VVSTORMSE provide storm observations into proper
6 context, without requiring user interpretation.

7 [00165] In some embodiments, the DATCM/VVSTORMSE finds the most unstable air
8 parcel and assumes that the parcel has potential instability at the LFC. The DATCM determines
9 if the parcel is moist, and if so, lifts the parcel along the moist adiabat (moist lifting line). Such
10 implementations allow for determination of interrelated factors, for example, knowing how high
11 the parcel is lifted (e.g., to the next level) can be used to determine the moisture content and
12 temperature based on the interrelationship. If the parcel is not moist, the EDR may, in some
13 implementations, be set to null, although in some embodiments, if the parcel is not moist, the
14 parcel may be raised along the dry adiabat (or dry lifting line). The DATCM may compare lifted
15 temperature to the environmental temperature to determine a buoyant acceleration. The
16 DATCM may utilize the acceleration and vertical velocity at the base of the layer to identify the
17 vertical velocity at the top of the layer, and may compute the updraft EDR based on the updraft
18 speed.

19 [00166] The DATCM, in some embodiments, determines the downdraft EDR based on the
20 maximum value of the downdraft (e.g., maximum downdraft velocity). In some
21 implementations, the DATCM begins at the freezing level (i.e., the level in atmosphere where
22 temp is zero degrees Celsius) and accelerates (e.g., via linear interpolation from freezing level to
23 the surface level) until the maximum velocity at the level of the ground.

24 [00167] The DATCM utilizes updraft and/or downdraft parameters (i.e., velocities) to
25 compute EDRS. In some embodiments, for example, if downdraft velocity is greater than
26 updraft velocity at a given point, the downdraft velocity is used to determine the EDR for the
27 point. In some embodiments of the DATCM/VVSTORMSE, if a parcel in a layer is warmer
28 than its environment, it gets accelerated upward, and that acceleration/velocity used to compute
29 EDR. In some implementations, the DATCM utilizes vertical temperature change in

1 determining the EDR, while further implementations also utilize horizontal temperature
2 changes.

3 **[00168]** Figure 31 provides an exemplary logic flow diagram illustrating storm EDR
4 determination and masking for an embodiment of the DATCM and/or VVSTORMSE
5 component. For each parcel 3130 (the parameters of which may be previously specified or may
6 dynamically configured for a particular user or implementation), a binary determination of
7 moist is made 3132 and if not, the EDR set to null. If the parcel is moist 3132, and if the lifted
8 condensation level pressure is greater than the current layer pressure level 3134, the parcel
9 temperature 3136 and environmental temperature 3138 are determined. The below example
10 code fragment illustrates parcel temperature determination at a particular level on a specified
11 moist adiabat:

12 **[00169]** Figure 31 provides and exemplary logic flow diagram illustrating storm EDR
13 determination and masking for an embodiment of the DATCM and/or VVSTORMSE
14 component. For each parcel 3130 (the parameters of which may be previously specified or may
15 dynamically configured for a particular user or implementation), a binary determination of
16 moist is made 3132 and if not, the EDR set to null. If the parcel is moist 3132, and if the lifted
17 condensation level pressure is greater than the current layer pressure level 3134, the parcel
18 temperature 3136 and environmental temperature 3138 are determined. The below example
19 code fragment illustrates parcel temperature determination at a particular level on a specified
20 moist adiabat:

```

21 C-----
22 IF ( ERMIS ( thte ) .or. ERMIS ( pres )
23     +           .or. ERMIS ( tguess ) .or. ( thte .le. 0. )
24     +           .or. ( pres .le. 0 ) .or. ( tguess .lt. 0. ) ) THEN
25     PR_TMST = RMISSD
26     RETURN
27 END IF
28 C
29 C*           Move tguess into another variable.
30 C
31 tg = tguess
32 C
33 C*           If TGUESS is passed as 0. it is computed from an MIT scheme.

```

88

```
1 C
2 IF ( tg .eq. 0. ) tg =
3     * ( thte - .5 * ( MAX ( thte-270., 0. ) ) ** 1.05 )
4     * * ( pres / 1000. ) ** .2
5 C
6 C*      Set convergence and initial guess in degrees C.
7 C
8 epsi = .01
9 tgnu = PR_TMKC ( tg )
10 C
11 C*      Set a limit of 100 iterations.  Compute TENU, TENUP, the
12 C*      THTE's at, one degree above the guess temperature.
13 C
14 DO i = 1, 100
15     tgnup = tgnu + 1.
16     tenu = PR_THTE ( pres, tgnu, tgnu )
17     tenup = PR_THTE ( pres, tgnup, tgnup )
18 C
19 C*      Check that the THTE's exist.
20 C
21 IF ( ( ERMISS ( tenu ) ) .or. ( ERMISS ( tenup ) ) ) THEN
22     PR_TMST = RMISSD
23     RETURN
24 END IF
25 C
26 C*      Compute the correction, DELTG; return on convergence.
27 C
28 cor = ( thte - tenu ) / ( tenup - tenu )
29 tgnu = tgnu + cor
30 IF ( ( cor .lt. epsi ) .and. ( -cor .lt. epsi ) ) THEN
31     PR_TMST = PR_TMCK ( tgnu )
32     RETURN
33 END IF
34 END DO
35 C
36 C*      Failed to converge - return missing.
37 C
38 PR_TMST = RMISSD
```

1 RETURN

2 END

3

4

5 **[00170]** The DATCM may determine the difference between the parcel temperature and
6 the environment temperature 3140 and determines the vertical acceleration 3144 (e.g., based on
7 the layer thickness, temperature difference, environmental temperature, gravitational constant,
8 and/or the like). If the parcel is moist 3132, and if the lifted condensation level pressure is not
9 greater than the current layer pressure level 3134, the vertical acceleration is set to zero 3135.
10 The vertical velocity at the top of the layer is determined 3148 (e.g., based on the acceleration
11 and the base vertical velocity) and the mean upward vertical velocity for the parcel is
12 determined 3150 (e.g., based on the average of the base and top vertical velocities). The mean
13 vertical velocity may then be utilized to determine the updraft EDR 3152 for that layer/parcel.
14 The actual downward vertical velocity is determined 3154 (e.g., based on the freezing level and
15 maximum downward vertical velocity) and the downdraft EDR determined 3158 for that
16 layer/parcel. The DATCM determines the overall EDR 3158 from the updraft and downdraft
17 determinations, for example, in some implementations, the larger of the updraft EDR and
18 downdraft EDR.

19 **[00171]** The DATCM may then retrieve and/or receive masking data 3171, such as radar
20 echo top data and/or lightning flash density data. In the radar echo top data implementation, for
21 each layer (point), if the echo top is less than the equilibrium level 3173, the EDR is masked
22 3175 (e.g., set to zero). If the echo top is not less than the equilibrium level 3173, the EDR is
23 unchanged 3177.

24 **[00172]** Figure 32 provides an exemplary logic flow diagram illustrating aspects of a
25 VVSTORMSE component operation for an embodiment of the DATCM. For each parcel 3230
26 (the parameters of which may be previously specified or may dynamically configured for a
27 particular user or implementation), a moist determination is made 3232 and if not, the EDR set
28 to null. If the parcel is moist 3232, and if the lifted condensation level pressure is not greater
29 than the current layer pressure level 3234, the vertical acceleration is set to zero 3235. If the
30 parcel is moist 3232, and if the lifted condensation level pressure is greater than the current
31 layer pressure level 3234, the parcel temperature is determined 3236 and environmental
32 temperature is determined 3238, along with the difference between them 3240. As a quality

1 control, if the determined difference is not within parameters 3242, the vertical acceleration is
 2 set to zero 3235. If the determined difference is within parameters 3242, the vertical
 3 acceleration is determined 3244. If the vertical acceleration is negative 3246, the vertical
 4 velocity at the top is set to zero 3247. If the vertical acceleration is not negative 3246, the
 5 vertical velocity at the top of the layer is determined 3248 and the mean upward vertical
 6 velocity is determined 3250. The mean vertical velocity may then be utilized to determine the
 7 updraft EDR 3252. The actual downward vertical velocity is determined 3254 and the
 8 downdraft EDR is determined 3258, and the overall EDR is determined 3258. The EDR data
 9 may then be masked by echo top data, lightning flash density data, and/or storm overshoot data
 10 3269.

11 **[00173]** Figure 33 illustrates an embodiment of the DATCM's integration component.
 12 Beginning with weather, turbulence, lightning, radar, satellite, terrain, model, sensor, and/or like
 13 data input 3301, which may, in some implementations, provide the DATCM with four-
 14 dimensional grid points (three-dimensional space plus time), temperature, winds, humidity,
 15 topography, current turbulent conditions, lightning data, radar data, satellite data, model data,
 16 historical conditions, and/or the like, the DATCM may, in some embodiments, first process the
 17 input through a mountain wave turbulence (MWAVE) component. The non-dimensional
 18 mountain wave amplitude (\hat{a}_{mv}) 3302 and computes the mountain top wave drag 3303. The
 19 following code fragment shows one embodiment of a methodology for such processing:

```

20
21 C
22 C* a is the non-dimensional wave amplitude (at mountain top)
23 C
24   a (i,m,n) = stab0*h(m,n)/spd0
25   h0 (m,n) = a(i,m,n)
26 C
27 C* ddrct is the wind and mountain top wind direction difference
28 C
29   ddrct = ABS(drct-drct0(m,n))
30   IF ( (ddrct .lt. 90.0) .or. (ddrct .gt. 270.0) ) THEN
31 C
32 C* a above the mountain top is adjusted for stability, wind,
33 C* and density changes.
```

```
1 C
2     a (i,m,n) = stab*h(m,n)/spd/COS(DDRCT*DTR)*
3     + SQRT(pnu0(m,n)/(pmodel*stab*spd))
4     ELSE
5     a (i,m,n) = 0.0
6     END IF
7 C
8 C* maximum a is 2.5
9 C
10    IF ( a(i,m,n) .gt. 2.5 ) a(i,m,n) = 2.5
11 C
12 C* Find max 'a' below h0max.
13 C
14    IF (ll .lt. nlyrs) THEN
15        amax0 = a(ll,m,n) - (zsdg(ll,m,n)-h0max)/
16        + (zsdg(ll,m,n)-zsdg(ll+1,m,n))*
17        + (a(ll,m,n)-a(ll+1,m,n))
18        lll = ll
19        DO i = ll,1,-1
20            IF ( (a(i,m,n) .ne. RMISSD) and.
21            + (a(i,m,n) .gt. amax0) ) THEN
22                lll = i-1
23                amax0 = a(i,m,n)
24            END IF
25        END DO
26 C
27 C* 'a' is increased at all levels below max 'a'.
28 C
29        DO i = lll,1,-1
30            IF (a(i,m,n) .ne. RMISSD) THEN
31                a(i,m,n) = amax0
32                enhc(i,m,n) = 1.0
33            END IF
34        END DO
35    END IF
36 C
37 C* Find .75 vertical wavelength (and 1.75, 2.75, 3.75).
38 C
```

```

1   zrefl = (nn + .75)*lambda(m,n) + elv(m,n)
2   ll = 1
3   DO i = 1,nlyrs
4     IF ( zsdg(i,m,n) .lt. zrefl ) ll = i
5   END DO
6   IF (ll .lt. nlyrs) THEN
7     ar = a(ll,m,n) - (zsdg(ll,m,n)-zrefl)/
8     + (zsdg(ll,m,n)-zsdg(ll+1,m,n))*
9     + (a(ll,m,n)-a(ll+1,m,n))
10  C
11 C* Find .50 vertical wavelength (and 1.50, 2.50, 3.75).
12 C
13   zhalf = (nn + .50)*lambda(m,n) + elv(m,n)
14   lll = 1
15   DO i = 1,ll
16     IF ( zsdg(i,m,n) .lt. zhalf ) lll = i
17   END DO
18   ahalf = a(lll,m,n) - (zsdg(lll,m,n)-zhalf)/
19   + (zsdg(lll,m,n)-zsdg(lll+1,m,n))*
20   + (a(lll,m,n)-a(lll+1,m,n))
21 C
22 C* 'a' is increased by reflected 'a' if layered
23 C* favorably.
24 C
25   IF ( ( ahalf .lt. ar ).and.( ahalf .lt. 0.85 ) )THEN
26     rcoeff = (ar-ahalf)**2/(ar+ahalf)**2
27     refl = rcoeff*ar
28     havrfl = .true.
29   DO i = ll,1,-1
30     IF ( (a(i,m,n) .ne. RMISSD) .and.
31     + (havrfl) ) THEN
32       arfl = a(i,m,n) + refl
33       a (i,m,n) = arfl
34       IF ( a(i,m,n) .gt. 2.5 ) a(i,m,n) = 2.5
35       enhc (i,m,n) = 1.0
36     END IF
37   END DO
38 C

```

1 C* Compute mountain top wave drag

2 C

3 drag (m,n) = PI/4.0*h(m,n)*pnu0(m,n)

4

5 **[00174]** In some embodiments of the DATCM, output obtained from the MWAVE
 6 component may then be directed into an integrated turbulence (INTTURB) component, which
 7 computes upper level non-dimensional gravity wave amplitude (\hat{a}_{ul}) 3304, and sum \hat{a}_{mv} and \hat{a}_{ul}
 8 into (\hat{a}) to determine buoyant turbulent kinetic energy (TKE_{buoy}) 3305. If \hat{a} is greater than 1
 9 3306, then $TKE_{buoy} = TKE_{mv} + TKE_{ul-buoy}$ 3307. Otherwise, $TKE_{buoy} = 0$ 3308. If \hat{a} greater than
 10 \hat{a}_{min} 3309, then $TKE = TKE_{ul-wshr}$ 3310. The boundary layer eddy dissipation rate (EDR) is
 11 computed 3311 and if EDR_{bl} is greater than zero and \hat{a}_{mv} is not enhanced 3312, then the $EDR =$
 12 EDR_{bl} 3313, else the EDR is the $TKE^{1/3}$ 3314.

13 **[00175]** The following code fragment shows one embodiment of a methodology for
 14 processing of the INTTURB:

15 C* Non-dimensional L-F amplitude is square root of L-F radiation

16 C* divided by constant. Constant is for 20km resolution grids

17 C* and is proportionally scaled to resolution of current grid.

18 C

19 ahatlf = SQRT(ABS(lfrac)/cc*gdd/20000.)

20 C

21 C

22 C* ahat is sum of lf and mw ahats

23 C

24 ahat = ahatlf + ahatmw(i)

25 C

26 C* Maximum ahat = 2.5

27 C

28 IF (ahat .gt. 2.5) ahat = 2.5

29 IF (ahat .gt. 1.0) THEN

30 C

31 C* mountain wave tke is proportional to drag.

32 C

33 tkemw = drag(i)*.0004

34 C

35 C* Reduce mw drag above this level

```

1 C
2   IF ( nhnc(i) .eq. 0.0 )
3     + drag(i) = drag(i)*((2.5-ahat)/1.5)
4     tkebuoy = kh*(ahat-1.0)*bvsq(i) + km*wshrsq(i)
5     + + tkemw
6   IF (ahat .lt. 1.0) THEN tkebuoy = 0.0
7   tke = km*wshrsq(i)*(1.0 + SQRT(rich)*ahat)**2
8     + -kh*bvsq(i)
9 C
10 C* Compute layer stability and wind shear
11 C
12   thtamn = ( thta + sfcthta )/2.0
13   bvsq = GRAVITY*thtadf/zdf/thtamn
14   udf = u - sfcu
15   vdf = v - sfcv
16   wshrsq = ( udf*udf + vdf*vdf )/zdf/zdf
17 C
18 C* Compute tke with equation
19 C
20   tke = km*wshrsq - kh*bvsq
21 C
22 C* If the < 0, we've reach top of boundary layer. Set topbl = T
23 C
24   IF ( tke .lt. 0.0 ) THEN
25     edrbl = 0.0
26     topbl = .true.
27   ELSE
28     edrbl = tke**.333
29   END IF

```

30

31

32 **[00176]** In some embodiments, output obtained from the MWAVE and INTTURB
33 components may then be processed through a VVSTORMSE integration component. For each
34 parcel 3330 a moist determination is made 3332 and if not, the EDR set to null. If the parcel is
35 moist 3332, and if the lifted condensation level pressure is greater than the current layer
36 pressure level 3334, the difference between the parcel temperature and environmental
37 temperature 3340 and vertical acceleration 3344 are determined (e.g., based on the layer

1 thickness, temperature difference, environmental temperature, gravitational constant, and/or the
2 like). If the parcel is moist 3332, and if the lifted condensation level pressure is not greater than
3 the current layer pressure level 3334, the vertical acceleration is set to zero 3335. The vertical
4 velocity at the top of the layer is determined 3348 and the mean upward vertical velocity is
5 determined 3350. The mean vertical velocity may then be utilized to determine the updraft EDR
6 3352. The actual downward vertical velocity is determined 3354 and the downdraft EDR
7 determined 3358. The overall EDR is determined 3358 for the layer/parcel (e.g., based on
8 updraft and downdraft determinations), and the mask/masking data applied 3359. EDRs from
9 INTURB and VVSTORMSE components are combined/integrated and output 3360. In some
10 embodiments, the EDRs may be summed. In some embodiments, the EDRs are converted to
11 TKE.

12 **[00177]** Figure 34 provides an illustrative overview of features of an implementation of
13 the DATCM. As shown in the figure, at time = 0, no convective storms have developed in the
14 current path of the aircraft. At time = 1, a cumulus tower develops enough to trigger a lightning
15 strike and is processed by the DATCM/VVSTORMSE to identify possible threat area. At time =
16 2, the DATCM/VVSTORMSE identifies that the storm is increasing, identifying threat areas.
17 Based on this, the aircraft is redirected along a path with fewer identified hazards.

18 **[00178]** Embodiments of the DATCM and/or the VVSTORMSE component(s) provide a
19 granular view of the vertical distribution of convective turbulence. In some embodiments, the
20 DATCM is configured for flight following. Some embodiments of DATCM combine
21 determinations of non-convective turbulence forecasts and convective turbulence into a nowcast
22 that may be utilized in the variety of ways, including those discussed herein with respect to
23 flight path determination and other aviation and weather-dependent activities and applications.
24 Some implementations of the DATCM integrate forecast turbulence and storm turbulence to
25 provide comprehensive flight planning, flight following, and/or comprehensive dynamic real-
26 time rerouting for all altitudes. DATCM flight following implementations may provide up-to-
27 date and/or short term forecasts for aircraft in a given area. In some implementations,
28 alerts/updates may be provided to aircraft directly, and/or to dispatchers or other personnel. In
29 some embodiments, the DATCM may be configured to integrate with management suite or
30 application, such as SCHEIDER ELECTRIC AVIATIONSENTRY.

1 [00179] In some embodiments, the DATCM, for example utilizing a VVSTORMSE
2 component, provides a 0-1 hour turbulence nowcast/forecast based on physical relationships
3 rather than solely based on observational/statistical relationships. The VVSTORMSE
4 component is configured with flexible input variables, allowing for elegant adaptation to include
5 indicators of current convection, and for and exploitation of the same, rather than requiring a
6 complete recalibration if a new variable is identified.

7 [00180] For example, in some embodiments of the DATCM, the magnitude of the united
8 effects of a conditionally unstable lapse rate and a parcel with a LFC are elegantly combined in
9 a diagnostic called convective available potential energy (CAPE). The DATCM/VVSTORMSE
10 (VVSTORMSE) may determine (i.e., compute) CAPE by lifting a parcel along the appropriate
11 dry and moist adiabats. If, by lifting, the parcel can become warmer than its environment, the
12 parcel could reach its LFC. Then the parcel will accelerate upward by buoyant forces until it
13 becomes cooler than its environment again – that level is called the Equilibrium Level (EL).
14 The amount of buoyant acceleration at any level is proportional to the temperature difference
15 between the lifted parcel and the environment. Using the determined parcel acceleration, the
16 VVSTORMSE can determine the updraft velocity (w) at any level in a potential storm. In some
17 embodiments, the integrated value of the buoyant potential energy between the LFC and the EL
18 is the CAPE and is equal to the maximum updraft velocity squared over two ($(w_{\max}^2)/2$), where
19 the maximum updraft velocity (w_{\max}) is a measure of the potential strength of a thunderstorm.

20 [00181] In some embodiments, a typical potentially unstable parcel has to be forcefully
21 lifted to its LFC. The integrated amount of force similarly computed as CAPE between the
22 original parcel level and the LFC is called the convective inhibition (CIN). CIN is a measure of
23 the strength of the “cap,” the stable layer above the parcel level that keeps the parcel at its
24 original level. The energy of forced lifting the parcel needs to be greater than the CIN in order
25 for the parcel to reach its LFC. This process may be referred to as “breaking” the cap.
26 VVSTORMSE identifies zones of forced upward lifting. If parcels in those zones can be lifted
27 to their LFC, then VVSTORMSE continues tracking the parcel until it returns to zero
28 somewhere above the EL. The maximum upward vertical velocity is a measure of the storm’s
29 potential strength. The level where the upward velocity returns to zero is a measure of its
30 potential top. If parcels cannot reach their LFC or if parcels have no LFC, then no
31 thunderstorms can form. Maximum vertical speeds that result from forced lifting in current

1 observed or numerical forecast diagnostics are only about 10 cm/s. These motions would be
2 sufficient if CIN values were zero. However, CIN values can be 100 j/kg or more in an
3 otherwise favorable environment. Even if $CIN = 0.5$ j/kg, the forced vertical speed to overcome
4 that value would be 1 m/s. As such, traditional numerical diagnostic vertical motions may be
5 inadequately low.

6 **[00182]** In some embodiments, VVSTORMSE utilizes numerical data to determine
7 vertical motion for lifting from three diagnostics: the dataset's own omega field, vertical motion
8 arising from divergence of frontogenesis vectors, and vertical motion arising from Eckman
9 pumping. The dataset's omega provides sources of vertical motion from processes such as
10 temperature advection and terrain elevation changes. Frontogenesis vectors contain divergence,
11 vorticity, and deformation forcing information so are a complete kinematic description of the
12 vertical motion field. Eckman pumping describes the frictional forcing of vertical motion at the
13 top of the boundary layer and is proportional to the vorticity.

14 **[00183]** In some embodiments, VVSTORMSE may utilize a framework for convective
15 triggers in numerical mechanisms. In some embodiments, VVSTORMSE inflates the maximum
16 diagnostic (w) by:

$$w = w_m * \delta x / L * (1 - z_{agl} / H)$$

17
18
19
20 **[00184]**

21 **[00185]** where w_m is the diagnostic vertical velocity, δx is the grid resolution, $L =$ the grid
22 resolution need to explicitly resolve the vertical motion (e.g., 1 km), z_{agl} is the height above
23 ground, and $H =$ is the threshold height (e.g., 4000 m). This inflated vertical velocity is the
24 maximum possible with the given environmental conditions. The formula shows that the higher
25 the grid resolution (lower δx), the less the inflation. Also, the inflation effect decreases the
26 higher above ground. For example, using a 40 km resolution, a parcel 1 km above ground will
27 have a parameterized vertical velocity 30 (40×0.75) times that computed by a diagnostic. With
28 this formula, a parameterized vertical velocity can be computed at any grid resolution and at
29 every grid level. In some embodiments, at any grid point, a diagnostic vertical velocity may first
30 be determined/computed at the lowest level above ground. If, at the inflated vertical velocity, a
31 parcel reaches its LFC, VVSTORMSE may continue to track the parcel's vertical velocity as it

1 rises buoyantly. If there is a more unstable parcel aloft or if the forced vertical velocity is higher
2 aloft, then the process may begin again at the new level.

3 **[00186]** In a horizontal temperature gradient parcels have an additional instability that
4 arises from an inertial imbalance. This instability reduces CINs and increases CAPEs. Since this
5 additional instability is a function of the square of the temperature gradient, it may be most
6 prominent in frontal zones where thunderstorms are likely to be forced. In some
7 implementations, VVSTORMSE adjusts the layer stability for this effect before determining the
8 parcel's acceleration.

9 **[00187]** In some embodiments, parcel buoyancy is reduced by an elegant bulk entrainment
10 function in which the parcel's wet bulb potential temperature is diluted by a 1% of the
11 environment's wet bulb potential temperature for a given rise (e.g., every 100 m rise) of the
12 parcel.

13 **[00188]** Once thunderstorms form, they may continue to exist even without external lifting
14 mechanisms by creating internal gust fronts that lift parcels into their updrafts. Utilizing mass
15 conservation, the speed of the lifted parcel at the updraft base (w_b) is proportional to the
16 maximum updraft speed by the ratio of the densities at the updraft maximum and at the lifted
17 parcel level. If a forecast updraft exists and the difference between forecast times is below a set
18 level (e.g., three hours or less), for the next forecast time VVSTORMSE predicts where that
19 updraft base will be using a combinatorial storm motion forecasting techniques. The parcel at
20 that new location is lifted at the w_b speed. If it is able to reach its LFC, then VVSTORMSE may
21 create a new updraft. In addition, VVSTORMSE may simulate downdraft effects by
22 suppressing the new forecast time's forced lifting at the storm's old location and at all points
23 between the old and new locations. Such an implementation allows VVSTORMSE to predict a
24 storm's location in an area without any lift evident from the diagnostics.

25 **[00189]** Figure 35 illustrates geostationary operational environmental satellite convective
26 initiation data providing a probability measure that convection will occur within the next two
27 hours. Figure 36 illustrates a convective cloud mask, with cloud mask values in red indicating
28 the presence of immature cumulus and values in green indicate mature cumulus or cirrus clouds.
29 A value of white indicates that no convective cloud is present. Figure 37 provides output of an
30 overshooting top mask for an embodiment. In some embodiments, VVSTORMSE outputs grids

1 of convective vertical velocities at all levels. In addition, it may output grids of the maximum
2 updraft, updraft tops, and updraft triggers. The maximum updraft display illustrates the location
3 and intensity of potential convection. With the temporal resolution of a numerical mechanism,
4 VVSTORMSE output gives guidance forecasts for thunderstorms at specific times for as far out
5 as a numerical mechanism can forecast.

6 **[00190]** Some embodiments of the DATCM provide an integrated turbulence product for
7 use in flight planning, and the product may integrate code/components from turbulence
8 components including ULTURB, BLTURB, and MWAVE into one component/program called
9 INTTURN and another integrating VVTURB with ULTURB and BLTURB called
10 VVINTTURB. Output from a component may in some embodiments be in eddy dissipation rate
11 (EDR), an aircraft-independent metric of turbulence intensity. The component/program may, for
12 example, assign an EDR value at each grid point and at each flight level (FL). Observations of
13 turbulence may also be used for further tuning of the forecast where and when they are available
14 in the near term forecast. Figures 38A-38C illustrate an example of such an integration of
15 turbulence components in a region where mountain wave and upper level turbulence coexist.
16 Figure 38A depicts a 3-hour ULTURB forecast for FL340 from the RUC2 calculation verifying
17 0900UTC, Figure 38B depicts a 3-hour MWAVE forecast for FL340 from the RUC2
18 calculation verifying 0900UTC (+`y), and Figure 38C depicts a 3-hour integrated turbulence
19 forecast for FL340 from the RUC2 calculation verifying 0900UTC (+1y). Note that, while
20 barely any turbulence from MWAVE, and no turbulence from ULTURB, appear in at least
21 some portions of their respective forecasts, the integration of the two together shows severe
22 turbulence. Also note how MWAVE turbulence over Utah is enhanced.

23 **[00191]** Figures 39A-39D show exemplary side-by-side illustrations of convective
24 turbulence forecasts, enhanced by integrating similar components/algorithm used in
25 INTTURB, and using thunderstormns as the source of wave genesis instead of Lighthill-Ford
26 Radiation and mountain barriers. Figures 39A and 39B depict 1-hour turbulence forecasts for
27 FL360 from the RUC2 calculation verifying 1400UTC and showing VVTURB output, without
28 and with storm perimeter turbulence, respectively. Figures 39C and 39D depict 1-hour
29 turbulence forecasts for FL400 from the RUC2 calculation verifying 1400UTC and showing
30 VVTURB output, without and with above storm turbulence, respectively.

1 [00192] Figure 40 provides an exemplary horizontal schematic at FL340 where regions of
2 turbulence are displayed for three sources of turbulence. The shaded areas in Figure 40
3 represent areas where integrated turbulence with multiple turbulence sources can occur. Figure
4 41 depicts an exemplary cross-sectional view of a horizontal schematic such as that of Figure
5 40, plotting from points A to B along a flight path through regions wherein different sources can
6 cause turbulence (e.g., upper level, thunderstorm, mountains), and where combinations of
7 multiple sources can interact with each other to potentially amplify turbulence or create
8 turbulence because of interaction of said sources.

9 [00193] An example flow diagram depicting an integrated turbulence forecast process
10 according to some embodiments is provided in Figure 42. In this example, the data input may
11 include temperatures, winds, humidity, heights, and/or observations such as pilot/aircraft eddy
12 dissipation rate (EDR) values. EDR value is defined as the rate at which kinetic energy from
13 turbulence is absorbed by breaking down the eddied smaller and smaller until all of the energy
14 is converted to heat by viscous forces. EDR is expressed as kinetic energy per unit mass per
15 second in units of velocity squared per second (m^2/s^3). Data inputs and/or terrain statistics may
16 be incorporated into the computation of MWAVE, INTTURB, and VVTURB2, which are in
17 turn factored into a turbulence forecast. An 'inflight' time sequence of forecasted turbulence (in
18 units of EDR*100), as may be generated in some embodiments, is provided in tabular form in
19 Figure 43.

20 [00194] In some embodiments, the output generated by the DATCM is a 4D grid of EDR
21 values in one or more forms, such as GRIB2 format and/or GIS shapefiles, an example of which
22 is provided in Figure 44. EDR is the cube root of the turbulent kinetic energy (TKE). As such,
23 in some embodiments adding the EDR values together from VVTURB2 and INTTURB may be
24 accomplished by first converting the values into TKE, adding them together, and then
25 converting back to EDR (i.e., by taking the cube root of the sum). The example Shapefile output
26 depicted in Figure 44 is for FL300, and could be used with any GIS geospatial display system.

27 [00195] Figure 45B, prepared using the sample dataset provided in Figure 45A, shows a
28 collection of observation points overlaying forecast data prior to interpolating into the forecast
29 data with a point data analysis scheme employing a radius of influence, according to one

1 embodiment. A selection of sample observations outside of the forecast EDR was employed in
2 the creation of Figure 45B.

3 **[00196]** Throughout this disclosure, ‘atmospheric data’ may refer to any environmental
4 data related to the atmosphere, e.g., at some point of interest. By way of non-limiting example,
5 the atmospheric data received and/or processed by the DATCM may include one or more of the
6 following: temperature, moisture/water content, humidity, pressure, wind speed, wind direction,
7 local EDR, wind shear, liquid water content, ozone concentration, pollution, and/or the like.
8 Atmospheric data may comprise partial or full contents of forecasts (e.g., numerical weather
9 forecast data), meteograms, atmospheric soundings, surface observations, radar pictures,
10 meteorological charts (e.g., surface pressure charts), weather maps, numerical weather
11 prediction maps, and/or the like. Atmospheric data may, in some embodiments, be obtained
12 directly or indirectly from sensors (e.g., infrared radiometers, microwave radiometers,
13 hygrometers, pitot-static systems, gyroscopes, thermometers, barometers, optical sensors, radar,
14 lidar, sodar, ceilometers, spectrometers, weather balloons, water vapor sensors, and/or the like),
15 as well as from pilot reports. Depending on the embodiment, instruments (e.g., sensors) for
16 measuring the atmospheric data used by the DATCM may be positioned in/on the aircraft itself,
17 may be located on earth (e.g., as part of a grounded weather station), and/or may be part of an
18 extraneous system, such as a weather balloon, a satellite, or avionics on another
19 aircraft/spacecraft, etc.

20 **[00197]** Various embodiments of the DATCM are contemplated by this disclosure, with
21 the below exemplary, non-limiting embodiments A1-E3 provided to illustrate aspects of some
22 implementations of embodiments of the DATCM.

23 **[00198]** A1. A dynamic DATCM platform processor-implemented flight planning method,
24 comprising: receiving parameter data for an initial anticipated flight plan; determining airfoil
25 type for an aircraft associated with the initial anticipated flight plan; obtaining atmospheric data
26 based on the flight plan parameter data; determining a plurality of four-dimensional grid points
27 based on the flight plan parameter data; determining corresponding icing data for each point of
28 the plurality of four-dimensional grid point based on the airfoil type; determining via a
29 processor a percent power increase for the initial anticipated flight plan; determining an at least
30 one alternative flight plan based on the flight plan parameter data and the determined percent

- 1 power increase for the initial anticipated flight plan; and providing the determined at least one
2 alternative flight plan.
- 3 **[00199]** A2. The method of embodiment A1, wherein the parameter data includes aircraft
4 data.
- 5 **[00200]** A3. The method of embodiment A1 or A2, wherein the parameter data includes
6 the airfoil type.
- 7 **[00201]** A4. The method of any of the preceding embodiments, wherein the initial
8 anticipated flight plan comprises a shortest route flight plan.
- 9 **[00202]** A5. The method of any of the preceding embodiments, wherein the at least one
10 alternative flight plan comprises an optimized route flight plan.
- 11 **[00203]** A6. The method of embodiment A5, wherein the optimized route flight plan is
12 optimized for safety.
- 13 **[00204]** A7. The method of embodiment A6, wherein the optimized route flight plan is
14 optimized for safety and fuel consumption.
- 15 **[00205]** A8. The method of any of the preceding embodiments, wherein the flight plan
16 parameter data includes take-off time.
- 17 **[00206]** A9. The method of any of the preceding embodiments, wherein the flight plan
18 parameter data includes take-off location.
- 19 **[00207]** A10. The method of any of the preceding embodiments, wherein the flight plan
20 parameter data includes destination location.
- 21 **[00208]** A11. A dynamic DATCM platform flight planning system, comprising: means to
22 receive parameter data for an initial anticipated flight plan; means to determine airfoil type for
23 an aircraft associated with the initial anticipated flight plan; means to obtain atmospheric data
24 based on the flight plan parameter data; means to determine a plurality of four-dimensional grid
25 points based on the flight plan parameter data; means to determine corresponding icing data for
26 each point of the plurality of four-dimensional grid point based on the airfoil type; means to
27 determine a percent power increase for the initial anticipated flight plan; means to determine an
28 at least one alternative flight plan based on the flight plan parameter data and the determined

1 percent power increase for the initial anticipated flight plan; and means to provide the
2 determined at least one alternative flight plan.

3 **[00209]** A12. The system of embodiment A11, wherein the parameter data includes
4 aircraft data.

5 **[00210]** A13. The system of embodiment A11 or A12, wherein the parameter data
6 includes the airfoil type.

7 **[00211]** A14. The system of any of embodiment(s) A11, A12, or A13, wherein the initial
8 anticipated flight plan comprises a shortest route flight plan.

9 **[00212]** A15. The system of any of embodiment(s) A11, A12, A13, or A14, wherein the at
10 least one alternative flight plan comprises an optimized route flight plan.

11 **[00213]** A16. The system of embodiment A15, wherein the optimized route flight plan is
12 optimized for safety.

13 **[00214]** A17. The system of embodiment A15 or A16, wherein the optimized route flight
14 plan is optimized fuel consumption.

15 **[00215]** A18. The system of any of embodiment(s) A11, A12, A13, A14, A15, A16, or
16 A17, wherein the flight plan parameter data includes take-off time.

17 **[00216]** A19. The system of any of embodiment(s) A11, A12, A13, A14, A15, A16, A17,
18 or A18, wherein the flight plan parameter data includes take-off location.

19 **[00217]** A20. The system of any of embodiment(s) A11, A12, A13, A14, A15, A16, A17,
20 A18, or A19, wherein the flight plan parameter data includes destination location.

21 **[00218]** A21. A processor-readable non-transitory medium storing processor-issuable
22 dynamic DATCM flight plan generating instructions to: receive parameter data for an initial
23 anticipated flight plan; determine airfoil type for an aircraft associated with the initial
24 anticipated flight plan; obtain atmospheric data based on the flight plan parameter data;
25 determine a plurality of four-dimensional grid points based on the flight plan parameter data;
26 determine corresponding icing data for each point of the plurality of four-dimensional grid point
27 based on the airfoil type; determine a percent power increase for the initial anticipated flight
28 plan; determine an at least one alternative flight plan based on the flight plan parameter data and

- 1 the determined percent power increase for the initial anticipated flight plan; and provide the
2 determined at least one alternative flight plan.
- 3 **[00219]** A22. The medium of embodiment A21, wherein the parameter data includes
4 aircraft data.
- 5 **[00220]** A23. The medium of embodiment A21 or A22, wherein the parameter data
6 includes the airfoil type.
- 7 **[00221]** A24. The medium of any of embodiment(s) A21, A22, or A23, wherein the initial
8 anticipated flight plan comprises a shortest route flight plan.
- 9 **[00222]** A25. The medium of any of embodiment(s) A21, A22, A23, or A24, wherein the
10 at least one alternative flight plan comprises an optimized route flight plan.
- 11 **[00223]** A26. The medium of embodiment A25, wherein the optimized route flight plan is
12 optimized for safety.
- 13 **[00224]** A27. The medium of embodiment A25 or A26, wherein the optimized route flight
14 plan is optimized for fuel consumption.
- 15 **[00225]** A28. The medium of any of embodiment(s) A21, A22, A23, A24, A25, A26, or
16 A27, wherein the flight plan parameter data includes take-off time.
- 17 **[00226]** A29. The medium of any of embodiment(s) A21, A22, A23, A24, A25, A26,
18 A27, or A28, wherein the flight plan parameter data includes take-off location.
- 19 **[00227]** A30. The medium of any of embodiment(s) A21, A22, A23, A24, A25, A26,
20 A27, A28, or A29, wherein the flight plan parameter data includes destination location.
- 21 **[00228]** A31. A dynamic airfoil icing controller/platform flight planning apparatus,
22 comprising: a processor; and a memory disposed in communication with the processor and
23 storing processor-issuable instructions to: receive parameter data for an initial anticipated flight
24 plan; determine airfoil type for an aircraft associated with the initial anticipated flight plan;
25 obtain atmospheric data based on the flight plan parameter data; determine a plurality of four-
26 dimensional grid points based on the flight plan parameter data; determine corresponding icing
27 data for each point of the plurality of four-dimensional grid point based on the airfoil type;
28 determine a percent power increase for the initial anticipated flight plan; determine an at least

1 one alternative flight plan based on the flight plan parameter data and the determined percent
2 power increase for the initial anticipated flight plan; and provide the determined at least one
3 alternative flight plan.

4 **[00229]** A32. The apparatus of embodiment A31, wherein the parameter data includes
5 aircraft data.

6 **[00230]** A33. The apparatus of embodiment A31 or A32, wherein the parameter data
7 includes the airfoil type.

8 **[00231]** A34. The apparatus of any of embodiment(s) A31, A32, or A33, wherein the
9 initial anticipated flight plan comprises a shortest route flight plan.

10 **[00232]** A35. The apparatus of any of embodiment(s) A31, A32, A33, or A34, wherein the
11 at least one alternative flight plan comprises an optimized route flight plan.

12 **[00233]** A36. The apparatus of embodiment A35, wherein the optimized route flight plan
13 is optimized for safety.

14 **[00234]** A37. The apparatus of embodiment A35 or A36, wherein the optimized route
15 flight plan is optimized fuel consumption.

16 **[00235]** A38. The apparatus of any of embodiment(s) A31, A32, A33, A34, A35, A36, or
17 A37, wherein the flight plan parameter data includes take-off time.

18 **[00236]** A39. The apparatus of any of embodiment(s) A31, A32, A33, A34, A35, A36,
19 A37, or A38, wherein the flight plan parameter data includes take-off location.

20 **[00237]** A40. A dynamic DATCM flight planning method, comprising: receiving a PPI
21 flight parameter input associated with an aircraft; determining an airfoil type for the aircraft
22 associated with the PPI flight parameter input; determining atmospheric data based on the PPI
23 flight parameter input; providing the determined airfoil type and atmospheric data to a PPI
24 component for the determination of a PPI icing avoidance value; receiving, from the PPI
25 component, an indication of the determined PPI icing avoidance value; and providing the
26 determined PPI icing avoidance value in response to the PPI flight parameter input.

- 1 [00238] A41. The method of embodiment A40, wherein the PPI flight parameter input is
2 configured to represent the present airfoil configuration and atmospheric conditions being
3 experienced by the aircraft.
- 4 [00239] A42. The method of embodiment A40, wherein the PPI flight parameter input is
5 configured to represent the expected airfoil configuration and atmospheric conditions that will
6 be experienced by the aircraft at a future point in time.
- 7 [00240] A43. The method of embodiment A40, wherein the determined atmospheric data
8 includes a temperature.
- 9 [00241] A44. The method of embodiment A40, wherein the determined atmospheric data
10 includes a value associated with the water content of the atmosphere about the aircraft at a point
11 in time.
- 12 [00242] A45. The method of any of the embodiment(s) A41, A42, A43 or A44 wherein
13 the PPI component is a hardware PPI component.
- 14 [00243] A46. The method of embodiment A45, wherein the hardware PPI component is
15 an ASIC.
- 16 [00244] A47. The method of embodiment A45, wherein the hardware PPI component is an
17 FPGA.
- 18 [00245] A48. The method of any of the embodiment(s) A41, A42, A43 or A44 wherein
19 the PPI component is a PPI component containing processor executable instructions.
- 20 [00246] A49. The method of any of the embodiment(s) A41, A42, A43 or A44 wherein
21 the PPI component is a PPI component composed of two-or-more sub-components.
- 22 [00247] A50. The method of embodiment A49, wherein the PPI component is comprised
23 of a first sub-component in hardware for determining a first value associated with the PPI icing
24 avoidance value and a second sub-component containing processor executable instructions for
25 determining a second value associated with the PPI icing avoidance value.
- 26 [00248] A51. The method of embodiment A50, wherein the first and second value
27 associated with the PPI icing avoidance value are used to determine the PPI icing avoidance
28 value.

1 [00249] AA51. A dynamic DATCM flight planning apparatus, comprising a processor,
2 and a memory disposed in communication with the processor and storing processor-issuable
3 instructions to perform the method of any of embodiments A40-A51.

4 [00250] A52. A dynamic DATCM flight planning system, comprising: means to receive a
5 PPI flight parameter input associated with an aircraft; means to determine an airfoil type for the
6 aircraft associated with the PPI flight parameter input; means to determine atmospheric data
7 based on the PPI flight parameter input; means to provide the determined airfoil type and
8 atmospheric data to a PPI component for the determination of a PPI icing avoidance value;
9 means to receive, from the PPI component, an indication of the determined PPI icing avoidance
10 value; and means to provide the determined PPI icing avoidance value in response to the PPI
11 flight parameter input.

12 [00251] A53. The system of embodiment A52, wherein the PPI flight parameter input is
13 configured to represent the present airfoil configuration and atmospheric conditions being
14 experienced by the aircraft.

15 [00252] A54. The system of embodiment A52, wherein the PPI flight parameter input is
16 configured to represent the expected airfoil configuration and atmospheric conditions that will
17 be experienced by the aircraft at a future point in time.

18 [00253] A55. The system of embodiment A52, wherein the determined atmospheric data
19 includes a temperature.

20 [00254] A56. The system of embodiment A52, wherein the determined atmospheric data
21 includes a value associated with the water content of the atmosphere about the aircraft at a point
22 in time.

23 [00255] A57. The system of any of the embodiment(s) A53, A54, A55 or A56 wherein the
24 PPI component is a hardware PPI component.

25 [00256] A58. The system of embodiment A57, wherein the hardware PPI component is
26 an ASIC.

27 [00257] A59. The system of embodiment A57, wherein the hardware PPI component is an
28 FPGA.

- 1 [00258] A60. The system of any of the embodiment(s) A53, A54, A55 or A56 wherein the
2 PPI component is a PPI component containing processor executable instructions.
- 3 [00259] A61. The system of any of the embodiment(s) A53, A54, A55 or A56 wherein the
4 PPI component is a PPI component composed of two-or-more sub-components.
- 5 [00260] A62. The system of embodiment A61, wherein the PPI component is comprised
6 of a first sub-component in hardware for determining a first value associated with the PPI icing
7 avoidance value and a second sub-component containing processor executable instructions for
8 determining a second value associated with the PPI icing avoidance value.
- 9 [00261] A63. The system of embodiment A62, wherein the first and second value
10 associated with the PPI icing avoidance value are used to determine the PPI icing avoidance
11 value.
- 12 [00262] A64. A dynamic DATCM flight planning system, comprising: means to receive
13 parameter data for an initial anticipated flight plan; means to determine airfoil type for an
14 aircraft associated with the initial anticipated flight plan; means to obtain atmospheric data
15 based on the flight plan parameter data; means to determine a plurality of grid points based on
16 the flight plan parameter data; means to determine corresponding icing data for each grid point
17 of the plurality of grid points based on the airfoil type and atmospheric data; and means to
18 determine a percent power increase for the initial anticipated flight plan.
- 19 [00263] A65. The system of embodiment A64, further comprising means to output the
20 determined percent power increase.
- 21 [00264] A66. The system of embodiment A64 or A65, further comprising means to
22 determine an at least one alternative flight plan.
- 23 [00265] A67. The system of embodiment A66, further comprising means to determine a
24 percent power increase for the at least one alternative flight plan.
- 25 [00266] A68. The system of embodiment A67, further comprising means to output the
26 determined percent power increase for the at least one alternative flight plan.
- 27 [00267] A69. The system of embodiment A67, further comprising means to compare the
28 initial anticipated flight plan and the at least one alternative flight plan.

- 1 [00268] A70. The system of embodiment A69, wherein the comparison is based on
2 determined percent power increase.
- 3 [00269] A71. The system of embodiment A69 or A70, wherein the comparison is based on
4 distance.
- 5 [00270] A72. The system of any of embodiments A69-A71, wherein the comparison is
6 based on flight time.
- 7 [00271] A73. The system of any of embodiments A69-A72, wherein the comparison is
8 based on fuel consumption.
- 9 [00272] A74. The system of any of embodiments A69-A73, wherein the comparison is
10 based on risk.
- 11 [00273] A75. The system of any of embodiments A66-A73, further comprising means to
12 determine at least one alternative flight plan based on the flight plan parameter data and the
13 determined percent power increase for the initial anticipated flight plan.
- 14 [00274] A76. The system of any of embodiments A66-A75, further comprising means to
15 provide the determined at least one alternative flight plan.
- 16 [00275] A77. The system of any of embodiments A64-A76, wherein the grid points are
17 four-dimensional grid points.
- 18 [00276] A78. The system of any of embodiments A64-A77, wherein the parameter data
19 includes aircraft data.
- 20 [00277] A79. The system of any of embodiments A64-A78, wherein the parameter data
21 includes the airfoil type.
- 22 [00278] A80. The system of any of embodiments A64-A79, wherein the initial anticipated
23 flight plan comprises a shortest route flight plan.
- 24 [00279] A81. The system of any of embodiments A66-A80, wherein the at least one
25 alternative flight plan comprises an optimized route flight plan.
- 26 [00280] A82. The system of embodiment A81, wherein the optimized route flight plan is
27 optimized for safety.

- 1 [00281] A83. The system of embodiment A81 or A82, wherein the optimized route flight
2 plan is optimized fuel consumption.
- 3 [00282] A84. The system of any of embodiments A64-A83, wherein the flight plan
4 parameter data includes take-off time.
- 5 [00283] A85. The system of any of embodiments A64-A84, wherein the flight plan
6 parameter data includes take-off location.
- 7 [00284] A86. The system of any of embodiments A64-A85, wherein the flight plan
8 parameter data includes destination location.
- 9 [00285] B1. A DATCM dynamic turbulence engine processor-implemented method,
10 comprising: determining a plurality of four-dimensional grid points for a specified temporal
11 geographic space-time area; obtaining terrain data based on the temporal geographic space-time
12 area; obtaining atmospheric data based on the temporal geographic space-time area; for each
13 point of the plurality of four-dimensional grid point, determining via a processor a non-
14 dimensional mountain wave amplitude and mountain top wave drag; determining an upper level
15 non-dimensional gravity wave amplitude; determining a buoyant turbulent kinetic energy;
16 determining a boundary layer eddy dissipation rate; determining storm velocity and eddy
17 dissipation rate from updrafts; determining maximum updraft speed at grid point equilibrium
18 level; determining storm divergence while the updraft speed is above the equilibrium level and
19 identifying storm top; determining storm overshoot and storm drag; determining Doppler speed;
20 determining eddy dissipation rate above the storm top; determining eddy dissipation rate from
21 downdrafts; determining at least one of the turbulent kinetic energy and the total eddy
22 dissipation rate for each grid point; and providing a four-dimensional grid map overlay with
23 comprehensive turbulence data for the specified temporal geographic space-time area.
- 24 [00286] B2. The method of embodiment B1, wherein the atmospheric data comprises
25 temperature data.
- 26 [00287] B3. The method of embodiment B1 or B2, wherein the atmospheric data
27 comprises wind data.
- 28 [00288] B4. The method of any of embodiments B1-B3, wherein the atmospheric data
29 comprises humidity data.

- 1 [00289] B5. The method of any of embodiment B1-B4, wherein the atmospheric data
2 comprises numerical weather forecast data.
- 3 [00290] B6. The method of any of embodiments B1-B5, wherein the atmospheric data
4 comprises aircraft sensor data.
- 5 [00291] B7. The method of any of embodiments B1-B6, wherein the atmospheric data
6 comprises pilot report data.
- 7 [00292] B8. The method of any of embodiments B1-B7, further comprising providing a
8 user interface for the four-dimensional grid map overlay with comprehensive turbulence data.
- 9 [00293] B9. The method of embodiment B8, wherein the user interface is displayed on a
10 two-dimensional display and the user interface includes an at least one widget for navigating
11 through at least one further dimension.
- 12 [00294] B10. The method of embodiment B8, wherein the user interface includes a
13 granularity widget that allows a user to adjust the displayed detail.
- 14 [00295] B11. A DATCM dynamic turbulence system, comprising: means to determine a
15 plurality of four-dimensional grid points for a specified temporal geographic space-time area;
16 means to obtain terrain data based on the temporal geographic space-time area; means to obtain
17 atmospheric data based on the temporal geographic space-time area; for each point of the
18 plurality of four-dimensional grid point, means to determine a non-dimensional mountain wave
19 amplitude and mountain top wave drag; means to determine an upper level non-dimensional
20 gravity wave amplitude; means to determine a buoyant turbulent kinetic energy; means to
21 determine a boundary layer eddy dissipation rate; means to determine storm velocity and eddy
22 dissipation rate from updrafts; means to determine maximum updraft speed at grid point
23 equilibrium level; means to determine storm divergence while the updraft speed is above the
24 equilibrium level and identifying storm top; means to determine storm overshoot and storm
25 drag; means to determine Doppler speed; means to determine eddy dissipation rate above the
26 storm top; means to determine eddy dissipation rate from downdrafts; means to determine at
27 least one of the turbulent kinetic energy and the total eddy dissipation rate for each grid point;
28 and means to provide a four-dimensional grid map overlay with comprehensive turbulence data
29 for the specified temporal geographic space-time area.

- 1 [00296] B12. The system of embodiment B11, wherein the atmospheric data comprises
2 temperature data.
- 3 [00297] B13. The system of embodiment B11 or B12, wherein the atmospheric data
4 comprises wind data.
- 5 [00298] B14. The system of any of embodiments B11-B13, wherein the atmospheric data
6 comprises humidity data.
- 7 [00299] B15. The system of any of embodiments B11-B14, wherein the atmospheric data
8 comprises numerical weather forecast data.
- 9 [00300] B16. The system of any of embodiments B11-B15, wherein the atmospheric data
10 comprises aircraft sensor data.
- 11 [00301] B17. The system of any of embodiments B11-B16, wherein the atmospheric data
12 comprises pilot report data.
- 13 [00302] B18. The system of any of embodiments B11-B17, further comprising: means to
14 provide a user interface for the four-dimensional grid map overlay with comprehensive
15 turbulence data.
- 16 [00303] B19. The system of embodiment B18, wherein the user interface is configured for
17 display on a two-dimensional display and the user interface includes an at least one widget for
18 navigating through at least one further dimension.
- 19 [00304] B20. The system of embodiment B18, wherein the user interface includes a
20 granularity widget that allows a user to adjust the displayed detail.
- 21 [00305] B21. A processor-readable tangible medium storing processor-issuable dynamic
22 turbulence grid map overlay generating instructions to: determine a plurality of four-
23 dimensional grid points for a specified temporal geographic space-time area; obtain terrain data
24 based on the temporal geographic space-time area; obtain atmospheric data based on the
25 temporal geographic space-time area; for each point of the plurality of four-dimensional grid
26 point, determine a non-dimensional mountain wave amplitude and mountain top wave drag;
27 determine an upper level non-dimensional gravity wave amplitude; determine a buoyant
28 turbulent kinetic energy; determine a boundary layer eddy dissipation rate; determine storm
29 velocity and eddy dissipation rate from updrafts; determine maximum updraft speed at grid

1 point equilibrium level; determine storm divergence while the updraft speed is above the
2 equilibrium level and identifying storm top; determine storm overshoot and storm drag;
3 determine Doppler speed; determine eddy dissipation rate above the storm top; determine eddy
4 dissipation rate from downdrafts; determine at least one of the turbulent kinetic energy and the
5 total eddy dissipation rate for each grid point; and provide a four-dimensional grid map overlay
6 with comprehensive turbulence data for the specified temporal geographic space-time area.

7 **[00306]** B22. The medium of embodiment B21, wherein the atmospheric data comprises
8 temperature data.

9 **[00307]** B23. The medium of embodiment B21 or B22, wherein the atmospheric data
10 comprises wind data.

11 **[00308]** B24. The medium of any of embodiments B21-B23, wherein the atmospheric data
12 comprises humidity data.

13 **[00309]** B25. The medium of any of embodiments B21-B24, wherein the atmospheric data
14 comprises numerical weather forecast data.

15 **[00310]** B26. The medium of any of embodiments B21-B25, wherein the atmospheric data
16 comprises aircraft sensor data.

17 **[00311]** B27. The medium of any of embodiments B21-B26, wherein the atmospheric data
18 comprises pilot report data.

19 **[00312]** B28. The medium of any of embodiments B21-B27, further comprising
20 instructions to: provide a user interface for the four-dimensional grid map overlay with
21 comprehensive turbulence data.

22 **[00313]** B29. The medium of embodiment B28, wherein the user interface is configured
23 for display on a two-dimensional display and the user interface includes an at least one widget
24 for navigating through at least one further dimension.

25 **[00314]** B30. The medium of embodiment B28, wherein the user interface includes a
26 granularity widget that allows a user to adjust the displayed detail.

27 **[00315]** B31. A DATCM dynamic turbulence apparatus, comprising a processor and a
28 memory disposed in communication with the processor and storing processor-issuable

1 instructions to: determine a plurality of four-dimensional grid points for a specified temporal
2 geographic space-time area; obtain terrain data based on the temporal geographic space-time
3 area; obtain atmospheric data based on the temporal geographic space-time area; for each point
4 of the plurality of four-dimensional grid point, determine a non-dimensional mountain wave
5 amplitude and mountain top wave drag; determine an upper level non-dimensional gravity wave
6 amplitude; determine a buoyant turbulent kinetic energy; determine a boundary layer eddy
7 dissipation rate; determine storm velocity and eddy dissipation rate from updrafts; determine
8 maximum updraft speed at grid point equilibrium level; determine storm divergence while the
9 updraft speed is above the equilibrium level and identifying storm top; determine storm
10 overshoot and storm drag; determine Doppler speed; determine eddy dissipation rate above the
11 storm top; determine eddy dissipation rate from downdrafts; determine at least one of the
12 turbulent kinetic energy and the total eddy dissipation rate for each grid point; and provide a
13 four-dimensional grid map overlay with comprehensive turbulence data for the specified
14 temporal geographic space-time area.

15 **[00316]** B32. The system of embodiment B31, wherein the atmospheric data comprises
16 temperature data.

17 **[00317]** B33. The apparatus of embodiment B31 or B32, wherein the atmospheric data
18 comprises wind data.

19 **[00318]** B34. The apparatus of any of embodiments B31-B33, wherein the atmospheric
20 data comprises humidity data.

21 **[00319]** B35. The apparatus of any of embodiment B31-B34, wherein the atmospheric
22 data comprises numerical weather forecast data.

23 **[00320]** B36. The apparatus of any of embodiments B31-B35, wherein the atmospheric
24 data comprises aircraft sensor data.

25 **[00321]** B37. The apparatus of any of embodiments B31-B36, wherein the atmospheric
26 data comprises pilot report data.

27 **[00322]** B38. The apparatus of any of embodiments B31-B37, further comprising
28 instructions to: provide a user interface for the four-dimensional grid map overlay with
29 comprehensive turbulence data.

- 1 [00323] B39. The apparatus of embodiment B38, wherein the user interface is displayed
2 on a two-dimensional display and the user interface includes an at least one widget for
3 navigating through at least one further dimension.
- 4 [00324] B40. The apparatus of embodiment B38, wherein the user interface includes a
5 granularity widget that allows a user to adjust the displayed detail.
- 6 [00325] B41. A DATCM dynamic turbulence system, comprising: means to determine a
7 plurality of grid points for an area; means to determine at least one of the turbulent kinetic
8 energy and the total eddy dissipation rate for each grid point; and means to provide a grid map
9 overlay with comprehensive turbulence data for the area.
- 10 [00326] B42. The system of embodiment B41, wherein the grid points are four-
11 dimensional grid points.
- 12 [00327] B43. The system of embodiment B41 or B42, wherein the area is specified.
- 13 [00328] B44. The system of any of embodiments B41-B43, wherein the area is a space-
14 time area.
- 15 [00329] B45. The system of any of embodiments B41-B44, wherein the area is a temporal
16 geographic area.
- 17 [00330] B46. The system of any of embodiments B41-B43, wherein the area is a temporal
18 geographic space-time area
- 19 [00331] B47. The system of any of embodiments B41-B46, wherein the grid map overlay
20 is a four-dimensional grid map overlay
- 21 [00332] B48. The system of any of embodiments B41-B47, comprising: means to obtain
22 area terrain data.
- 23 [00333] B49. The system of any of embodiments B41-B48, comprising: means to obtain
24 area atmospheric data.
- 25 [00334] B50. The system of any of embodiments B41-B49, comprising: means to
26 determine non-dimensional mountain wave amplitude.
- 27 [00335] B51. The system of any of embodiments B41-B50, comprising: means to
28 determine mountain top wave drag.

- 1 [00336] B52. The system of any of embodiments B41-B51, comprising: means to
2 determine upper level non-dimensional gravity wave amplitude.
- 3 [00337] B53. The system of any of embodiments B41-B52, comprising: means to
4 determine buoyant turbulent kinetic energy.
- 5 [00338] B54. The system of any of embodiments B41-B53, comprising: means to
6 determine boundary layer eddy dissipation rate.
- 7 [00339] B55. The system of any of embodiments B41-B54, comprising: means to
8 determine storm velocity.
- 9 [00340] B56. The system of any of embodiments B41-B55, comprising: means to
10 determine eddy dissipation rate from updrafts.
- 11 [00341] B57. The system of any of embodiments B41-B56, comprising: means to
12 determine maximum updraft speed at equilibrium level.
- 13 [00342] B58. The system of any of embodiments B41-B57, comprising: means to
14 determine storm divergence.
- 15 [00343] B59. The system of any of embodiments B41-B57, comprising: means to
16 determine storm divergence while the updraft speed is above the equilibrium level.
- 17 [00344] B60. The system of any of embodiments B41-B59, comprising: means to identify
18 storm top.
- 19 [00345] B61. The system of any of embodiments B41-B60, comprising: means to
20 determine storm overshoot.
- 21 [00346] B62. The system of any of embodiments B41-B61, comprising: means to
22 determine storm drag.
- 23 [00347] B63. The system of any of embodiments B41-B62, comprising: means to
24 determine Doppler speed.
- 25 [00348] B64. The system of any of embodiments B41-B63, comprising: means to
26 determine eddy dissipation rate above the storm top.

- 1 [00349] B65. The system of any of embodiments B41-B64, comprising: means to
2 determine eddy dissipation rate from downdrafts.
- 3 [00350] B66. The system of any of embodiments B41-B65, comprising: means to
4 determine grid point non-dimensional mountain wave amplitude.
- 5 [00351] B67. The system of any of embodiments B41-B66, comprising: means to
6 determine grid point mountain top wave drag.
- 7 [00352] B68. The system of any of embodiments B41-B67, comprising: means to
8 determine grid point upper level non-dimensional gravity wave amplitude.
- 9 [00353] B69. The system of any of embodiments B41-B68, comprising: means to
10 determine grid point buoyant turbulent kinetic energy.
- 11 [00354] B70. The system of any of embodiments B41-B69, comprising: means to
12 determine grid point boundary layer eddy dissipation rate.
- 13 [00355] B71. The system of any of embodiments B41-B70, comprising: means to
14 determine grid point storm velocity.
- 15 [00356] B72. The system of any of embodiments B41-B71, comprising: means to
16 determine grid point eddy dissipation rate from updrafts.
- 17 [00357] B73. The system of any of embodiments B41-B72, comprising: means to
18 determine maximum updraft speed at grid point equilibrium level.
- 19 [00358] B74. The system of any of embodiments B41-B73, comprising: means to
20 determine grid point storm divergence.
- 21 [00359] B75. The system of any of embodiments B41-B74, comprising: means to
22 determine grid point storm divergence while the updraft speed is above the equilibrium level.
- 23 [00360] B76. The system of any of embodiments B41-B75, comprising: means to identify
24 grid point storm top.
- 25 [00361] B77. The system of any of embodiments B41-B76, comprising: means to
26 determine grid point storm overshoot.

- 1 [00362] B78. The system of any of embodiments B41-B77, comprising: means to
2 determine grid point storm drag.
- 3 [00363] B79. The system of any of embodiments B41-B78, comprising: means to
4 determine grid point Doppler speed.
- 5 [00364] B80. The system of any of embodiments B41-B79, comprising: means to
6 determine grid point eddy dissipation rate above the storm top.
- 7 [00365] B81. The system of any of embodiments B41-B80, comprising: means to
8 determine grid point eddy dissipation rate from downdrafts.
- 9 [00366] B82. The system of any of embodiments B41-B81, wherein the atmospheric data
10 comprises temperature data.
- 11 [00367] B83. The system of any of embodiments B41-B82, wherein the atmospheric data
12 comprises wind data.
- 13 [00368] B84. The system of any of embodiments B41-B83, wherein the atmospheric data
14 comprises humidity data.
- 15 [00369] B85. The system of any of embodiments B41-B84, wherein the atmospheric data
16 comprises numerical weather forecast data.
- 17 [00370] B86. The system of any of embodiments B41-B85, wherein the atmospheric data
18 comprises aircraft sensor data.
- 19 [00371] B87. The system of any of embodiments B41-B86, wherein the atmospheric data
20 comprises pilot report data.
- 21 [00372] B88. The system of any of embodiments B41-B87, further comprising: means to
22 provide a user interface for a four-dimensional grid map overlay with comprehensive
23 turbulence data.
- 24 [00373] B89. The system of embodiment B88, wherein the user interface is configured for
25 display on a two-dimensional display and the user interface includes an at least one widget for
26 navigating through at least one further dimension.
- 27 [00374] B90. The system of embodiment B88, wherein the user interface includes a
28 granularity widget that allows a user to adjust the displayed detail.

- 1 [00375] C1. A DATCM manager real-time flight plan modification processor-
2 implemented method, comprising: receiving a flight profile for an aircraft, the flight profile
3 including an at least one initial route; identifying an initial predicted comprehensive turbulence
4 for the at least one initial route; determining a real-time comprehensive turbulence for the the at
5 least one initial route; determining turbulence threshold compliance based on the real-time
6 comprehensive turbulence and at least one of the flight profile and the initial predicted
7 comprehensive turbulence; and generating a turbulence exception if the real-time
8 comprehensive turbulence exceeds threshold turbulence parameters.
- 9 [00376] C2. The method of embodiment C1, wherein the turbulence exception comprises
10 an alert for the aircraft.
- 11 [00377] C3. The method of embodiment C1, wherein the turbulence exception comprises
12 determining an at least one adjusted route.
- 13 [00378] C4. The method of embodiment C3, wherein the determination of the at least one
14 adjusted route is based on flight profile data.
- 15 [00379] C5. The method of embodiment C4, wherein the flight profile data comprises at
16 least one of flight service type, aircraft airframe, and available fuel reserves.
- 17 [00380] C6. The method of embodiment C4, wherein the flight profile data comprises
18 flight destination location.
- 19 [00381] C7. The method of embodiment C1, wherein comprehensive turbulence
20 determination comprises: determining a plurality of four-dimensional grid points for a specified
21 temporal geographic space-time area; obtaining terrain data based on the temporal geographic
22 space-time area; obtaining atmospheric data based on the temporal geographic space-time area;
23 for each point of the plurality of four-dimensional grid point, determining via a processor a non-
24 dimensional mountain wave amplitude and mountain top wave drag; determining an upper level
25 non-dimensional gravity wave amplitude; determining a buoyant turbulent kinetic energy;
26 determining a boundary layer eddy dissipation rate; determining storm velocity and eddy
27 dissipation rate from updrafts; determining maximum updraft speed at grid point equilibrium
28 level; determining storm divergence while the updraft speed is above the equilibrium level and
29 identifying storm top; determining storm overshoot and storm drag; determining Doppler speed;

1 determining eddy dissipation rate above the storm top; determining eddy dissipation rate from
2 downdrafts; and determining at least one of the turbulent kinetic energy and the total eddy
3 dissipation rate for each grid point.

4 **[00382]** C8. The method of embodiment C7, wherein the atmospheric data comprises at
5 least one of temperature data, wind data, and humidity data.

6 **[00383]** C9. The method of embodiment C7, wherein the atmospheric data comprises
7 numerical weather forecast data.

8 **[00384]** C10. The method of embodiment C7, wherein the atmospheric data comprises
9 aircraft sensor data.

10 **[00385]** C11. A DATCM dynamic turbulence real-time flight plan modification apparatus,
11 comprising a processor and a memory disposed in communication with the processor and
12 storing processor-issuable instructions to: receive a flight profile for an aircraft, the flight profile
13 including an at least one initial route; identify an initial predicted comprehensive turbulence for
14 the at least one initial route; determine a real-time comprehensive turbulence for the the at least
15 one initial route; determine turbulence threshold compliance based on the real-time
16 comprehensive turbulence and at least one of the flight profile and the initial predicted
17 comprehensive turbulence; and generate a turbulence exception if the real-time comprehensive
18 turbulence exceeds threshold turbulence parameters.

19 **[00386]** C12. The apparatus of embodiment C11, wherein the turbulence exception
20 comprises an alert for the aircraft.

21 **[00387]** C13. The apparatus of embodiment C11, wherein the turbulence exception
22 comprises determining an at least one adjusted route.

23 **[00388]** C14. The apparatus of embodiment C13, wherein the determination of the at least
24 one adjusted route is based on flight profile data.

25 **[00389]** C15. The apparatus of embodiment C14, wherein the flight profile data comprises
26 at least one of flight service type, aircraft airframe, and available fuel reserves.

27 **[00390]** C16. The apparatus of embodiment C14, wherein the flight profile data comprises
28 flight destination location.

1 [00391] C17. The apparatus of embodiment C11, wherein comprehensive turbulence
2 determination comprises instructions to: determine a plurality of four-dimensional grid points
3 for a specified temporal geographic space-time area; obtain terrain data based on the temporal
4 geographic space-time area; obtain atmospheric data based on the temporal geographic space-
5 time area; for each point of the plurality of four-dimensional grid point: determine a non-
6 dimensional mountain wave amplitude and mountain top wave drag, determine an upper level
7 non-dimensional gravity wave amplitude, determine a buoyant turbulent kinetic energy,
8 determine a boundary layer eddy dissipation rate, determine storm velocity and eddy dissipation
9 rate from updrafts, determine maximum updraft speed at grid point equilibrium level, determine
10 storm divergence while the updraft speed is above the equilibrium level and identifying storm
11 top, determine storm overshoot and storm drag, determine Doppler speed, determine eddy
12 dissipation rate above the storm top, determine eddy dissipation rate from downdrafts; and
13 determine at least one of the turbulent kinetic energy and the total eddy dissipation rate for each
14 grid point.

15 [00392] C18. The apparatus of embodiment C17, wherein the atmospheric data comprises
16 at least one of temperature data, wind data, and humidity data.

17 [00393] C19. The apparatus of embodiment C17, wherein the atmospheric data comprises
18 numerical weather forecast data.

19 [00394] C20. The apparatus of embodiment C17, wherein the atmospheric data comprises
20 aircraft sensor data.

21 [00395] C21. A processor-readable tangible medium storing processor-issuable dynamic
22 turbulence manager real-time flight plan modification instructions to: receive a flight profile for
23 an aircraft, the flight profile including an at least one initial route; identify an initial predicted
24 comprehensive turbulence for the at least one initial route; determine a real-time comprehensive
25 turbulence for the the at least one initial route; determine turbulence threshold compliance based
26 on the real-time comprehensive turbulence and at least one of the flight profile and the initial
27 predicted comprehensive turbulence; and generate a turbulence exception if the real-time
28 comprehensive turbulence exceeds threshold turbulence parameters.

29 [00396] C22. The medium of embodiment C21, wherein the turbulence exception
30 comprises an alert for the aircraft.

- 1 [00397] C23. The medium of embodiment C21, wherein the turbulence exception
2 comprises determining an at least one adjusted route.
- 3 [00398] C24. The medium of embodiment C23, wherein the determination of the at least
4 one adjusted route is based on flight profile data.
- 5 [00399] C25. The medium of embodiment C24, wherein the flight profile data comprises
6 at least one of flight service type, aircraft airframe, and available fuel reserves.
- 7 [00400] C26. The medium of embodiment C24, wherein the flight profile data comprises
8 flight destination location.
- 9 [00401] C27. The medium of embodiment C21, wherein comprehensive turbulence
10 determination comprises instructions to: determine a plurality of four-dimensional grid points
11 for a specified temporal geographic space-time area; obtain terrain data based on the temporal
12 geographic space-time area; obtain atmospheric data based on the temporal geographic space-
13 time area; for each point of the plurality of four-dimensional grid point, determine a non-
14 dimensional mountain wave amplitude and mountain top wave drag; determine an upper level
15 non-dimensional gravity wave amplitude; determine a buoyant turbulent kinetic energy;
16 determine a boundary layer eddy dissipation rate; determine storm velocity and eddy dissipation
17 rate from updrafts; determine maximum updraft speed at grid point equilibrium level; determine
18 storm divergence while the updraft speed is above the equilibrium level and identifying storm
19 top; determine storm overshoot and storm drag; determine Doppler speed; determine eddy
20 dissipation rate above the storm top; determine eddy dissipation rate from downdrafts; and
21 determine at least one of the turbulent kinetic energy and the total eddy dissipation rate for each
22 grid point.
- 23 [00402] C28. The medium of embodiment C27, wherein the atmospheric data comprises
24 at least one of temperature data, wind data, and humidity data.
- 25 [00403] C29. The medium of embodiment C27, wherein the atmospheric data comprises
26 numerical weather forecast data.
- 27 [00404] C30. The medium of embodiment C27, wherein the atmospheric data comprises
28 aircraft sensor data.

- 1 [00405] C31. A DATCM dynamic turbulence manager real-time flight plan modification
2 system, comprising: means to receive a flight profile for an aircraft, the flight profile including
3 an at least one initial route; means to identify an initial predicted comprehensive turbulence for
4 the at least one initial route; means to determine a real-time comprehensive turbulence for the
5 the at least one initial route; means to determine turbulence threshold compliance based on the
6 real-time comprehensive turbulence and at least one of the flight profile and the initial predicted
7 comprehensive turbulence; and means to generate a turbulence exception if the real-time
8 comprehensive turbulence exceeds threshold turbulence parameters.
- 9 [00406] C32. The system of embodiment C31, wherein the turbulence exception
10 comprises an alert for the aircraft.
- 11 [00407] C33. The system of embodiment C31 or C32, wherein the turbulence exception
12 comprises determining an at least one adjusted route.
- 13 [00408] C34. The system of embodiment C33, wherein the determination of the at least
14 one adjusted route is based on flight profile data.
- 15 [00409] C35. The system of embodiment C34, wherein the flight profile data comprises at
16 least one of flight service type, aircraft airframe, and available fuel reserves.
- 17 [00410] C36. The system of embodiment C34 or C35, wherein the flight profile data
18 comprises flight destination location.
- 19 [00411] C37. The system of any of embodiments C31-C36, comprising: means to
20 determine a plurality of four-dimensional grid points for a specified temporal geographic space-
21 time area.
- 22 [00412] C38. The system of any of embodiments C31-C37, comprising: means to obtain
23 terrain data.
- 24 [00413] C39. The system of any of embodiments C31-C38, comprising: means to obtain
25 atmospheric data.
- 26 [00414] C40. The system of any of embodiments C31-C39, comprising: means to
27 determine a non-dimensional mountain wave amplitude.

- 1 [00415] C41. The system of any of embodiments C31-C40, comprising: means to
2 determine mountain top wave drag.
- 3 [00416] C42. The system of any of embodiments C31-C41, comprising: means to
4 determine an upper level non-dimensional gravity wave amplitude.
- 5 [00417] C43. The system of any of embodiments C31-C42, comprising: means to
6 determine a buoyant turbulent kinetic energy.
- 7 [00418] C44. The system of any of embodiments C31-C43, comprising: means to
8 determine a boundary layer eddy dissipation rate.
- 9 [00419] C45. The system of any of embodiments C31-C44, comprising: means to
10 determine storm velocity.
- 11 [00420] C46. The system of any of embodiments C31-C45, comprising: means to
12 determine eddy dissipation rate from updrafts.
- 13 [00421] C47. The system of any of embodiments C31-C46, comprising: means to
14 determine storm velocity and eddy dissipation rate from updrafts.
- 15 [00422] C48. The system of any of embodiments C31-C47, comprising: means to
16 determine maximum updraft speed.
- 17 [00423] C49. The system of any of embodiments C31-C48, comprising: means to
18 determine maximum updraft speed at equilibrium level.
- 19 [00424] C50. The system of any of embodiments C31-C49, comprising: means to
20 determine storm divergence.
- 21 [00425] C51. The system of any of embodiments C31-C50, comprising: means to
22 determine storm divergence while the updraft speed is above the equilibrium level.
- 23 [00426] C52. The system of any of embodiments C31-C51, comprising: means to identify
24 storm top.
- 25 [00427] C53. The system of any of embodiments C31-C52, comprising: means to
26 determine storm divergence while the updraft speed is above the equilibrium level and identify
27 storm top.

- 1 [00428] C54. The system of any of embodiments C31-C53, comprising: means to
2 determine storm overshoot.
- 3 [00429] C55. The system of any of embodiments C31-C54, comprising: means to
4 determine storm drag.
- 5 [00430] C56. The system of any of embodiments C31-C55, comprising: means to
6 determine Doppler speed.
- 7 [00431] C57. The system of any of embodiments C31-C56, comprising: means to
8 determine eddy dissipation rate above storm top.
- 9 [00432] C58. The system of any of embodiments C31-C57, comprising: means to
10 determine eddy dissipation rate from downdrafts.
- 11 [00433] C59. The system of any of embodiments C31-C58, comprising at least one of:
12 means to determine turbulent kinetic energy; and means to determine total eddy dissipation rate.
- 13 [00434] C60. The system of any of embodiments C31-C59, comprising: means to
14 determine grid point non-dimensional mountain wave amplitude.
- 15 [00435] C61. The system of any of embodiments C31-C60, comprising: means to
16 determine grid point mountain top wave drag.
- 17 [00436] C62. The system of any of embodiments C31-C61, comprising: means to
18 determine grid point upper level non-dimensional gravity wave amplitude.
- 19 [00437] C63. The system of any of embodiments C31-C62, comprising: means to
20 determine grid point buoyant turbulent kinetic energy.
- 21 [00438] C64. The system of any of embodiments C31-C63, comprising: means to
22 determine grid point boundary layer eddy dissipation rate.
- 23 [00439] C65. The system of any of embodiments C31-C64, comprising: means to
24 determine grid point storm velocity.
- 25 [00440] C66. The system of any of embodiments C31-C65, comprising: means to
26 determine grid point eddy dissipation rate from updrafts.

- 1 [00441] C67. The system of any of embodiments C31-C66, comprising: means to
2 determine grid point storm velocity and eddy dissipation rate from updrafts.
- 3 [00442] C68. The system of any of embodiments C31-C67, comprising: means to
4 determine grid point maximum updraft speed.
- 5 [00443] C69. The system of any of embodiments C31-C68, comprising: means to
6 determine grid point maximum updraft speed at grid point equilibrium level.
- 7 [00444] C70. The system of any of embodiments C31-C69, comprising: means to
8 determine grid point storm divergence.
- 9 [00445] C71. The system of any of embodiments C31-C70, comprising: means to
10 determine grid point storm divergence while the updraft speed is above the equilibrium level.
- 11 [00446] C72. The system of any of embodiments C31-C71, comprising: means to identify
12 grid point storm top.
- 13 [00447] C73. The system of any of embodiments C31-C72, comprising: means to
14 determine grid point storm divergence while the updraft speed is above the equilibrium level
15 and identify storm top.
- 16 [00448] C74. The system of any of embodiments C31-C73, comprising: means to
17 determine grid point storm overshoot.
- 18 [00449] C75. The system of any of embodiments C31-C74, comprising: means to
19 determine grid point storm drag.
- 20 [00450] C76. The system of any of embodiments C31-C75, comprising: means to
21 determine grid point Doppler speed.
- 22 [00451] C77. The system of any of embodiments C31-C76, comprising: means to
23 determine grid point eddy dissipation rate above storm top.
- 24 [00452] C78. The system of any of embodiments C31-C77, comprising: means to
25 determine grid point eddy dissipation rate from downdrafts.
- 26 [00453] C79. The system of any of embodiments C31-C78, comprising: means to
27 determine grid point turbulent kinetic energy.

- 1 [00454] C80. The system of any of embodiments C31-C79, comprising: means to
2 determine grid point total eddy dissipation rate.
- 3 [00455] C81. The system of any of embodiments C31-C80, comprising, for each point of
4 the plurality of four-dimensional grid point, means to: determine a non-dimensional mountain
5 wave amplitude and mountain top wave drag; determine an upper level non-dimensional gravity
6 wave amplitude; determine a buoyant turbulent kinetic energy; determine a boundary layer eddy
7 dissipation rate; determine storm velocity and eddy dissipation rate from updrafts; determine
8 maximum updraft speed at grid point equilibrium level; determine storm divergence while the
9 updraft speed is above the equilibrium level and identifying storm top; determine storm
10 overshoot and storm drag; determine Doppler speed; determine eddy dissipation rate above the
11 storm top; determine eddy dissipation rate from downdrafts; and determine at least one of the
12 turbulent kinetic energy and the total eddy dissipation rate for each grid point.
- 13 [00456] C82. The system of any of embodiments C31-C81, wherein the atmospheric data
14 comprises at least one of temperature data, wind data, and humidity data.
- 15 [00457] C83. The system of any of embodiments C31-C82, wherein the atmospheric data
16 comprises numerical weather forecast data.
- 17 [00458] C84. The system of any of embodiments C31-C83, wherein the atmospheric data
18 comprises aircraft sensor data.
- 19 [00459] D1. A DATCM dynamic turbulence controller processor-implemented flight
20 planning method, comprising: receiving anticipated flight plan parameter data; obtaining terrain
21 data based on the flight plan parameter data; obtaining atmospheric data based on the flight plan
22 parameter data; determining a plurality of four-dimensional grid points based on the flight plan
23 parameter data; for each point of the plurality of four-dimensional grid point: determining via a
24 processor a non-dimensional mountain wave amplitude and mountain top wave drag,
25 determining an upper level non-dimensional gravity wave amplitude, determining a buoyant
26 turbulent kinetic energy, determining a boundary layer eddy dissipation rate, determining storm
27 velocity and eddy dissipation rate from updrafts, determining maximum updraft speed at grid
28 point equilibrium level, determining storm divergence while the updraft speed is above the
29 equilibrium level and identifying storm top, determining storm overshoot and storm drag,
30 determining Doppler speed, determining eddy dissipation rate above the storm top, and

1 determining eddy dissipation rate from downdrafts; determining the turbulent kinetic energy for
2 each grid point; identifying an at least one flight plan based on the flight plan parameter data
3 and the determined turbulent kinetic energy; and providing the identified at least one flight plan.

4 **[00460]** D2. The method of embodiment D1, wherein the flight plan parameter data
5 includes aircraft data.

6 **[00461]** D3. The method of embodiment D2, wherein the aircraft data includes airframe
7 information.

8 **[00462]** D4. The method of embodiment D2 or D3, wherein the aircraft data includes
9 airfoil information.

10 **[00463]** D5. The method of any of embodiments D1–D4, wherein the flight plan
11 parameter data includes take-off time.

12 **[00464]** D6. The method of any of embodiments D1–D5, wherein the flight plan parameter
13 data includes take-off location.

14 **[00465]** D7. The method of any of embodiments D1–D6 wherein the flight plan parameter
15 data includes destination location.

16 **[00466]** D8. The method of any of embodiments D1–D7, wherein the flight plan parameter
17 data includes cargo information.

18 **[00467]** D9. The method of any of embodiments D1–D8, wherein the flight plan parameter
19 data indicates the flight is a passenger flight.

20 **[00468]** D10. The method of any of embodiments D1–D9, wherein the flight plan
21 parameter data indicates the flight is a cargo flight.

22 **[00469]** D11. A DATCM platform flight planning apparatus, comprising a processor and a
23 memory disposed in communication with the processor and storing processor-issuable
24 instructions to: receive anticipated flight plan parameter data; obtain terrain data based on the
25 flight plan parameter data; obtain atmospheric data based on the flight plan parameter data;
26 determine a plurality of four-dimensional grid points based on the flight plan parameter data;
27 determine a non-dimensional mountain wave amplitude and mountain top wave drag; determine
28 an upper level non-dimensional gravity wave amplitude; determine a buoyant turbulent kinetic

1 energy; determine a boundary layer eddy dissipation rate; determine storm velocity and eddy
2 dissipation rate from updrafts; determine maximum updraft speed at grid point equilibrium
3 level; determine storm divergence while the updraft speed is above the equilibrium level and
4 identify storm top; determine storm overshoot and storm drag; determine Doppler speed;
5 determine eddy dissipation rate above the storm top; determine eddy dissipation rate from
6 downdrafts; determine the turbulent kinetic energy for each grid point; identify an at least one
7 flight plan based on the flight plan parameter data and the determined turbulent kinetic energy;
8 and provide the identified at least one flight plan.

9 **[00470]** D12. The apparatus of embodiment D11, wherein the flight plan parameter data
10 includes aircraft data.

11 **[00471]** D13. The apparatus of embodiment D12, wherein the aircraft data includes
12 airframe information.

13 **[00472]** D14. The apparatus of embodiment D12 or D13, wherein the aircraft data
14 includes airfoil information.

15 **[00473]** D15. The apparatus of any of embodiments D11-D14, wherein the flight plan
16 parameter data includes take-off time.

17 **[00474]** D16. The apparatus of any of embodiments D11-D15, wherein the flight plan
18 parameter data includes take-off location.

19 **[00475]** D17. The apparatus of any of embodiments D11-D16, wherein the flight plan
20 parameter data includes destination location.

21 **[00476]** D18. The apparatus of any of embodiments D11-D17, wherein the flight plan
22 parameter data includes cargo information.

23 **[00477]** D19. The apparatus of any of embodiments D11-D18, wherein the flight plan
24 parameter data indicates the flight is a passenger flight.

25 **[00478]** D20. The apparatus of any of embodiment D11-D19, wherein the flight plan
26 parameter data indicates the flight is a cargo flight.

27 **[00479]** D21. A processor-readable tangible medium storing processor-issuable DATCM
28 flight plan generating instructions to: receive anticipated flight plan parameter data; obtain

1 terrain data based on the flight plan parameter data; obtain atmospheric data based on the flight
2 plan parameter data; determine a plurality of four-dimensional grid points based on the flight
3 plan parameter data; determine a non-dimensional mountain wave amplitude and mountain top
4 wave drag; determine an upper level non-dimensional gravity wave amplitude; determine a
5 buoyant turbulent kinetic energy; determine a boundary layer eddy dissipation rate; determine
6 storm velocity and eddy dissipation rate from updrafts; determine maximum updraft speed at
7 grid point equilibrium level; determine storm divergence while the updraft speed is above the
8 equilibrium level and identify storm top; determine storm overshoot and storm drag; determine
9 Doppler speed; determine eddy dissipation rate above the storm top; determine eddy dissipation
10 rate from downdrafts; determine the turbulent kinetic energy for each grid point; and identify an
11 at least one flight plan based on the flight plan parameter data and the determined turbulent
12 kinetic energy.

13 **[00480]** D22. The medium of embodiment D21, wherein the flight plan parameter data
14 includes aircraft data.

15 **[00481]** D23. The medium of embodiment D22, wherein the aircraft data includes
16 airframe information.

17 **[00482]** D24. The medium of embodiment D22 or D23, wherein the aircraft data includes
18 airfoil information.

19 **[00483]** D25. The medium of any of embodiments D21-D24, wherein the flight plan
20 parameter data includes take-off time.

21 **[00484]** D26. The medium of any of embodiments D21-D25, wherein the flight plan
22 parameter data includes take-off location.

23 **[00485]** D27. The medium of any of embodiments D21-D26, wherein the flight plan
24 parameter data includes destination location.

25 **[00486]** D28. The medium of any of embodiments D21-D27, wherein the flight plan
26 parameter data includes cargo information.

27 **[00487]** D29. The medium of any of embodiments D21-D28, wherein the flight plan
28 parameter data indicates the flight is a passenger flight.

1 [00488] D30. The medium of any of embodiments D21-D29, wherein the flight plan
2 parameter data indicates the flight is a cargo flight.

3 [00489] D31. A dynamic turbulence platform flight planning system, comprising: means
4 to receive anticipated flight plan parameter data; means to obtain terrain data based on the flight
5 plan parameter data; means to obtain atmospheric data based on the flight plan parameter data;
6 means to determine a plurality of four-dimensional grid points based on the flight plan
7 parameter data; means to determine a non-dimensional mountain wave amplitude and mountain
8 top wave drag; means to determine an upper level non-dimensional gravity wave amplitude;
9 means to determine a buoyant turbulent kinetic energy; means to determine a boundary layer
10 eddy dissipation rate; means to determine storm velocity and eddy dissipation rate from
11 updrafts; means to determine maximum updraft speed at grid point equilibrium level; means to
12 determine storm divergence while the updraft speed is above the equilibrium level and identify
13 storm top; means to determine storm overshoot and storm drag; means to determine Doppler
14 speed; means to determine eddy dissipation rate above the storm top; means to determine eddy
15 dissipation rate from downdrafts; means to determine the turbulent kinetic energy for each grid
16 point; means to identify an at least one flight plan based on the flight plan parameter data and
17 the determined turbulent kinetic energy; and means to provide the identified at least one flight
18 plan.

19 [00490] D32. The system of embodiment D31, wherein the flight plan parameter data
20 includes aircraft data.

21 [00491] D33. The system of embodiment D32, wherein the aircraft data includes airframe
22 information.

23 [00492] D34. The system of embodiment D32, wherein the aircraft data includes airfoil
24 information.

25 [00493] D35. The system of any of embodiments D31-D34, wherein the flight plan
26 parameter data includes take-off time.

27 [00494] D36. The system of any of embodiments D31-D35, wherein the flight plan
28 parameter data includes take-off location.

- 1 [00495] D37. The system of any of embodiments D31-D36, wherein the flight plan
2 parameter data includes destination location.
- 3 [00496] D38. The system of any of embodiments D31-D37, wherein the flight plan
4 parameter data includes cargo information.
- 5 [00497] D39. The system of any of embodiments D31-D38, wherein the flight plan
6 parameter data indicates the flight is a passenger flight.
- 7 [00498] D40. The system of any of embodiments D31-D39, wherein the flight plan
8 parameter data indicates the flight is a cargo flight.
- 9 [00499] D41. A DATCM platform flight planning system, comprising: means to receive
10 anticipated flight plan data; means to obtain atmospheric data based on the flight plan data;
11 means to determine a plurality of grid points based on the flight plan data; means to determine
12 turbulent kinetic energy for each grid point; means to identify an at least one flight plan based
13 on the flight plan data and the determined turbulent kinetic energy; and means to provide the
14 identified at least one flight plan.
- 15 [00500] D42. The system of embodiment D41, comprising: means to determine a non-
16 dimensional mountain wave amplitude and mountain top wave drag.
- 17 [00501] D43. The system of embodiment D41 or D42, comprising: means to determine an
18 upper level non-dimensional gravity wave amplitude.
- 19 [00502] D44. The system of any of embodiments D41-D43, comprising: means to
20 determine a buoyant turbulent kinetic energy.
- 21 [00503] D45. The system of any of embodiments D41-D44, comprising: means to
22 determine a boundary layer eddy dissipation rate.
- 23 [00504] D46. The system of any of embodiments D41-D45, comprising: means to
24 determine storm velocity.
- 25 [00505] D47. The system of any of embodiments D41-D46, comprising: means to
26 determine eddy dissipation rate from updrafts.
- 27 [00506] D48. The system of any of embodiments D41-D47, comprising: means to
28 determine maximum updraft speed.

- 1 [00507] D49. The system of any of embodiments D41-D47, comprising: means to
2 determine maximum updraft speed at grid point equilibrium level.
- 3 [00508] D50. The system of any of embodiments D41-D49, comprising: means to
4 determine storm divergence.
- 5 [00509] D51. The system of any of embodiments D41-D49, comprising: means to
6 determine storm divergence while the updraft speed is above the equilibrium level.
- 7 [00510] D52. The system of any of embodiments D41-D51, comprising: means to identify
8 storm top.
- 9 [00511] D53. The system of any of embodiments D41-D49, comprising: means to
10 determine storm divergence while the updraft speed is above the equilibrium level and identify
11 storm top.
- 12 [00512] D54. The system of any of embodiments D41-D53, comprising: means to
13 determine storm overshoot and storm drag.
- 14 [00513] D55. The system of any of embodiments D41-D54, comprising: means to
15 determine Doppler speed.
- 16 [00514] D56. The system of any of embodiments D41-D55, comprising: means to
17 determine eddy dissipation rate above the storm top.
- 18 [00515] D57. The system of any of embodiments D41-D56, comprising: means to
19 determine eddy dissipation rate from downdrafts.
- 20 [00516] D58. The system of any of embodiments D41-D57, wherein the flight plan data
21 includes aircraft data.
- 22 [00517] D59. The system of embodiment D58, wherein the aircraft data includes at least
23 one of airframe information and airfoil information.
- 24 [00518] D60. The system of any of embodiments D41-D59, wherein the flight plan data
25 includes take-off time.
- 26 [00519] D61. The system of any of embodiments D41-D60, wherein the flight plan data
27 includes take-off location.

1 [00520] D62. The system of any of embodiments D41-D61, wherein the flight plan data
2 includes destination location.

3 [00521] D63. The system of any of embodiments D41-D62, wherein the flight plan data
4 includes cargo information.

5 [00522] D64. The system of any of embodiments D41-D63, wherein the flight plan
6 parameter data indicates the flight is a passenger flight.

7 [00523] D65. The system of any of embodiments D41-D63, wherein the flight plan
8 parameter data indicates the flight is a cargo flight.

9 [00524] E1. A DATCM system for providing integrated flight hazard/threat identification
10 and resolution comprising a combination of any of the preceding embodiments (A, B, C, D)
11 such that turbulence and icing hazards are addressed.

12 [00525] E2. A DATCM flight planning system, comprising: means to receive parameter
13 data for a flight; means to determine airfoil type for an aircraft associated with the flight; means
14 to obtain atmospheric data based on the flight parameter data; means to determine a plurality of
15 grid points based on the flight data; means to determine turbulent kinetic energy for each grid
16 point; means to determine corresponding icing data for each grid point of the plurality of grid
17 points based on the airfoil type and atmospheric data; means to identify an at least one flight
18 plan based on the flight data and the determined turbulent kinetic energy and icing data; and
19 means to provide the identified at least one flight plan.

20 [00526] E3. The flight planning system of embodiment E2, comprising: means to
21 determine a percent power increase for the at least one flight plan.

22

DATCM Controller

23 [00527] FIGURE 46 shows a block diagram illustrating embodiments of DATCM
24 controller 4601. In this embodiment, the DATCM controller 4601 may serve to aggregate,
25 process, store, search, serve, identify, instruct, generate, match, and/or facilitate interactions
26 with a computer through various technologies, and/or other related data.

27 [00528] Typically, users, e.g., 4633a, which may be people and/or other systems, may
28 engage information technology systems (e.g., computers) to facilitate information processing.

1 In turn, computers employ processors to process information; such processors 4603 may be
2 referred to as central processing units (CPU). One form of processor is referred to as a
3 microprocessor. CPUs use communicative circuits to pass binary encoded signals acting as
4 instructions to enable various operations. These instructions may be operational and/or data
5 instructions containing and/or referencing other instructions and data in various processor
6 accessible and operable areas of memory 4629 (e.g., registers, cache memory, random access
7 memory, etc.). Such communicative instructions may be stored and/or transmitted in batches
8 (e.g., batches of instructions) as programs and/or data components to facilitate desired
9 operations. These stored instruction codes, e.g., programs, may engage the CPU circuit
10 components and other motherboard and/or system components to perform desired operations.
11 One type of program is a computer operating system, which, may be executed by CPU on a
12 computer; the operating system enables and facilitates users to access and operate computer
13 information technology and resources. Some resources that may be employed in information
14 technology systems include: input and output mechanisms through which data may pass into
15 and out of a computer; memory storage into which data may be saved; and processors by which
16 information may be processed. These information technology systems may be used to collect
17 data for later retrieval, analysis, and manipulation, which may be facilitated through a database
18 program. These information technology systems provide interfaces that allow users to access
19 and operate various system components.

20 **[00529]** In one embodiment, the DATCM controller 4601 may be connected to and/or
21 communicate with entities such as, but not limited to: one or more users from user input devices
22 4611; peripheral devices 4612; an optional cryptographic processor device 4628; and/or a
23 communications network 4613. For example, the DATCM controller 4601 may be connected to
24 and/or communicate with users, e.g., 4633a, operating client device(s), e.g., 4633b, including,
25 but not limited to, personal computer(s), server(s) and/or various mobile device(s) including, but
26 not limited to, cellular telephone(s), smartphone(s) (e.g., iPhone®, Blackberry®, Android OS-
27 based phones etc.), tablet computer(s) (e.g., Apple iPad™, HP Slate™, Motorola Xoom™, etc.),
28 eBook reader(s) (e.g., Amazon Kindle™, Barnes and Noble's Nook™ eReader, etc.), laptop
29 computer(s), notebook(s), netbook(s), gaming console(s) (e.g., XBOX Live™, Nintendo® DS,
30 Sony PlayStation® Portable, etc.), portable scanner(s), and/or the like.

1 [00530] Networks are commonly thought to comprise the interconnection and
2 interoperation of clients, servers, and intermediary nodes in a graph topology. It should be noted
3 that the term “server” as used throughout this application refers generally to a computer, other
4 device, program, or combination thereof that processes and responds to the requests of remote
5 users across a communications network. Servers serve their information to requesting “clients.”
6 The term “client” as used herein refers generally to a computer, program, other device, user
7 and/or combination thereof that is capable of processing and making requests and obtaining and
8 processing any responses from servers across a communications network. A computer, other
9 device, program, or combination thereof that facilitates, processes information and requests,
10 and/or furthers the passage of information from a source user to a destination user is commonly
11 referred to as a “node.” Networks are generally thought to facilitate the transfer of information
12 from source points to destinations. A node specifically tasked with furthering the passage of
13 information from a source to a destination is commonly called a “router.” There are many forms
14 of networks such as Local Area Networks (LANs), Pico networks, Wide Area Networks
15 (WANs), Wireless Networks (WLANs), etc. For example, the Internet is generally accepted as
16 being an interconnection of a multitude of networks whereby remote clients and servers may
17 access and interoperate with one another.

18 [00531] The DATCM controller 4601 may be based on computer systems that may
19 comprise, but are not limited to, components such as: a computer systemization 4602 connected
20 to memory 4629.

21 **Computer Systemization**

22 [00532] A computer systemization 4602 may comprise a clock 4630, central processing
23 unit (“CPU(s)” and/or “processor(s)” (these terms are used interchangeable throughout the
24 disclosure unless noted to the contrary)) 4603, a memory 4629 (e.g., a read only memory
25 (ROM) 4606, a random access memory (RAM) 4605, etc.), and/or an interface bus 4607, and
26 most frequently, although not necessarily, are all interconnected and/or communicating through
27 a system bus 4604 on one or more (mother)board(s) 4602 having conductive and/or otherwise
28 transportive circuit pathways through which instructions (e.g., binary encoded signals) may
29 travel to effectuate communications, operations, storage, etc. The computer systemization may
30 be connected to a power source 4686; e.g., optionally the power source may be internal.

1 Optionally, a cryptographic processor 4626 and/or transceivers (e.g., ICs) 4674 may be
2 connected to the system bus. In another embodiment, the cryptographic processor and/or
3 transceivers may be connected as either internal and/or external peripheral devices 4612 via the
4 interface bus I/O. In turn, the transceivers may be connected to antenna(s) 4675, thereby
5 effectuating wireless transmission and reception of various communication and/or sensor
6 protocols; for example the antenna(s) may connect to: a Texas Instruments WiLink WL1283
7 transceiver chip (e.g., providing 802.11n, Bluetooth 3.0, FM, global positioning system (GPS)
8 (thereby allowing DATCM controller to determine its location)); Broadcom BCM4329FKUBG
9 transceiver chip (e.g., providing 802.11n, Bluetooth 2.1 + EDR, FM, etc.); a Broadcom
10 BCM4750IUB8 receiver chip (e.g., GPS); an Infineon Technologies X-Gold 618-PMB9800
11 (e.g., providing 2G/3G HSDPA/HSUPA communications); and/or the like. The system clock
12 typically has a crystal oscillator and generates a base signal through the computer
13 systemization's circuit pathways. The clock is typically coupled to the system bus and various
14 clock multipliers that will increase or decrease the base operating frequency for other
15 components interconnected in the computer systemization. The clock and various components
16 in a computer systemization drive signals embodying information throughout the system. Such
17 transmission and reception of instructions embodying information throughout a computer
18 systemization may be commonly referred to as communications. These communicative
19 instructions may further be transmitted, received, and the cause of return and/or reply
20 communications beyond the instant computer systemization to: communications networks, input
21 devices, other computer systemizations, peripheral devices, and/or the like. It should be
22 understood that in alternative embodiments, any of the above components may be connected
23 directly to one another, connected to the CPU, and/or organized in numerous variations
24 employed as exemplified by various computer systems.

25 **[00533]** The CPU comprises at least one high-speed data processor adequate to execute
26 program components for executing user and/or system-generated requests. Often, the processors
27 themselves will incorporate various specialized processing units, such as, but not limited to:
28 integrated system (bus) controllers, memory management control units, floating point units, and
29 even specialized processing sub-units like graphics processing units, digital signal processing
30 units, and/or the like. Additionally, processors may include internal fast access addressable
31 memory, and be capable of mapping and addressing memory 4629 beyond the processor itself;

1 internal memory may include, but is not limited to: fast registers, various levels of cache
2 memory (e.g., level 1, 2, 3, etc.), RAM, etc. The processor may access this memory through the
3 use of a memory address space that is accessible via instruction address, which the processor
4 can construct and decode allowing it to access a circuit path to a specific memory address space
5 having a memory state. The CPU may be a microprocessor such as: AMD's Athlon, Duron
6 and/or Opteron; ARM's application, embedded and secure processors; IBM and/or Motorola's
7 DragonBall and PowerPC; IBM's and Sony's Cell processor; Intel's Celeron, Core (2) Duo,
8 Itanium, Pentium, Xeon, and/or XScale; and/or the like processor(s). The CPU interacts with
9 memory through instruction passing through conductive and/or transportive conduits (e.g.,
10 (printed) electronic and/or optic circuits) to execute stored instructions (i.e., program code)
11 according to conventional data processing techniques. Such instruction passing facilitates
12 communication within the DATCM controller and beyond through various interfaces. Should
13 processing requirements dictate a greater amount speed and/or capacity, distributed processors
14 (e.g., Distributed DATCM), mainframe, multi-core, parallel, and/or super-computer
15 architectures may similarly be employed. Alternatively, should deployment requirements dictate
16 greater portability, smaller Personal Digital Assistants (PDAs) may be employed.

17 **[00534]** Depending on the particular implementation, features of the DATCM may be
18 achieved by implementing a microcontroller such as CAST's R8051XC2 microcontroller;
19 Intel's MCS 51 (i.e., 8051 microcontroller); and/or the like. Also, to implement certain features
20 of the DATCM, some feature implementations may rely on embedded components, such as:
21 Application-Specific Integrated Circuit ("ASIC"), Digital Signal Processing ("DSP"), Field
22 Programmable Gate Array ("FPGA"), and/or the like embedded technology. For example, any
23 of the DATCM component collection (distributed or otherwise) and/or features may be
24 implemented via the microprocessor and/or via embedded components; e.g., via ASIC,
25 coprocessor, DSP, FPGA, and/or the like. Alternately, some implementations of the DATCM
26 may be implemented with embedded components that are configured and used to achieve a
27 variety of features or signal processing. An example DATCM component (e.g., PPI Component
28 4649) substantially in the form of a field-programmable gate array configured as an integrated
29 circuit for performing the features of the PPI component may be found with respect to Figures
30 18A-F. It should be appreciated that the example PPI hardware component disclosed is
31 provided to enhance the reader's understanding of the instant disclosure and is but one

1 embodiment of the DATCM disclosed herein. Furthermore, as substantially all integrated
2 circuits may be represented as one or more alternative integrated circuits, hardware description
3 language statements (e.g., VHDL, Verilog, and/or the like), programming language commands,
4 and/or the like, embodiments of the disclosed PPI hardware component represented as
5 alternative hardware designs and/or software or software/hardware combinations are possible
6 based on this disclosure.

7 **[00535]** Depending on the particular implementation, the embedded components may
8 include software solutions, hardware solutions, and/or some combination of both
9 hardware/software solutions. For example, DATCM features discussed herein may be achieved
10 through implementing FPGAs, which are a semiconductor devices containing programmable
11 logic components called "logic blocks", and programmable interconnects, such as the high
12 performance FPGA Virtex series and/or the low cost Spartan series manufactured by Xilinx.
13 Logic blocks and interconnects can be programmed by the customer or designer, after the FPGA
14 is manufactured, to implement any of the DATCM features. A hierarchy of programmable
15 interconnects allow logic blocks to be interconnected as needed by the DATCM system
16 designer/administrator, somewhat like a one-chip programmable breadboard. An FPGA's logic
17 blocks can be programmed to perform the operation of basic logic gates such as AND, and
18 XOR, or more complex combinational operators such as decoders or simple mathematical
19 operations. In most FPGAs, the logic blocks also include memory elements, which may be
20 circuit flip-flops or more complete blocks of memory. In some circumstances, the DATCM may
21 be developed on regular FPGAs and then migrated into a fixed version that more resembles
22 ASIC implementations. Alternate or coordinating implementations may migrate DATCM
23 controller features to a final ASIC instead of or in addition to FPGAs. Depending on the
24 implementation all of the aforementioned embedded components and microprocessors may be
25 considered the "CPU" and/or "processor" for the DATCM.

26

Power Source

27 **[00536]** The power source 4686 may be of any standard form for powering small
28 electronic circuit board devices such as the following power cells: alkaline, lithium hydride,
29 lithium ion, lithium polymer, nickel cadmium, solar cells, and/or the like. Other types of AC or
30 DC power sources may be used as well. In the case of solar cells, in one embodiment, the case

1 provides an aperture through which the solar cell may capture photonic energy. The power cell
2 4686 is connected to at least one of the interconnected subsequent components of the DATCM
3 thereby providing an electric current to all subsequent components. In one example, the power
4 source 4686 is connected to the system bus component 4604. In an alternative embodiment, an
5 outside power source 4686 is provided through a connection across the I/O 4608 interface. For
6 example, a USB and/or IEEE 1394 connection carries both data and power across the
7 connection and is therefore a suitable source of power.

8

Interface Adapters

9 **[00537]** Interface bus(es) 4607 may accept, connect, and/or communicate to a number of
10 interface adapters, conventionally although not necessarily in the form of adapter cards, such as
11 but not limited to: input output interfaces (I/O) 4608, storage interfaces 4609, network interfaces
12 4610, and/or the like. Optionally, cryptographic processor interfaces 4627 similarly may be
13 connected to the interface bus. The interface bus provides for the communications of interface
14 adapters with one another as well as with other components of the computer systemization.
15 Interface adapters are adapted for a compatible interface bus. Interface adapters conventionally
16 connect to the interface bus via a slot architecture. Conventional slot architectures may be
17 employed, such as, but not limited to: Accelerated Graphics Port (AGP), Card Bus, (Extended)
18 Industry Standard Architecture ((E)ISA), Micro Channel Architecture (MCA), NuBus,
19 Peripheral Component Interconnect (Extended) (PCI(X)), PCI Express, Personal Computer
20 Memory Card International Association (PCMCIA), and/or the like.

21 **[00538]** Storage interfaces 4609 may accept, communicate, and/or connect to a number of
22 storage devices such as, but not limited to: storage devices 4614, removable disc devices, and/or
23 the like. Storage interfaces may employ connection protocols such as, but not limited to: (Ultra)
24 (Serial) Advanced Technology Attachment (Packet Interface) ((Ultra) (Serial) ATA(PI)),
25 (Enhanced) Integrated Drive Electronics ((E)IDE), Institute of Electrical and Electronics
26 Engineers (IEEE) 1394, fiber channel, Small Computer Systems Interface (SCSI), Universal
27 Serial Bus (USB), and/or the like.

28 **[00539]** Network interfaces 4610 may accept, communicate, and/or connect to a
29 communications network 4613. Through a communications network 4613, the DATCM

1 controller is accessible through remote clients 4633b (e.g., computers with web browsers) by
2 users 4633a. Network interfaces may employ connection protocols such as, but not limited to:
3 direct connect, Ethernet (thick, thin, twisted pair 10/100/1000 Base T, and/or the like), Token
4 Ring, wireless connection such as IEEE 802.11a-x, and/or the like. Should processing
5 requirements dictate a greater amount speed and/or capacity, distributed network controllers
6 (e.g., Distributed DATCM), architectures may similarly be employed to pool, load balance,
7 and/or otherwise increase the communicative bandwidth required by the DATCM controller. A
8 communications network may be any one and/or the combination of the following: a direct
9 interconnection; the Internet; a Local Area Network (LAN); a Metropolitan Area Network
10 (MAN); an Operating Missions as Nodes on the Internet (OMNI); a secured custom connection;
11 a Wide Area Network (WAN); a wireless network (e.g., employing protocols such as, but not
12 limited to a Wireless Application Protocol (WAP), I-mode, and/or the like); and/or the like. A
13 network interface may be regarded as a specialized form of an input output interface. Further,
14 multiple network interfaces 4610 may be used to engage with various communications network
15 types 4613. For example, multiple network interfaces may be employed to allow for the
16 communication over broadcast, multicast, and/or unicast networks.

17 **[00540]** Input Output interfaces (I/O) 4608 may accept, communicate, and/or connect to
18 user input devices 4611, peripheral devices 4612, cryptographic processor devices 4628, and/or
19 the like. I/O may employ connection protocols such as, but not limited to: audio: analog, digital,
20 monaural, RCA, stereo, and/or the like; data: Apple Desktop Bus (ADB), IEEE 1394a-b, serial,
21 universal serial bus (USB); infrared; joystick; keyboard; midi; optical; PC AT; PS/2; parallel;
22 radio; video interface: Apple Desktop Connector (ADC), BNC, coaxial, component, composite,
23 digital, Digital Visual Interface (DVI), high-definition multimedia interface (HDMI), RCA, RF
24 antennae, S-Video, VGA, and/or the like; wireless transceivers: 802.11a/b/g/n/x; Bluetooth;
25 cellular (e.g., code division multiple access (CDMA), high speed packet access (HSPA(+)),
26 high-speed downlink packet access (HSDPA), global system for mobile communications
27 (GSM), long term evolution (LTE), WiMax, etc.); and/or the like. One typical output device
28 may include a video display, which typically comprises a Cathode Ray Tube (CRT) or Liquid
29 Crystal Display (LCD) based monitor with an interface (e.g., DVI circuitry and cable) that
30 accepts signals from a video interface, may be used. The video interface composites information
31 generated by a computer systemization and generates video signals based on the composited

1 information in a video memory frame. Another output device is a television set, which accepts
2 signals from a video interface. Typically, the video interface provides the composited video
3 information through a video connection interface that accepts a video display interface (e.g., an
4 RCA composite video connector accepting an RCA composite video cable; a DVI connector
5 accepting a DVI display cable, etc.).

6 **[00541]** User input devices 4611 often are a type of peripheral device 4612 (see below)
7 and may include: card readers, dongles, finger print readers, gloves, graphics tablets, joysticks,
8 keyboards, microphones, mouse (mice), remote controls, retina readers, touch screens (e.g.,
9 capacitive, resistive, etc.), trackballs, trackpads, sensors (e.g., accelerometers, ambient light,
10 GPS, gyroscopes, proximity, etc.), styluses, and/or the like.

11 **[00542]** Peripheral devices 4612 may be connected and/or communicate to I/O and/or
12 other facilities of the like such as network interfaces, storage interfaces, directly to the interface
13 bus, system bus, the CPU, and/or the like. Peripheral devices may be external, internal and/or
14 part of the DATCM controller. Peripheral devices may include: antenna, audio devices (e.g.,
15 line-in, line-out, microphone input, speakers, etc.), cameras (e.g., still, video, webcam, etc.),
16 dongles (e.g., for copy protection, ensuring secure transactions with a digital signature, and/or
17 the like), external processors (for added capabilities; e.g., crypto devices 4628), force-feedback
18 devices (e.g., vibrating motors), network interfaces, printers, scanners, storage devices,
19 transceivers (e.g., cellular, GPS, etc.), video devices (e.g., goggles, monitors, etc.), video
20 sources, visors, and/or the like. Peripheral devices often include types of input devices (e.g.,
21 cameras).

22 **[00543]** It should be noted that although user input devices and peripheral devices may be
23 employed, the DATCM controller may be embodied as an embedded, dedicated, and/or
24 monitor-less (i.e., headless) device, wherein access would be provided over a network interface
25 connection.

26 **[00544]** Cryptographic units such as, but not limited to, microcontrollers, processors 4626,
27 interfaces 4627, and/or devices 4628 may be attached, and/or communicate with the DATCM
28 controller. A MC68HC16 microcontroller, manufactured by Motorola Inc., may be used for
29 and/or within cryptographic units. The MC68HC16 microcontroller utilizes a 16-bit multiply-
30 and-accumulate instruction in the 16 MHz configuration and requires less than one second to

1 perform a 512-bit RSA private key operation. Cryptographic units support the authentication of
2 communications from interacting agents, as well as allowing for anonymous transactions.
3 Cryptographic units may also be configured as part of the CPU. Equivalent microcontrollers
4 and/or processors may also be used. Other commercially available specialized cryptographic
5 processors include: the Broadcom's CryptoNetX and other Security Processors; nCipher's
6 nShield, SafeNet's Luna PCI (e.g., 7100) series; Semaphore Communications' 40 MHz
7 Roadrunner 184; Sun's Cryptographic Accelerators (e.g., Accelerator 6000 PCIe Board,
8 Accelerator 500 Daughtercard); Via Nano Processor (e.g., L2100, L2200, U2400) line, which is
9 capable of performing 500+ MB/s of cryptographic instructions; VLSI Technology's 33 MHz
10 6868; and/or the like.

11 **Memory**

12 **[00545]** Generally, any mechanization and/or embodiment allowing a processor to affect
13 the storage and/or retrieval of information is regarded as memory 4629. However, memory is a
14 fungible technology and resource, thus, any number of memory embodiments may be employed
15 in lieu of or in concert with one another. It is to be understood that the DATCM controller
16 and/or a computer systemization may employ various forms of memory 4629. For example, a
17 computer systemization may be configured wherein the operation of on-chip CPU memory
18 (e.g., registers), RAM, ROM, and any other storage devices are provided by a paper punch tape
19 or paper punch card mechanism; however, such an embodiment would result in an extremely
20 slow rate of operation. In a typical configuration, memory 4629 will include ROM 4606, RAM
21 4605, and a storage device 4614. A storage device 4614 may be any conventional computer
22 system storage. Storage devices may include a drum; a (fixed and/or removable) magnetic disk
23 drive; a magneto-optical drive; an optical drive (i.e., Blu-ray, CD ROM/RAM/Recordable
24 (R)/ReWritable (RW), DVD R/RW, HD DVD R/RW etc.); an array of devices (e.g., Redundant
25 Array of Independent Disks (RAID)); solid state memory devices (USB memory, solid state
26 drives (SSD), etc.); other processor-readable storage mediums; and/or other devices of the like.
27 Thus, a computer systemization generally requires and makes use of memory.

Component Collection

1
2 [00546] The memory 4629 may contain a collection of program and/or database
3 components and/or data such as, but not limited to: operating system component(s) 4615
4 (operating system); information server component(s) 4616 (information server); user interface
5 component(s) 4617 (user interface); Web browser component(s) 4618 (Web browser);
6 database(s) 4619; mail server component(s) 4621; mail client component(s) 4622; cryptographic
7 server component(s) 4620 (cryptographic server); the DATCM component(s) 4635; and/or the
8 like (i.e., collectively a component collection). These components may be stored and accessed
9 from the storage devices and/or from storage devices accessible through an interface bus.
10 Although non-conventional program components such as those in the component collection,
11 typically, are stored in a local storage device 4614, they may also be loaded and/or stored in
12 memory such as: peripheral devices, RAM, remote storage facilities through a communications
13 network, ROM, various forms of memory, and/or the like.

Operating System

14
15 [00547] The operating system component 4615 is an executable program component
16 facilitating the operation of the DATCM controller. Typically, the operating system facilitates
17 access of I/O, network interfaces, peripheral devices, storage devices, and/or the like. The
18 operating system may be a highly fault tolerant, scalable, and secure system such as: Apple
19 Macintosh OS X (Server); AT&T Plan 9; Be OS; Unix and Unix-like system distributions (such
20 as AT&T's UNIX; Berkley Software Distribution (BSD) variations such as FreeBSD, NetBSD,
21 OpenBSD, and/or the like; Linux distributions such as Red Hat, Ubuntu, and/or the like); and/or
22 the like operating systems. However, more limited and/or less secure operating systems also
23 may be employed such as Apple Macintosh OS, IBM OS/2, Microsoft DOS, Microsoft
24 Windows 2000/2003/3.1/95/98/CE/Millennium/NT/Vista/XP (Server), Palm OS, and/or the like.
25 An operating system may communicate to and/or with other components in a component
26 collection, including itself, and/or the like. Most frequently, the operating system communicates
27 with other program components, user interfaces, and/or the like. For example, the operating
28 system may contain, communicate, generate, obtain, and/or provide program component,
29 system, user, and/or data communications, requests, and/or responses. The operating system,
30 once executed by the CPU, may enable the interaction with communications networks, data,

1 I/O, peripheral devices, program components, memory, user input devices, and/or the like. The
2 operating system may provide communications protocols that allow the DATCM controller to
3 communicate with other entities through a communications network 4613. Various
4 communication protocols may be used by the DATCM controller as a subcarrier transport
5 mechanism for interaction, such as, but not limited to: multicast, TCP/IP, UDP, unicast, and/or
6 the like.

7 **Information Server**

8 **[00548]** An information server component 4616 is a stored program component that is
9 executed by a CPU. The information server may be a conventional Internet information server
10 such as, but not limited to Apache Software Foundation's Apache, Microsoft's Internet
11 Information Server, and/or the like. The information server may allow for the execution of
12 program components through facilities such as Active Server Page (ASP), ActiveX, (ANSI
13 (Objective-) C (++), C# and/or .NET, Common Gateway Interface (CGI) scripts, dynamic (D
14 hypertext markup language (HTML), FLASH, Java, JavaScript, Practical Extraction Report
15 Language (PERL), Hypertext Pre-Processor (PHP), pipes, Python, wireless application protocol
16 (WAP), WebObjects, and/or the like. The information server may support secure
17 communications protocols such as, but not limited to, File Transfer Protocol (FTP); HyperText
18 Transfer Protocol (HTTP); Secure Hypertext Transfer Protocol (HTTPS), Secure Socket Layer
19 (SSL), messaging protocols (e.g., America Online (AOL) Instant Messenger (AIM), Application
20 Exchange (APEX), ICQ, Internet Relay Chat (IRC), Microsoft Network (MSN) Messenger
21 Service, Presence and Instant Messaging Protocol (PRIM), Internet Engineering Task Force's
22 (IETF's) Session Initiation Protocol (SIP), SIP for Instant Messaging and Presence Leveraging
23 Extensions (SIMPLE), open XML-based Extensible Messaging and Presence Protocol (XMPP)
24 (i.e., Jabber or Open Mobile Alliance's (OMA's) Instant Messaging and Presence Service
25 (IMPS)), Yahoo! Instant Messenger Service, and/or the like. The information server provides
26 results in the form of Web pages to Web browsers, and allows for the manipulated generation of
27 the Web pages through interaction with other program components. After a Domain Name
28 System (DNS) resolution portion of an HTTP request is resolved to a particular information
29 server, the information server resolves requests for information at specified locations on the
30 DATCM controller based on the remainder of the HTTP request. For example, a request such as

1 http://123.124.125.126/myInformation.html might have the IP portion of the request
2 “123.124.125.126” resolved by a DNS server to an information server at that IP address; that
3 information server might in turn further parse the http request for the “/myInformation.html”
4 portion of the request and resolve it to a location in memory containing the information
5 “myInformation.html.” Additionally, other information serving protocols may be employed
6 across various ports, e.g., FTP communications across port 21, and/or the like. An information
7 server may communicate to and/or with other components in a component collection, including
8 itself, and/or facilities of the like. Most frequently, the information server communicates with
9 the DATCM database 4619, operating systems, other program components, user interfaces,
10 Web browsers, and/or the like.

11 **[00549]** Access to the DATCM database may be achieved through a number of database
12 bridge mechanisms such as through scripting languages as enumerated below (e.g., CGI) and
13 through inter-application communication channels as enumerated below (e.g., CORBA,
14 WebObjects, etc.). Any data requests through a Web browser are parsed through the bridge
15 mechanism into appropriate grammars as required by the DATCM. In one embodiment, the
16 information server would provide a Web form accessible by a Web browser. Entries made into
17 supplied fields in the Web form are tagged as having been entered into the particular fields, and
18 parsed as such. The entered terms are then passed along with the field tags, which act to instruct
19 the parser to generate queries directed to appropriate tables and/or fields. In one embodiment,
20 the parser may generate queries in standard SQL by instantiating a search string with the proper
21 join/select commands based on the tagged text entries, wherein the resulting command is
22 provided over the bridge mechanism to the DATCM as a query. Upon generating query results
23 from the query, the results are passed over the bridge mechanism, and may be parsed for
24 formatting and generation of a new results Web page by the bridge mechanism. Such a new
25 results Web page is then provided to the information server, which may supply it to the
26 requesting Web browser.

27 **[00550]** Also, an information server may contain, communicate, generate, obtain, and/or
28 provide program component, system, user, and/or data communications, requests, and/or
29 responses.

User Interface

1

2 [00551] Computer interfaces in some respects are similar to automobile operation
3 interfaces. Automobile operation interface elements such as steering wheels, gearshifts, and
4 speedometers facilitate the access, operation, and display of automobile resources, and status.
5 Computer interaction interface elements such as check boxes, cursors, menus, scrollers, and
6 windows (collectively and commonly referred to as widgets) similarly facilitate the access,
7 capabilities, operation, and display of data and computer hardware and operating system
8 resources, and status. Operation interfaces are commonly called user interfaces. Graphical user
9 interfaces (GUIs) such as the Apple Macintosh Operating System's Aqua, IBM's OS/2,
10 Microsoft's Windows 2000/2003/3.1/95/98/CE/Millennium/NT/XP/Vista/7 (i.e., Aero), Unix's
11 X-Windows (e.g., which may include additional Unix graphic interface libraries and layers such
12 as K Desktop Environment (KDE), mythTV and GNU Network Object Model Environment
13 (GNOME)), web interface libraries (e.g., ActiveX, AJAX, (D)HTML, FLASH, Java,
14 JavaScript, etc. interface libraries such as, but not limited to, Dojo, jQuery(UI), MooTools,
15 Prototype, script.aculo.us, SWFObject, Yahoo! User Interface, any of which may be used and)
16 provide a baseline and means of accessing and displaying information graphically to users.

17 [00552] A user interface component 4617 is a stored program component that is executed
18 by a CPU. The user interface may be a conventional graphic user interface as provided by, with,
19 and/or atop operating systems and/or operating environments such as already discussed. The
20 user interface may allow for the display, execution, interaction, manipulation, and/or operation
21 of program components and/or system facilities through textual and/or graphical facilities. The
22 user interface provides a facility through which users may affect, interact, and/or operate a
23 computer system. A user interface may communicate to and/or with other components in a
24 component collection, including itself, and/or facilities of the like. Most frequently, the user
25 interface communicates with operating systems, other program components, and/or the like. The
26 user interface may contain, communicate, generate, obtain, and/or provide program component,
27 system, user, and/or data communications, requests, and/or responses.

Web Browser

1
2 **[00553]** A Web browser component 4618 is a stored program component that is executed
3 by a CPU. The Web browser may be a conventional hypertext viewing application such as
4 Microsoft Internet Explorer or Netscape Navigator. Secure Web browsing may be supplied with
5 128bit (or greater) encryption by way of HTTPS, SSL, and/or the like. Web browsers allowing
6 for the execution of program components through facilities such as ActiveX, AJAX, (D)HTML,
7 FLASH, Java, JavaScript, web browser plug-in APIs (e.g., FireFox, Safari Plug-in, and/or the
8 like APIs), and/or the like. Web browsers and like information access tools may be integrated
9 into PDAs, cellular telephones, and/or other mobile devices. A Web browser may communicate
10 to and/or with other components in a component collection, including itself, and/or facilities of
11 the like. Most frequently, the Web browser communicates with information servers, operating
12 systems, integrated program components (e.g., plug-ins), and/or the like; e.g., it may contain,
13 communicate, generate, obtain, and/or provide program component, system, user, and/or data
14 communications, requests, and/or responses. Also, in place of a Web browser and information
15 server, a combined application may be developed to perform similar operations of both. The
16 combined application would similarly affect the obtaining and the provision of information to
17 users, user agents, and/or the like from the DATCM enabled nodes. The combined application
18 may be nugatory on systems employing standard Web browsers.

Mail Server

19
20 **[00554]** A mail server component 4621 is a stored program component that is executed by
21 a CPU 4603. The mail server may be a conventional Internet mail server such as, but not limited
22 to sendmail, Microsoft Exchange, and/or the like. The mail server may allow for the execution
23 of program components through facilities such as ASP, ActiveX, (ANSI) (Objective-) C (++),
24 C# and/or .NET, CGI scripts, Java, JavaScript, PERL, PHP, pipes, Python, WebObjects, and/or
25 the like. The mail server may support communications protocols such as, but not limited to:
26 Internet message access protocol (IMAP), Messaging Application Programming Interface
27 (MAPI)/Microsoft Exchange, post office protocol (POP3), simple mail transfer protocol
28 (SMTP), and/or the like. The mail server can route, forward, and process incoming and
29 outgoing mail messages that have been sent, relayed and/or otherwise traversing through and/or
30 to the DATCM.

1 [00555] Access to the DATCM mail may be achieved through a number of APIs offered
2 by the individual Web server components and/or the operating system.

3 [00556] Also, a mail server may contain, communicate, generate, obtain, and/or provide
4 program component, system, user, and/or data communications, requests, information, and/or
5 responses.

6 Mail Client

7 [00557] A mail client component 4622 is a stored program component that is executed by
8 a CPU 4603. The mail client may be a conventional mail viewing application such as Apple
9 Mail, Microsoft Entourage, Microsoft Outlook, Microsoft Outlook Express, Mozilla,
10 Thunderbird, and/or the like. Mail clients may support a number of transfer protocols, such as:
11 IMAP, Microsoft Exchange, POP3, SMTP, and/or the like. A mail client may communicate to
12 and/or with other components in a component collection, including itself, and/or facilities of the
13 like. Most frequently, the mail client communicates with mail servers, operating systems, other
14 mail clients, and/or the like; e.g., it may contain, communicate, generate, obtain, and/or provide
15 program component, system, user, and/or data communications, requests, information, and/or
16 responses. Generally, the mail client provides a facility to compose and transmit electronic mail
17 messages.

18 Cryptographic Server

19 [00558] A cryptographic server component 4620 is a stored program component that is
20 executed by a CPU 4603, cryptographic processor 4626, cryptographic processor interface
21 4627, cryptographic processor device 4628, and/or the like. Cryptographic processor interfaces
22 will allow for expedition of encryption and/or decryption requests by the cryptographic
23 component; however, the cryptographic component, alternatively, may run on a conventional
24 CPU. The cryptographic component allows for the encryption and/or decryption of provided
25 data. The cryptographic component allows for both symmetric and asymmetric (e.g., Pretty
26 Good Protection (PGP)) encryption and/or decryption. The cryptographic component may
27 employ cryptographic techniques such as, but not limited to: digital certificates (e.g., X.509
28 authentication framework), digital signatures, dual signatures, enveloping, password access
29 protection, public key management, and/or the like. The cryptographic component will facilitate

1 numerous (encryption and/or decryption) security protocols such as, but not limited to:
2 checksum, Data Encryption Standard (DES), Elliptical Curve Encryption (ECC), International
3 Data Encryption Algorithm (IDEA), Message Digest 5 (MD5, which is a one way hash
4 operation), passwords, Rivest Cipher (RC5), Rijndael, RSA (which is an Internet encryption and
5 authentication system that uses an algorithm developed in 1977 by Ron Rivest, Adi Shamir, and
6 Leonard Adleman), Secure Hash Algorithm (SHA), Secure Socket Layer (SSL), Secure
7 Hypertext Transfer Protocol (HTTPS), and/or the like. Employing such encryption security
8 protocols, the DATCM may encrypt all incoming and/or outgoing communications and may
9 serve as node within a virtual private network (VPN) with a wider communications network.
10 The cryptographic component facilitates the process of “security authorization” whereby access
11 to a resource is inhibited by a security protocol wherein the cryptographic component effects
12 authorized access to the secured resource. In addition, the cryptographic component may
13 provide unique identifiers of content, e.g., employing and MD5 hash to obtain a unique
14 signature for a digital audio file. A cryptographic component may communicate to and/or with
15 other components in a component collection, including itself, and/or facilities of the like. The
16 cryptographic component supports encryption schemes allowing for the secure transmission of
17 information across a communications network to enable the DATCM component to engage in
18 secure transactions if so desired. The cryptographic component facilitates the secure accessing
19 of resources on the DATCM and facilitates the access of secured resources on remote systems;
20 i.e., it may act as a client and/or server of secured resources. Most frequently, the cryptographic
21 component communicates with information servers, operating systems, other program
22 components, and/or the like. The cryptographic component may contain, communicate,
23 generate, obtain, and/or provide program component, system, user, and/or data communications,
24 requests, and/or responses.

25

The DATCM Database

26 **[00559]** The DATCM database component 4619 may be embodied in a database and its
27 stored data. The database is a stored program component, which is executed by the CPU; the
28 stored program component portion configuring the CPU to process the stored data. The database
29 may be a conventional, fault tolerant, relational, scalable, secure database such as Oracle or
30 Sybase. Relational databases are an extension of a flat file. Relational databases consist of a

1 series of related tables. The tables are interconnected via a key field. Use of the key field allows
2 the combination of the tables by indexing against the key field; i.e., the key fields act as
3 dimensional pivot points for combining information from various tables. Relationships
4 generally identify links maintained between tables by matching primary keys. Primary keys
5 represent fields that uniquely identify the rows of a table in a relational database. More
6 precisely, they uniquely identify rows of a table on the “one” side of a one-to-many relationship.

7 **[00560]** Alternatively, the DATCM database may be implemented using various standard
8 data-structures, such as an array, hash, (linked) list, struct, structured text file (e.g., XML), table,
9 and/or the like. Such data-structures may be stored in memory and/or in (structured) files. In
10 another alternative, an object-oriented database may be used, such as Frontier, ObjectStore,
11 Poet, Zope, and/or the like. Object databases can include a number of object collections that are
12 grouped and/or linked together by common attributes; they may be related to other object
13 collections by some common attributes. Object-oriented databases perform similarly to
14 relational databases with the exception that objects are not just pieces of data but may have
15 other types of capabilities encapsulated within a given object. If the DATCM database is
16 implemented as a data-structure, the use of the DATCM database 4619 may be integrated into
17 another component such as the DATCM component 4635. Also, the database may be
18 implemented as a mix of data structures, objects, and relational structures. Databases may be
19 consolidated and/or distributed in countless variations through standard data processing
20 techniques. Portions of databases, e.g., tables, may be exported and/or imported and thus
21 decentralized and/or integrated.

22 **[00561]** In one embodiment, the database component 4619 includes several tables 4619a-
23 p. A User table 4619a may include fields such as, but not limited to: user_id, ssn, dob,
24 first_name, last_name, age, state, address_firstline, address_secondline, zipcode, devices_list,
25 contact_info, contact_type, alt_contact_info, alt_contact_type, user_equipment, user_plane,
26 user_profile, and/or the like. An Account table 4619b may include fields such as, but not
27 limited to: acct_id, acct_user, acct_history, acct_access, acct_status, acct_subscription,
28 acct_profile, and/or the like.

29 **[00562]** A Profile table 4619c may include fields such as, but not limited to: prof_id,
30 prof_assets, prof_history, prof_details, profile_aircraft, and/or the like. A Terrain table 4619d

1 may include fields such as, but not limited to: terrain_id, terrain_details, terrain_parameters,
2 terrain_var, and/or the like. A Resource table 4619e may include fields such as, but not limited
3 to: resource_id, resource_location, resource_acct, and/or the like. An Equipment table 4619f
4 may include fields such as, but not limited to: equip_id, equip_location, equip_acct,
5 equip_contact, equip_type, and/or the like. A Model table 4619g may include fields such as, but
6 not limited to: model_id, model_assc, model_PPI, model_feedback, model_param, model_var,
7 and/or the like. A Weather data table 4619h may include fields such as, but not limited to:
8 weather_data_id, weather_source, weather_location, weather_data_type, weather_acct,
9 weather_icing, weather_var, and/or the like. In one embodiment, the weather data table is
10 populated through one or more weather data feeds. A Feedback table 4619i may include fields
11 such as, but not limited to: feedback_id, feedback_source, source_location, feedback_time,
12 feedback_acct, and/or the like.

13 **[00563]** An Aircraft table 4619j may include fields such as, but not limited to: aircraft_id,
14 aircraft_type, aircraft_profile, aircraft_fuel_capacity, aircraft_route, aircraft_use,
15 aircraft_owner, aircraft_location, aircraft_acct, aircraft_flightplan, aircraft_parameters,
16 aircraft_airfoil, aircraft_alerts, and/or the like. A Flight Plan table 4619k may include fields
17 such as, but not limited to: flightplan_id, flightplan_source, flightplan_start_location,
18 flightplan_start_time, flightplan_end_location, flightplan_end_time, flightplan_acct,
19 flightplan_aircraft, flightplan_profile, flightplan_type, flightplan_alerts, flightplan_parameters,
20 flightplan_airfoil, flightplan_PPI and/or the like. An Airfoil table 4619l may include fields such
21 as, but not limited to: airfoil_id, airfoil_source, airfoil_aircraft, airfoil_icing_profile,
22 airfoil_icing_determination, airfoil_profile, airfoil_type, airfoil_pi, airfoil_alerts,
23 airfoil_parameters, airfoil_PPI, and/or the like.

24 **[00564]** A Radar table 4619m may include fields such as, but not limited to: radar_id,
25 radar_source, radar_profile, radar_data, radar_type, radar_feed, radar_alerts, radar_parameters,
26 and/or the like.

27 **[00565]** A Lightning data table 4619n may include fields such as, but not limited to:
28 lightning_data_id, lightning_data_source, lightning_source_profile, lightning_location,
29 lightning_type, lightning_feed, lightning_alerts, lightning_data_parameters, and/or the like.

1 [00566] A Satellite table 4619p may include fields such as, but not limited to: satellite_id,
2 satellite_source, satellite_profile, satellite_type, satellite_feed, satellite_parameters, and/or the
3 like.

4 [00567] In one embodiment, the DATCM database may interact with other database
5 systems. For example, employing a distributed database system, queries and data access by
6 search DATCM component may treat the combination of the DATCM database, an integrated
7 data security layer database as a single database entity.

8 [00568] In one embodiment, user programs may contain various user interface primitives,
9 which may serve to update the DATCM. Also, various accounts may require custom database
10 tables depending upon the environments and the types of clients the DATCM may need to
11 serve. It should be noted that any unique fields may be designated as a key field throughout. In
12 an alternative embodiment, these tables have been decentralized into their own databases and
13 their respective database controllers (i.e., individual database controllers for each of the above
14 tables). Employing standard data processing techniques, one may further distribute the
15 databases over several computer systemizations and/or storage devices. Similarly,
16 configurations of the decentralized database controllers may be varied by consolidating and/or
17 distributing the various database components 4619a-p. The DATCM may be configured to keep
18 track of various settings, inputs, and parameters via database controllers.

19 [00569] The DATCM database may communicate to and/or with other components in a
20 component collection, including itself, and/or facilities of the like. Most frequently, the
21 DATCM database communicates with the DATCM component, other program components,
22 and/or the like. The database may contain, retain, and provide information regarding other
23 nodes and data.

24

The DATCMs

25 [00570] The DATCM component 4635 is a stored program component that is executed by
26 a CPU. In one embodiment, the DATCM component incorporates any and/or all combinations
27 of the aspects of the DATCM discussed in the previous figures. As such, the DATCM affects
28 accessing, obtaining and the provision of information, services, transactions, and/or the like
29 across various communications networks. The features and embodiments of the DATCM

1 discussed herein increase network efficiency by reducing data transfer requirements by the use
2 of more efficient data structures and mechanisms for their transfer and storage. As a
3 consequence, more data may be transferred in less time, and latencies with regard to
4 transactions, are also reduced. In many cases, such reduction in storage, transfer time,
5 bandwidth requirements, latencies, etc., will reduce the capacity and structural infrastructure
6 requirements to support the DATCM's features and facilities, and in many cases reduce the
7 costs, energy consumption/requirements, and extend the life of DATCM's underlying
8 infrastructure; this has the added benefit of making the DATCM more reliable. Similarly, many
9 of the features and mechanisms are designed to be easier for users to use and access, thereby
10 broadening the audience that may enjoy/employ and exploit the feature sets of the DATCM;
11 such ease of use also helps to increase the reliability of the DATCM. In addition, the feature sets
12 include heightened security as noted via the Cryptographic components 4620, 4626, 4628 and
13 throughout, making access to the features and data more reliable and secure. Additionally, the
14 DATCM enables more efficient and safe flight planning and routing, including real-time
15 dynamic responsiveness to changing weather conditions.

16 **[00571]** The DATCM component may transform weather data input via DATCM
17 components into real-time and/or predictive icing feeds and displays, and/or the like and use of
18 the DATCM. In one embodiment, the DATCM component 4635 takes inputs (e.g., weather
19 forecast data, atmospheric data, models, sensor data, and/or the like) etc., and transforms the
20 inputs via various components (a Tracking component 4644; a Path component 4645; a Display
21 component 4646; an Alerting component 4647; a Planning component 4648; a PPI component
22 4649; an input component 4650; an icing component 4651; a CFD component 4652; a TdA
23 component 4653; an NWF component 4654; an MWAVE component 4655; an INTTURB
24 component 4656; a VVTURB2 component 4657; a VVSTORMSE component 4658; an AIP
25 component 4659, and/or the like), into outputs (e.g., predictive flight path icing, percent power
26 increase needed, real-time airfoil-specific icing data, flight path modifications/optimizations,
27 icing alerts, and/or the like).

28 **[00572]** The DATCM component enabling access of information between nodes may be
29 developed by employing standard development tools and languages such as, but not limited to:
30 Apache components, Assembly, ActiveX, binary executables, (ANSI) (Objective-) C (++), C#
31 and/or .NET, database adapters, CGI scripts, Java, JavaScript, mapping tools, procedural and

1 object oriented development tools, PERL, PHP, Python, shell scripts, SQL commands, web
2 application server extensions, web development environments and libraries (e.g., Microsoft's
3 ActiveX; Adobe AIR, FLEX & FLASH; AJAX; (D)HTML; Dojo, Java; JavaScript; jQuery(UI);
4 MooTools; Prototype; script.aculo.us; Simple Object Access Protocol (SOAP); SWFObject;
5 Yahoo! User Interface; and/or the like), WebObjects, and/or the like. In one embodiment, the
6 DATCM server employs a cryptographic server to encrypt and decrypt communications. The
7 DATCM component may communicate to and/or with other components in a component
8 collection, including itself, and/or facilities of the like. Most frequently, the DATCM
9 component communicates with the DATCM database, operating systems, other program
10 components, and/or the like. The DATCM may contain, communicate, generate, obtain, and/or
11 provide program component, system, user, and/or data communications, requests, and/or
12 responses.

13 **Distributed DATCMs**

14 **[00573]** The structure and/or operation of any of the DATCM node controller components
15 may be combined, consolidated, and/or distributed in any number of ways to facilitate
16 development and/or deployment. Similarly, the component collection may be combined in any
17 number of ways to facilitate deployment and/or development. To accomplish this, one may
18 integrate the components into a common code base or in a facility that can dynamically load the
19 components on demand in an integrated fashion.

20 **[00574]** The component collection may be consolidated and/or distributed in countless
21 variations through standard data processing and/or development techniques. Multiple instances
22 of any one of the program components in the program component collection may be instantiated
23 on a single node, and/or across numerous nodes to improve performance through load-balancing
24 and/or data-processing techniques. Furthermore, single instances may also be distributed across
25 multiple controllers and/or storage devices; e.g., databases. All program component instances
26 and controllers working in concert may do so through standard data processing communication
27 techniques.

28 **[00575]** The configuration of the DATCM controller will depend on the context of system
29 deployment. Factors such as, but not limited to, the budget, capacity, location, and/or use of the

1 underlying hardware resources may affect deployment requirements and configuration.
2 Regardless of if the configuration results in more consolidated and/or integrated program
3 components, results in a more distributed series of program components, and/or results in some
4 combination between a consolidated and distributed configuration, data may be communicated,
5 obtained, and/or provided. Instances of components consolidated into a common code base from
6 the program component collection may communicate, obtain, and/or provide data. This may be
7 accomplished through intra-application data processing communication techniques such as, but
8 not limited to: data referencing (e.g., pointers), internal messaging, object instance variable
9 communication, shared memory space, variable passing, and/or the like.

10 **[00576]** If component collection components are discrete, separate, and/or external to one
11 another, then communicating, obtaining, and/or providing data with and/or to other components
12 may be accomplished through inter-application data processing communication techniques such
13 as, but not limited to: Application Program Interfaces (API) information passage; (distributed)
14 Component Object Model ((D)COM), (Distributed) Object Linking and Embedding ((D)OLE),
15 and/or the like), Common Object Request Broker Architecture (CORBA), Jini local and remote
16 application program interfaces, JavaScript Object Notation (JSON), Remote Method Invocation
17 (RMI), SOAP, process pipes, shared files, and/or the like. Messages sent between discrete
18 component components for inter-application communication or within memory spaces of a
19 singular component for intra-application communication may be facilitated through the creation
20 and parsing of a grammar. A grammar may be developed by using development tools such as
21 lex, yacc, XML, and/or the like, which allow for grammar generation and parsing capabilities,
22 which in turn may form the basis of communication messages within and between components.

23 **[00577]** For example, a grammar may be arranged to recognize the tokens of an HTTP
24 post command, e.g.:

```
25         w3c -post http://... Value1  
26
```

27 **[00578]** where Value1 is discerned as being a parameter because “http://” is part of the
28 grammar syntax, and what follows is considered part of the post value. Similarly, with such a
29 grammar, a variable “Value1” may be inserted into an “http://” post command and then sent.
30 The grammar syntax itself may be presented as structured data that is interpreted and/or
31 otherwise used to generate the parsing mechanism (e.g., a syntax description text file as

1 processed by lex, yacc, etc.). Also, once the parsing mechanism is generated and/or instantiated,
2 it itself may process and/or parse structured data such as, but not limited to: character (e.g., tab)
3 delineated text, HTML, structured text streams, XML, and/or the like structured data. In another
4 embodiment, inter-application data processing protocols themselves may have integrated and/or
5 readily available parsers (e.g., JSON, SOAP, and/or like parsers) that may be employed to parse
6 (e.g., communications) data. Further, the parsing grammar may be used beyond message
7 parsing, but may also be used to parse: databases, data collections, data stores, structured data,
8 and/or the like. Again, the desired configuration will depend upon the context, environment, and
9 requirements of system deployment.

10 **[00579]** For example, in some implementations, the DATCM controller may be executing
11 a PHP script implementing a Secure Sockets Layer (“SSL”) socket server via the information
12 server, which listens to incoming communications on a server port to which a client may send
13 data, e.g., data encoded in JSON format. Upon identifying an incoming communication, the
14 PHP script may read the incoming message from the client device, parse the received JSON-
15 encoded text data to extract information from the JSON-encoded text data into PHP script
16 variables, and store the data (e.g., client identifying information, etc.) and/or extracted
17 information in a relational database accessible using the Structured Query Language (“SQL”).
18 An exemplary listing, written substantially in the form of PHP/SQL commands, to accept
19 JSON-encoded input data from a client device via a SSL connection, parse the data to extract
20 variables, and store the data to a database, is provided below:

```
21 <?PHP
22 header('Content-Type: text/plain');
23
24 // set ip address and port to listen to for incoming data
25 $address = '192.168.0.100';
26 $port = 255;
27
28 // create a server-side SSL socket, listen for/accept incoming communication
29 $sock = socket_create(AF_INET, SOCK_STREAM, 0);
30 socket_bind($sock, $address, $port) or die('Could not bind to address');
31 socket_listen($sock);
32 $client = socket_accept($sock);
33
34 // read input data from client device in 1024 byte blocks until end of message
```

```
1 do {
2     $input = "";
3     $input = socket_read($client, 1024);
4     $data .= $input;
5 } while($input != "");
6
7 // parse data to extract variables
8 $obj = json_decode($data, true);
9
10 // store input data in a database
11 mysql_connect("201.408.185.132",$DBserver,$password); // access database server
12 mysql_select("CLIENT_DB.SQL"); // select database to append
13 mysql_query("INSERT INTO UserTable (transmission)
14 VALUES ($data)"); // add data to UserTable table in a CLIENT database
15 mysql_close("CLIENT_DB.SQL"); // close connection to database
16 ?>
17
```

18 **[00580]** Also, the following resources may be used to provide example embodiments
19 regarding SOAP parser implementation:

```
20 http://www.xav.com/perl/site/lib/SOAP/Parser.html
21 http://publib.boulder.ibm.com/infocenter/tivihelp/v2r1/index.jsp?topic=/com.ibm
22 .IBMDI.doc/referenceguide295.htm
23
```

24 **[00581]** and other parser implementations:

```
25 http://publib.boulder.ibm.com/infocenter/tivihelp/v2r1/index.jsp?topic=/com.ibm
26 .IBMDI.doc/referenceguide259.htm
27
```

28 **[00582]** all of which are hereby expressly incorporated by reference herein.

29 **[00583]** In order to address various issues and advance the art, the entirety of this
30 application for DYNAMIC AIRCRAFT THREAT CONTROLLER MANAGER
31 APPARATUSES, METHODS AND SYSTEMS (including the Cover Page, Title, Headings,
32 Field, Background, Summary, Brief Description of the Drawings, Detailed Description, Claims,
33 Abstract, Figures, Appendices and/or otherwise) shows by way of illustration various
34 embodiments in which the claimed innovations may be practiced. The advantages and features
35 of the application are of a representative sample of embodiments only, and are not exhaustive
36 and/or exclusive. They are presented only to assist in understanding and teach the claimed
37 principles. It should be understood that they are not representative of all claimed innovations.

1 As such, certain aspects of the disclosure have not been discussed herein. That alternate
2 embodiments may not have been presented for a specific portion of the innovations or that
3 further undescribed alternate embodiments may be available for a portion is not to be
4 considered a disclaimer of those alternate embodiments. It will be appreciated that many of
5 those undescribed embodiments incorporate the same principles of the innovations and others
6 are equivalent. Thus, it is to be understood that other embodiments may be utilized and
7 functional, logical, operational, organizational, structural and/or topological modifications may
8 be made without departing from the scope and/or spirit of the disclosure. As such, all examples
9 and/or embodiments are deemed to be non-limiting throughout this disclosure. Also, no
10 inference should be drawn regarding those embodiments discussed herein relative to those not
11 discussed herein other than it is as such for purposes of reducing space and repetition. For
12 instance, it is to be understood that the logical and/or topological structure of any combination
13 of any program components (a component collection), other components and/or any present
14 feature sets as described in the figures and/or throughout are not limited to a fixed operating
15 order and/or arrangement, but rather, any disclosed order is exemplary and all equivalents,
16 regardless of order, are contemplated by the disclosure. Furthermore, it is to be understood that
17 such features are not limited to serial execution, but rather, any number of threads, processes,
18 services, servers, and/or the like that may execute asynchronously, concurrently, in parallel,
19 simultaneously, synchronously, and/or the like are contemplated by the disclosure. As such,
20 some of these features may be mutually contradictory, in that they cannot be simultaneously
21 present in a single embodiment. Similarly, some features are applicable to one aspect of the
22 innovations, and inapplicable to others. In addition, the disclosure includes other innovations
23 not presently claimed. Applicant reserves all rights in those presently unclaimed innovations,
24 including the right to claim such innovations, file additional applications, continuations,
25 continuations in part, divisions, and/or the like thereof. As such, it should be understood that
26 advantages, embodiments, examples, functional, features, logical, operational, organizational,
27 structural, topological, and/or other aspects of the disclosure are not to be considered limitations
28 on the disclosure as defined by the claims or limitations on equivalents to the claims. It is to be
29 understood that, depending on the particular needs and/or characteristics of a DATCM
30 individual and/or enterprise user, database configuration and/or relational model, data type, data
31 transmission and/or network framework, syntax structure, and/or the like, various embodiments

1 of the DATCM may be implemented that enable a great deal of flexibility and customization.
2 For example, aspects of the DATCM may be adapted for integration with flight planning and
3 route optimization. While various embodiments and discussions of the DATCM have been
4 directed to predictive icing, however, it is to be understood that the embodiments described
5 herein may be readily configured and/or customized for a wide variety of other applications
6 and/or implementations.

7

CLAIMS

1
2 What is claimed is:

3 1. A dynamic comprehensive hazard processor-implemented flight planning
4 method, comprising:

5 receiving parameter data for an initial anticipated flight plan;

6 determining aircraft data for an aircraft associated with the initial
7 anticipated flight plan;

8 obtaining atmospheric data based on the flight plan parameter data;

9 determining a plurality of four-dimensional grid points based on the flight
10 plan parameter data; and

11 determining via a processor corresponding comprehensive hazard data for
12 each point of the plurality of four-dimensional grid point based on the airfoil type, the
13 comprehensive hazard data including comprehensive turbulence data and icing data.

14 2. The method of claim 1, further comprising determining an at least one
15 alternative flight plan based on the flight plan parameter data and the determined
16 comprehensive hazard data for the initial anticipated flight plan; and

17 providing the determined at least one alternative flight plan.

18 3. The method of claim 1 or 2, further comprising generating a real-time
19 hazard map and providing the generated real-time hazard map.

20 4. The method of any preceding claim, wherein the parameter data includes
21 aircraft data.

22 5. The method of any preceding claim, wherein the parameter data includes
23 the airfoil type.

24 6. The method of any preceding claim, wherein the initial anticipated flight
25 plan comprises a shortest route flight plan.

26 7. The method of any preceding claim, wherein the at least one alternative
27 flight plan comprises an optimized route flight plan.

28 8. The method of claim 7, wherein the optimized route flight plan is
29 optimized for safety.

- 1 9. The method of claim 7, wherein the optimized route flight plan is
2 optimized for safety and fuel consumption.
- 3 10. The method of any preceding claim, wherein the flight plan parameter
4 data includes take-off time.
- 5 11. The method of any preceding claim, wherein the flight plan parameter
6 data includes take-off location.
- 7 12. The method of any preceding claim, wherein the flight plan parameter
8 data includes destination location.
- 9 13. A dynamic comprehensive hazard flight planning apparatus, comprising:
10 a processor; and
11 a memory disposed in communication with the processor and storing processor-
12 issuable instructions to:
13 receive parameter data for an initial anticipated flight plan;
14 determine aircraft data for an aircraft associated with the initial
15 anticipated flight plan;
16 obtain atmospheric data based on the flight plan parameter data;
17 determine a plurality of four-dimensional grid points based on the flight
18 plan parameter data;
19 determine corresponding comprehensive hazard data for each point of the
20 plurality of four-dimensional grid point based on the airfoil type, the comprehensive
21 hazard data including comprehensive turbulence data and icing data;
22 determine an at least one alternative flight plan based on the flight plan
23 parameter data and the determined comprehensive hazard data for the initial
24 anticipated flight plan; and
25 provide the determined at least one alternative flight plan.
- 26 14. The apparatus of claim 13, wherein the parameter data includes aircraft
27 data.
- 28 15. The apparatus of claim 13, wherein the parameter data includes the airfoil
29 type.
- 30 16. The apparatus of claim 13, wherein the initial anticipated flight plan
31 comprises a shortest route flight plan.

1 17. The apparatus of claim 13, wherein the at least one alternative flight plan
2 comprises an optimized route flight plan.

3 18. The apparatus of claim 17, wherein the optimized route flight plan is
4 optimized for safety.

5 19. The apparatus of claim 17, wherein the optimized route flight plan is
6 optimized for safety and fuel consumption.

7 20. The apparatus of claim 13, wherein the flight plan parameter data includes
8 take-off time.

9 21. The apparatus of claim 13, wherein the flight plan parameter data includes
10 take-off location.

11 22. The apparatus of claim 13, wherein the flight plan parameter data includes
12 destination location.

13 23. A processor-readable tangible medium storing processor-issuable dynamic
14 comprehensive hazard flight plan generating instructions to:

15 receive parameter data for an initial anticipated flight plan;

16 determine aircraft data for an aircraft associated with the initial anticipated flight
17 plan;

18 obtain atmospheric data based on the flight plan parameter data;

19 determine a plurality of four-dimensional grid points based on the flight plan
20 parameter data;

21 determine corresponding comprehensive hazard data for each point of the
22 plurality of four-dimensional grid point based on the airfoil type, the comprehensive
23 hazard data including comprehensive turbulence data and icing data;

24 determine an at least one alternative flight plan based on the flight plan
25 parameter data and the determined comprehensive hazard data for the initial
26 anticipated flight plan; and

27 provide the determined at least one alternative flight plan.

28 24. The medium of claim 23, wherein the parameter data includes aircraft
29 data.

30 25. The medium of claim 23, wherein the parameter data includes the airfoil
31 type.

1 26. The medium of claim 23, wherein the initial anticipated flight plan
2 comprises a shortest route flight plan.

3 27. The medium of claim 23, wherein the at least one alternative flight plan
4 comprises an optimized route flight plan.

5 28. The medium of claim 27, wherein the optimized route flight plan is
6 optimized for safety.

7 29. The medium of claim 27, wherein the optimized route flight plan is
8 optimized for safety and fuel consumption.

9 30. The medium of claim 23, wherein the flight plan parameter data includes
10 take-off time.

11 31. The medium of claim 23, wherein the flight plan parameter data includes
12 take-off location.

13 32. The medium of claim 23, wherein the flight plan parameter data includes
14 destination location.

15 33. A dynamic comprehensive hazard flight plan generating system,
16 comprising:

17 means to receive parameter data for an initial anticipated flight plan;

18 means to determine aircraft data for an aircraft associated with the initial
19 anticipated flight plan;

20 means to obtain atmospheric data based on the flight plan parameter data;

21 means to determine a plurality of four-dimensional grid points based on the
22 flight plan parameter data;

23 means to determine corresponding comprehensive hazard data for each point of
24 the plurality of four-dimensional grid point based on the airfoil type, the comprehensive
25 hazard data including comprehensive turbulence data and icing data;

26 means to determine an at least one alternative flight plan based on the flight plan
27 parameter data and the determined comprehensive hazard data for the initial
28 anticipated flight plan; and

29 means to provide the determined at least one alternative flight plan.

30 34. The system of claim 33, wherein the parameter data includes aircraft data.

31 35. The system of claim 33 or 34, wherein the parameter data includes the
32 airfoil type.

1 36. The system of any of claims 33-35, wherein the initial anticipated flight
2 plan comprises a shortest route flight plan.

3 37. The system of any of claims 33-36, wherein the at least one alternative
4 flight plan comprises an optimized route flight plan.

5 38. The system of claim 37, wherein the optimized route flight plan is
6 optimized for safety.

7 39. The system of claim 37, wherein the optimized route flight plan is
8 optimized for safety and fuel consumption.

9 40. The system of any of claims 33-39, wherein the flight plan parameter data
10 includes take-off time.

11 41. The system of any of claims 33-40, wherein the flight plan parameter data
12 includes take-off location.

13 42. The system of any of claims 33-41, wherein the flight plan parameter data
14 includes destination location.

15 43. The system of any of claims 33-42, comprising:

16 means to determine at least one of the turbulent kinetic energy and the total eddy
17 dissipation rate for each grid point.

18 44. A DATCM flight planning system, comprising: means to receive parameter
19 data for a flight; means to determine airfoil type for an aircraft associated with the
20 flight; means to obtain atmospheric data based on the flight parameter data; means to
21 determine a plurality of grid points based on the flight data; means to determine
22 turbulent kinetic energy for each grid point; means to determine icing data for each grid
23 point of the plurality of grid points based on the airfoil type and atmospheric data;
24 means to identify an at least one flight plan based on the flight data and the determined
25 turbulent kinetic energy and icing data; and means to provide the identified at least one
26 flight plan.

27 45. A DATCM system, comprising:

28 means to receive a PPI flight parameter input associated with an aircraft;

29 means to determine an airfoil type for the aircraft associated with the PPI
30 flight parameter input;

31 means to determine atmospheric data based on the PPI flight parameter
32 input;

1 means to provide the determined airfoil type and atmospheric data to a
2 PPI component for the determination of a PPI icing avoidance value;

3 means to receive, from the PPI component, an indication of the
4 determined PPI icing avoidance value; and

5 means to provide the determined PPI icing avoidance value in response to
6 the PPI flight parameter input.

7 46. The system of claim 45, wherein the PPI flight parameter input is configured
8 to represent the present airfoil configuration and atmospheric conditions being
9 experienced by the aircraft.

10 47. The system of claim 45 or 46, wherein the PPI flight parameter input is
11 configured to represent the expected airfoil configuration and atmospheric conditions
12 that will be experienced by the aircraft at a future point in time.

13 48. The system of any of claims 45-47, wherein the determined atmospheric data
14 includes a temperature.

15 49. The system of any of claims 45-48, wherein the determined atmospheric data
16 includes a value associated with the water content of the atmosphere about the aircraft
17 at a point in time.

18 50. The system of any of claims 45-49, wherein the PPI component is a hardware
19 PPI component.

20 51. The system of claim 50, wherein the hardware PPI component is an ASIC.

21 52. The system of claim 50, wherein the hardware PPI component is an FPGA.

22 53. The system of any of the claims 45-49, wherein the PPI component is a PPI
23 component containing processor executable instructions.

24 54. The system of any of the claims 45-49, wherein the PPI component is a PPI
25 component composed of two-or-more sub-components.

26 55. The system of claim 54, wherein the PPI component is comprised of a first
27 sub-component in hardware for determining a first value associated with the PPI icing
28 avoidance value and a second sub-component containing processor executable
29 instructions for determining a second value associated with the PPI icing avoidance
30 value.

31 56. The system of claim 55, wherein the first and second value associated with the
32 PPI icing avoidance value are used to determine the PPI icing avoidance value.

1 57. The DATCM flight planning system of claim 44, comprising the DATCM
2 system according to any of claims 45-56.

3

4

5

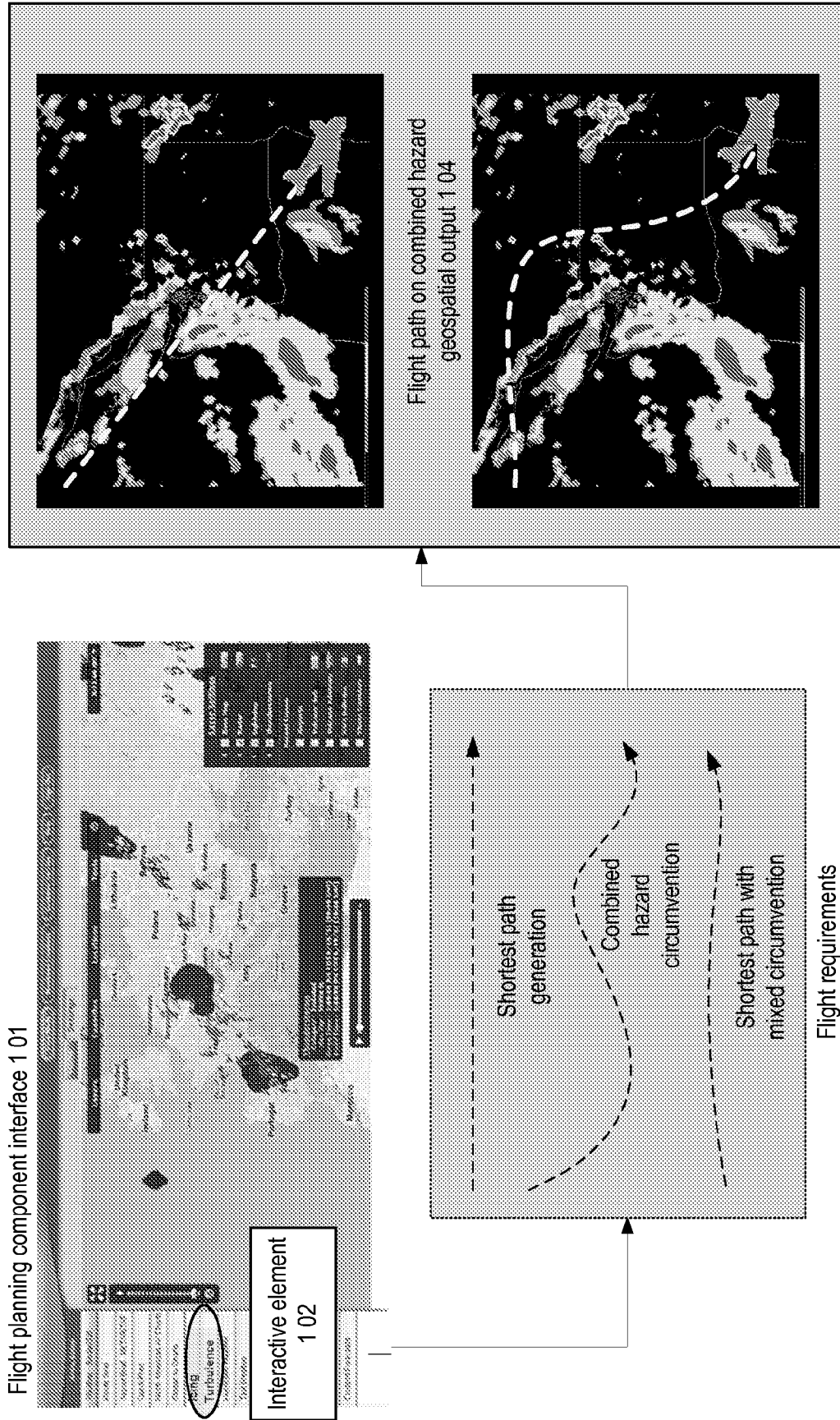


FIG 1A – Example DATCM Combined Hazard Flight Planning Implementation

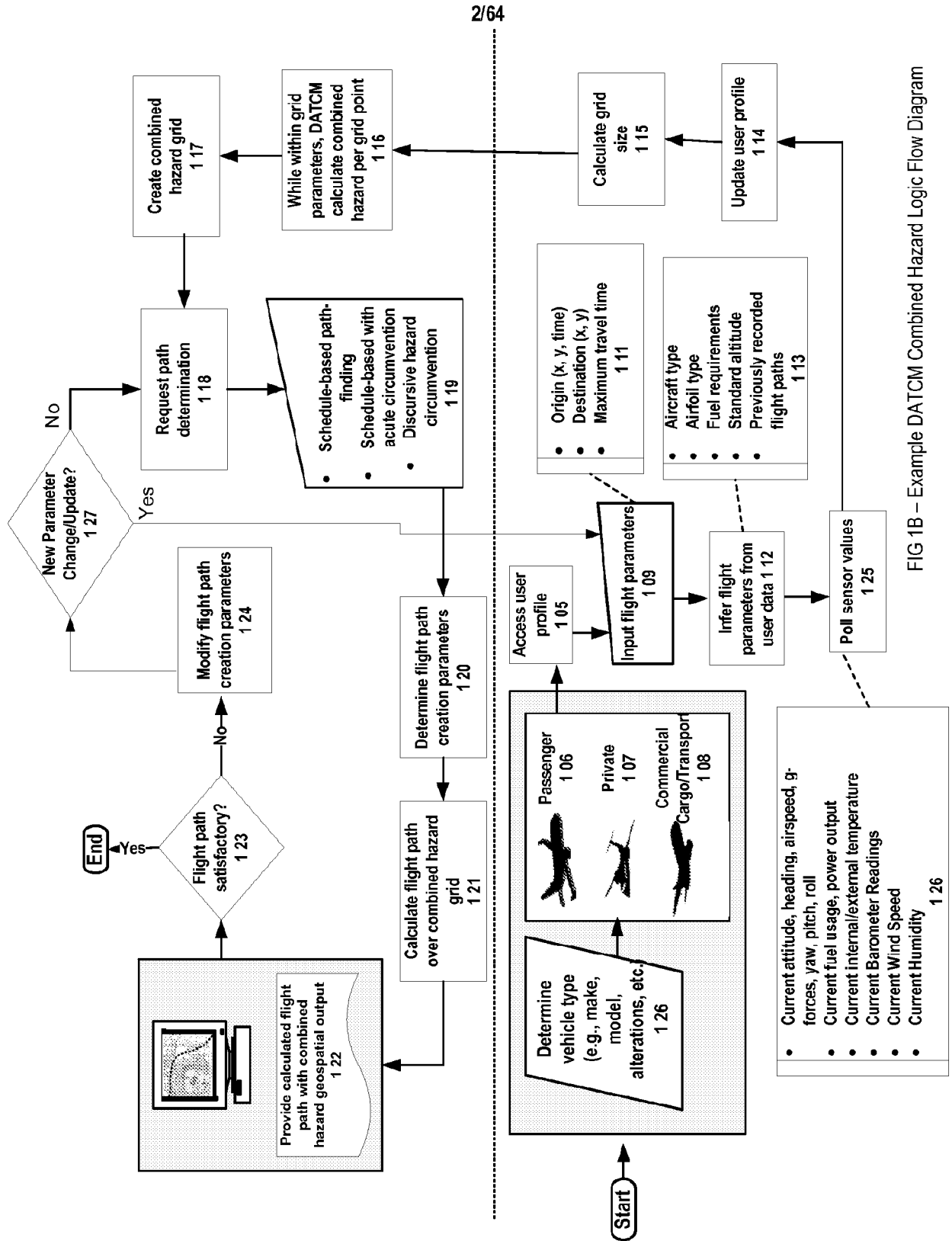


FIG 1B – Example DATCM Combined Hazard Logic Flow Diagram

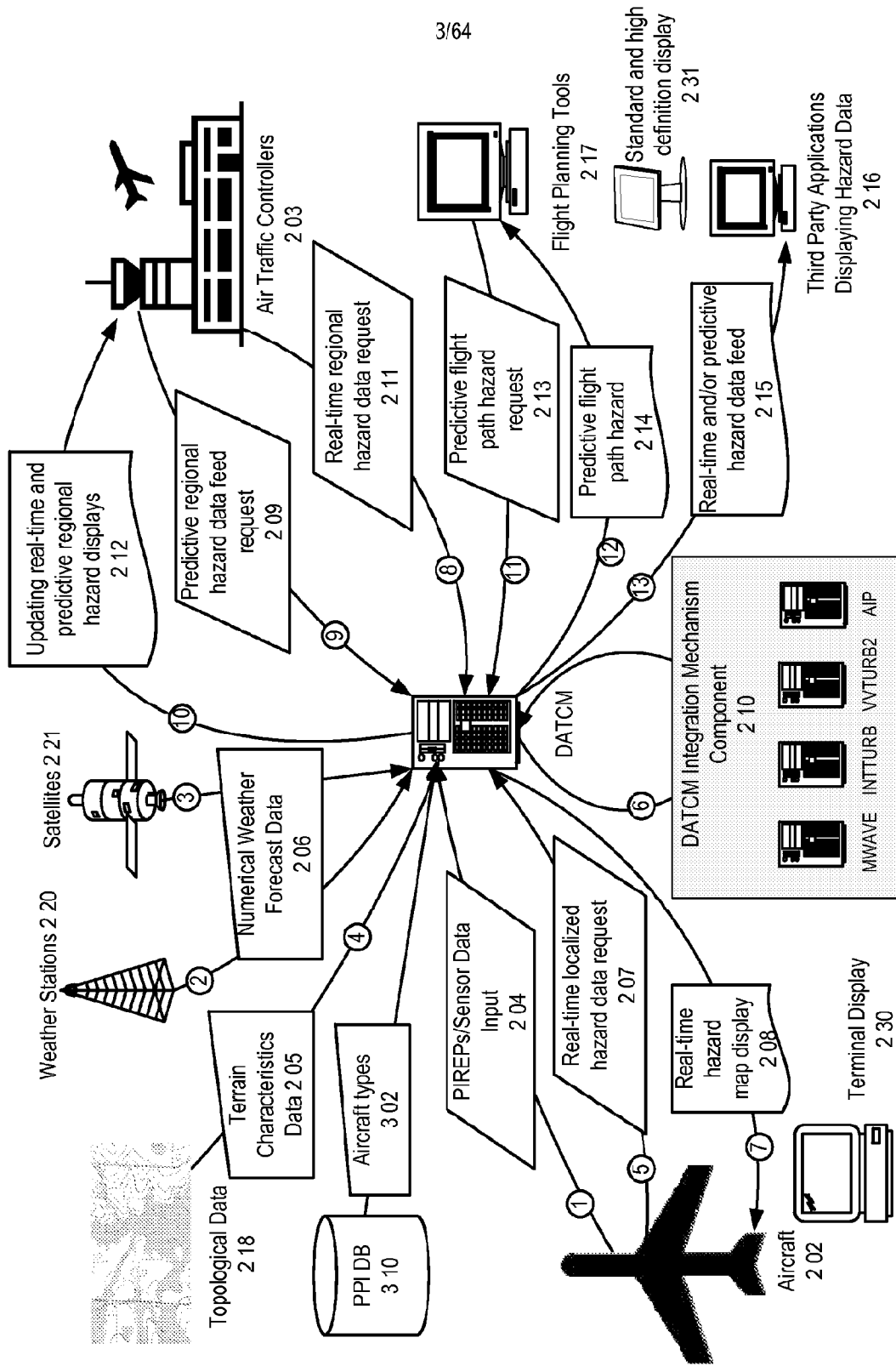


FIG 2 – Example DATCM Combined Hazard Data Flow Diagram

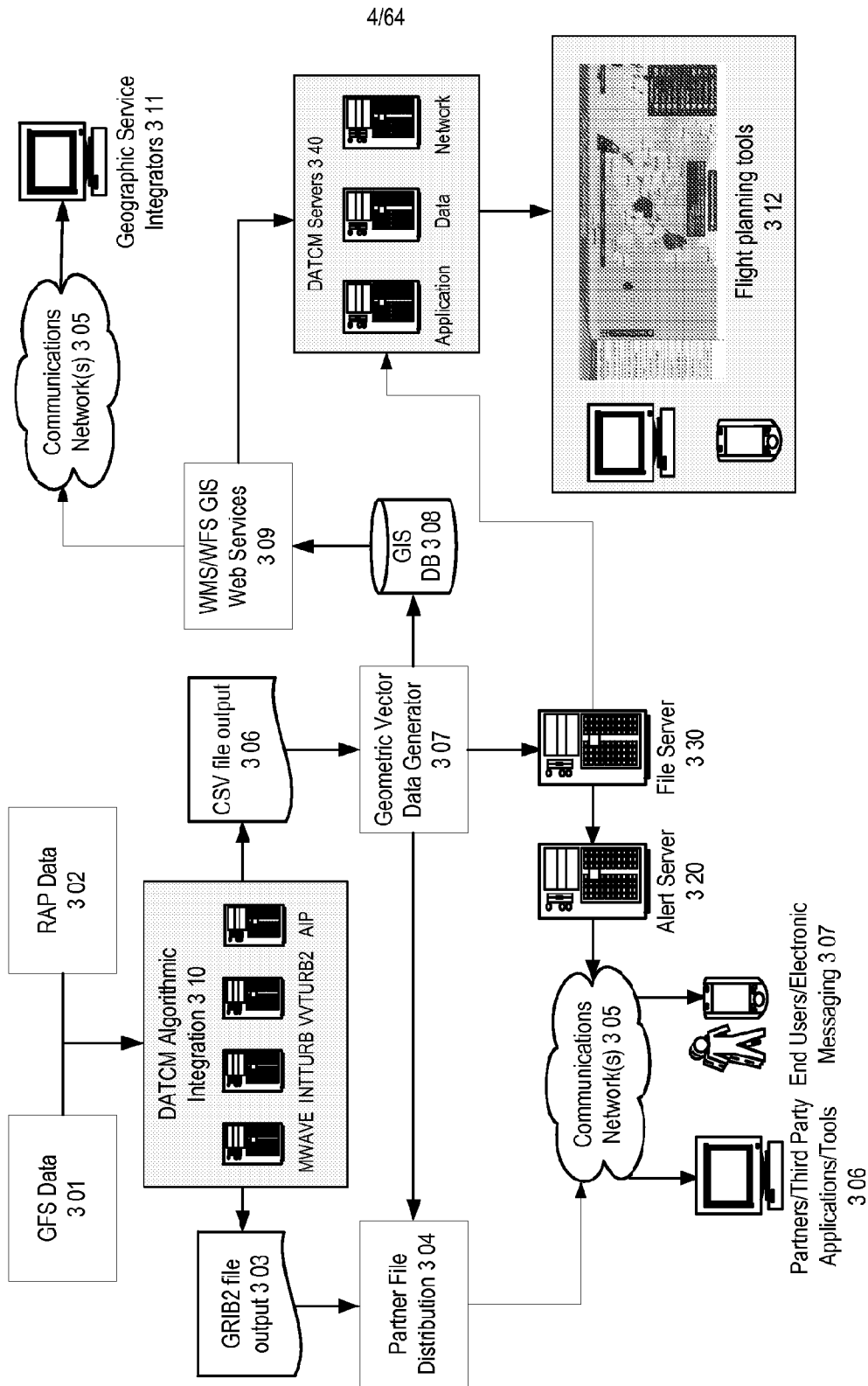


FIG 3 – Example DATCM Combined Hazard Data Flow Diagram

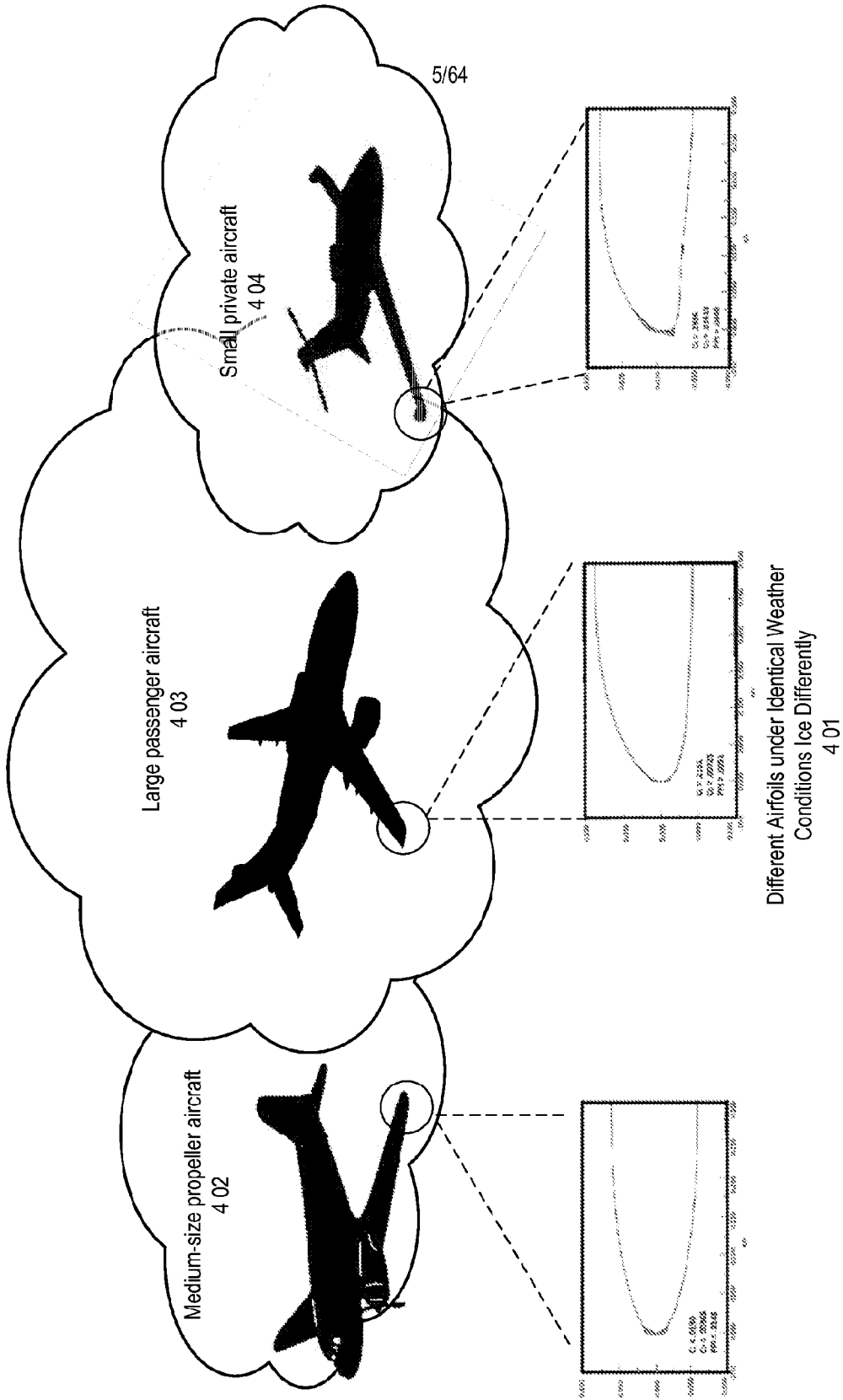


FIG 4 - Example DATCM Airfoil Icing Overview Diagram

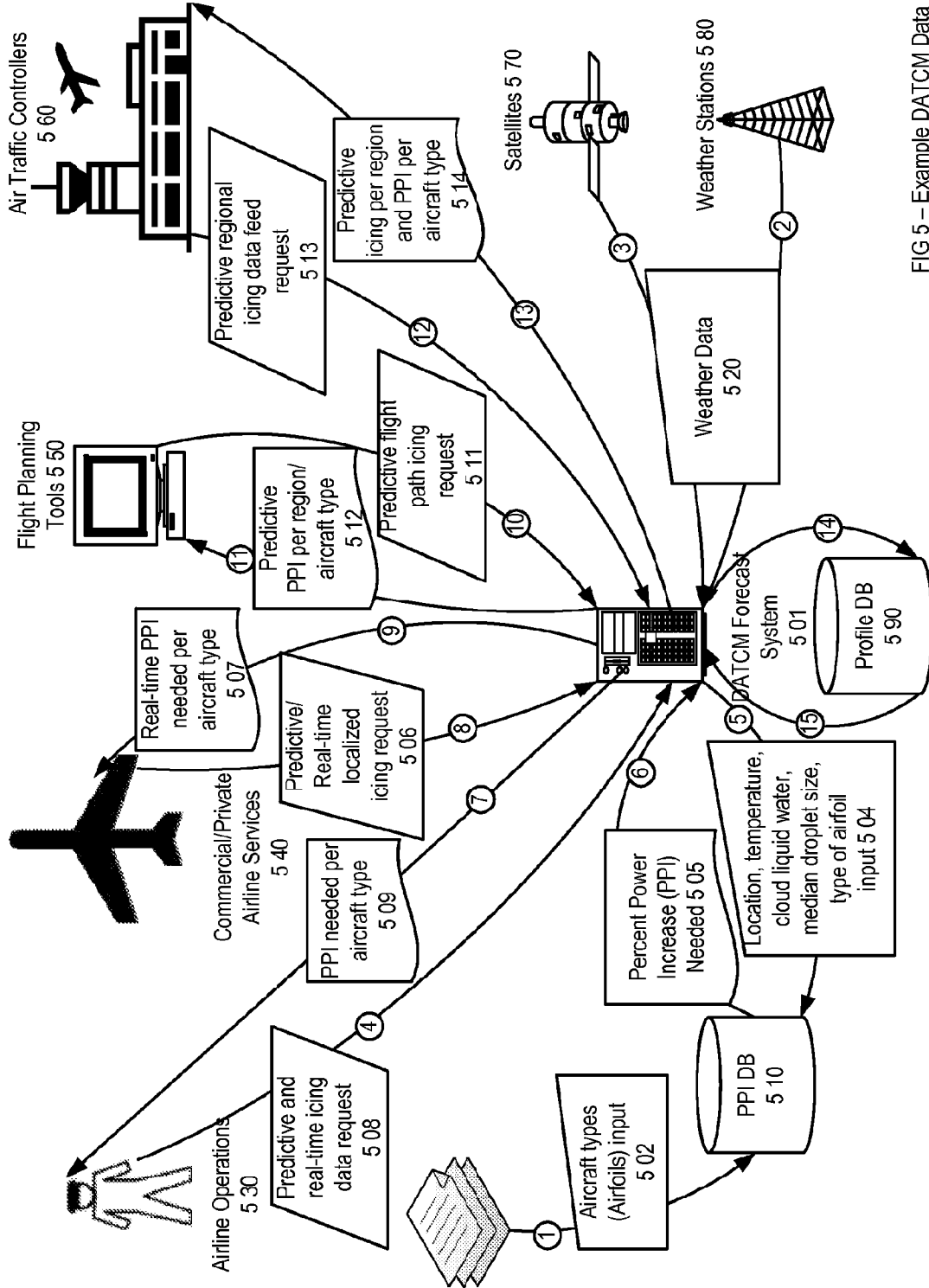


FIG 5 – Example DATCM Data Flow Diagram

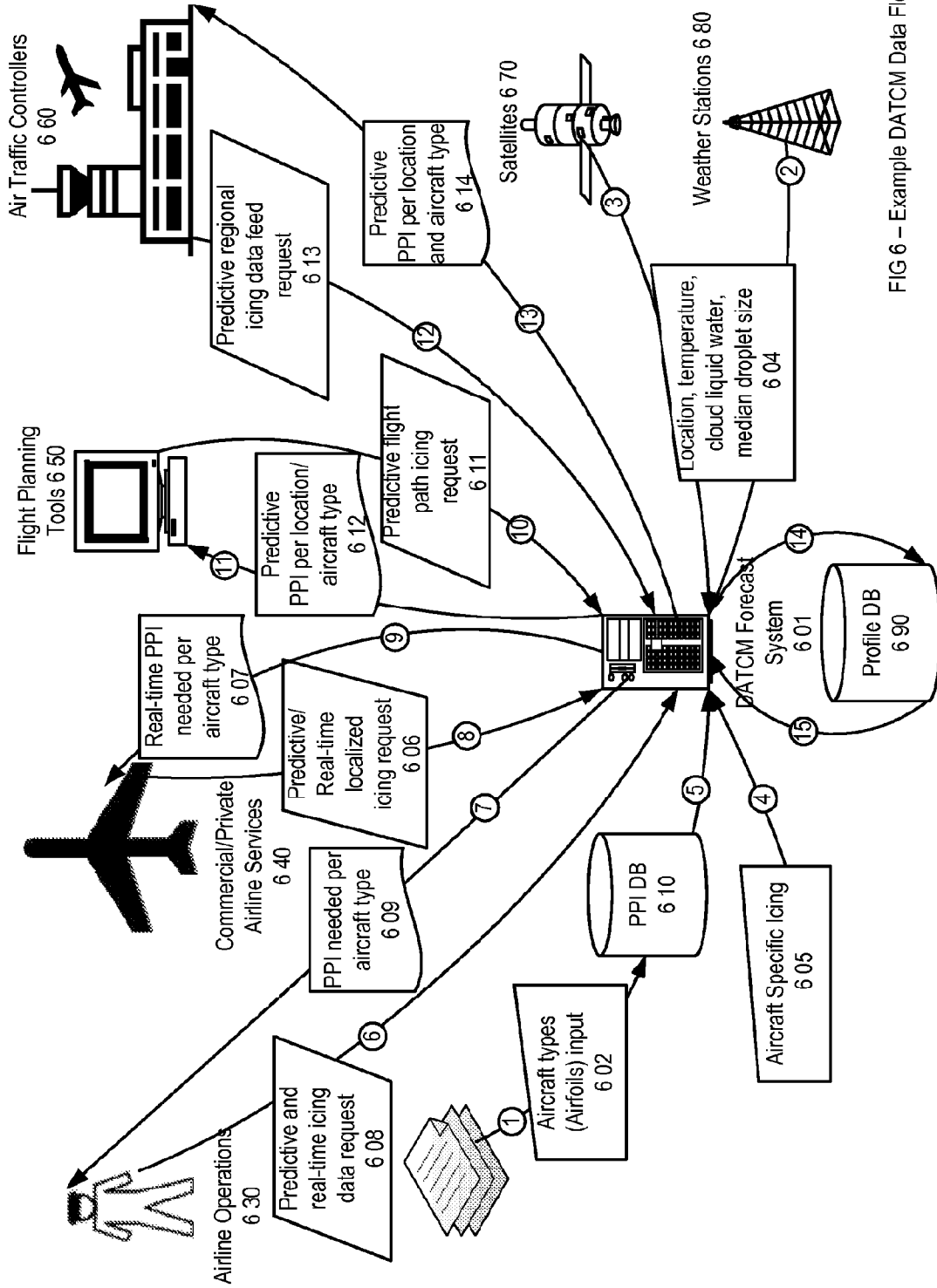


FIG 6 – Example DATCM Data Flow Diagram

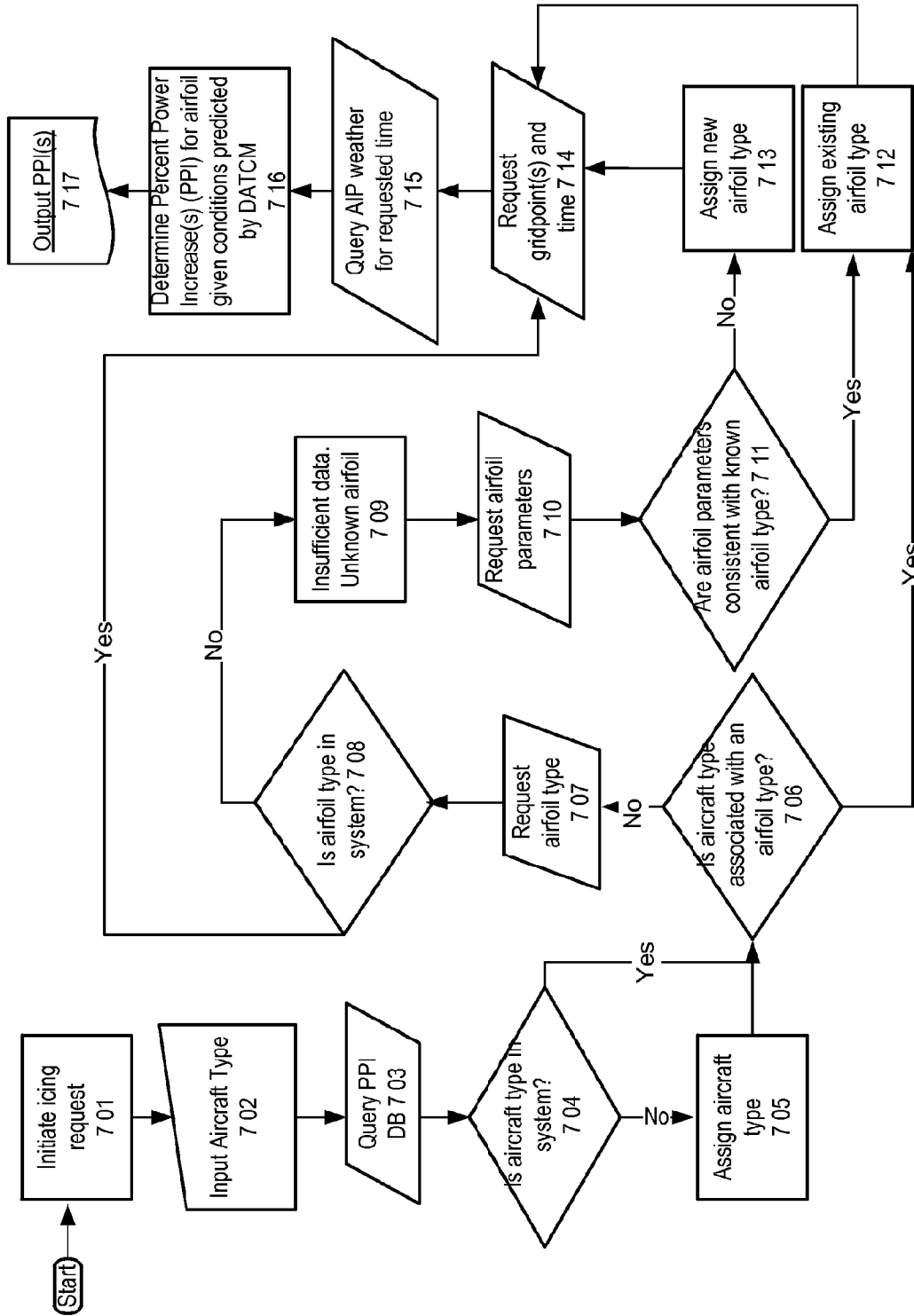


FIG 7 – Example DATCM PPI Logic Flow Diagram

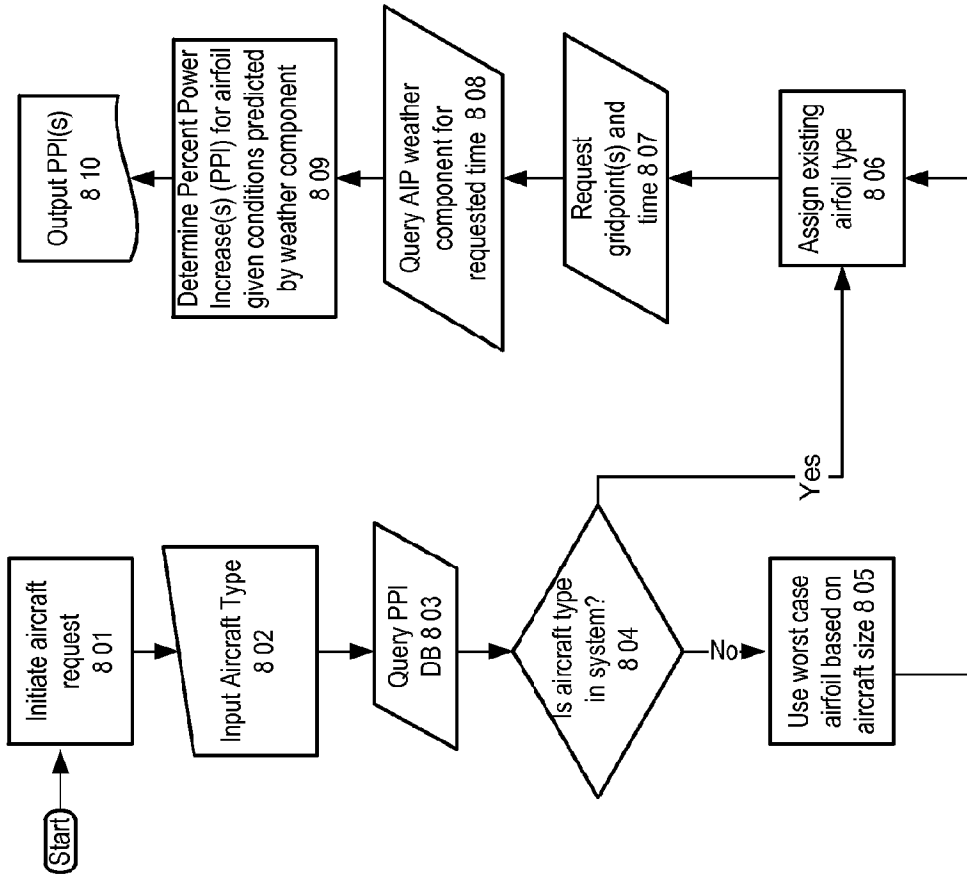


FIG 8 – Example DATCM PPI Logic Flow Diagram

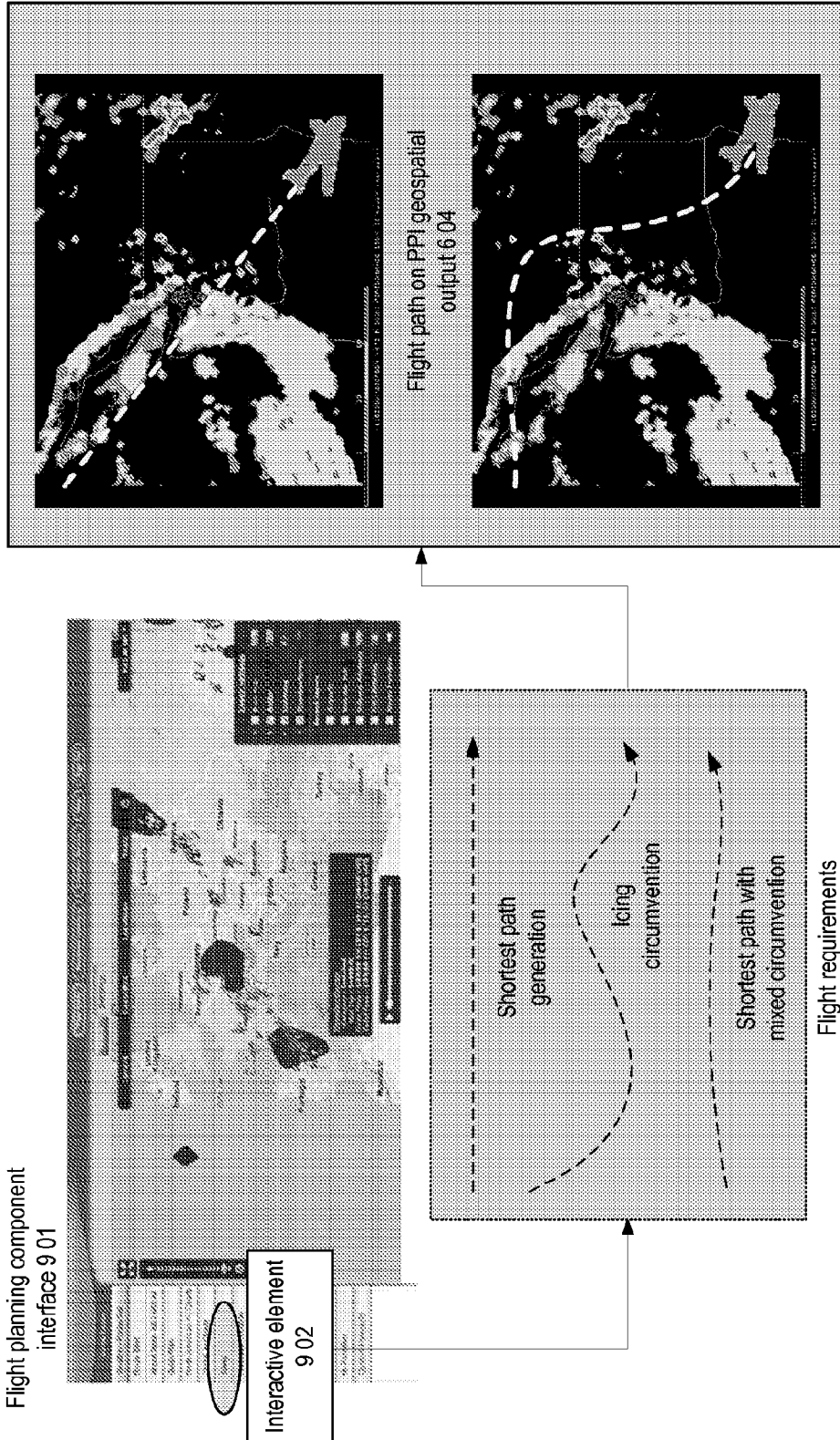


FIG 9 - Example DATCM User Interface

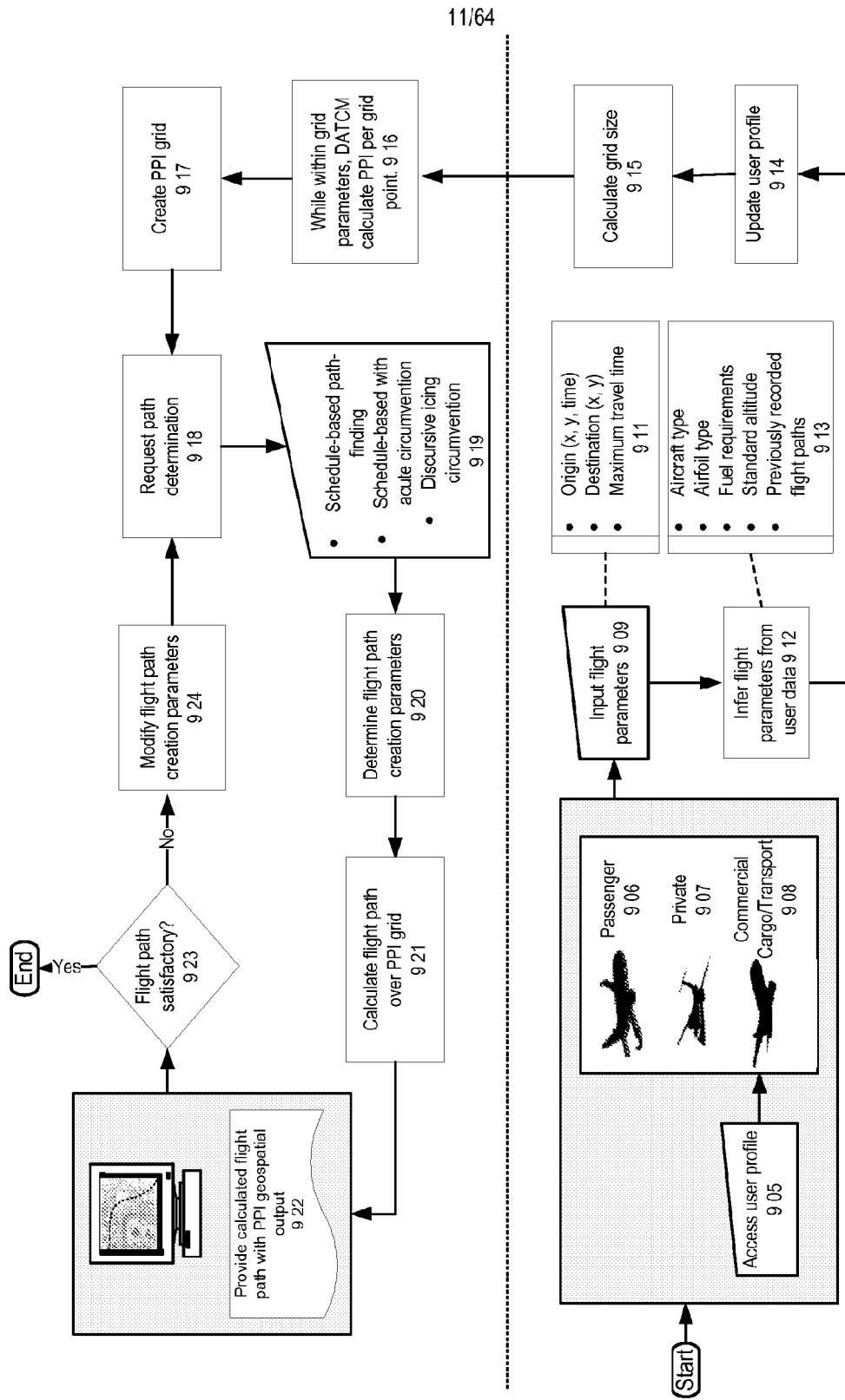
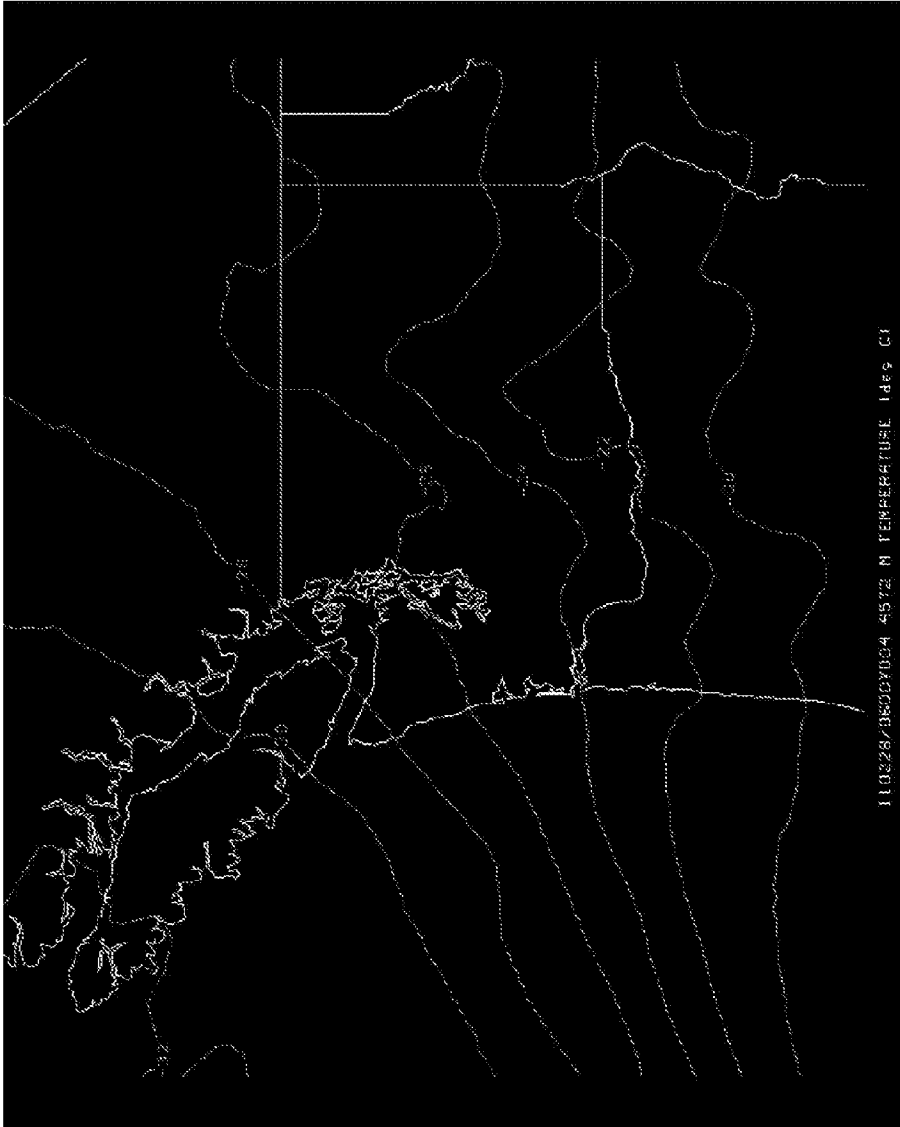
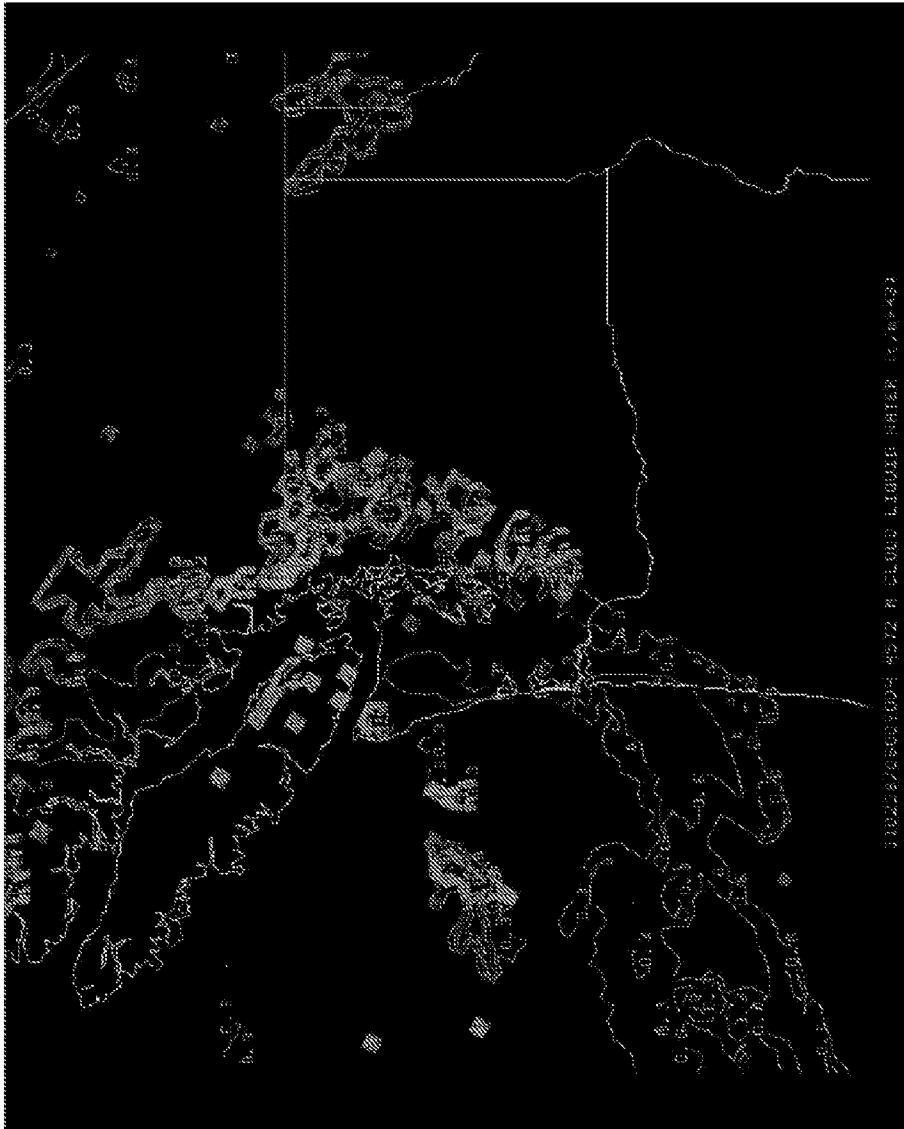


FIG 9A – Example DATCM Logic Flow Diagram with PPI Calculation



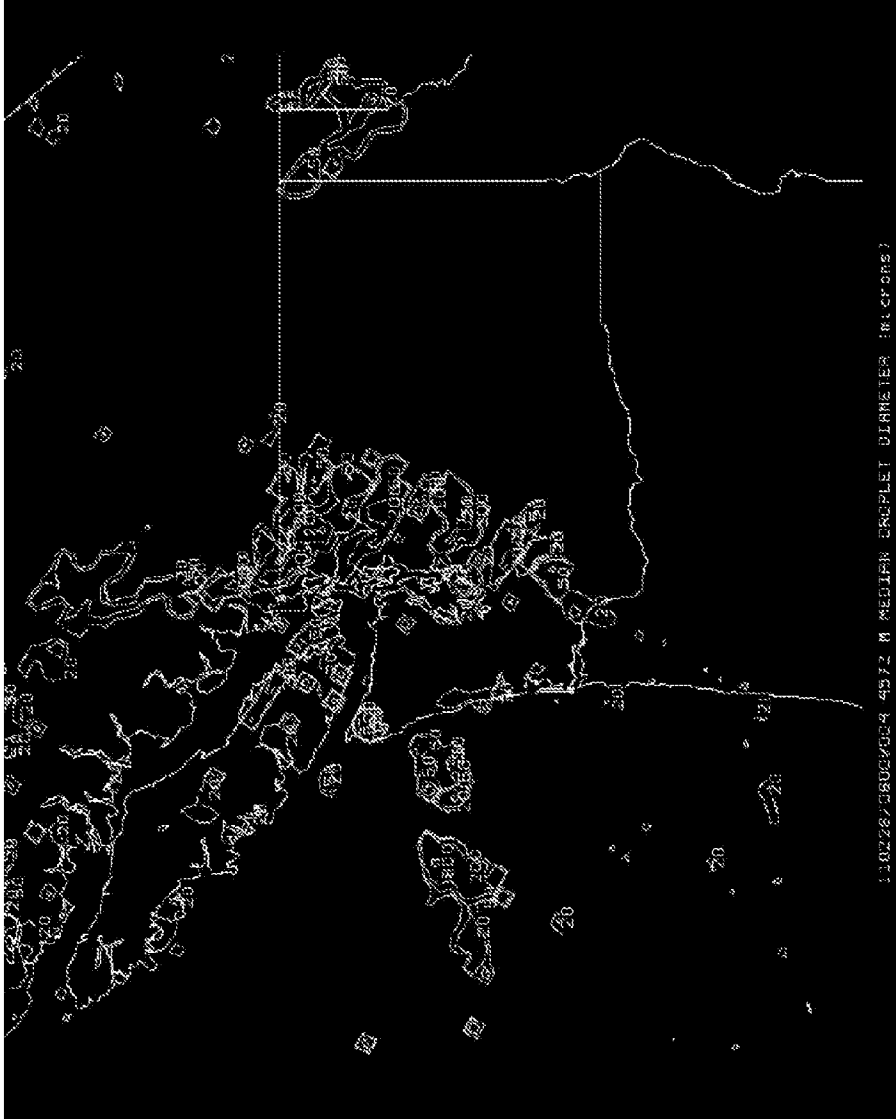
RUC2 numerical temperature
forecast 10 01

FIG 10



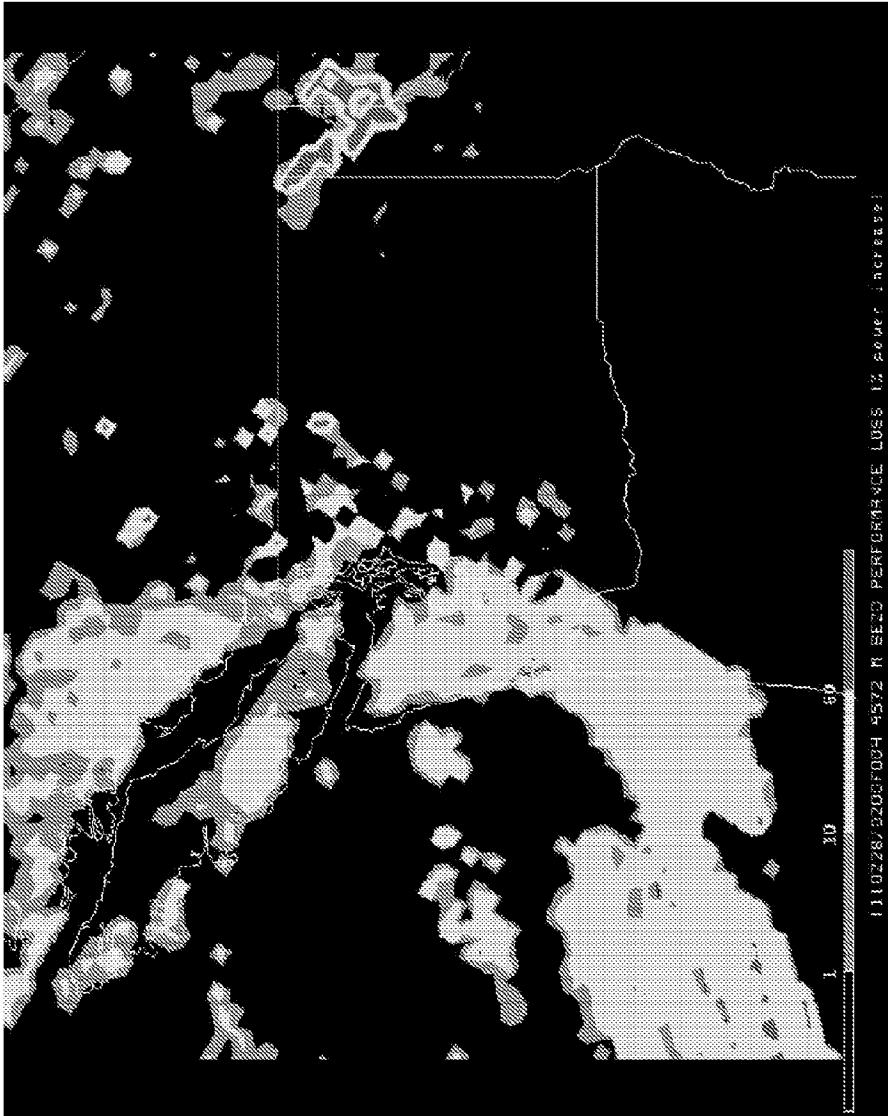
VV/ICE cloud liquid water
forecast 11 01

FIG 11



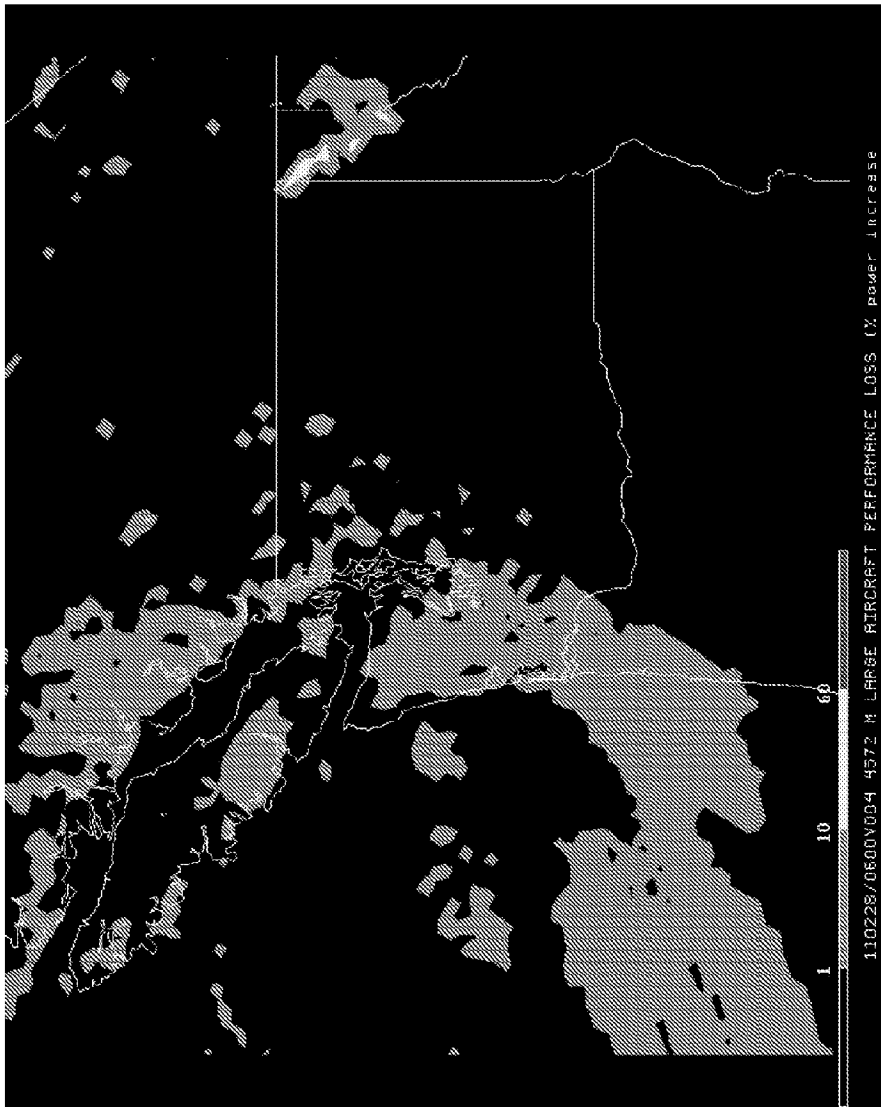
WVICE median droplet diameter
forecast 12 01

FIG 12



Small aircraft forecast
performance loss 13 01

FIG 13



Large aircraft forecast performance loss 14 01

FIG 14

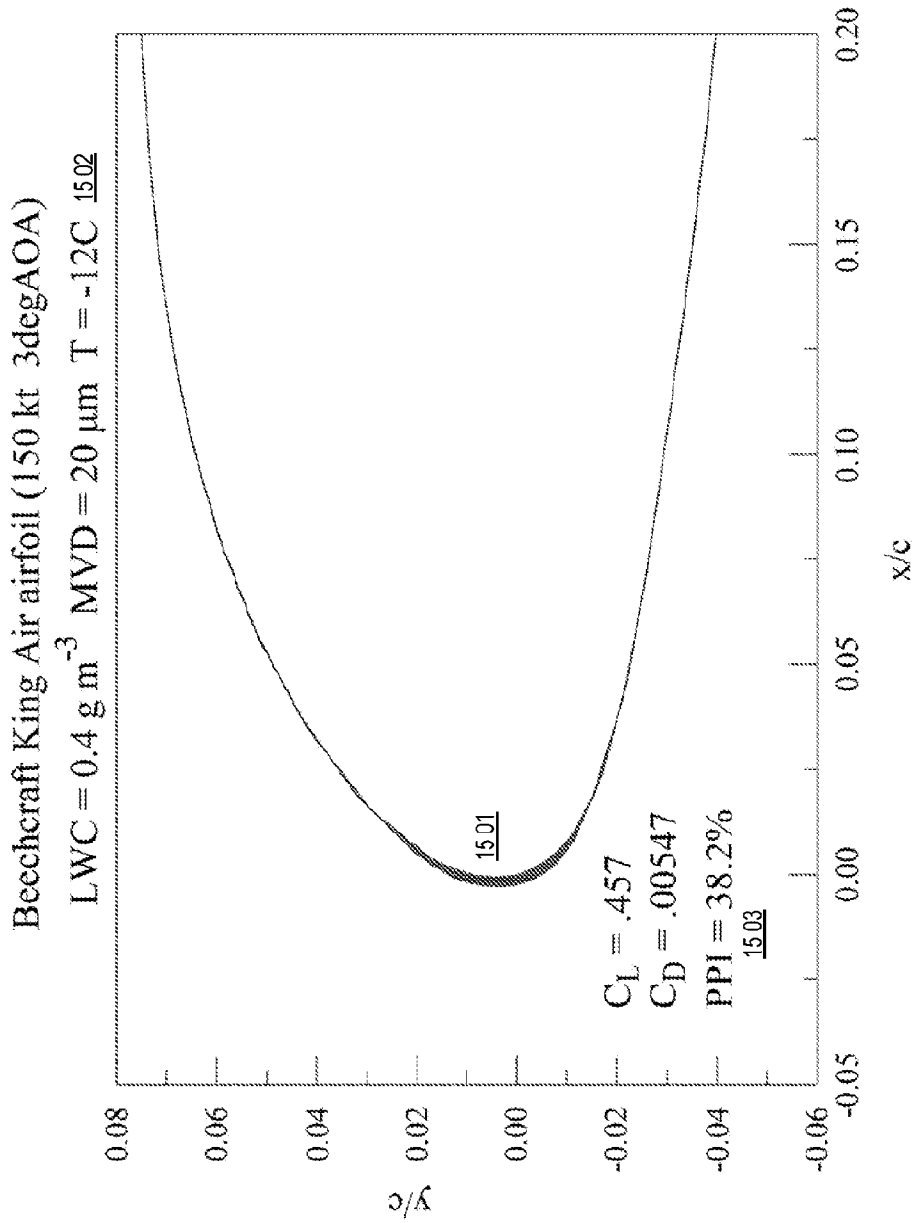


FIG 15 - Example Ice Accumulation and PPI for Beechcraft King Air Airfoil

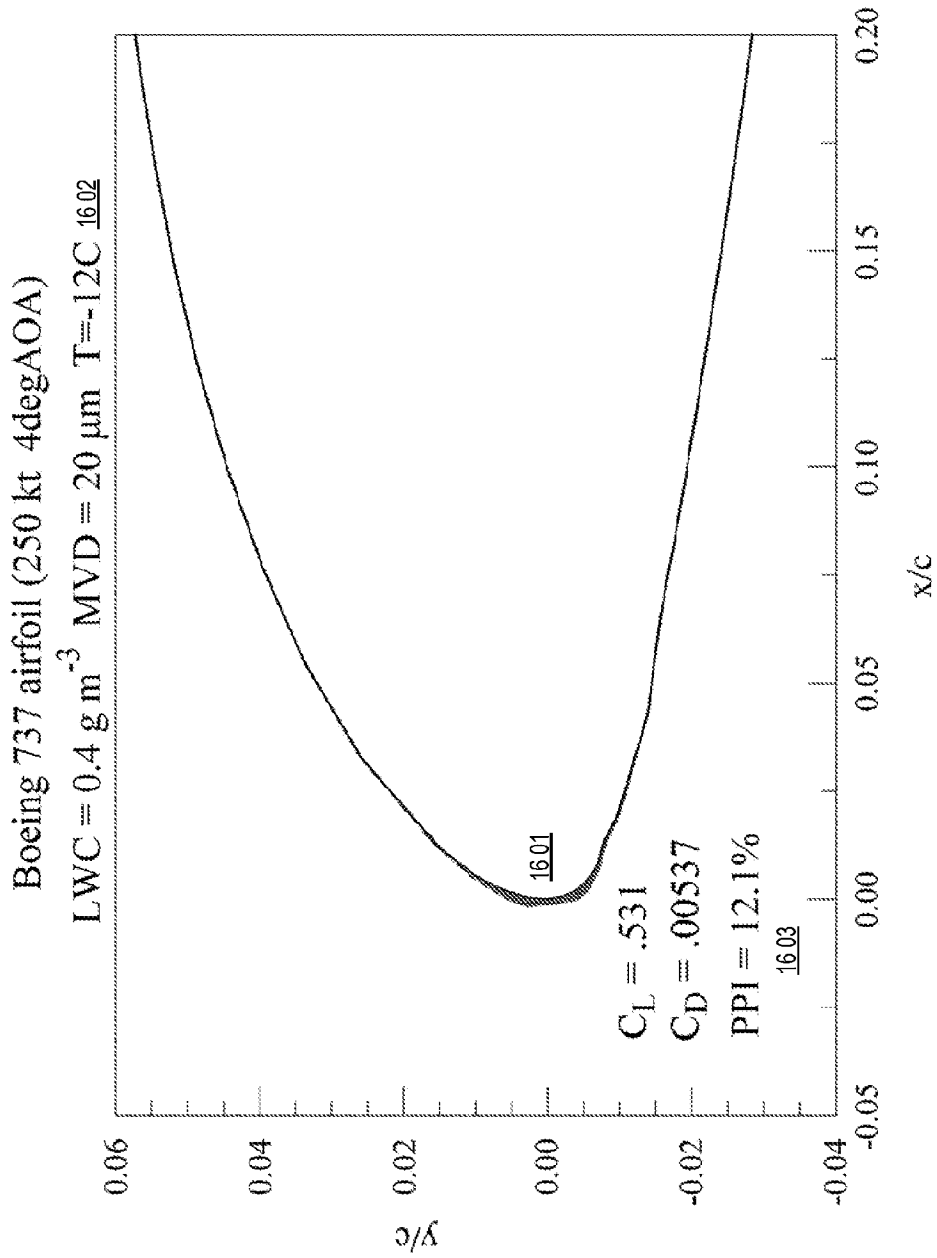


FIG 16 - Example Ice Accumulation and PPI for Boeing 737 Airfoil

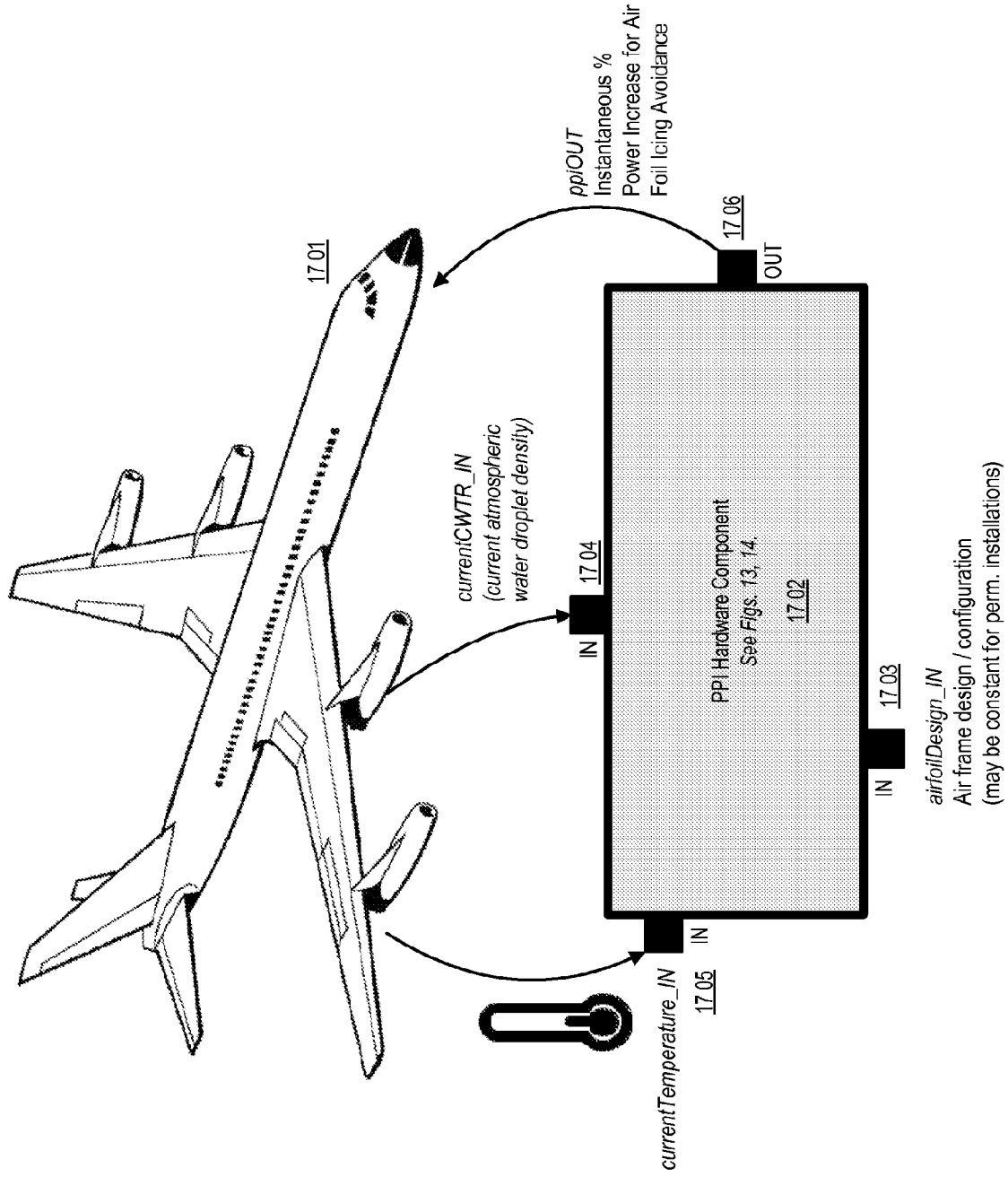


FIG 17 - Example PPI Installation

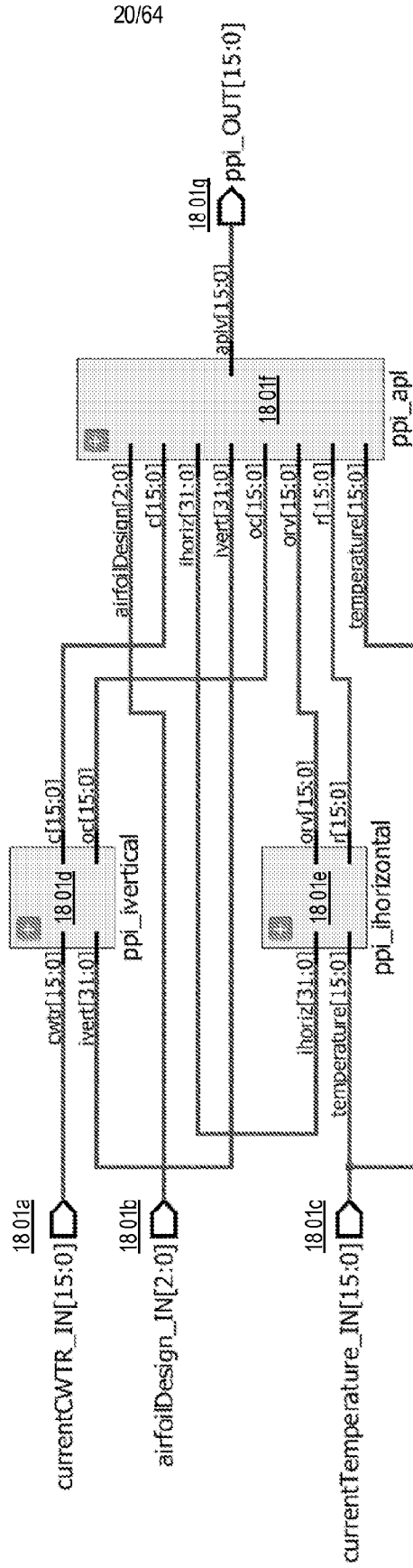


FIG 18A - Example PPI Component, Overview

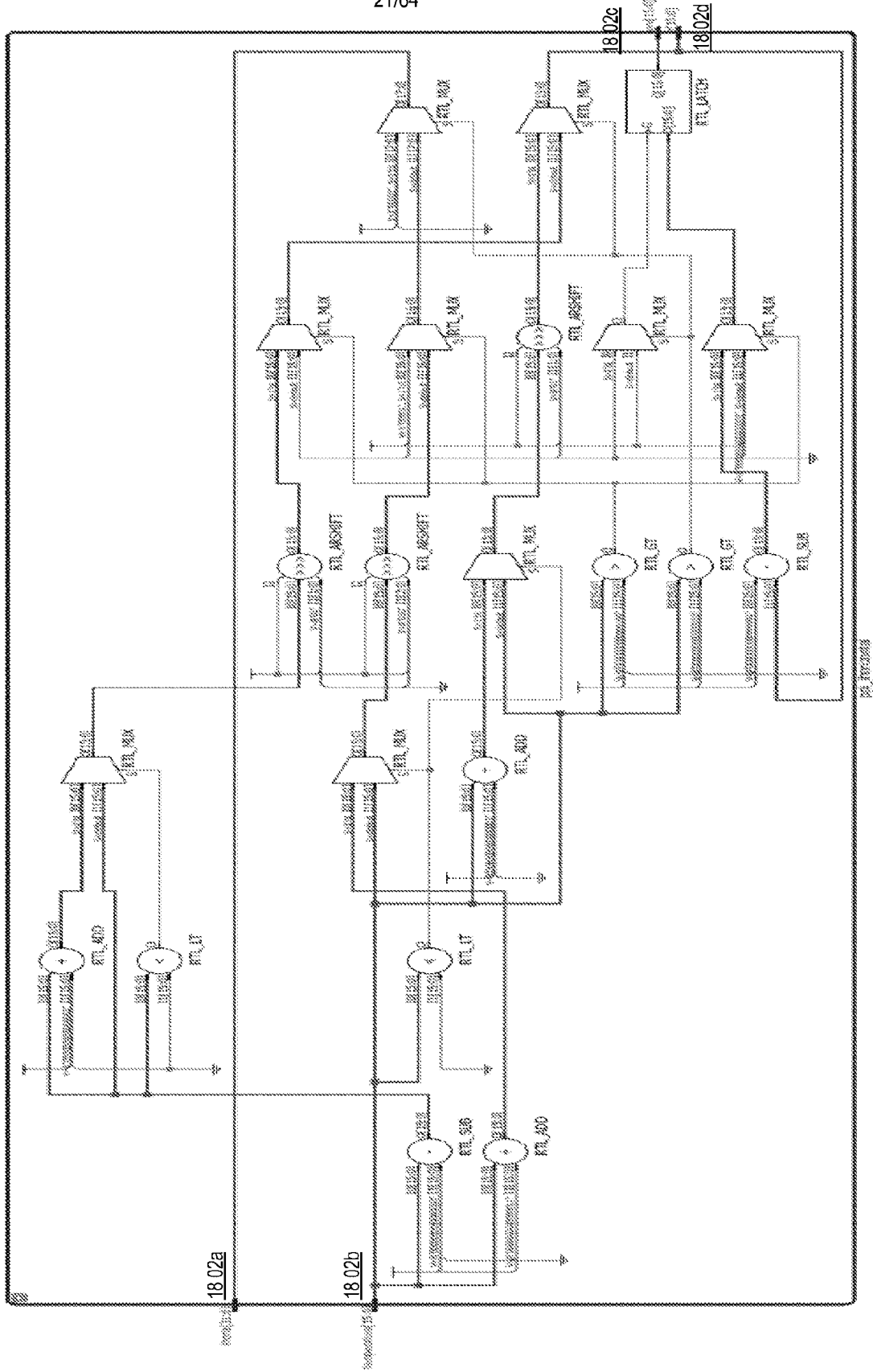


FIG 18B - Example PPI Component (sub-component view: ppi_horizontal)

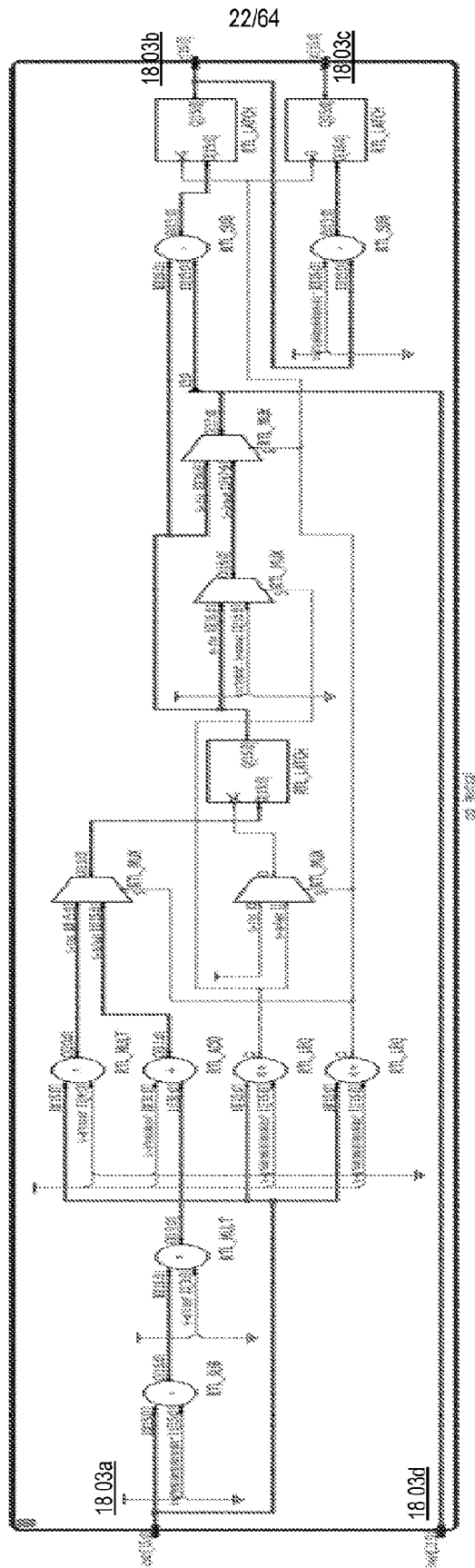


FIG 18C - Example PPI Component (sub-component view: ppi_vertical)

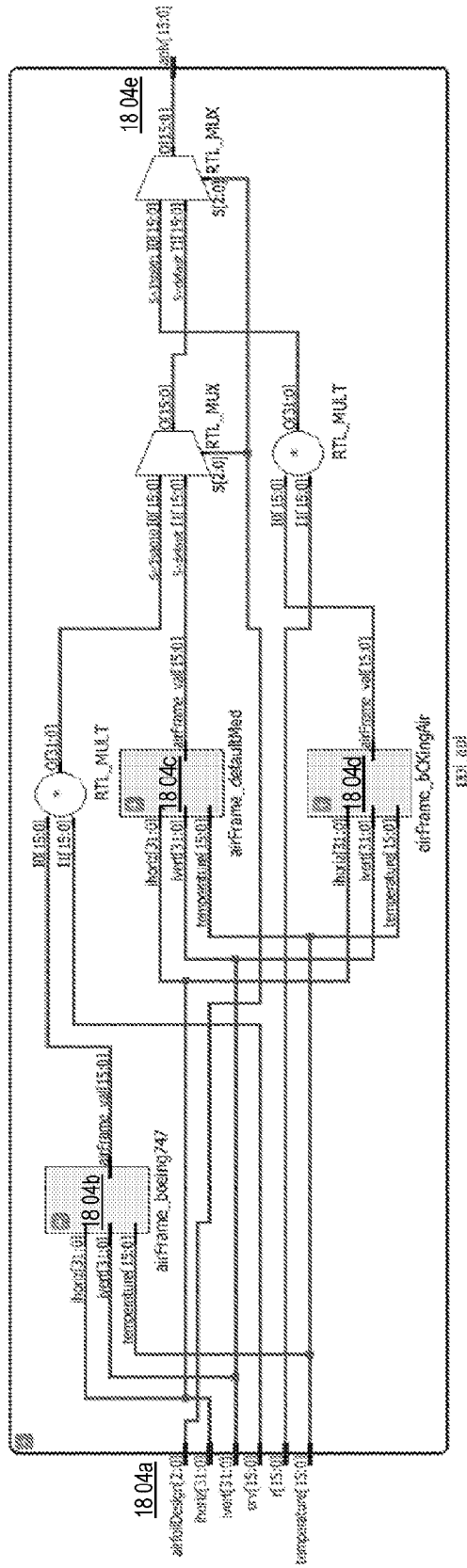


FIG 18D - Example: PPI Component (sub-component view: ppi_apl)

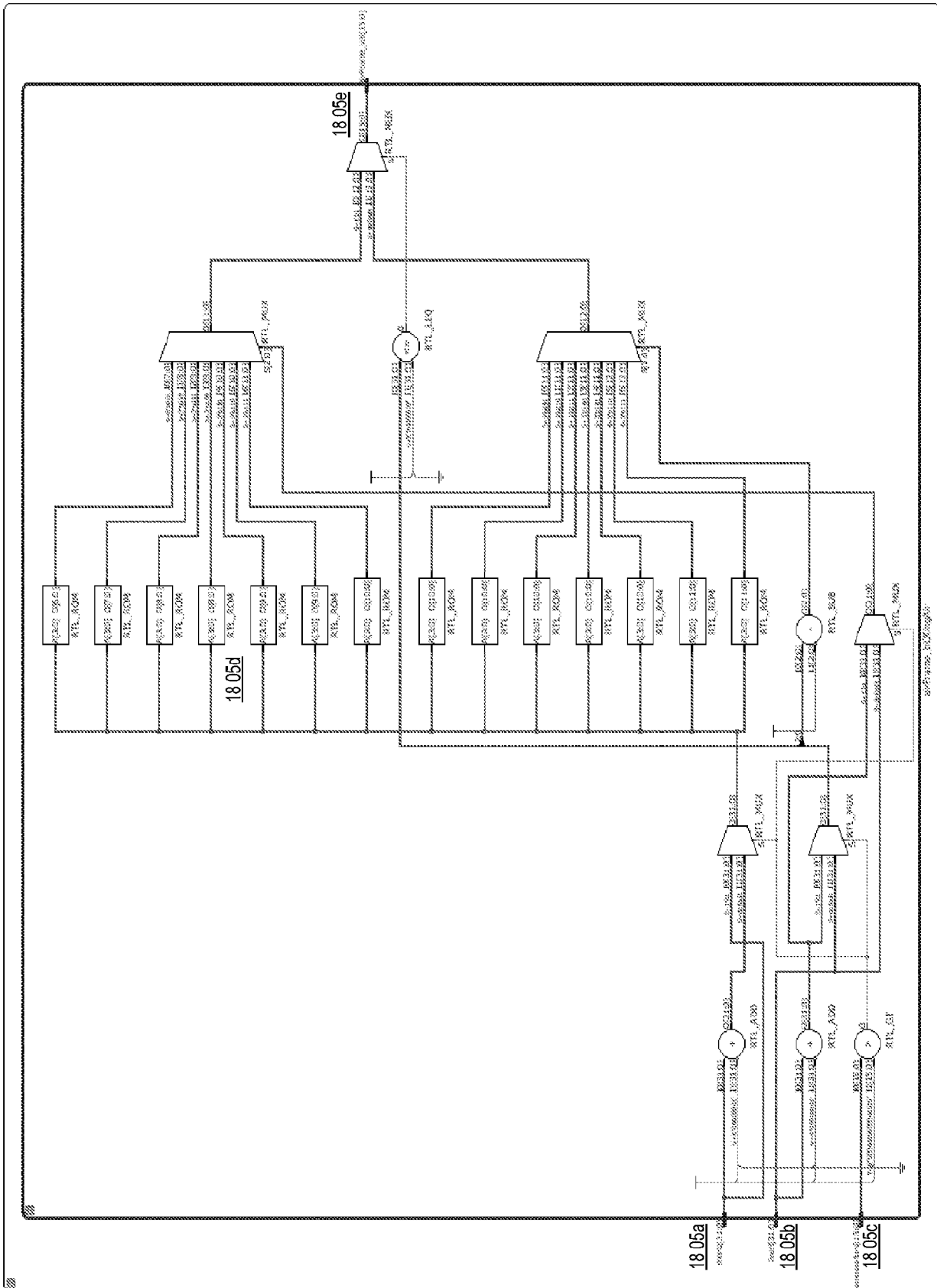


FIG 18E - Example PPI Component (sub-component sub-view: airFrame Customization Module)

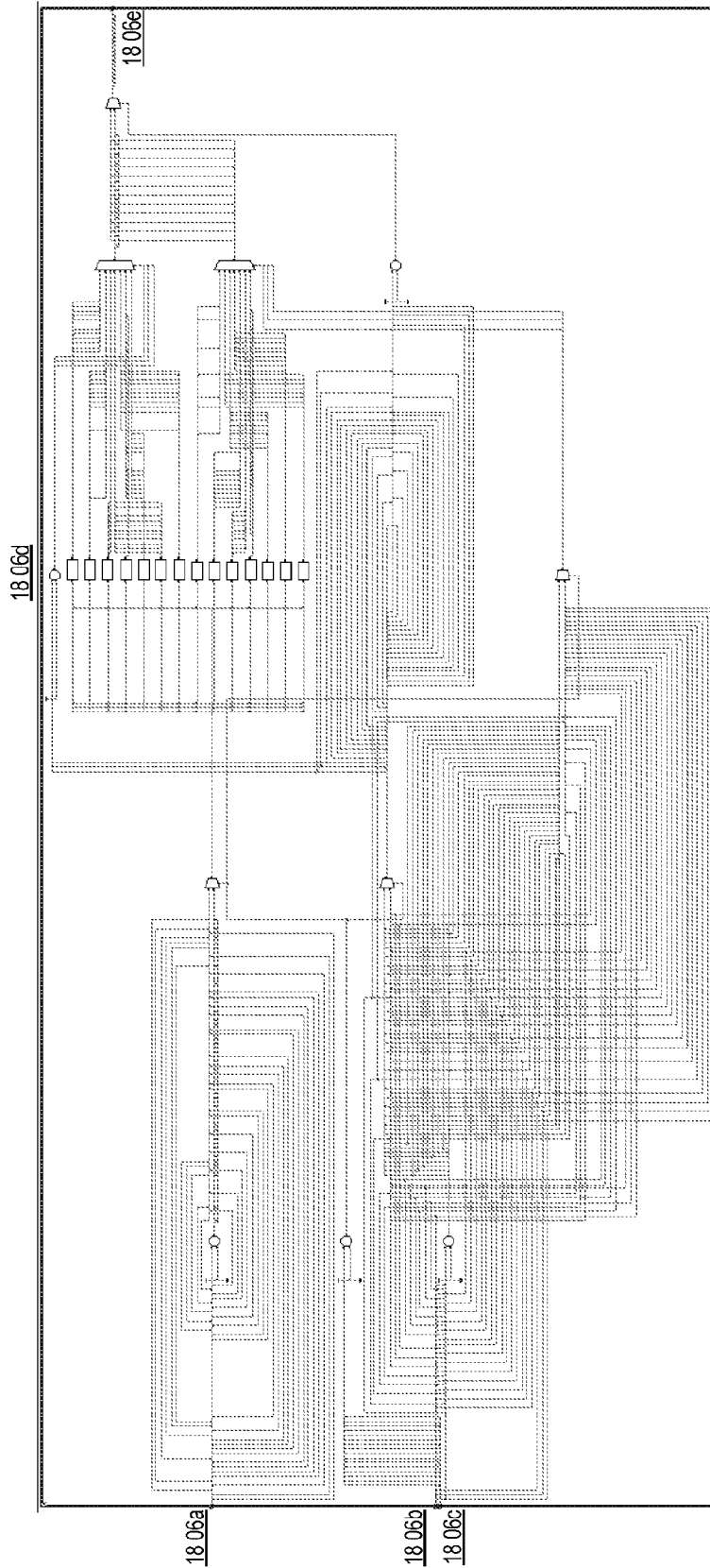


FIG 18F - Example PPI Component (sub-component sub-view: airFrame Customization Module Breakout)

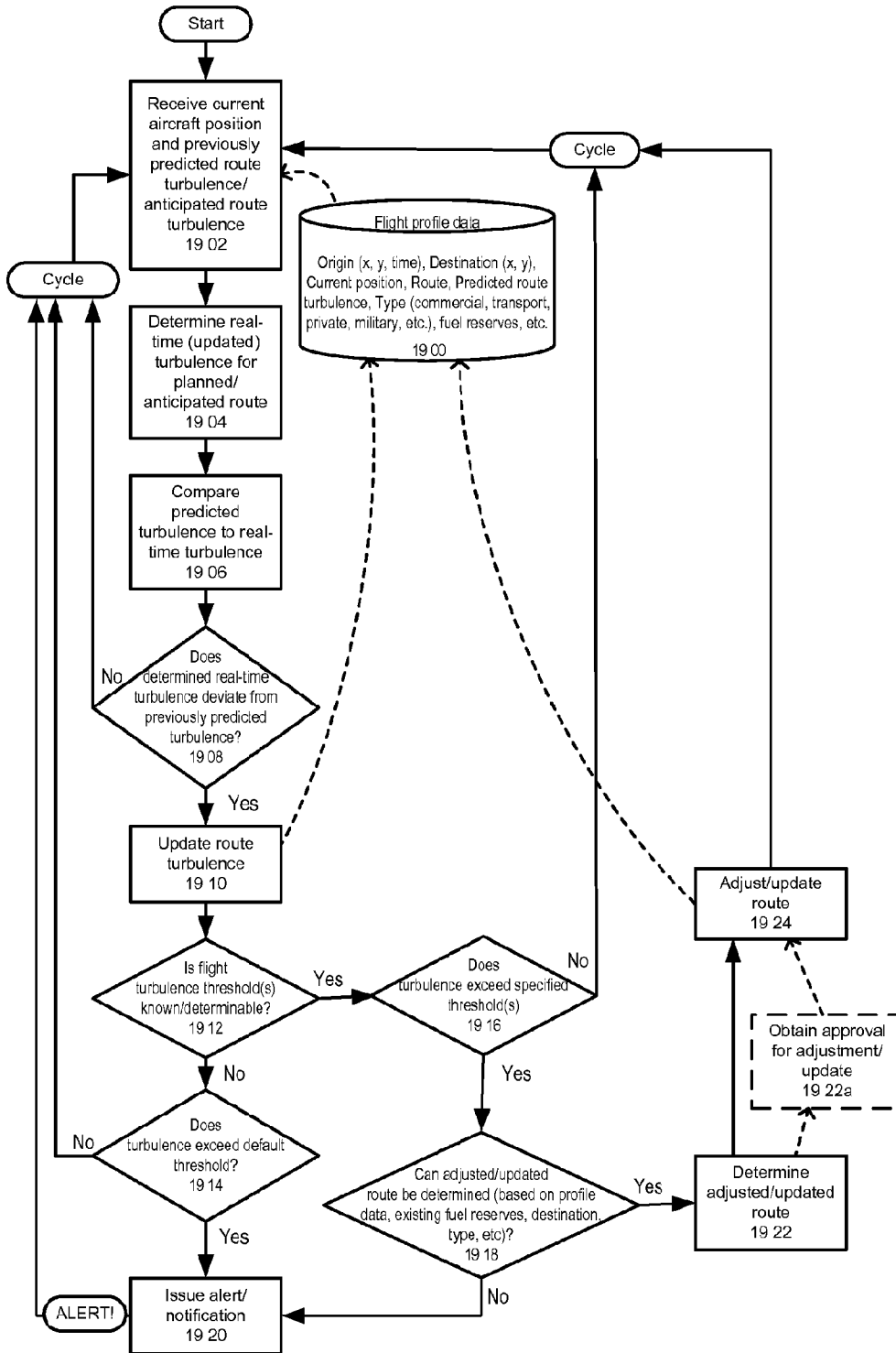


FIG 19A – Example DATCM Real-Time Flight Alerting and Planning Logic Flow

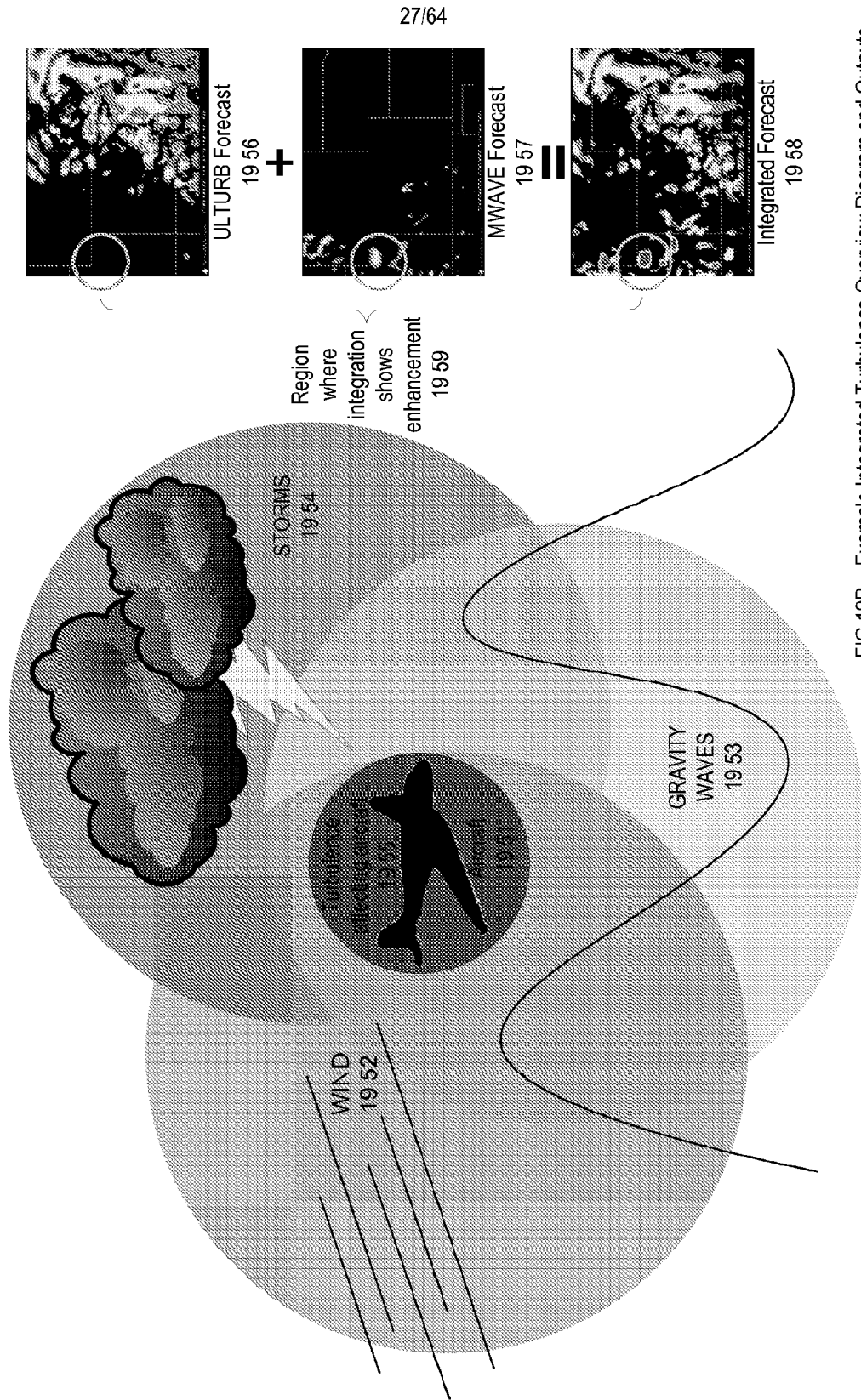


FIG 19B – Example Integrated Turbulence Overview Diagram and Outputs

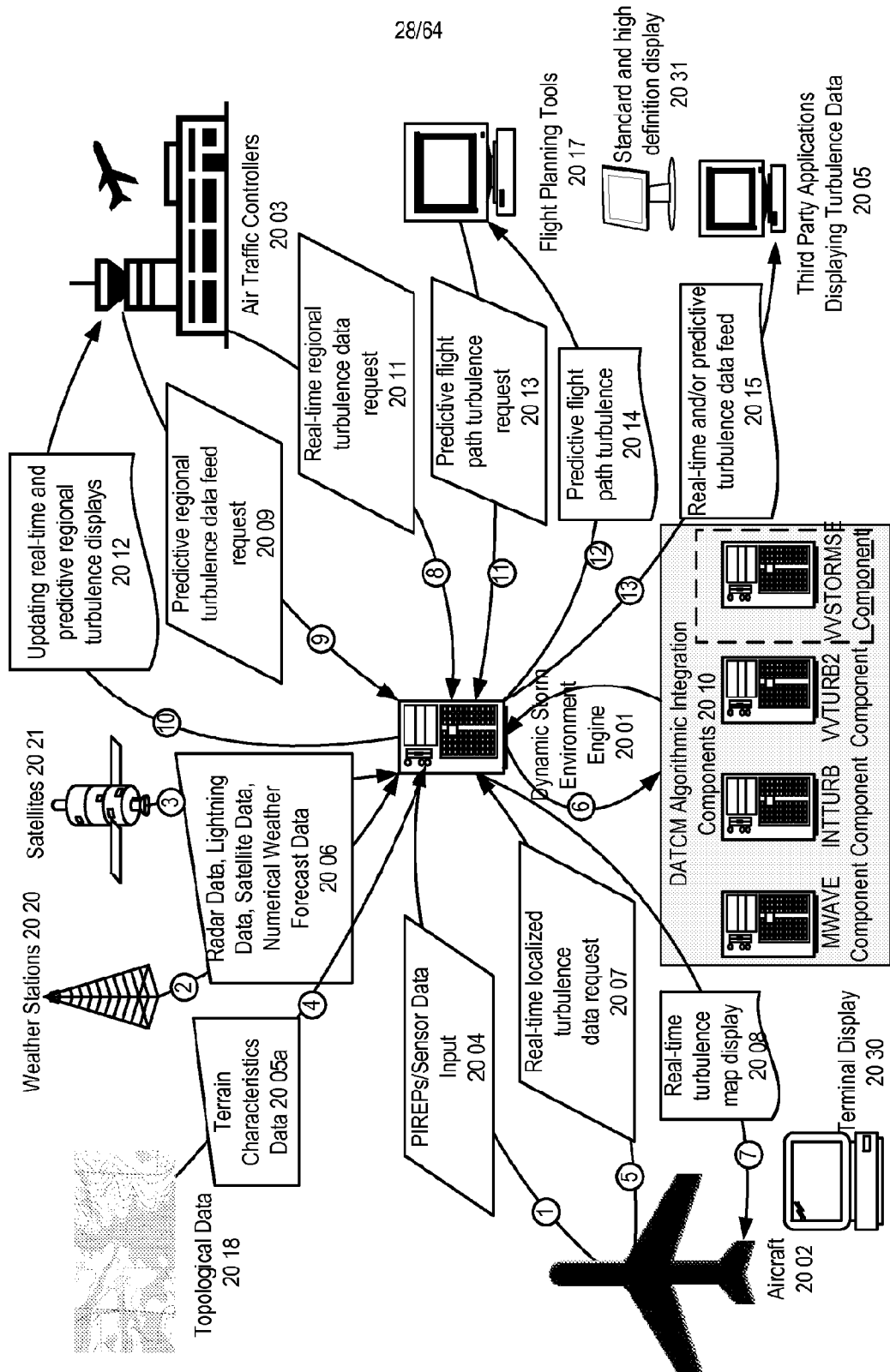


FIG 20 - Example DATCM Data Flow Diagram

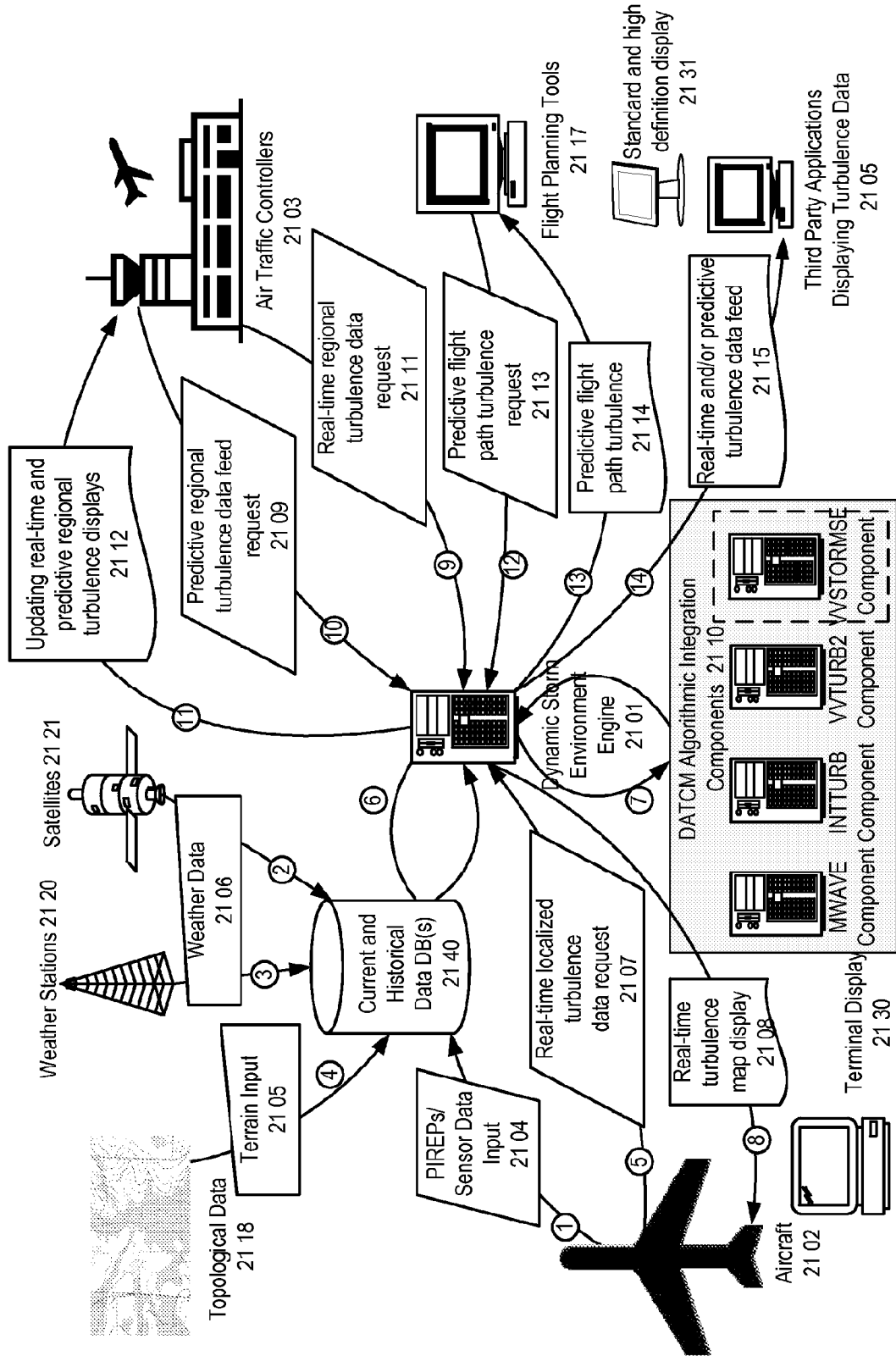


FIG 21 – Example DATCM Data Flow Diagram

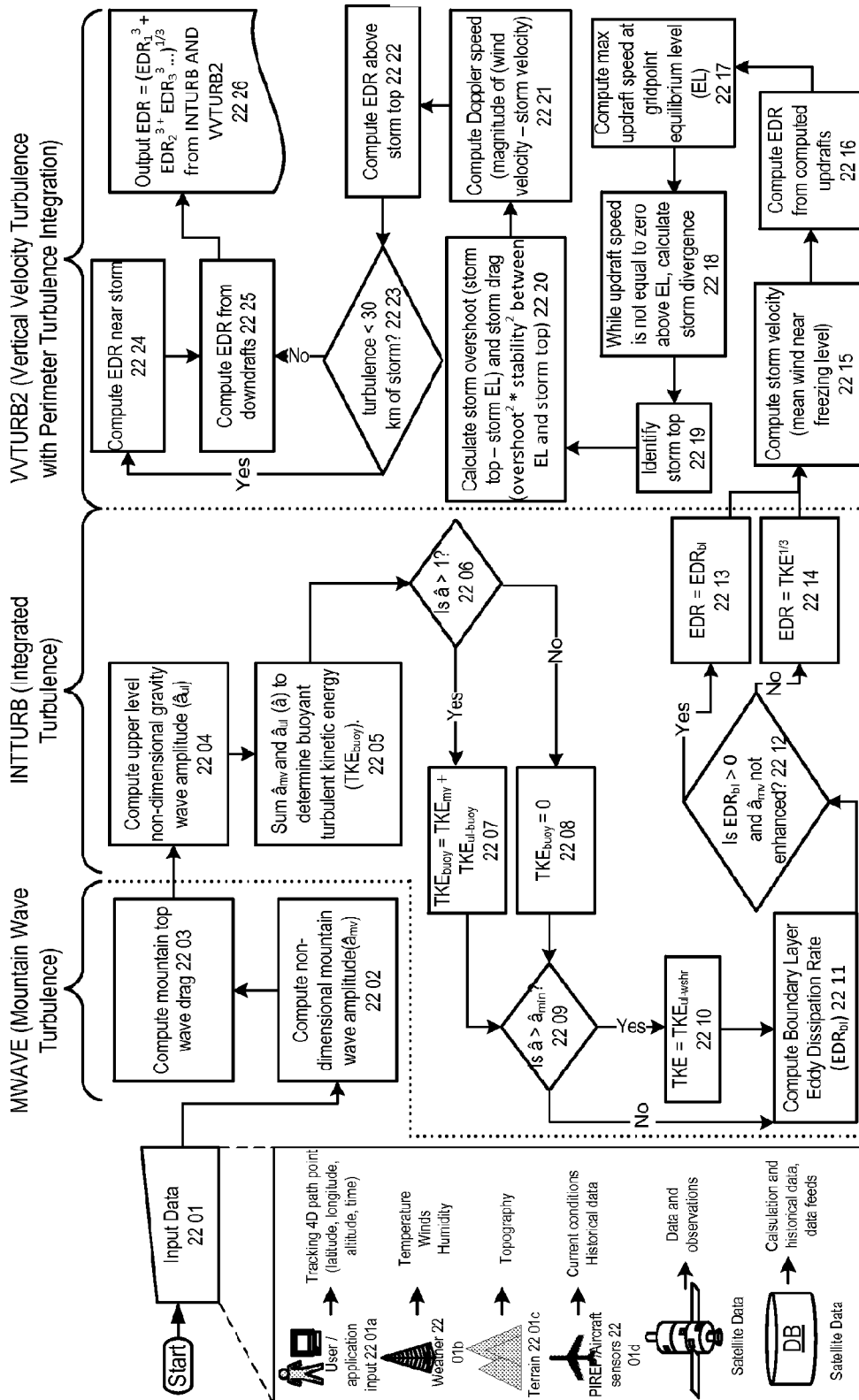


FIG 22A - Example DATCM Logic Flow Diagram

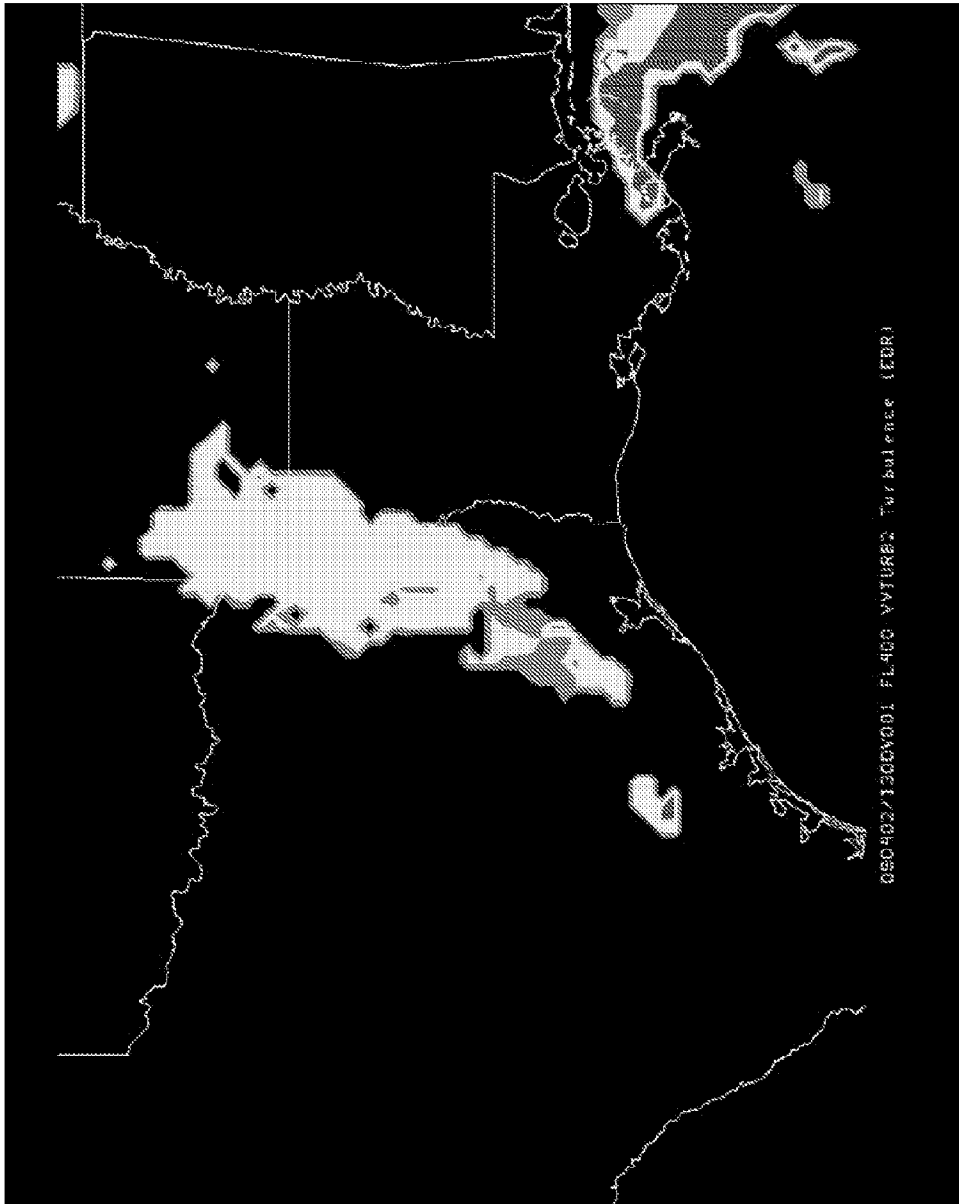


FIG. 22B - Example DATCM Above-Storm Turbulence Output

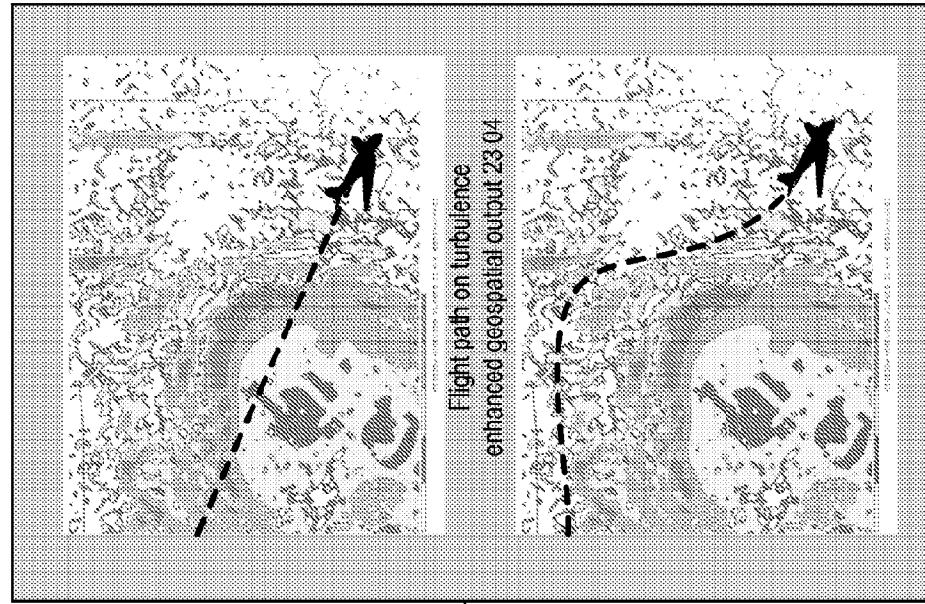
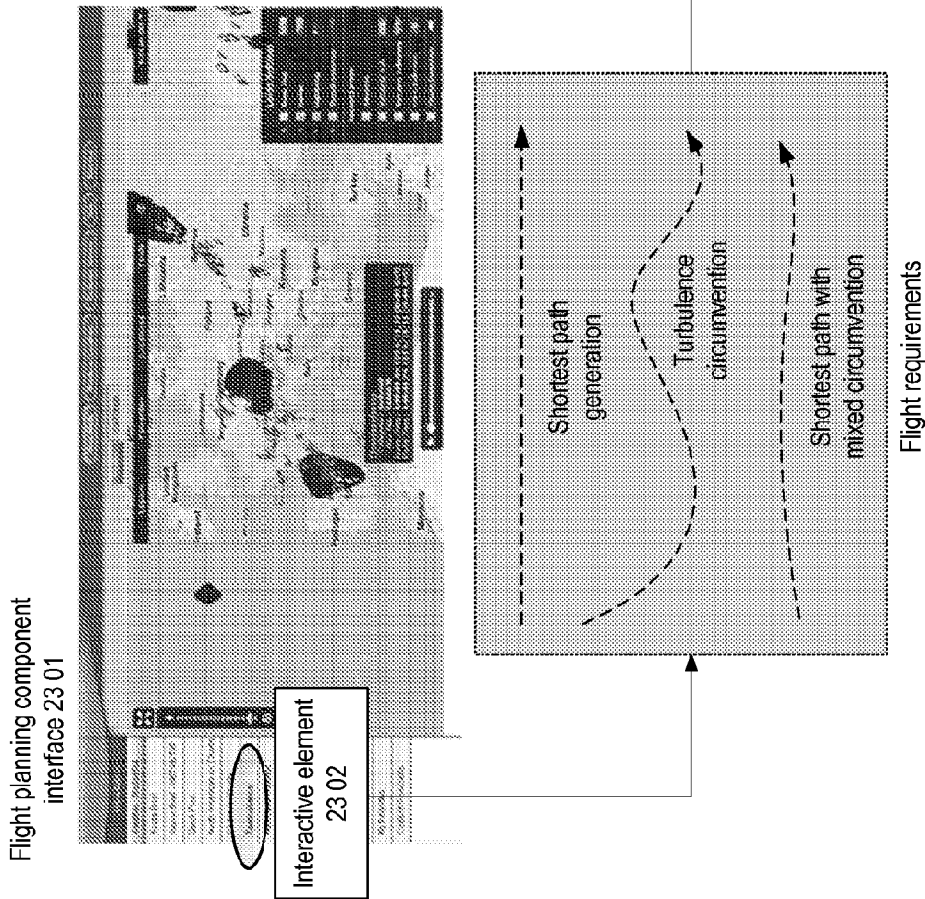


FIG 23 – Example DATCM User Interface



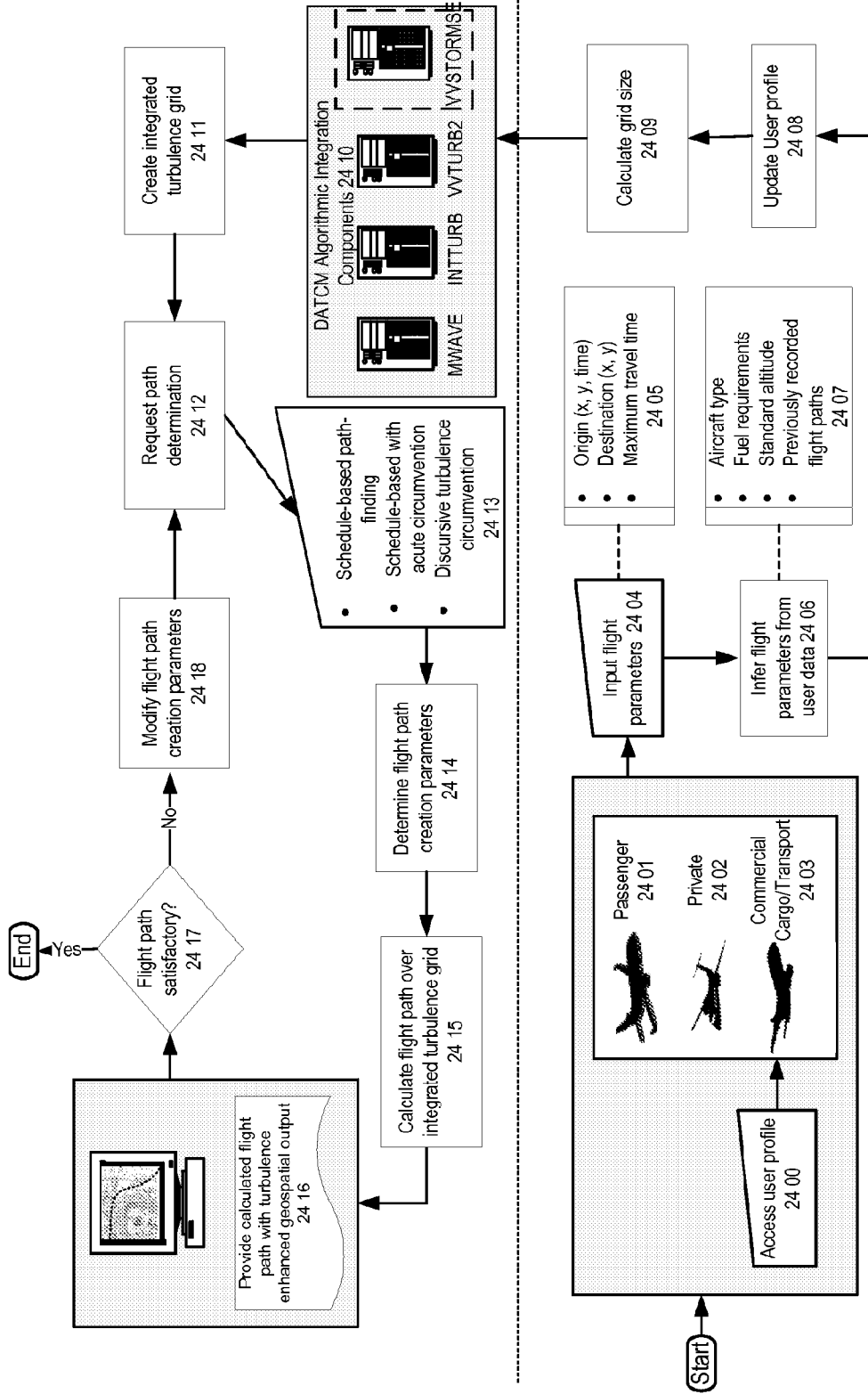


FIG 24 – Example DATCM Logic Flow Diagram with Flight Path Determination

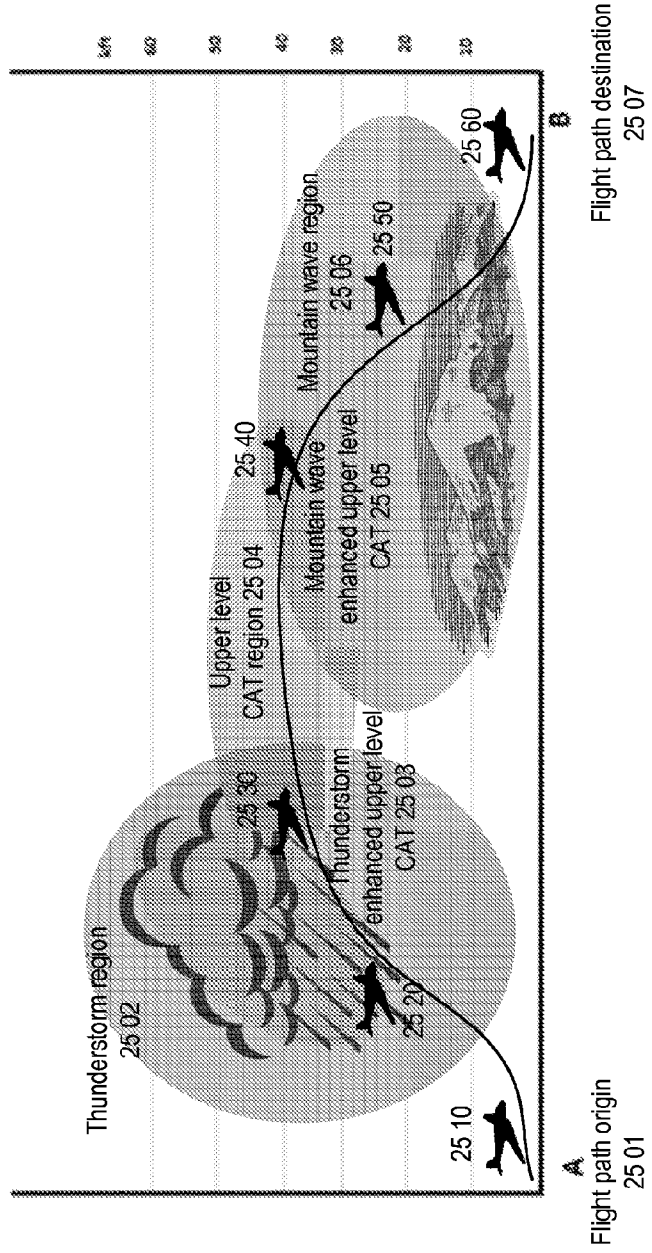
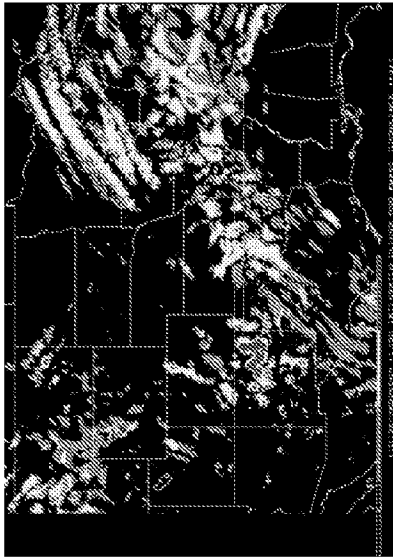
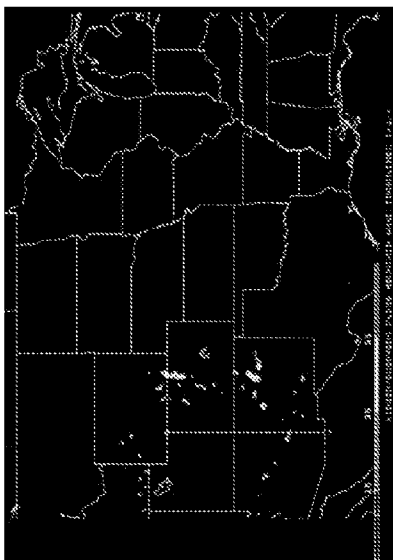
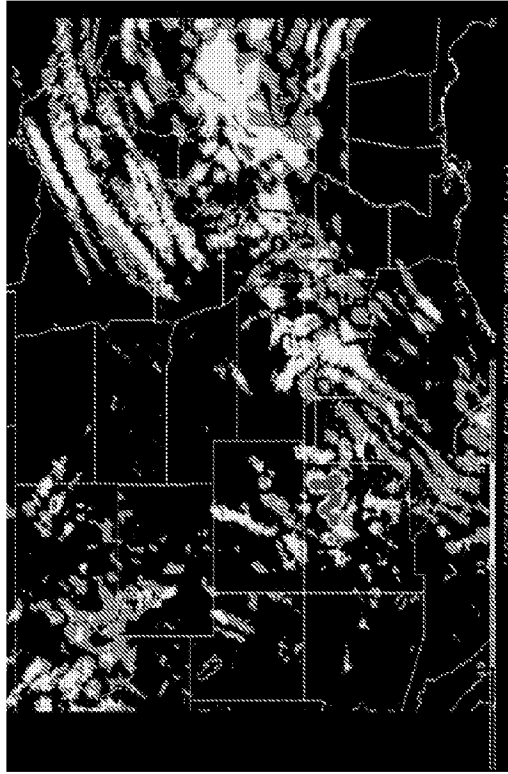


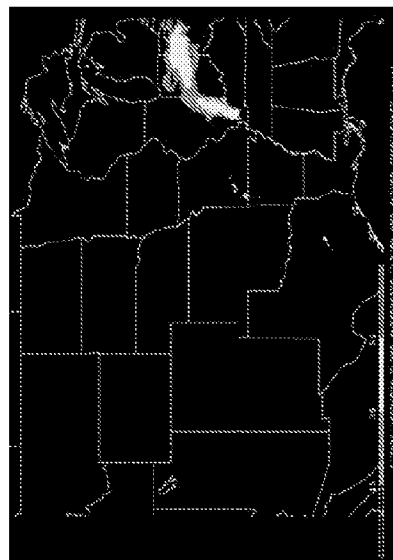
FIG 25 – Example Turbulence Overview Diagram



MWAVE integrated with INTTURB 26 02



MWAVE grid output 26 01



INTTURB integrated with VVTURB2 26 03

FIG 26 – Example DATCM Grid Outputs

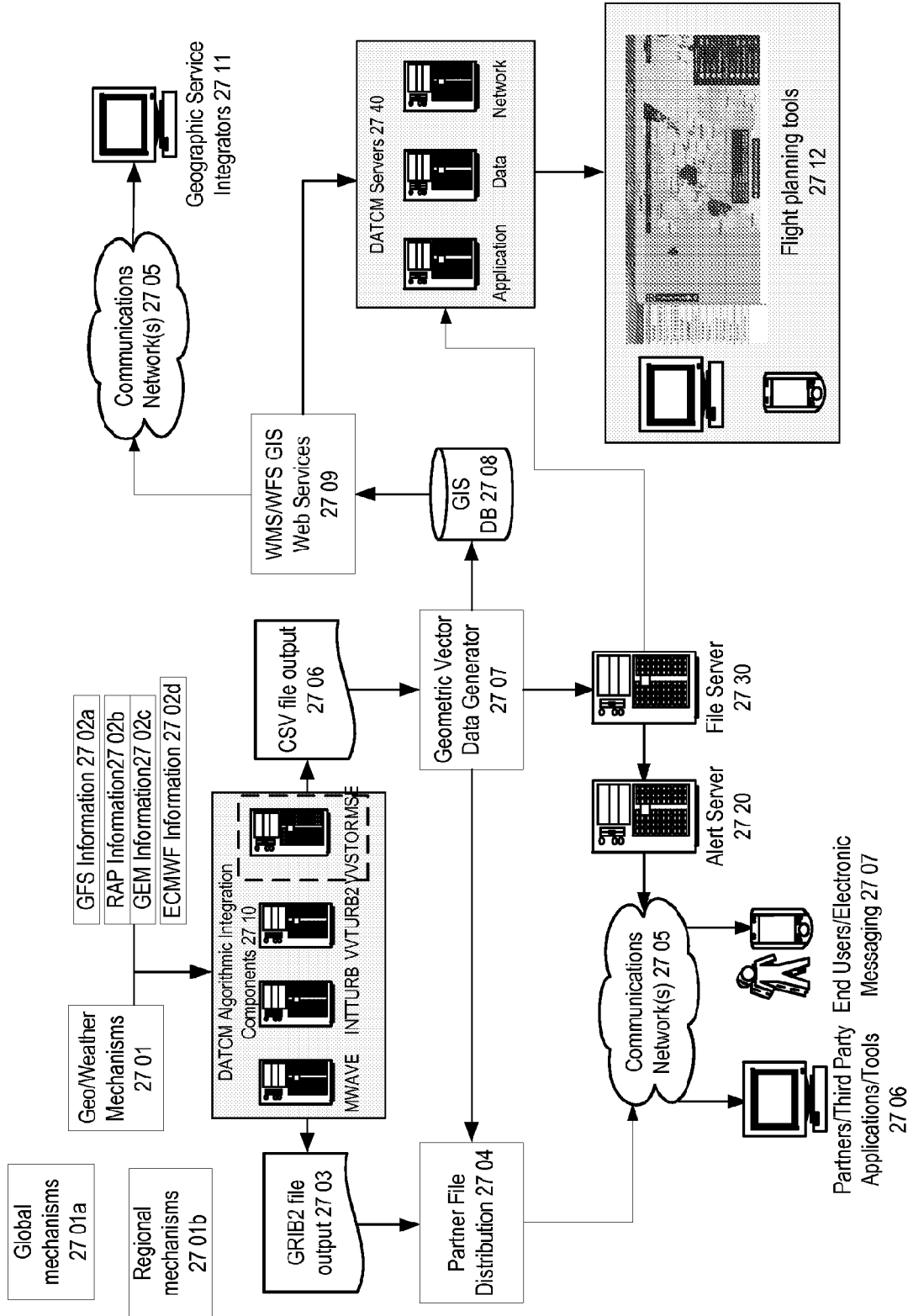
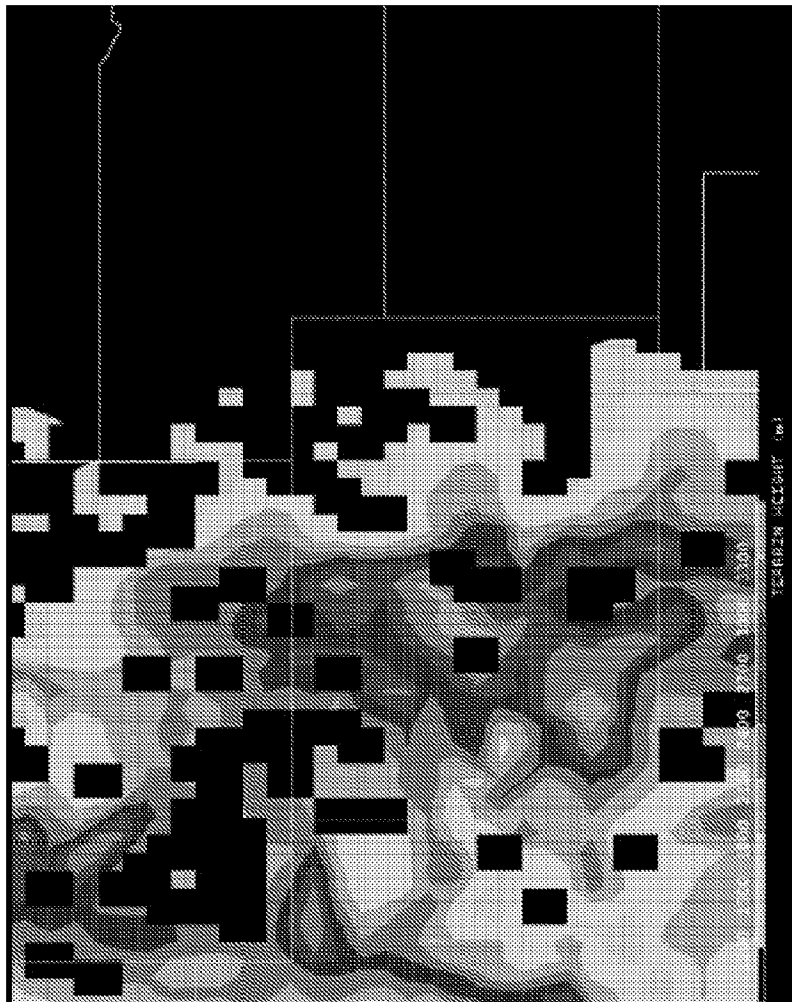


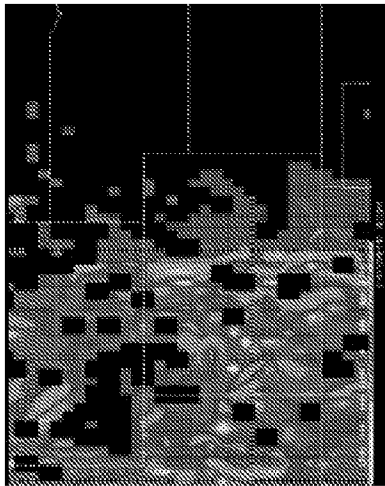
FIG 27 – Example DATCM Turbulence Data Flow Diagram

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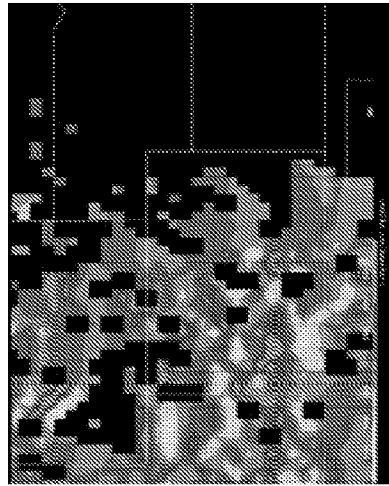


Terrain Height
28 01

FIG 28A

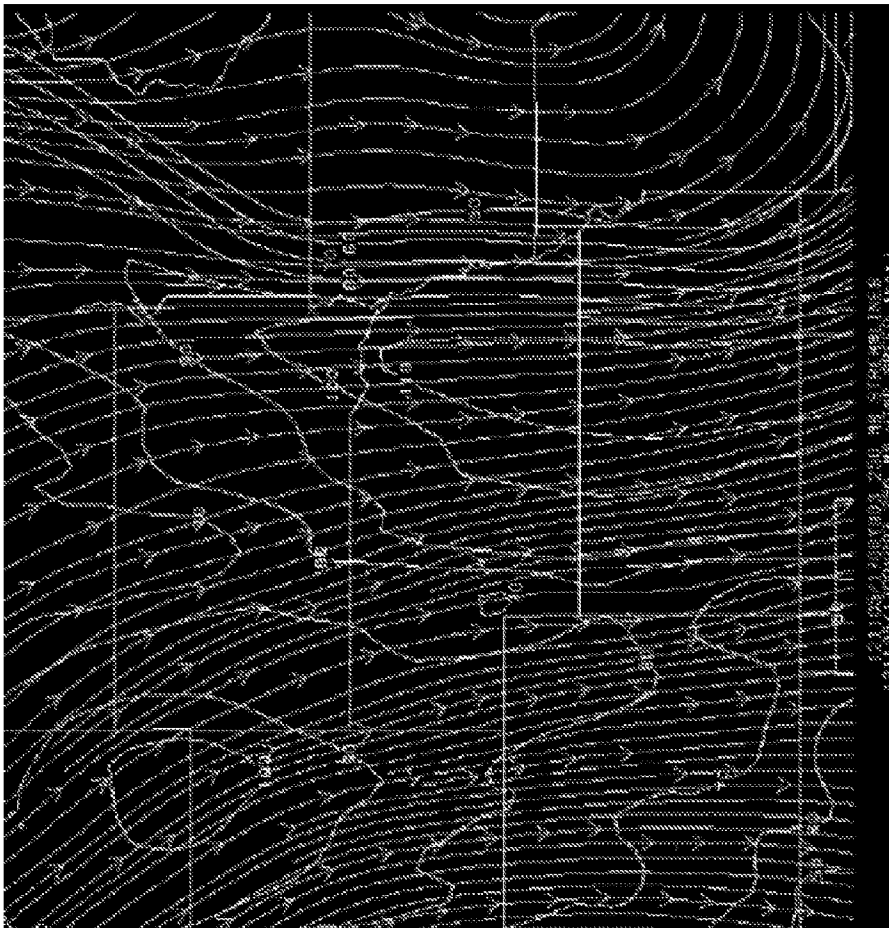


X Direction Asymmetry in
Terrain Height
28 02



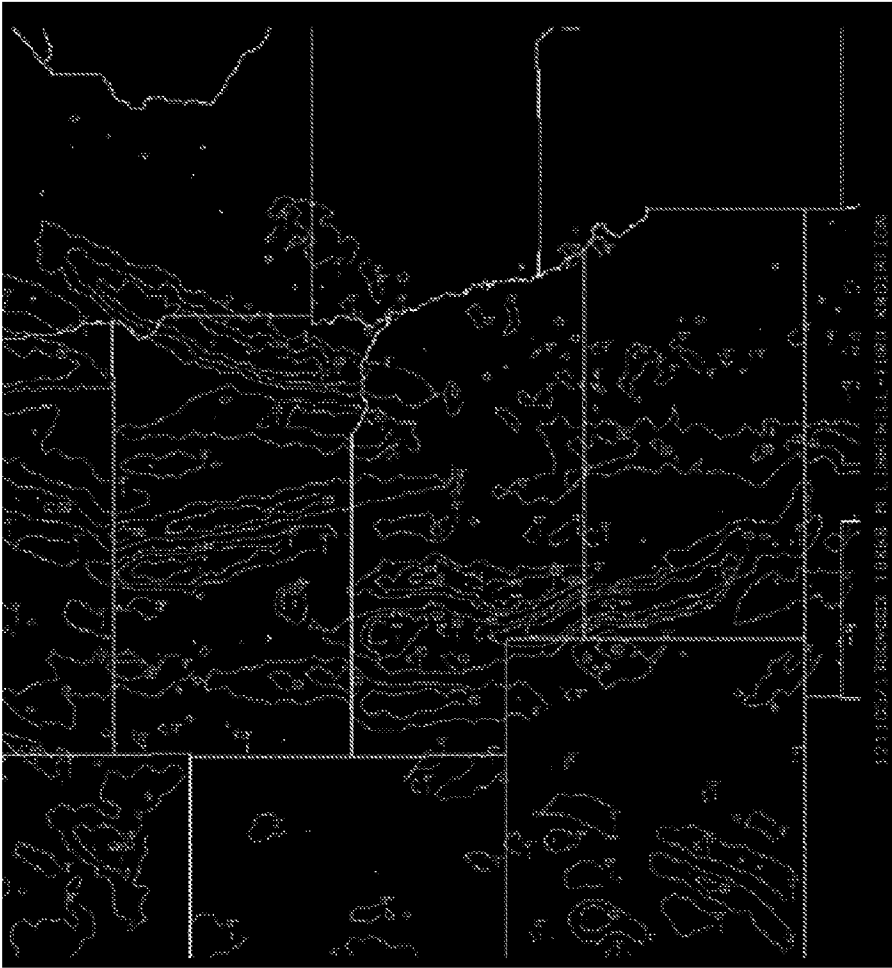
Y Direction Asymmetry in
Terrain Height
28 03

FIG 28B



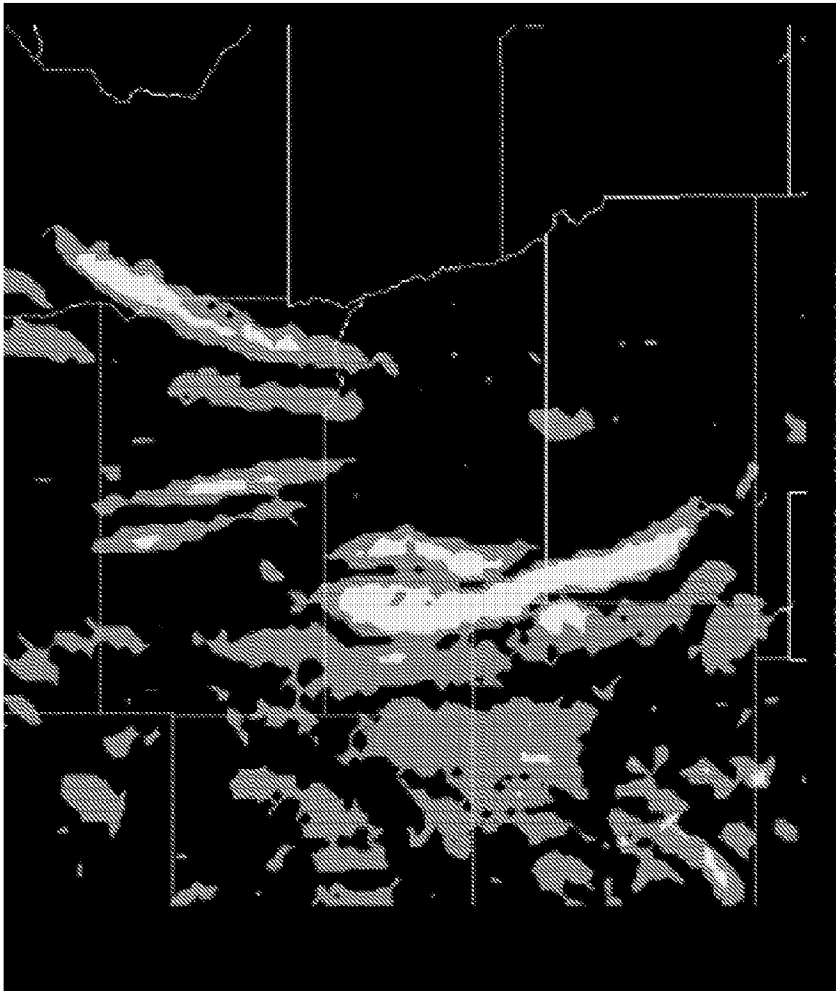
RAP Forecast Streamlines
over 3 hour period 29 01

FIG 29A



Lighthill-Ford Radiation computed
for RAP forecast flow 29 02

FIG 29B



ULTURB Forecast in EDR for
RAP forecast flow 29 03

FIG. 29C

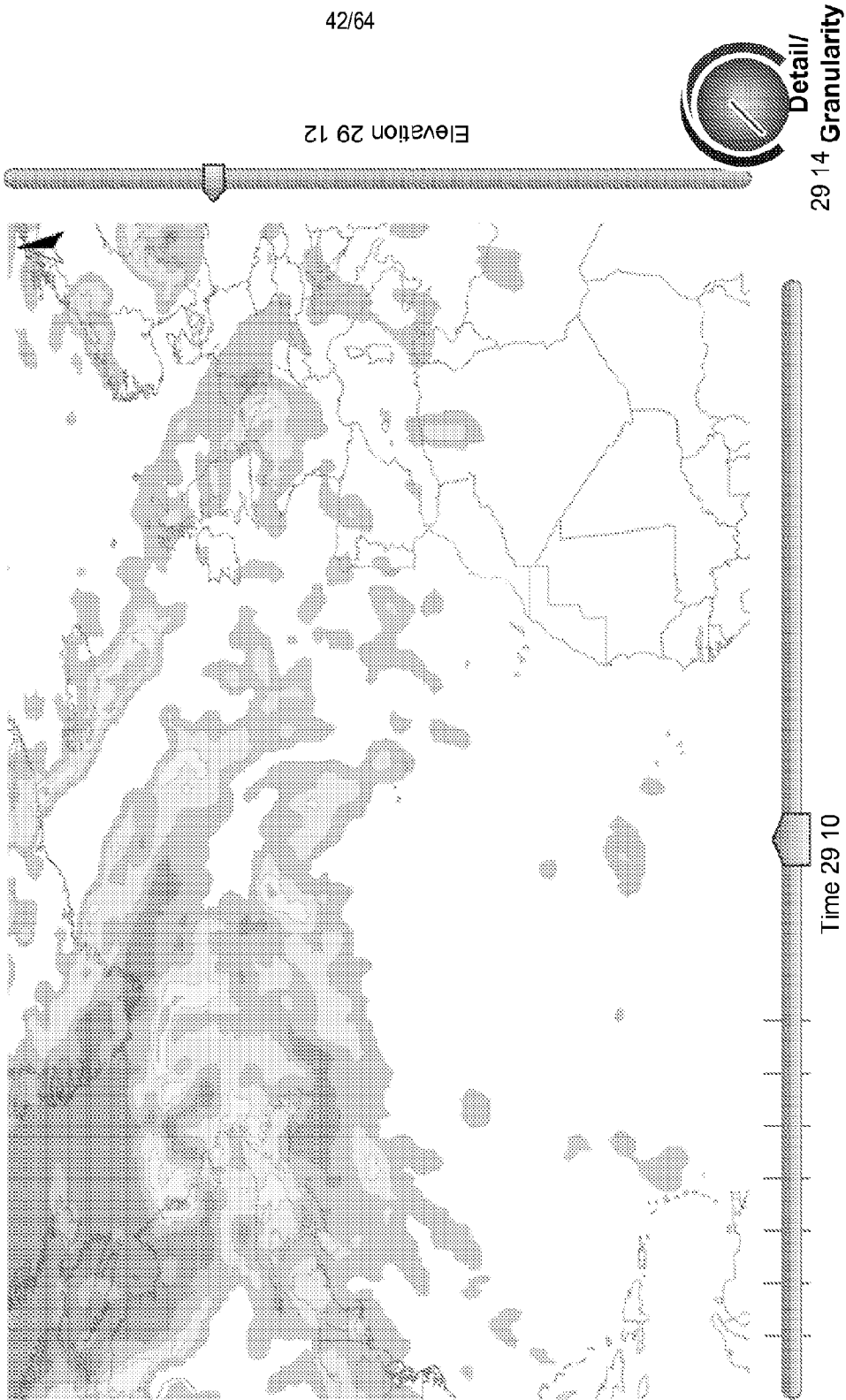


FIG 29D

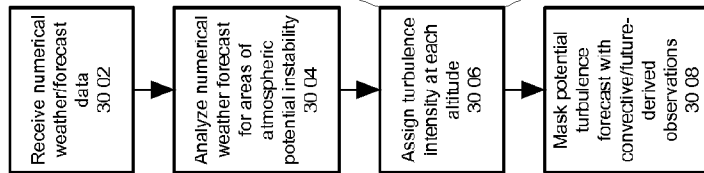
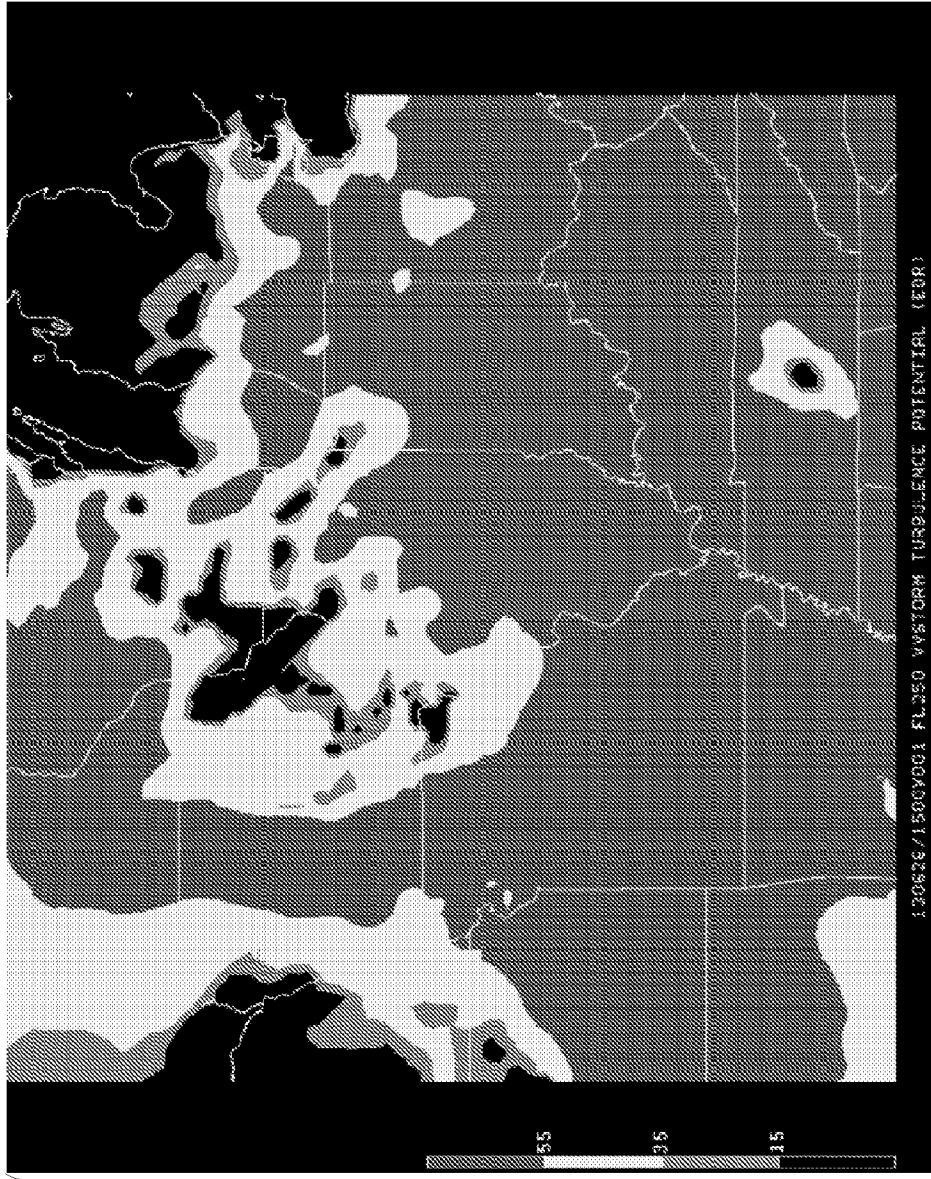


FIG. 30

FIG. 30A - Example DATCM Data Display

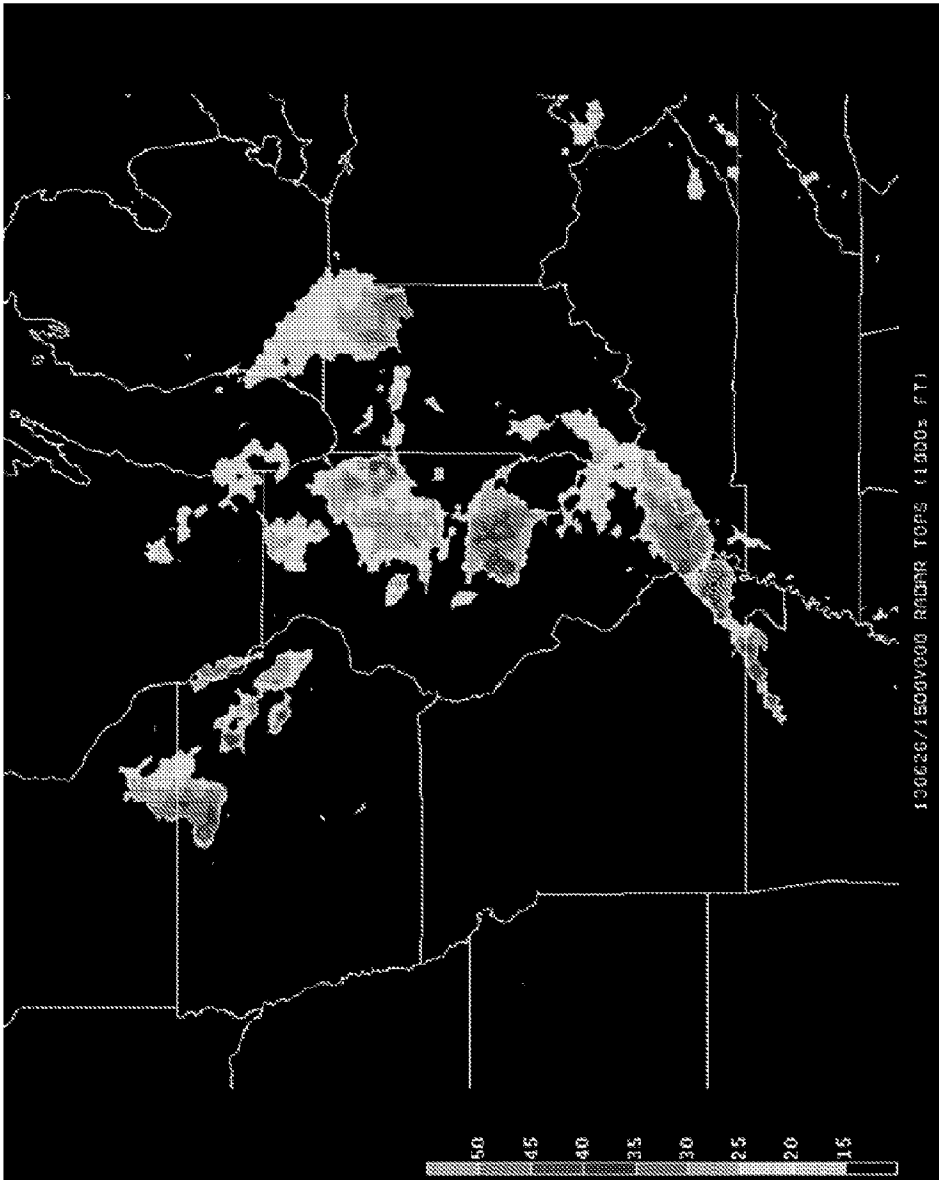


FIG. 30B - Example DATCM Data Display

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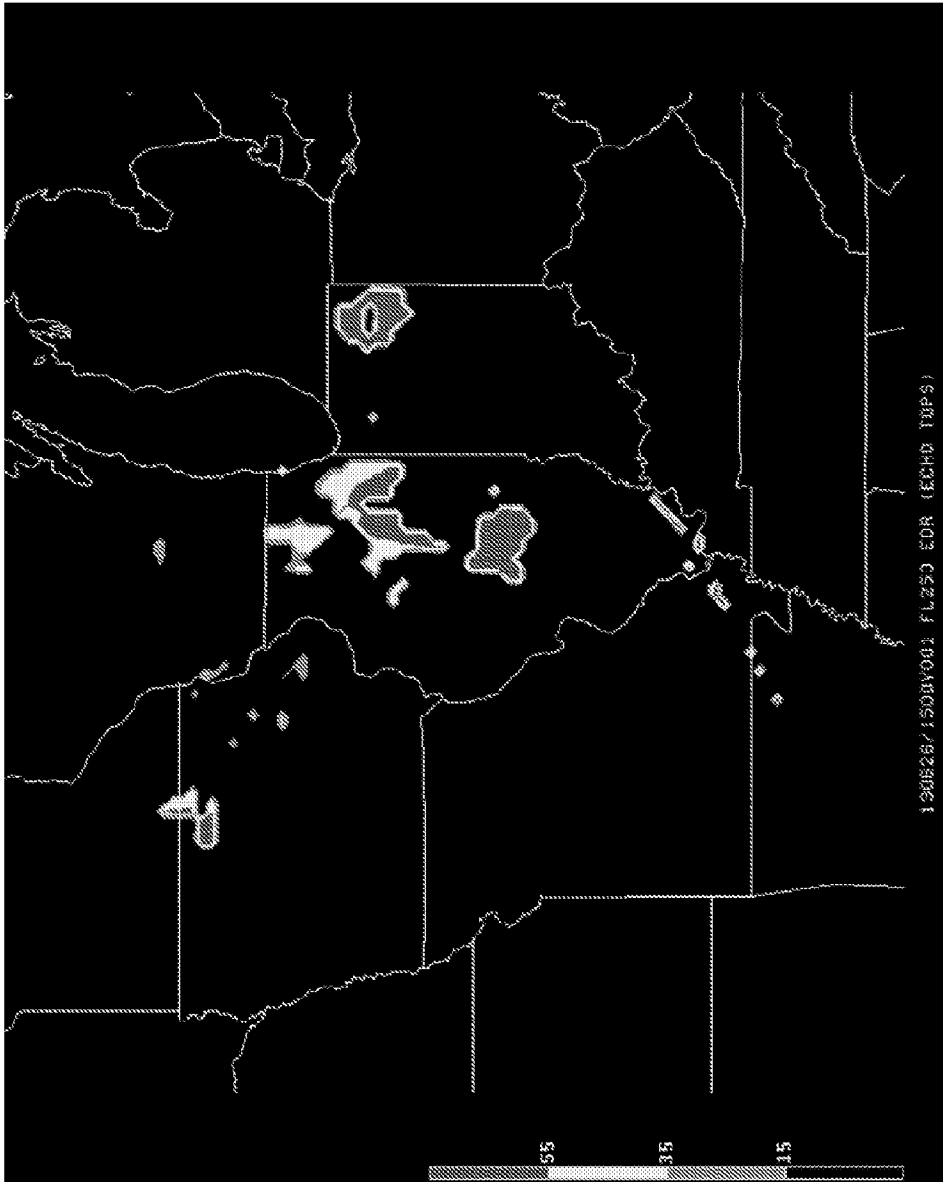


FIG. 30C - Example DATCM Data Display

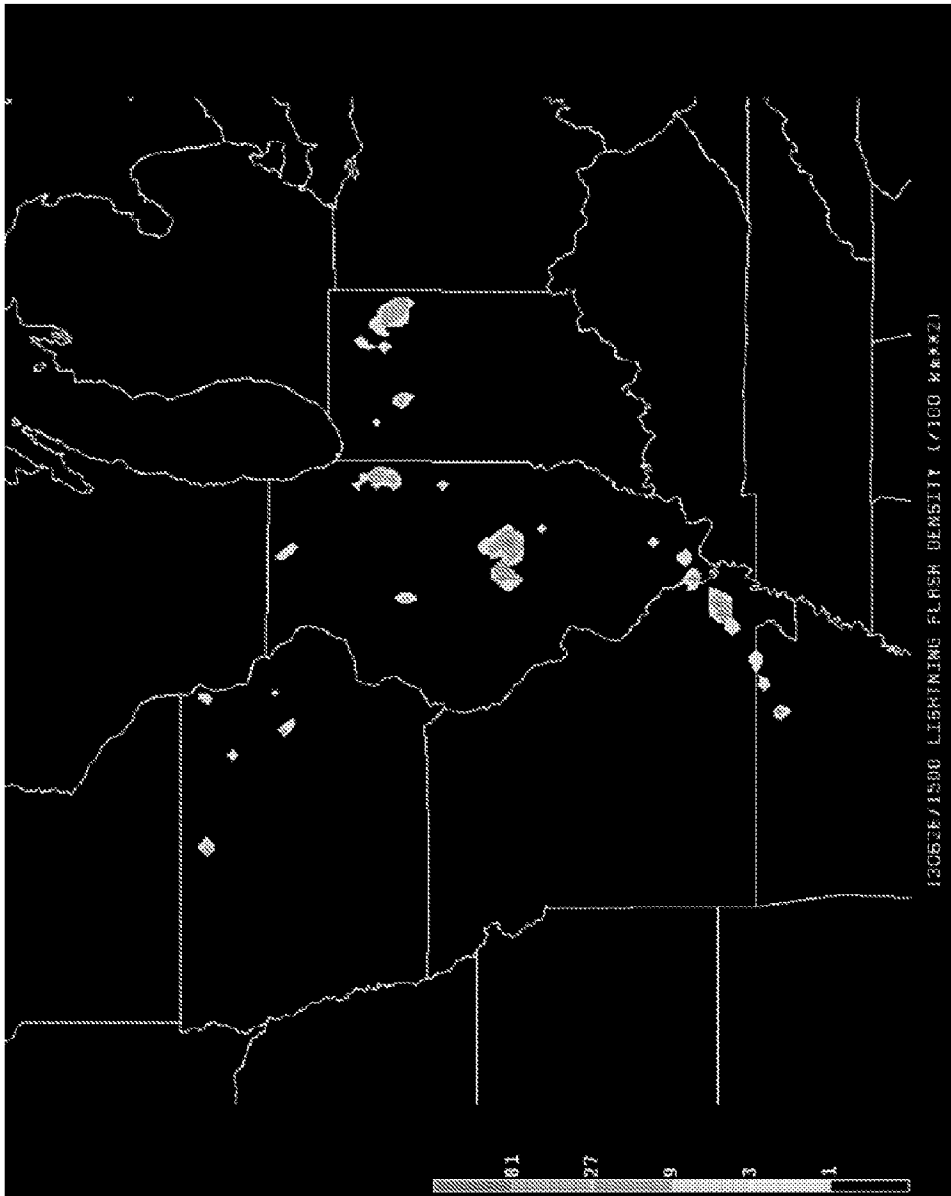


FIG. 30D - Example DATCM Data Display

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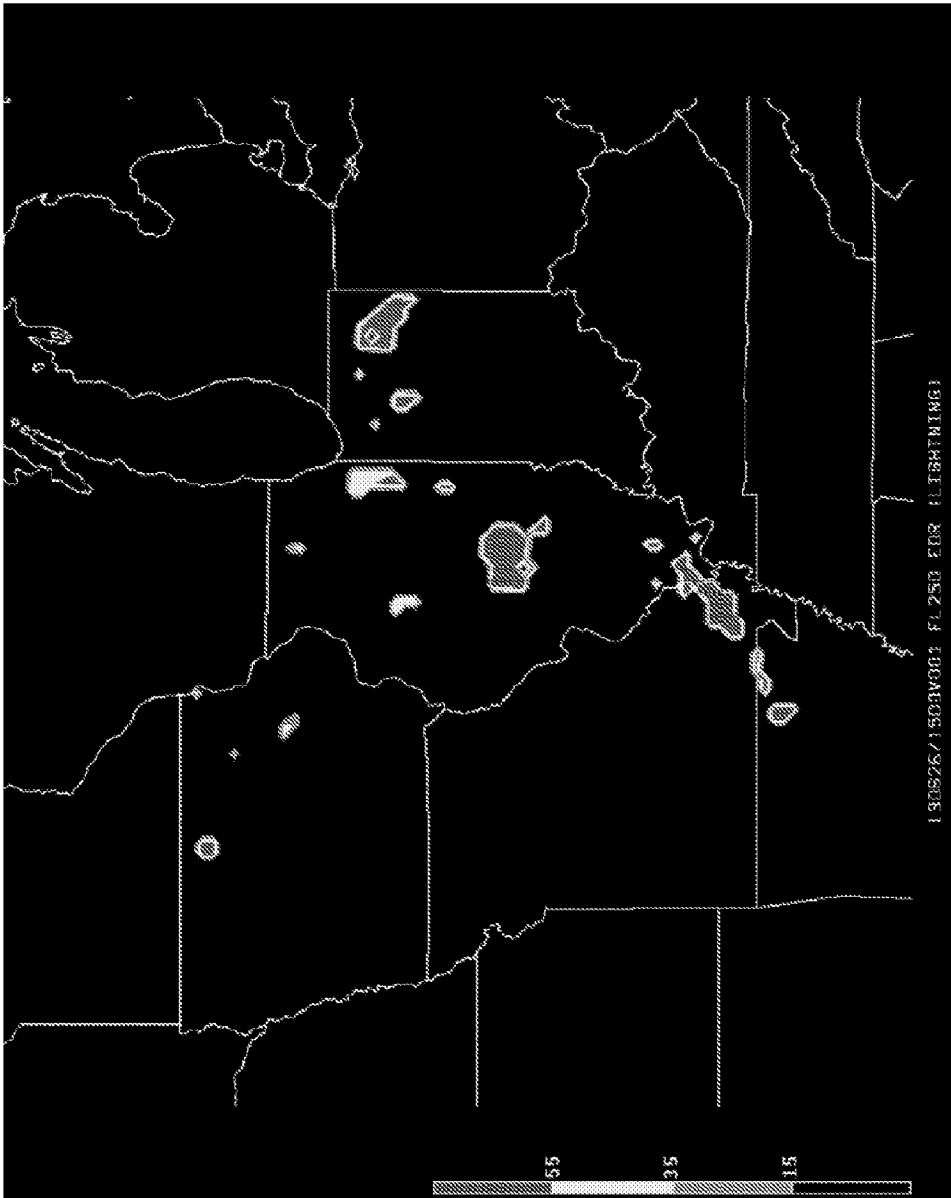


FIG. 30E - Example DATCM Data Display

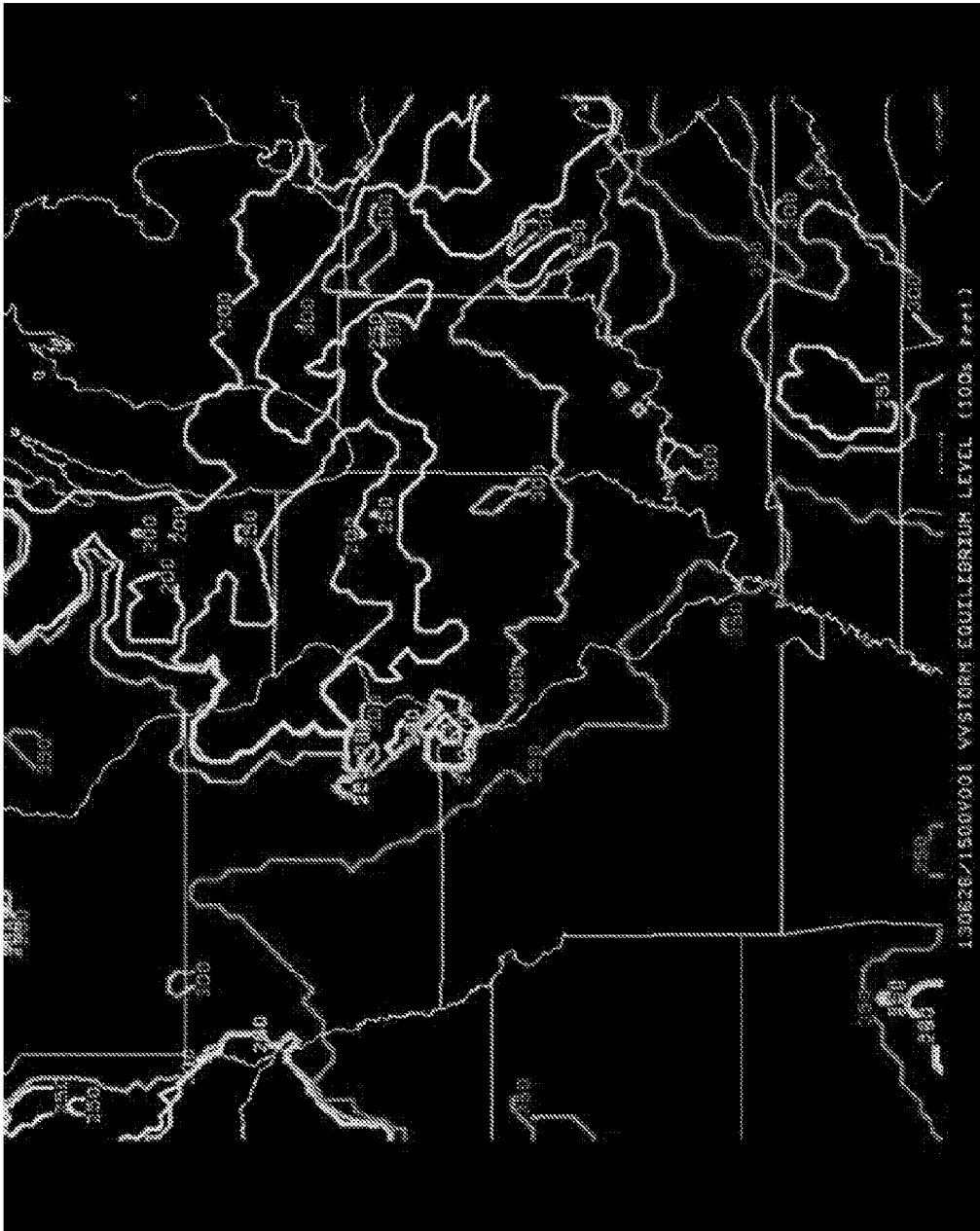


FIG. 30F - Example DATCM Data Display

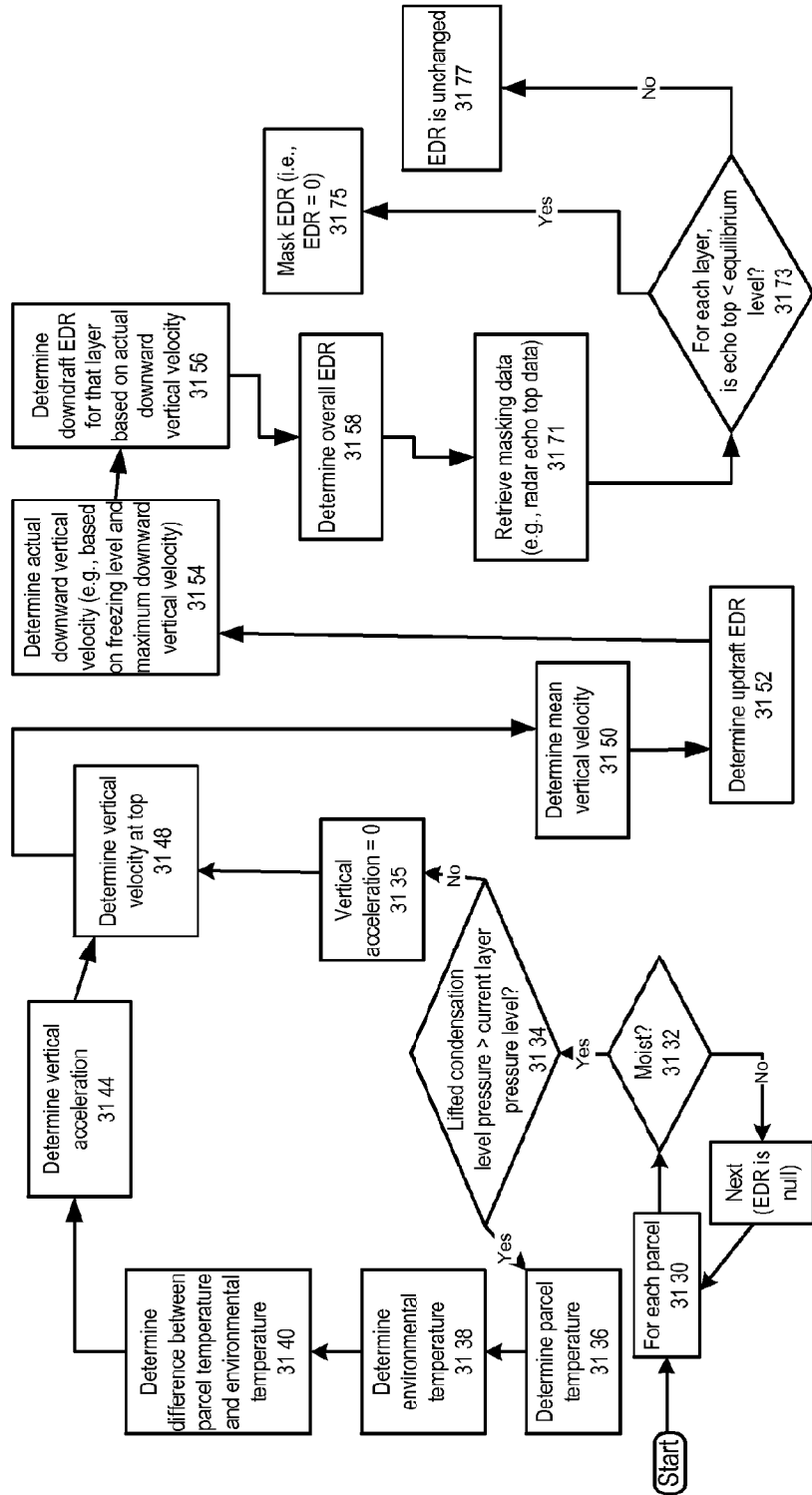


FIG. 31 - Example DATCM Logic Flow Diagram with EDR Determination

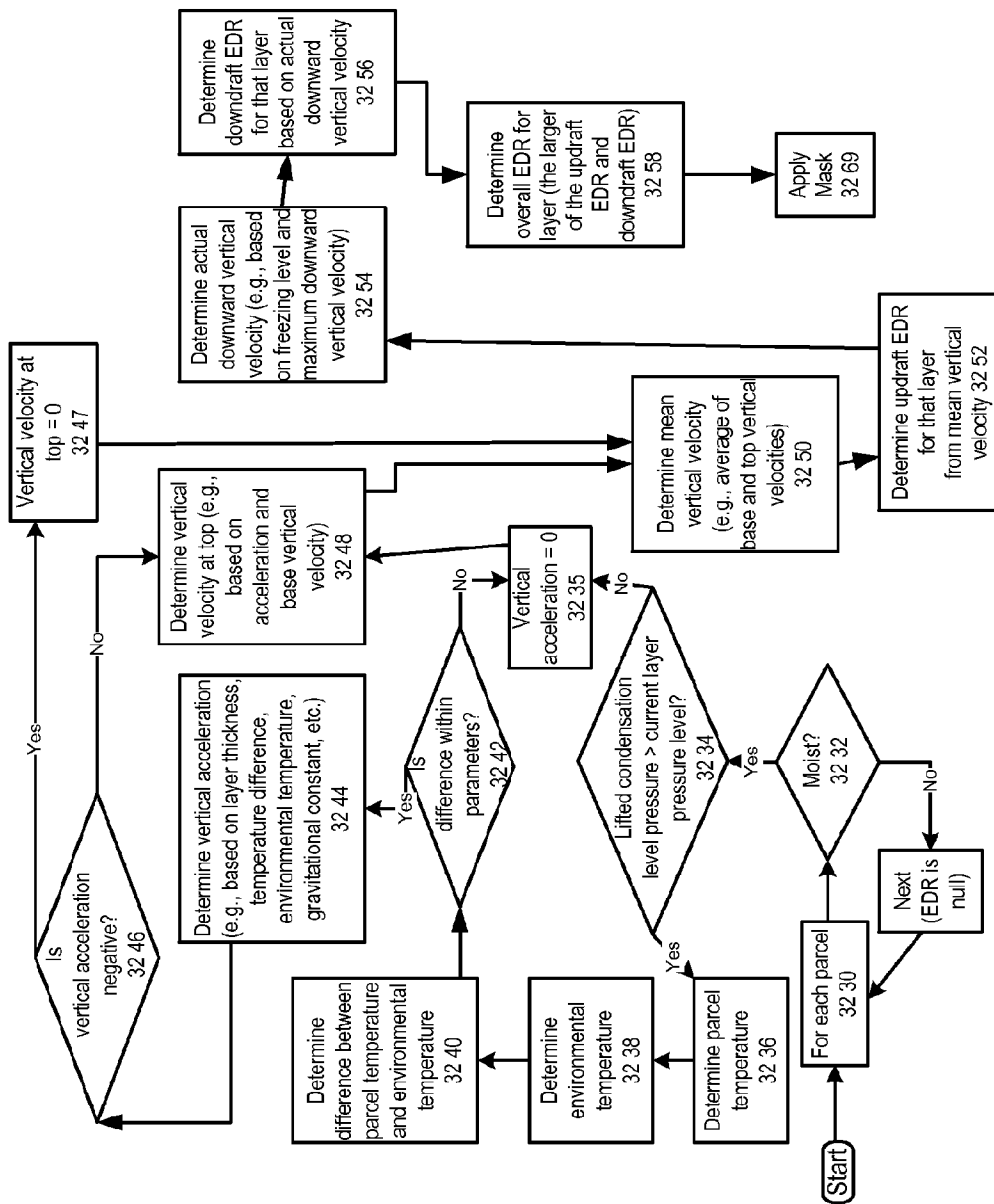


FIG. 32 - Example Logic Flow Diagram Depicting WVSTORMSE Component Operation

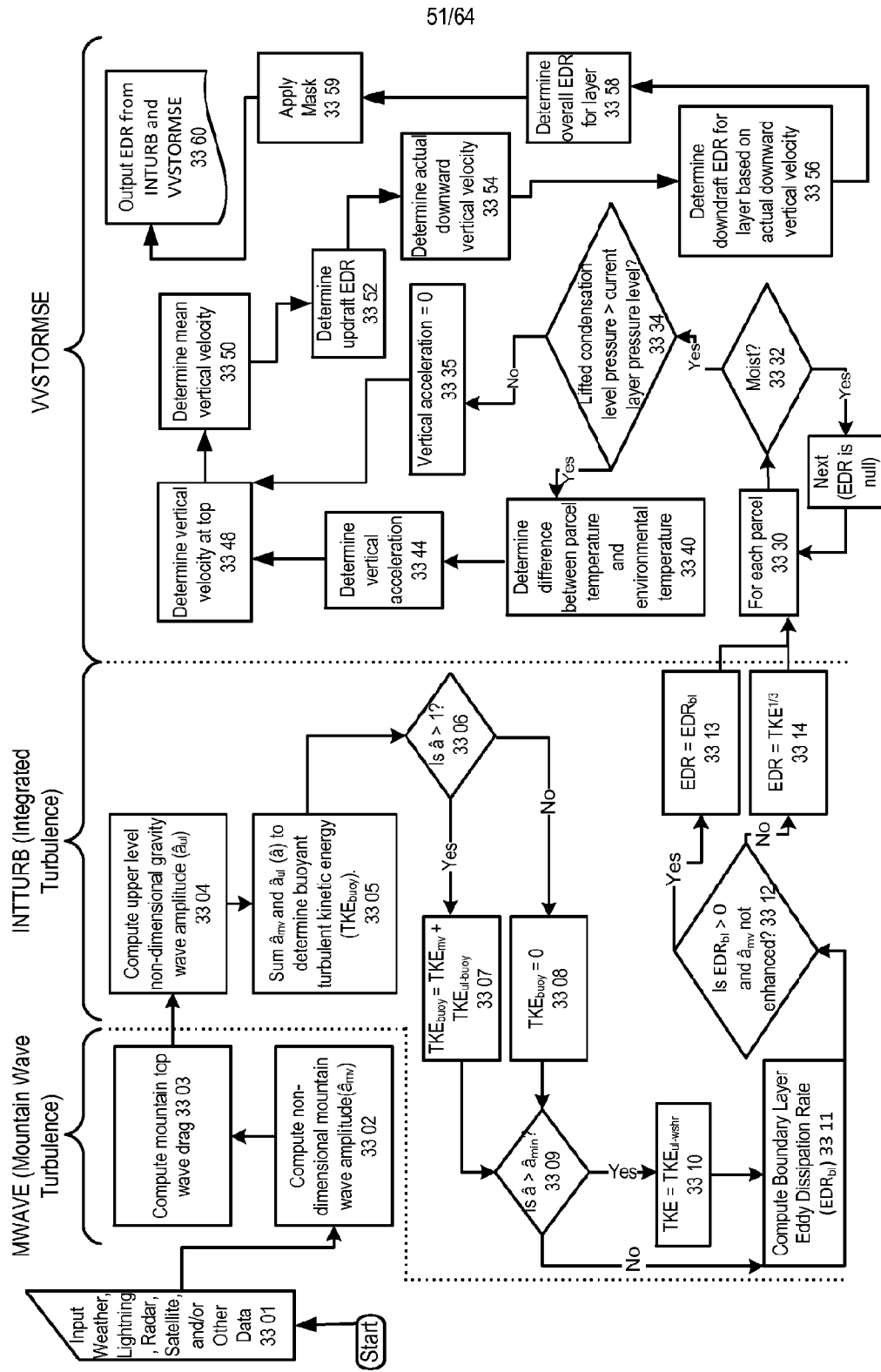
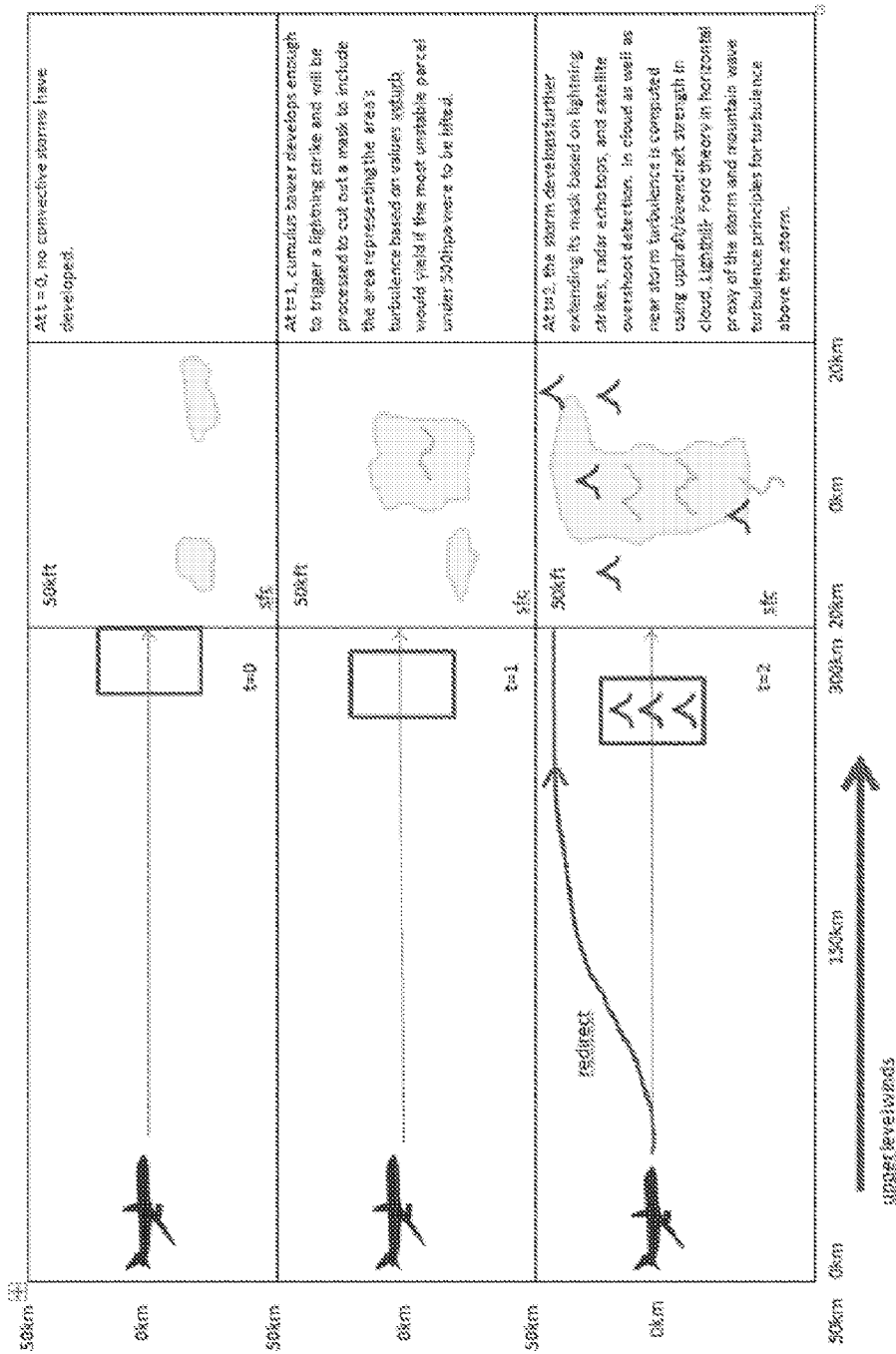


FIG. 33 - Example DATCM Logic Flow Diagram (Integration Component)



At t=0, no convective storms have developed.

At t=1, cumulus tower develops enough to trigger a lightning strike and will be processed to cut out a mask to include the area representing the areas turbulence based on values which would yield if the most unstable parcel under 200hpa were to be lifted.

At t=2, the storm develops further extending its mask based on lightning strikes, radar echoes, and satellite overcast detection. In cloud as well as near storm turbulence is computed using updraft/downdraft strength in cloud. Lightbulb Ford theory in horizontal proxy of the storm and resistive wave turbulence principles for turbulence above the storm.

FIG. 34 - Example Overview of DATCM Implementation

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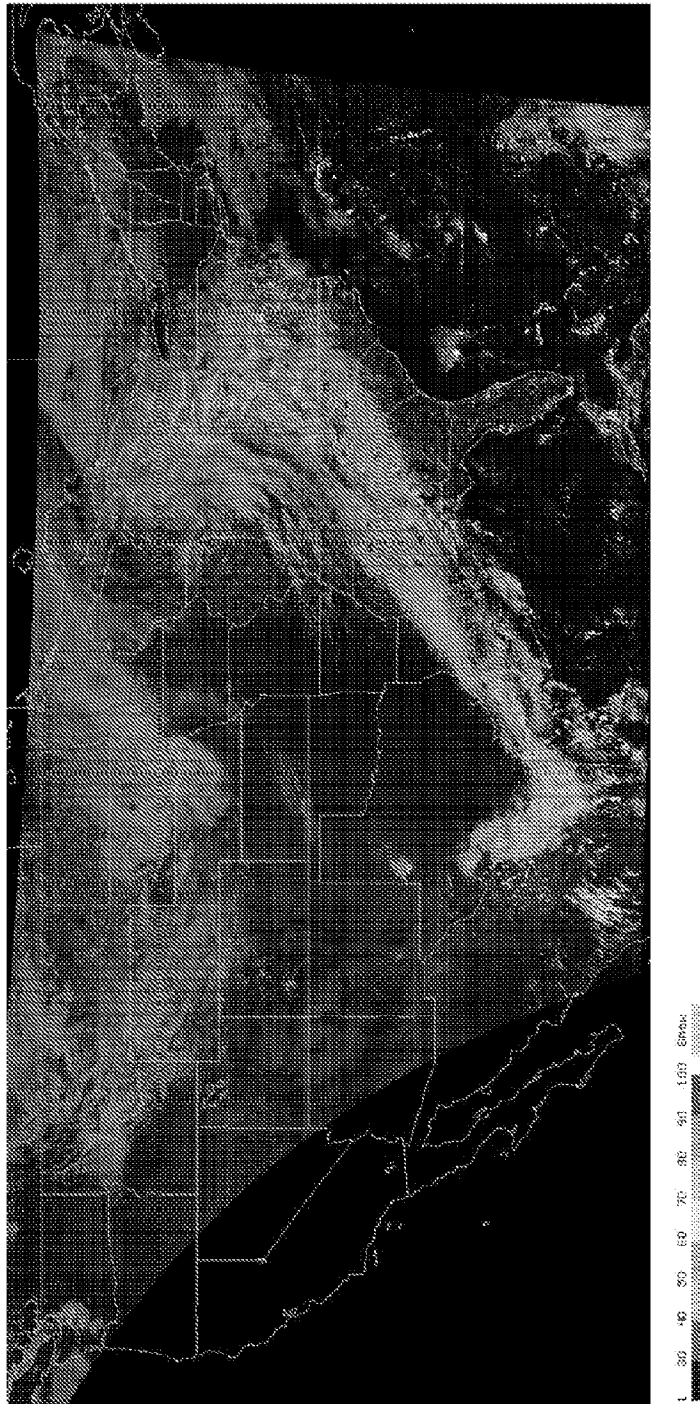


FIG. 35 - Example DATCM Geostationary Satellite Data

Satellite data
Cumulus Mask: Immature Cu (Red), Mature Cu and Cirrus Cloud (Green)

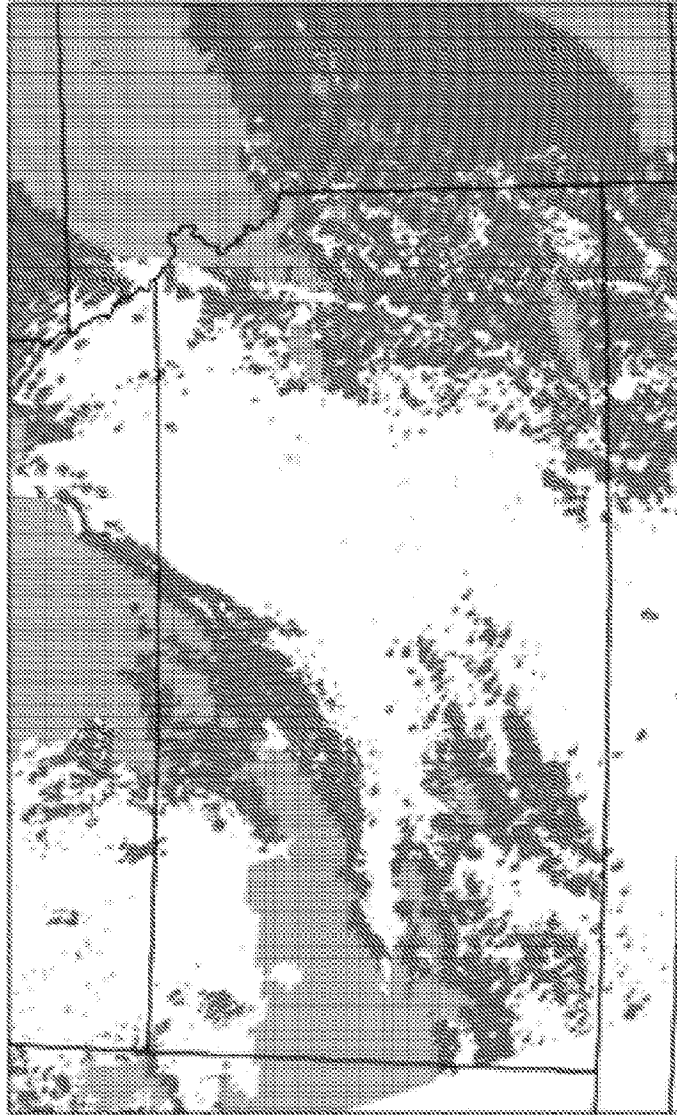


FIG. 36

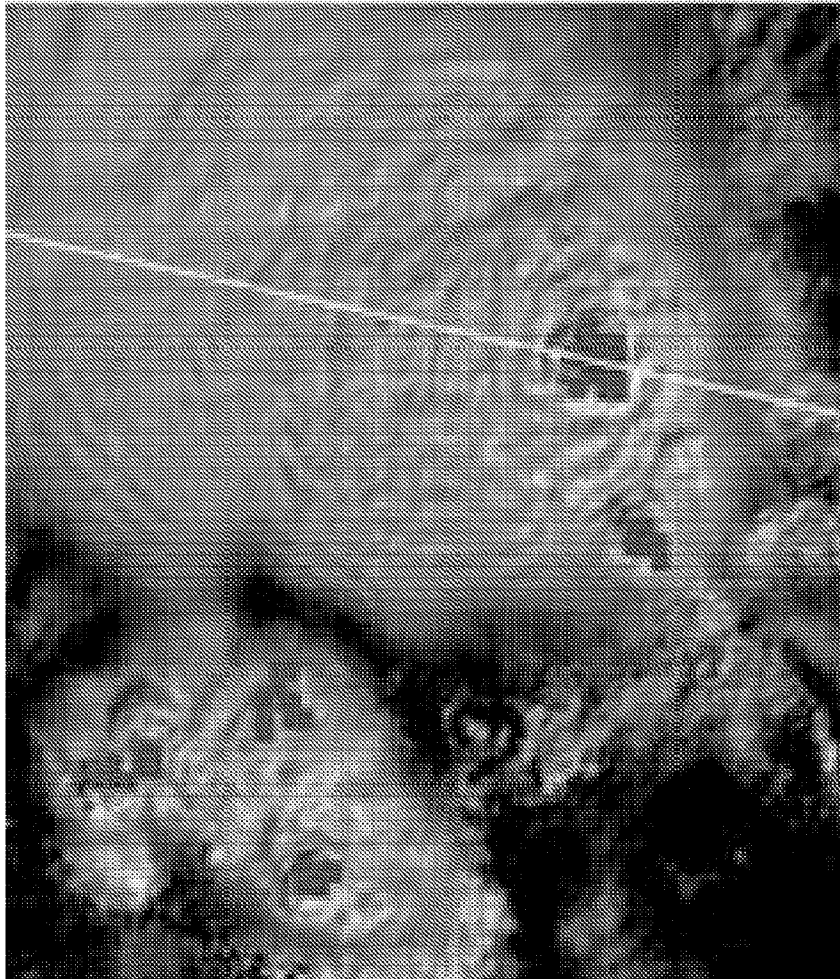


FIG. 37 - Exemplary DATCM Overshooting Top Mask Output

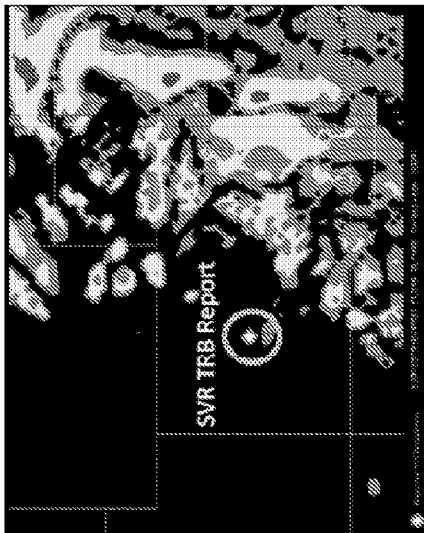


FIG 38A

FIG 38B

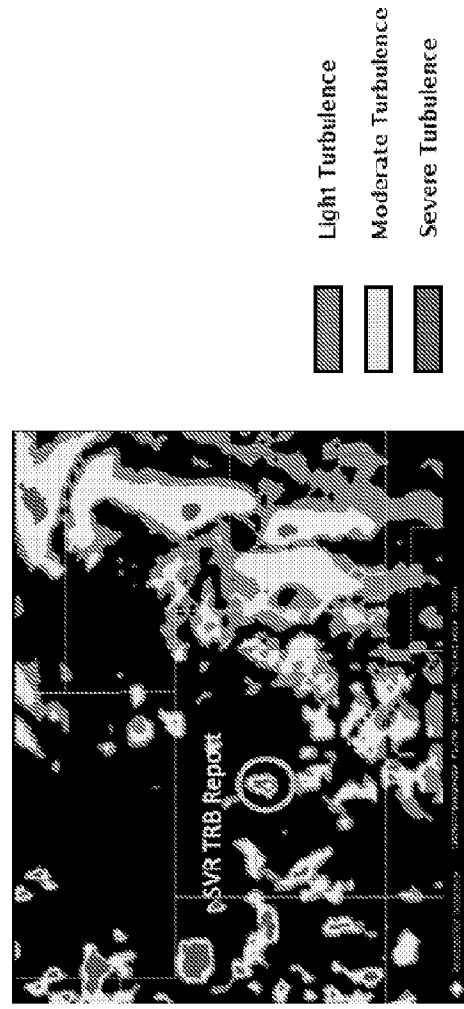


FIG 38C

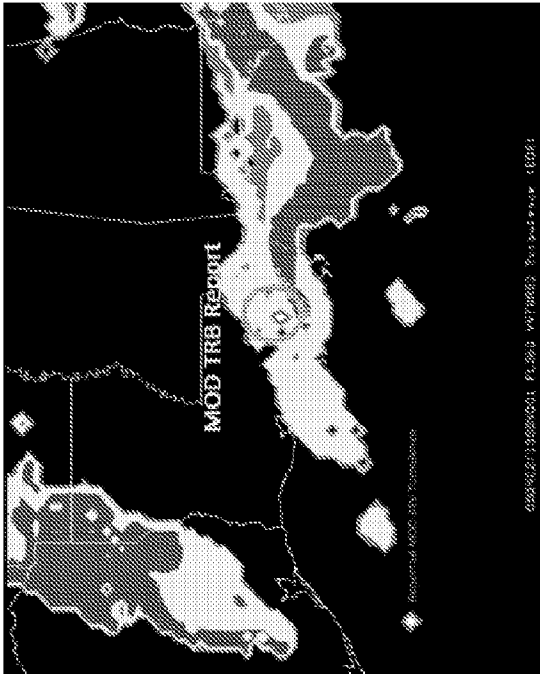


FIG 39B

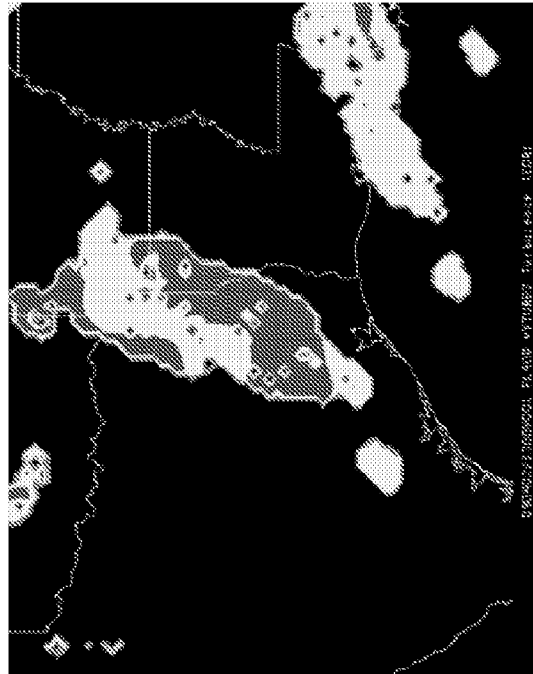


FIG 39D

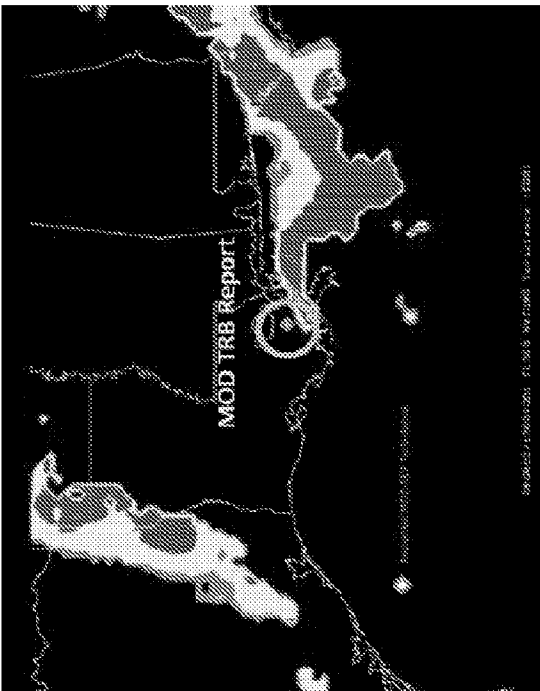


FIG 39A

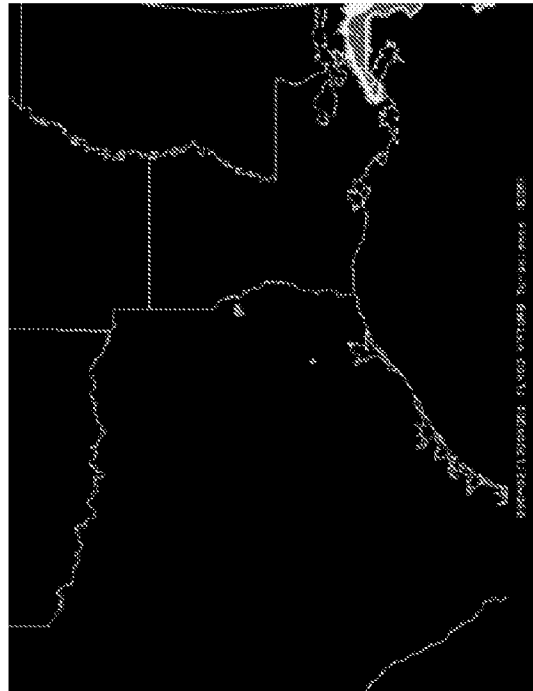


FIG 39C

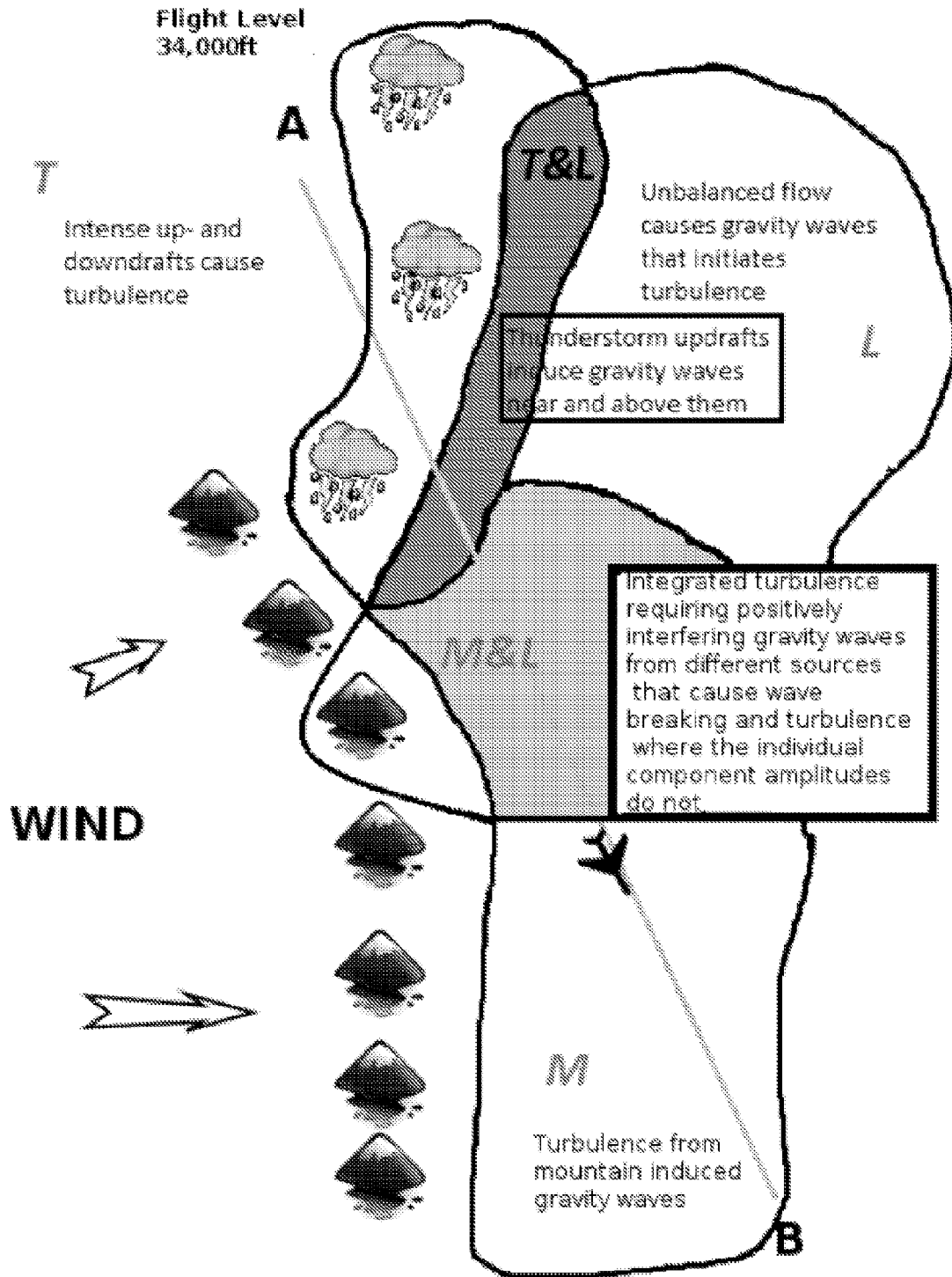


FIG. 40 – Example Schematic of Turbulence Regions

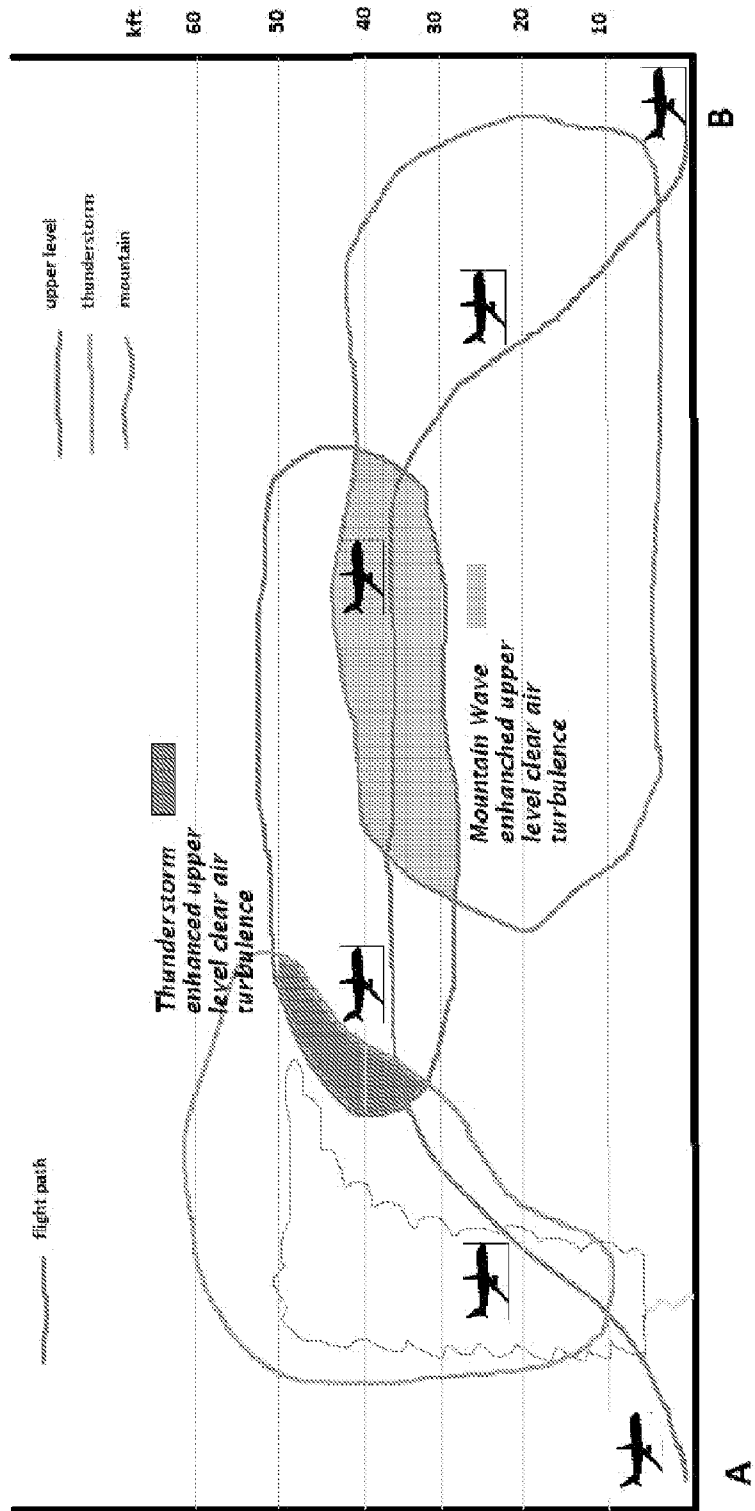


FIG. 41 – Example Cross-Sectional View of Flight Path through Turbulence Regions

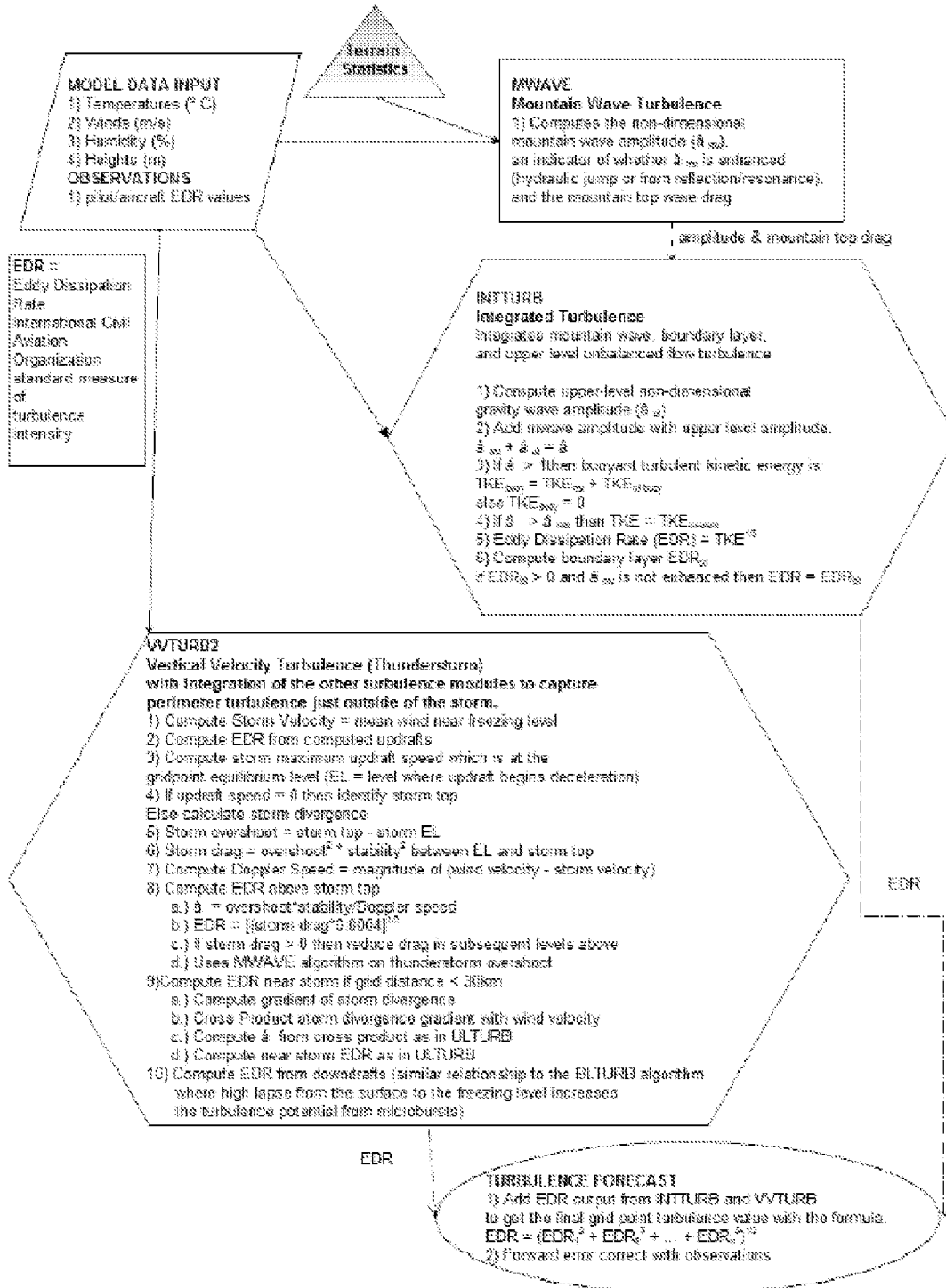


FIG. 42 – Example DATCM Integrated Turbulence Forecast Process Flow Diagram

Flight PHX-MSP		Leave: 0413Z		Arrive: 0846Z		Turbulence Forecast (EDR*100)					
Time	Latitude	Longitude	Altitude (ft)	MWAVE	COMTUR5	WVTURB	INTTURB	WINTURB	FINAL	Explanation of differences	
415	33.5	-111.8	50	0	0	0	0	1	1		
425	34.5	-111.6	250	0	0	0	0	26	26	Near-storm turbulence	
435	35.4	-110.3	370	0	0	0	0	1	1		
445	36.2	-109	370	0	0	1	25	1	25	Mountain wave and free gravity wave amplitudes combine	
455	36.9	-107.7	370	0	0	0	0	0	0		
505	37.3	-106	370	0	0	0	0	34	34	Storm top turbulence	
515	38.1	-104.7	370	0	0	1	35	1	35	Mountain wave and free gravity wave amplitudes combine	
525	38.0	-103.6	370	0	0	1	0	1	1		
535	39.9	-102.3	370	0	45	0	45	0	45		
545	40.9	-101	370	0	0	1	0	1	1		
555	41.8	-99.7	370	0	51	1	51	1	51		
605	42.6	-98.5	370	0	34	0	34	0	34		
615	43.5	-97	370	0	30	1	30	1	30		
625	44.4	-95.3	290	0	18	43	18	43	43		
635	44.7	-94	180	0	0	24	0	24	24		
645	44.8	-93.2	20	0	19	0	19	51	51	Near-storm turbulence	

FIG. 43 – Example DATCM In-Flight Time Sequence of Turbulence Forecasts

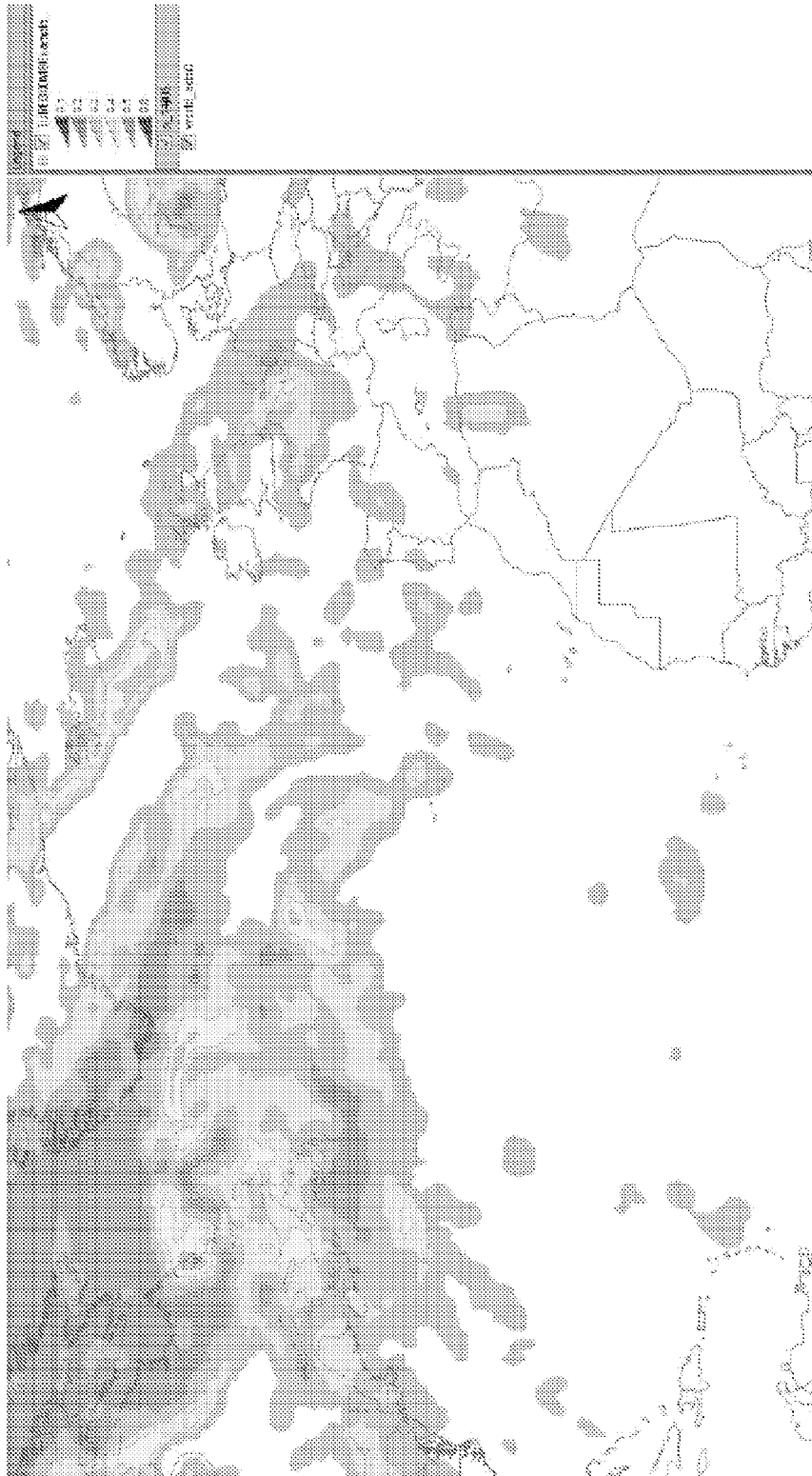


FIG. 44 – Example DATCM Shapefile Output

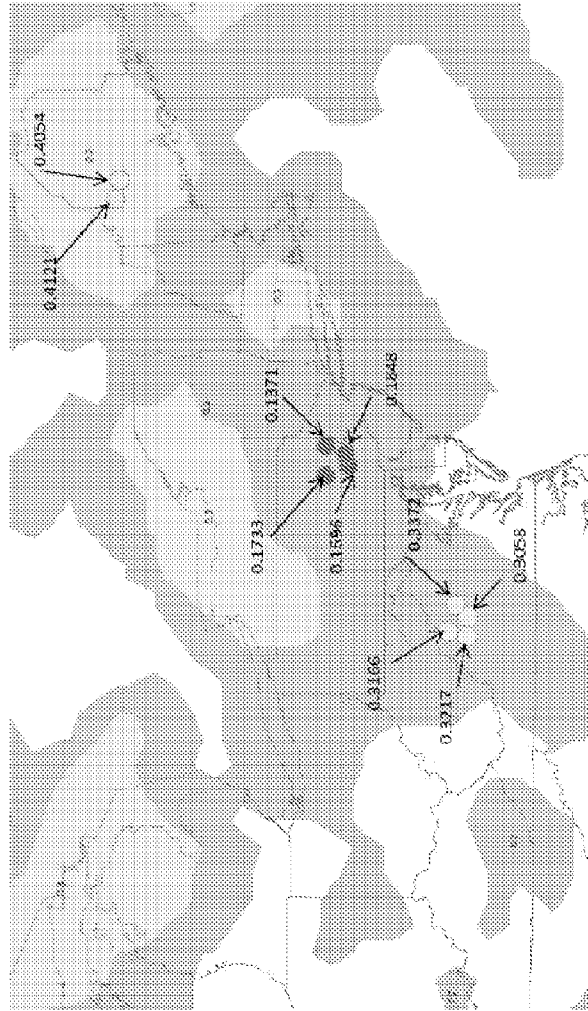
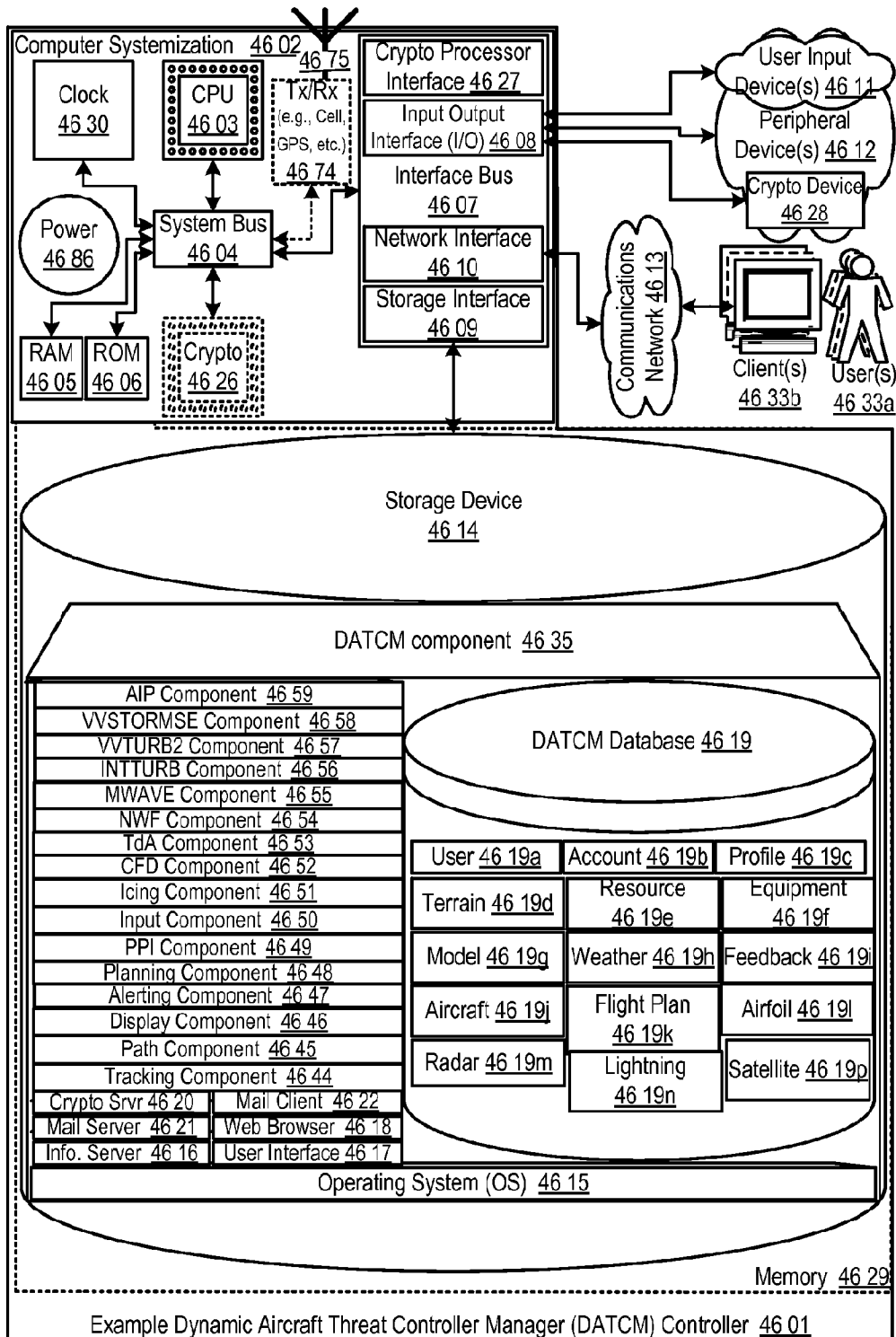


FIG. 45B – Example DATCM Overlay of Observation Points on Forecast Plot

FLIGHT	LAT	LDN	FL	EDR
1732	45.33	-70.13	300	0.4121
4627	45.06	-69.68	300	0.4054
2356	40.8	-75.94	300	0.1733
2057	40.94	-75.22	300	0.1371
1254	40.22	-75.83	300	0.1696
1368	40.35	-75.3	300	0.1848
7643	38.09	-78.65	300	0.3372
8247	37.73	-78.89	300	0.3058
5520	37.78	-78.89	300	0.3217
2239	38.34	-79.26	300	0.3166

FIG. 45A

FIGURE 46



A. CLASSIFICATION OF SUBJECT MATTER**G06F 19/00(2011.01)i**

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)

G06F 19/00; G05D 1/00; G01W 1/00; G01P 3/36

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

Korean utility models and applications for utility models

Japanese utility models and applications for utility models

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

eKOMPASS(KIPO internal) & Keywords: atmosphere, airfoil, plan, hazard, grid point, update

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	EP 1826647 A1 (HONEYWELL INTERNATIONAL INC.) 29 August 2007 See paragraphs [0003]-[0004], [0027]-[0028] and claims 1, 3, 7, 9-10.	1-3, 13-35, 44-47
A	US 2005-0251341 A1 (EVAN NIELSEN) 10 November 2005 See paragraph [0037]; claims 1, 21; and figure 3.	1-3, 13-35, 44-47
A	US 2004-0189976 A1 (JOSEPH D. BURNS et al.) 30 September 2004 See paragraphs [0015]-[0016], [0022]; claims 9, 14, 15; and figure 1.	1-3, 13-35, 44-47
A	US 2002-0024652 A1 (YASUISA OOGA) 28 February 2002 See paragraphs [0014]-[0015]; claim 1; and figure 1.	1-3, 13-35, 44-47
A	US 2009-0132103 A1 (NICOLAS MARTY, et al.) 21 May 2009 See paragraphs [0050]-[0057]; claim 1; and figure 1.	1-3, 13-35, 44-47

 Further documents are listed in the continuation of Box C. See patent family annex.

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"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

Date of the actual completion of the international search

28 April 2014 (28.04.2014)

Date of mailing of the international search report

29 April 2014 (29.04.2014)

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Box No. II Observations where certain claims were found unsearchable (Continuation of item 2 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. Claims Nos.: 8-9, 38-39, 51-52, and 55-56
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
they are referring to unsearchable claims respectively.

3. Claims Nos.: 4-7, 10-12, 36-37, 40-43, 48-50, and 53-54, and 57
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box No. III Observations where unity of invention is lacking (Continuation of item 3 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

1. As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of any additional fees.

3. As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

- The additional search fees were accompanied by the applicant's protest and, where applicable, the payment of a protest fee.
- The additional search fees were accompanied by the applicant's protest but the applicable protest fee was not paid within the time limit specified in the invitation.
- No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No.

PCT/US2013/078540

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