1 Opening of the Oral Proceedings: 8:55.

2 The chairman asked the parties to indicate their request.

3 The Opponent confirmed his request to revoke the entire patent as granted, based on Art. 100(a) and Art. 100(c).

4 The Patentee confirmed his main request to maintain the patent as granted, and his auxiliary requests filed with telefax of 23.02.2011.

5 The Chairman asked the Opponent to comment on the telefax of the Patentee dated 22.03.2011 objecting that document D12, D13 and D13A were late filed and not prima facie relevant.

6 The Opponent explained that these documents were filed to underline the common general knowledge at the time of filing of the patent application. He indicated that the relevance of a late filed document is only a admissibility criteria for prior art documents, not for documents supporting common general knowledge.

7 The Patentee answered that prima facie relevance was the appropriate criteria for admissibility and stated that general knowledge is not linked to the number of documents in which an information is disclosed.

8 The oral proceedings were adjourned from 9:06 to 9:15.

9 The Chairman indicated that the late filed documents were not prima facie relevant regarding the requests on file and announced that they are not considered as admissible at this stage of the proceedings.

10 The Chairman gave the floor to the Opponent regarding the compliance of the main request with Art. 123(2) EPC.

11 The Opponent argued that claims 1 and 4 do not meet the requirement of Art. 123(2) since:

a. the point in time the restoration is made is not undefined:
par. [0012] of the patent application as filed indicates a specific time.
par. [0014] indicates that "Δt, will be estimated based on the failure mode".
Claiming an unspecified time leads to an unallowable generalisation.

b. a propagation (or reconstruction) is absent from claims 1 and 4. Such a propagation is considered as indispensable.

c. from par. [0012] and [0014], it is apparent that the restoration only takes place once the system has switched in coasting mode.

12 The Patentee responded that claim 1 repeats par. [0012]. The purported generalisation is only possible if the claim is misinterpreted. The Patentee indicated that features (c-e) relate to a coasting filter, even if coasting is not mentioned as such. He further added that the arguments provided by the Opponent merely relate to clarity, which is a matter of Examination, not of Opposition.
The Patentee adhered to the preliminary opinion of the Opposition division provided in the summons.

13 The Opponent and the Patentee were given several further opportunities to comment on the arguments provided by the other party.

14 The oral proceedings were adjourned from 10:00 to 10:16.

15 The Charmain indicated that the Opposition division is of the opinion that claims 1 and 4 meet the requirement of Art. 123(2) EPC and gave the floor to the Opponent to argue about the compliance with Art. 123(2) of the dependent claims.

16 The Opponent raised an objection regarding claim 3. He indicated that

a. the closest support found is claim 4 as filed which is directed to a skipping filter comprising two integrators.
A skipping filter is a filter complementary to the coasting filter. In claim 3, "said filter" refers to a filter having as input GPS and inertial signals and

therefore designates the coasting filter. The application as filed discloses that the integrators are present in the skipping filter, whereas claim 3 is directed to a coasting filter comprising the integrators.

b. The integrators claimed are X4 and X5 in fig. 2. Claim 3 reads "two integrators for inertial and global positioning system signals **respectively**". However, from fig. 2, it is clear that the input of X4 is a combination of inertial and GPS signal. The word "respectively" is therefore not supported by the application as filed.

c. From paragraph [0018], lines 1-2 juncto par. [0019] of the patent as published, the filter are directed to the avoid corruption of the IRU velocity/ position guidance signal. However, in claim 3, the integrators are only to avoid corruption of the IRU velocity signal. The limitation to velocity signals infringes Art. 123(2) EPC.

17 The Patentee responded that the argumentation provided by the Opponent relates to clarity and stated that claim 3 is more limited than claim 1. Claim 3 is moreover considered to be clear.

18 The Opponent and the Patentee were given several further opportunities to comment on the arguments provided by the other party.

19 The oral proceedings were adjourned from 10:32 to 10:57.

20 The Charmain indicated that the argument provided by the Opponent were convincing and that the Opposition division is of the opinion that the subject matter of claim 3 offends the requirements of Art. 123(2) EPC. He indicated that the Patentee will be offered an opportunity to amend claim 3 later in the oral proceedings and invited the Opponent to discuss inventive step.

21 The Opponent indicated that claim 1 is directed to a landing system , which according to par. [002] of the patent application is capable to carry out cat. II or III approach.
The closest prior art is considered to the the AIME system. This system is disclosed in D5, D8, D9 and D10 (These documents describes the same system and are cross-referenced: D5 refers to D10, D10 to D8 and D8 to D9).

According the GL (C-IV, 11.5.1), the closest prior art is the most promising starting point. The problem to be solved by the present invention is to avoid

the corruption of data in hybrid positioning system (see par. [0001], [0008] and [0012]).
The AIME system is directed to the same purpose (see D10, p. 1600, left col., end of the first paragraph "detection and isolation of failure"; p. 1602, left col. second par. "If failed satellites were isolated, these measurements are excluded in this processing"; D8, p. 684, right col. end of first par.).

AIME can be used for cat II landing (D5, p. 519, left col. last line, p. 522, left col., 2nd par. , 2nd line).

AIME can be used with WAAS (D5, abstract; p. 521, left col, beginning of last par.) or LAAS (D5, p. 524, right col. first 2 lines). AIME is therefore receiving differential GPS signals.
According to D8, p. 687, fig. 5, IRS signals (lon, lat, speed and position) are input AIME signals, a compensated position is outputed ("Update: present position" (square in the middle of fig. 5)).
An error state is estimated (D8, p. 687, right col., l. 4-5; p. 685, table 1).

D10 discloses (p. 1601) "How AIME isolates and excludes failures". AIME uses a "least square filter" (D10, p. 1601, right col., 2nd paragraph) whose output is used to determine the corrected position. Different other filters are used (D10, p. 1601, right col., 4th paragraph: "bank of parallel "hypothesis test" Kalman filters"). A "past history" filter is used (D10, p. 1601, right col., last paragraph). The main filter updates the error state, which comprises bias and bias rate (D8, table 1).

AIME foresees coasting (D10, p. 1604, right col., 2nd and 3rd par.; D8, p.685, 5 lines before fig. 2).

Therefore the AIME system discloses an inertially augmented landing ((D5, p. 519, left col. last line, p. 522, left col., 2nd par. , 2nd line)) system comprising:
a) a filter receiving differential (D5, abstract; p. 521, left col, beginning of last par.; p. 524, right col. first 2 lines; D3, P. 9, 1st square, 2nd lines indicates that LAAS sends differential correction) global positioning system positioning signals and receiving inertial reference unit velocity signals (D8, figure 5),
b) said filter identifying the bias and bias rate in the inertial reference unit velocity signals (D8, table 1),
c) storing means storing filter states for a specified time period (D10, p. 160, right col., last paragraph: "past history")and
d) upon an anomalous differential global positioning system signal being

detected the filter states are reset to the filter states corresponding to the values at the earlier specified time period (end of page 1601)
e) to allow the bias and bias rote of the inertial reference unit velocity signals to be determined based on the reset filter states (this feature is the consequence of the reset carried out).

The disclosure of the AIME system differs from the subject matter of claim 1 in that the GPS does not provide a velocity signal. No technical effect has been found regarding this difference which is there not solving a technical problem.
The determination of both position and velocity information by a GPS receiver is usual. The error state comprises the determination of the bias of the IRU velocity which implies that the GPS velocity is internally determined. The Opponent stated that the noted difference does not involve an inventive step and that the same reasoning applies mutatis mutandis to corresponding claim 4.

22 The Patentee responded that the invention is directed to an automatic landing system (Cat III(c)) and that D1 constitutes the closest prior art. The invention provides a quick and simple filter (6 seconds), whereas AIME is a complex and slow algorithm (2.5 minute cycle) not directed at correcting errors but at improving calculation.
AIME is not disclosing a differential GPS system, since its aim is to avoid the use of assistance data.(D8 teaches away from WAAS; see also D10 p. 1604 "conclusion"). WAAS and LAAS are not used by AIME.
AIME is not a landing system.
AIME is not storing filter states but Kalman data.
The Patentee indicated that it is difficult to find any technical features of claim 1 in D10 which cannot be the closest prior art.

The Patentee was surprised by the new argumentation provided by the Opponent. He noted that it is the first time that the Opponent states that bias and bias rate are disclosed in D8, table 1.

23 The Opponent and the Patentee were given a further opportunity to comment on the arguments provided by the other party.
The Opponent responded that the wording of the claim per se matters and that nothing in the claim relates to the calculation speed. The Opponent noted that the opposed patent also discloses saving filter states (par. [0016]) and that AIME saves the filter states (D10, p. 1600 right col. line 2). The Opponent

stressed that the patent also performs calculation (description par. [0018])) and that claim 1 is not claiming a simple system.
The Patentee insisted that D1 which is also dealing with corruption is the closest prior art.

24 The oral proceedings were adjourned from 12:40 to 14:30.

25 The Charmain indicated that the argument provided by the Opponent were convincing and that the Opposition division is of the opinion that the subject matter of claims 1 and 4 offends the requirements of Art. 52(1) and 56 EPC based on the AIME system disclosed in D5, D8, D9 and D10. The Chairman invited the Opponent to comment the auxiliary request I.

26 The Opponent stated the "at the earlier specified stage" is not clear in the light of the amendment carried out (Art. 84). He repeated that the propagation is not specified (Art. 123(2)). He indicated the expression "to allow the bias.." applies both the restoration and to the propagation, and not to the restoration only (Art. 123(2)). The Opponent argued that the propagation implies that the filter is switched into coasting mode and that not claiming it leads to an unallowable intermediate generalisation.

27 The Patentee responded that the request incorporates the features of par. [0012] and considered it clear.

28 The oral proceedings were adjourned from 14:48 to 14:55.

29 The Charmain indicated that the Opposition division is of the opinion that the subject matter of claims 1 and 4 of auxiliary request I meets the requirements of Art. 84 and 123(2) EPC. The Chairman invited the Opponent to comment regarding inventive step.

30 The Opponent indicated that the amended features are disclosed in D10, in the paragraph at the end of page 1601 continuing at the beginning of page 1602 and in the following paragraph.

31 The Patentee argued that AIME does not disclose the propagation of an early stage. The amended features are specific and realise the quick and dirty trick of the invention by skipping the intermediate calculation and taking directly the states.

32 The oral proceedings were adjourned from 15:04 to 15:09.

33 The Charmain indicated that the Opposition division is of the opinion that the subject matter of claims 1 and 4 of auxiliary request I does not meet the requirements of Art. 52 (1) and 56 EPC. The Patentee asked if it will be possible to file a further auxiliary request.
The Chairman responded that the Patentee will be accorded such an opportunity later during the oral proceedings and invited the Opponent to comment the auxiliary request II.

34 The Opponent questioned the admissibility of auxiliary request II. He stated that he received it on the 03.03.2011 and that the request is directed to limiters which were never claimed before, and that three weeks were too short for reaching experts and perform a search.

35 The Patentee responded that filing auxiliary requests as fall back position is a matter of normal practice.

36 The oral proceedings were adjourned from 15:17 to 15:19.

37 The Charmain indicated that the Opposition division is of the opinion that the auxiliary request II is admissible.

38 The Opponent repeated the clarity objections previously raised regarding feature (e) and "at the earlier specified time period". He added that the amended features compare GPS **position and velocity** to inertial **velocity**. It is not clear how a velocity is compared to a positon, there is a unity issue.

39 The Patentee repeated that the clarity of granted claims have to be accepted. The amendment is based on paragraph [0021] and figure 2 which provide a clear support.

40 The Opponent argued that the claims have to be clear per se (T454/89).

41 The oral proceedings were adjourned from 15:33 to 15:53.

42 The Charmain indicated that the Opposition division is of the opinion that the auxiliary request II does not meet the requirement of Art. 84 EPC and invited the Opponent to comment the auxiliary request III.

43 The Opponent argued that "switch to pure INS mode" in claim 1 is not clear, and how the integrator of claim 3 allow to prevent the corruption is obscure. The Opponent added that the subject matter of claim 1 is not supported by the application as filed (Art. 123(2)) since the precise time is not indicated and since the coasting mode is not switched. The objection regarding claim 3 raised (Art. 123(2)) regarding the main request still applies.

44 The Patentee indicated that the present patent is a follow up patent. Switching to pure inertial guidance mode is straight forward from D1 and from the patent (par. [002], [005], [0014], [0018]).

45 The oral proceedings were adjourned from 16:03 to 16:11.

46 The Charmain indicated that the Opposition division is of the opinion that claims 1 and 4 of the auxiliary request III do meet the requirement of Art. 84 and 123(2) EPC provided that two minor corrections are carried out line 24 (bias rate ~~in~~ **of**) and and line 25 (determined **based** on) and reminded the issue regarding claim 3. He invited the Opponent to comment the auxiliary request III regarding inventive step.

47 The Opponent indicated that AIME can perform coasting that is to ignore GPS signals (D10, p. 1604, right column 2nd paragraph; D8 p. 685 text above fig. 2). AIME discloses a software realisation of the switches. The Opponent indicated that the calibration is an ongoing process in the AIME system that is repeated over time and referred to D8 p. 685, right column, last 8 lines.

48 The Patentee argued that coasting filters are well known and noted that D8 teaches away from the invention: "AIME is declared unavailable". AIME stop to operate in coasting mode in the system disclosed in D5, D8, D9 and D10,

whereas the patent teaches to perform some steps to improve the accuracy of the purely inertial guidance.

49 The Opponent responded that D10 teaches coasting after calibration by the GPS (p. 1604 right col., par. 2, l. 4) based on the error state.

50 The Patentee stressed that AIME being unavailable, nothing is restored.

51 The oral proceedings were adjourned from 16:36 to 16:49.

52 The Charmain indicated that the Opposition division is of the opinion that claims 1 and 4 of the auxiliary request III do meet the requirement of Art. 52 (1) and 56 EPC.

53 The Patentee filed an auxiliary request IV based on the auxiliary request III with two minor corrections are carried out line 24 (bias rate ~~in~~ **of**) and and line 25 (determined **based** on) in claim 1 and deleting claim 3.

54 The Charmain indicated that the opposition division therefore is of the opinion that, taking into consideration the amendments made by the patent proprietor during opposition proceedings, the patent and the invention to which it relates meet the requirements of the EPC. The Chairman announced that the patent will be maintained in amended form according to the auxiliary request IV filed during the oral proceedings pursuant to Article 101(3)(a) EPC, provided that the requirements of Rule 82(2) EPC are fulfilled.

55 At 17:03, the oral proceedings were closed.

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Application No.: 02 079 013.5

Patent No.: EP-B-1 308 746

Direct decision:

☐ **yes** ☒ **no**

Interlocutory decision in opposition proceedings (Art. 101(3)(a) and 106(2) EPC)

The Opposition Division - at the oral proceedings dated 24.03.2011 - has decided:

Account being taken of the amendments made by the patent proprietor during the opposition proceedings, the patent EP-B-1 308 746 and the invention to which it relates are found to meet the requirements of the Convention.

The currently valid documents are:

Description, Pages

2,3* of the patent specification

Claims, Numbers

1-4 of auxiliary request IV filed during oral proceedings on 24.03.2011

Drawings, Figures

1, 2 of the patent specification

With the following amendments:
* removal of granted claims

The Grounds for the decision (Form 2916) are enclosed.

06/04/11
Date

Chairman	1st Examiner	2nd Examiner	Legally qualified member
Mercier, Francois	Fanjul Caudevilla, J	Kern, Olivier	

1. Summary of facts and submissions

1.1 Patent EP-B1-1 308 746 was granted on the basis of application 02 079 013.5 filed on 27.09.2002 and claiming priority from application US 1077 filed on 31.10.2001 in the United States. The mentioning of the grant of the patent was published on 06.06.2007 in Bulletin 2007/23.

The patent proprietors is:

The Boeing Company,

Seattle,

Washington 98124-2207,

United States of America

1.2 Opposition was entered by fax of 05.03.2008 (received by the EPO on the same date) in the name of:

AIRBUS SAS

1 Rond-Pont Maurice Bellonte,

31700, France

AIRBUS France SAS

AIRBUS UK Limited

AIRBUS Deutschland GmbH

AIRBUS España S.L.

The Opponent requested revocation of the patent in its entirety on the ground that the subject matter of the granted patent extends beyond the content of the application as filed (Article 100(c) EPC), and on the ground that its subject matter does not involve an inventive step (Article 100(a) EPC), relying on the following prior art documents, renumbered according to the proposal submitted by the Patentee in his letter of 20.09.2008:

D1: US 6 178 363

D2: A340 landing experiment

D3: National Civilian GPS

D4: Instrument approach

D5: Advantages of autonomous integrity monitored extrapolation for precision approach

D6: A performance analysis of a tightly coupled GPS/Inertial system for two integrity monitoring methods

D7: WO 95/34850

D8: Integration of navigation systems for fault detection, exclusion and integrity determination - without WAAS

D9: A new approach to GPS integrity / availability: immediate global sale means without WAAS

D10: GPS-IRS AIME

D11: Tutorial Litton

In particular, the Opponent submitted that the subject-matter of claim 1 and claim 4 includes added subject-matter (Article 123(2) EPC) and does not involve an inventive step (Article 56 EPC) when considering the closest prior art (D1), in combination with the common knowledge in the field represented by the AIME (Autonomous Integrity Monitored Extrapolation) system (references D5, D8, D9, D10). Moreover, dependent claims 2, 3 and 5 were regarded as including added subject-matter and lacking inventive step.

1.3 By letter of 16 December 2008 the Patentee filed a Counterstatement to the Notice of Opposition. The Patentee requested that the opposition be rejected and the patent maintained on the basis of the claims 1 - 5 as granted. The Patentee submitted that D5, D8, D9, D10 cannot be regarded as representing the common general knowledge, but prior art relevant to the patent and cannot be combined thus with D1. The Patentee requested also oral proceedings.

1.4 In the communication dated 31.03.2010 and annexed to the Summons to attend Oral Proceedings, the Opposition Division arrived at the preliminary opinion that the Opponent had failed to proof that the patent contains added subject-matter and that the person skilled in the art would arrive at the subject - matter of claims 1 and 4 by departing from the teaching of D1 and using the common knowledge in the field represented by the AIME system.

1.5 With telefax of 23.02.2011, the Patentee filed three auxiliary requests for the case that the preliminary opinion of the Opposition Division of 31.03.2010 would not be followed.

1.6 With telefax of 24.02.2011, the Opponent filed additional documents (renumbered D12, D13, D13'), which would represent the general knowledge in the field, as referred to in the notice of opposition. The Opponent presented additional remarks in respect of the preliminary opinion of the opposition division, and maintained all their requests.

1.7 With telefax of 22.03.2011, the Patentee objected the admissibility of D12, D13 and D13', since they did not provide new information and it was not clear that they were publicly available. In addition, the Patentee submitted further arguments in reply to the Opponents' submissions in the telefax of 24.02.2011.

1.8 Oral proceedings were held on 24.03.2011. During the proceedings, the Patentee filed a fourth auxiliary request, based on the third auxiliary request on file. At the end of the oral proceedings, the Chairman of the Opposition Division announced the interlocutory decision that the patent according to the fourth auxiliary request met the requirements of the EPC. The amended claims are annexed to this decision.

2. Grounds for the decision

2.1 Since the content of the notice of opposition was properly substantiated, the opposition meets the requirements of Article 99 (1) and Rule 76 EPC and was thus admissible.

2.2 Having considered the submissions of all the parties, the Opposition Division has concluded that:

a) the subject-matter of claims 1 and 4 of the granted patent complies with Article 123(2) EPC

b) the subject-matter of claims 1 and 4 of the granted patent lacks inventive step (Article 56 EPC)

c) the subject-matter of

claim 3 of the granted patent

claim 3 of auxiliary requests I and III

claim 4 of auxiliary request II

contains added subject-matter (Article 123 EPC).

d) the subject-matter of claims 1 and 4 of the first auxiliary request, lacks inventive step (Article 56 EPC)

e) the subject-matter of claims 1 and 4 of the second auxiliary request is unclear (Article 84 EPC)

f) the claims of the fourth auxiliary request meet the requirements of the EPC.

2.3 Claims 1 and 4 of the granted patent

2.3.1 Granted claim 1 reads as follows, whereby their exact wording is used:

An inertially augmented landing system comprising:

a) a filter receiving differential global positioning system positioning and velocity signals and receiving inertial reference unit velocity signals,

b) said filter identifying the bias and bias rate in the inertial reference unit velocity signals,

characterized by:

c) storing means storing filter states for a specified time period and

d) upon an anomalous differential global positioning system signal being detected the filter states are reset to the filter states corresponding to the values at the earlier specified time period

e) to allow the bias and bias rote of the inertial reference unit velocity signals to be determined based on the reset filter states.

Granted claim 4 reads as follows:

A method for correcting the corruption of an inertial guidance signal resulting from an anomalous differential global positioning system signal, the method comprising

a) receiving differential global positioning system positioning and velocity signals and an inertial reference unit velocity signal at a filter

b) to allow the filter to identify the bias and bias rates in the inertial reference unit velocity signals

characterized by

c) storing filter states for a specified time period and

d) upon an anomalous differential global positioning system signal being detected the filter states are reset to the filter states corresponding to the values at the earlier specified time period

e) to allow the bias and bias rates of the inertial reference unit velocity signal to be determined based on the reset filter states.

2.3.2 Interpretation of claims 1 and 4

The invention relates to a landing system comprising a filter which combines information of the inertial unit and GPS satellites for producing positioning data. The system is switched to inertial mode when an anomaly is detected in the GPS signals. The technical problem to be solved by the patent is to avoid the potential corruption of the filter when switched to inertial mode, due to a delay in the detection of the loss of the GPS signals. Claim 1 defines a technical solution comprising means for storing filter states for a specified time period, which are used to reset the filter when an anomalous GPS signal is detected. This procedure permits the accurate determination of the bias and bias rate of the inertial reference unit velocity signals at the point in time of switching to inertial mode, which are essential during the coasting phase after the switching.

2.3.3 Requirements of Article 123(2) EPC

After consideration of the arguments of the parties, the opposition division has reached the conclusion that the subject-matter of independent claim 1 and claim 4 of the granted patent does not include added subject-matter. Because of the relevance of this decision when considering the patentability of the three auxiliary requests, a summary of the supportive reasons is presented herewith.

In the notice of opposition, the Opponent has interpreted the wording introduced during the examination phase “at the earlier specified time period” of feature (d) as meaning "at the start of the earlier specified time period". Since the application as originally filed (par. [0012] - [0014]) did not explicitly disclose this feature, the limitation would result in added subject-matter. In agreement with the arguments of the Patentee, the opposition division is of the opinion that this objection relates to a potential lack of clarity in the amended feature, which is a matter of Examination, not of Opposition. In fact, the Opponent has interpreted the feature in a way which is neither directly derivable from the wording of the claim, nor supported in the description, in order to raise an objection regarding added subject-matter. The opposition division is of the opinion that the purportedly ambiguous feature of the granted patent would be reasonably interpreted by the skilled person in the sense that the filter states are reset to the filter states corresponding to values of a point in time within the specified time period (including the start), which is in agreement with the teaching of the description in par. [0012] - [0014] of the application as originally filed, which indicates a recording period (for example, 6 seconds) and a restoration point in time (N seconds) within the recording period.

During the oral proceedings, the Opponent responded that this interpretation of the opposition division implies a restoration of the filter values at an unspecified time. This fact results, according to the Opponent, in an unallowable generalisation, since according to par. [0012] or par. [0014] of the patent application as filed, the time of restoration is specific and not undefined, for example, based on the failure mode. Again, the opposition division agrees with the Patentee that this argument relates to Article 84 EPC (lack of essential features). In particular, no specific restoration time was claimed in claim 1 of the application as originally filed. Therefore, its absence in claim 1 as granted cannot be regarded as a generalization and does not offend the requirements of Article 123(2) EPC.

The opposition division uses similar arguments to refute additional objections of the Opponent under Article 123(2) EPC:

a) The restoration only takes place once the system has switched in coasting mode (par. [00121 and [0014]). Therefore, its absence in claim 1 as granted, results in added subject-matter.

b) The feature contained in par. [0016] of the patent, related to the propagation the restored states of the filters, is essential to the definition of the invention. The omission of this feature in claim 1 results in subject-matter extending beyond the content of the application as filed.

The Opposition Division is of the opinion that the absence of these features in claim 1 relates to Article 84 EPC (lack of essential features) and cannot be regarded as offending Article 123(2) EPC. Independent claim 1 as originally filed, which constitutes a possible antecedent to claim 1 of the patent, does not mention that the restoration takes place upon the switching to coasting mode, or that the filter states are propagated. Since theses features were not claimed in the application as originally filed, their absence in granted claim 1 does not offend the requirements of Article 123 (2) EPC.

2.3.4 Closest prior art

In view of the above interpretation, the Opposition Division considers, in agreement with the Opponent's statements made during the oral proceedings, that the closest prior art is represented by the AIME system described in the family of documents D5, D8, D9 and D10. As it will be explained in more detail, the reason is that D10 unambiguously addresses the technical problem associated to the corruption of the data in a coasting filter, said corruption being caused by a delay in the detection of the loss of the GPS signals entering the filter. D8 and D5 provide additional details of the AIME system and can be used together with D10, since the documents relate to the same disclosure and are cross-referenced each other. D5 refers to D10, D10 to D8 and D8 to D9.

D10 (abstract, page 1599) describes the Autonomous Integrity Monitored Extrapolation system (AIME), which consists of a filter integrating GPS with IRS (fig. 1 of D10 and fig. 5 of D8) to achieve high levels of availability for both failure detection and exclusion (FDE). The operation of the filter is explained in the sections entitled "HOW AIME KALMAN FILTERS WORK", "HOW AIME DETECTS FAILURES" and "HOW AIME ISOLATES AND EXCLUDES FAILURES" on pages 1600 and 1602, in combination with table 1 of D8. GPS and inertial data (observation data) are used with a Kalman filter to update an error state vector comprising the IRS states "linear velocity error" and "accelerometer bias error" (table 1 of D8). The error states are used to correct the IRS position in order to obtain the final AIME position. Differential GPS can be implemented by combining AIME with the Wide Area Augmentation System (WAAS), as disclosed in D5, page 521, left column, last paragraph. AIME is therefore receiving differential GPS signals.

When looking at the features in the preamble of claim 1, the AIME system discloses:

a) a filter receiving differential global positioning system positioning signals (pseudorange $PR_i(t)$) and receiving inertial reference unit velocity signals (V_N, V_E, V_Z),

b) said filter identifying the bias and bias rate in the inertial reference unit velocity signals ("linear velocity error" and "accelerometer bias error", as in table 1 of D8),

At this point, it should be noted that the filter of the AIME system, represented in fig. 5 of D8, does not receive velocity signals from the differential global positioning system, as it is the case of feature (a) of claim 1.

In addition of producing a bias corrected inertial solution, the AIME system can detect and exclude failures in the satellite signals. As indicated in D10 (page 1601, right column, par. 2 - 3), the Kalman filter used in AIME uses measurements from all satellites in view. The normalized sum squared mean residuals from this filter are used as the statistic to detect failures. In order to isolate and exclude the failures, the measurements can be processed in a bank of parallel Kalman filters designed to each exclude a different satellite from its measurements. If a satellite failure is detected, the satellite can be isolated by comparing residuals from the parallel filters. All of the test filters will have large residuals except the one which did not use the bad satellite.

Finally, the AIME system is capable to remedy the effect of incorrect GPS data in the past history of the filter. The procedure is explained in the passage bridging pages 1601 and 1602 "once the failure is both detected and isolated, the failure is excluded by re-computing the least squares filter solution over the past 30 minute interval. This is made possible by continually saving the GPS averaged measurements in a 30 minute circular buffer. Also an additional 'past history' Kalman filter is always operating with measurements 30 minutes in the past. This filter is only used when necessary to re-initialize the least squares filter at 30 minutes in the past when failures are detected".

When looking at the features in the characterizing of claim 1, the AIME system described in fig. 5 of D8 discloses:

c) storing filter states for a specified time period and

d) upon an anomalous differential global positioning system signal being detected the filter states are reset to the filter states corresponding to the values at the earlier specified time period

e) to allow the bias and bias rates of the inertial reference unit velocity signal to be determined based on the reset filter states.

2.3.5 Lack of inventive step of claim 1 and claim 4

The subject-matter of claim 1 differs from the AIME system in that it provides velocity signals from the differential global positioning system as input to the filter, in addition to the positioning signals represented by the pseudoranges. No technical effect has

been found regarding this feature which appears to be related merely to the kind of GPS receiver used. As previously explained, the Kalman filter of the AIME system calculates the velocity errors of the inertial unit (IRS) by using GPS pseudoranges provided by the receiver unit ARINC 743, represented in fig. 5 of D8. This particular model of receiver may be replaced by equivalent equipment during the expected life cycle of the AIME system. Many of the available GPS receivers provide an estimation of the speed, in addition to the position and/or pseudoranges. When connecting one of such receivers to the Kalman filter represented in fig. 5 of D8, the skilled person will have to modify the Kalman filter to use the information provided by the receiver, namely position and velocity. The Kalman filter is a well established technology in the field of positioning and its theory and mode of operation are part of the common knowledge in this field. For this reason, the required adaptation does not involve an inventive step. Therefore, the subject-matter of claim 1 and claim 4 does not involve an inventive step.

Consideration of the arguments of the Patentee

During the oral proceedings, the Patentee expressed the opinion that the technical solution defined in claim 1 is much simpler than the AIME system. According to the diagram depicted in fig. 2, all that is needed is to reset the values of the integrators X1-X4 to the values just before the corruption of the GPS signal. This is achieved by storing said values in a buffer for a period of normally less than 6 seconds. This procedure cannot be compared with the solution proposed in D10, which requires a complete recalculation of the Kalman filter states of the last 30 minutes. In particular, the Kalman filter recalculates the whole error vector, instead of replacing the filter states.

After consideration of the previous arguments, the opposition division takes the view, in line with statements made by the Opponent, that the limitations indicated by the Patentee cannot be derived from the language of claim 1. In particular, claim 1 does not contain any feature indicating the length of the “specified time period” of storage. In respect to the calculation of the values of bias and bias rate, claim 1 merely indicates that after resetting the filter states to the values at the earlier specified time period, the bias and bias rates of the inertial reference unit velocity signal are determined based on the reset filter states, without indicating any particular way of carrying out said determination. When looking at the embodiment described in par. [0016] of the published patent, the determination takes place by propagating the filter states forward in time by applying the filter information recorded over the last period (including any filter inputs if necessary). For the skilled person, the process of propagating the filter states is equivalent to the recalculation of the filter states carried out by the AIME filter, as explained in the previous section 2.3.3.

2.4 Claim 3 of the granted patent and auxiliary requests I and III. Claim 4 of auxiliary request II

Granted claim 3 of the main request and of the auxiliary requests I, III and claim 4 of auxiliary request II read as follows:

> The system according to claim 1 or 2, wherein said filter comprising a complementary filter including two integrators for inertial and global positioning signals respectively to avoid corruption of the inertial reference unit velocity signal as a result in the delayed detection of an anomalous differential global positioning system signal.

In the notice of opposition, the Opponent stated that the wording "two integrators for inertial and global positioning signals respectively", added during the examination procedure, indicates that one of the integrators processes only the inertial signal, whereas the other integrator processes the GPS signal. When looking at figure 2, the integrator X5 receives the data signals of the IRU accordingly, but the integrator X4 receives the result of a combination of the signals "GPS velocity" and "IRU velocity". After due consideration of the arguments of the Patentee during the oral proceedings, the opposition division concluded that the allocation of one of the two integrators of claim 1 exclusively to GPS signals resulted in a limitation not disclosed in the application as originally filed and offends the provisions of Article 123(2) EPC.

2.5 Claims 1 and 4 of the first auxiliary request

In addition to the features in claim 1 of the main request, claim 1 of the first auxiliary request includes the additional feature:

> f) propagation means for propagating forward in time the filter states corresponding to the values at the earlier specified time period.

Regarding the requirements of Article 123(2) EPC, the opposition division takes the view that feature (f) is supported by par. [0016] of the granted patent, which states that after the filter states being reset to the states from N seconds prior, said filter states "are propagated forward in time by applying the filter information recorded over the last N seconds". With respect to potential lack of clarity or added subject-matter introduced by the wording “at the earlier specified time period” in the new feature (f), reference is made to section 2.3.3 of the present decision, which concluded that the feature was allowable in view of the disclosure in par. [0012] - [0014] of the granted patent.

Regarding the potential inventive step provided by such forward propagation of the filter states, reference is made to the previous section 2.3.4, where the prior art closest to the subject-matter of claim 1 of the main request was discussed. The AIME system is capable to remedy the effect of incorrect GPS data in the past history of the filter by means of the procedure explained in the passage bridging pages 1601 and 1602. In short, once the GPS failure is detected, it is excluded by re-computing the least squares filter solution over the past 30 minute interval. This is made possible by saving the GPS averaged measurements and an additional past history Kalman filter in a 30 minutes buffer. This procedure is equivalent to propagating forward in time the filter states corresponding to the values at the earlier specified time period (in this cases, 30 minutes), as in feature (f) of claim 1 of the first auxiliary request.

For similar reasons, it considered that the corresponding feature "propagating forward in time the filter states corresponding to the values at the earlier specified time period", to be found in claim 4 of the first auxiliary request, is disclosed in the prior art documents describing the AIME system (D10, pages 1601 and 1602). In conclusion, the subject matter of claims 1 and 4 of the first auxiliary request does not involve an inventive step (Article 56 EPC) for the reasons presented in section 2.3.5 above.

2.6 Claims 1 and 4 of the second auxiliary request

In addition to the features in claim 1 of the main request, claim 1 of the second auxiliary request includes the additional feature:

> f) limiting means for limiting the difference between differential global positioning system position and velocity signals and inertial reference unit velocity signals.

Having considered the arguments of the parties during the oral proceedings, the opposition division arrives at the conclusion that the feature is unclear (Article 84 EPC). According to the wording of feature (f), the filter limits the difference between position and velocity signals from differential global positioning system and velocity signals from the inertial reference unit. It is not apparent how a limitation between signals representing position and velocity on one side and signals representing velocity on the other side can be implemented. Allegedly, the feature is supported by the text in par. [0021] of the granted patent. Said paragraph indicates that in order to minimize temporary misguidance during delayed error detection, two limiters are placed on "the difference between GLS and IRU position/velocity". If interpreted in connection with fig. 2, which depicts two limiters placed immediately after the respective coasting switches, said passage of the description appears to indicate that the filter includes a first limiter for limiting the difference between GLS and IRU velocities and a second limiter for limiting the difference between GLS and IRU

positions. The opposition division finds that these features have not been correctly defined by feature (f) of claim 1, leading to lack of clarity of the claim as a whole. The same applies to the corresponding feature (f) "limiting the difference between differential global positioning system position and velocity signals and inertial reference unit velocity signals" of claim 4.

2.7 Claims 1 and 4 of the third auxiliary request

Claims 1 and 4 of the auxiliary request III were amended to meet the requirement of Art. 84 EPC by means of two corrections carried out in line 24 and in line 25. Claim 3, which was regarded as offending Article 123(2) EPC (see section 2.4), was deleted. The resulting claims, renumbered as claim 1 and claim 3, were included, together with claims 2 and 5 of the auxiliary request III, in a new fourth auxiliary request.

Claim 1 of the fourth auxiliary request reads as follows (emphasis has been added to the features not present in claim 1 of the main request):

> An inertially augmented landing system comprising:
>
> a) a coasting filter receiving differential global positioning system positioning and velocity signals and receiving inertial reference unit velocity signals,
>
> b) said coasting filter identifying the bias and bias rate in the inertial reference unit velocity signals,
>
> b1) the coasting filter comprising a switch arranged to switch to pure inertial guidance mode upon an anomalous differential global positioning system signal being detected,
>
> characterized by:
>
> c) storing means storing coasting filter states for a specified time period and
>
> d) upon an anomalous differential global positioning system signal being detected the coasting filter states are reset to the coasting filter states corresponding to the values at the earlier specified time period
>
> e) to allow the bias and bias rate of the inertial reference unit velocity signals to be determined based on the reset coasting filter states.

In addition of providing velocity signals from the differential global positioning system as input to the filter (see section 2.3.5), the subject-matter of claim 1 of the fourth auxiliary request differs from the AIME system in that the filter comprises a switch arranged to switch to pure inertial guidance mode upon an anomalous differential global positioning system signal being detected. By reading the feature (b1) in connection with the feature (d), it is understood that the system of claim 1 takes the following actions upon an anomalous differential global positioning system signal being detected:

a) the switch is changed to pure inertial guidance mode

b) the filter states are reset to the filter states corresponding to the values at the earlier specified time period

According to this interpretation, the opposition division is of the opinion that the AIME system as disclosed in documents D10, D8 and D5 teaches away from the the subject-matter of claim 1 of the fourth auxiliary request. Upon an anomalous differential global positioning system signal being detected, the AIME system identifies and isolates the defective satellite, recalculates the filter states using the stored past filter history and continues operating by using input data from the remaining satellites. In contrast, the system of claim 1 switches to pure inertial guidance mode upon an anomalous differential global positioning system signal being detected and determines the bias and bias rate of the inertial reference unit velocity signals based on the reset filter states, in order to continue the navigation. Even admitting that the AIME system may obtain the bias and bias rate of the inertial reference unit internally in the Kalman filter, they are not used for a pure inertial navigation mode upon the detection of an anomalous differential global positioning system signal, as in claim 1. Therefore, the subject-matter of claim 1 of the fourth auxiliary request is regarded as new and involving an inventive step Article 54, 56 EPC.

Independent claim 3 of the fourth auxiliary request defines the corresponding steps of a method for correcting the corruption of an inertial guidance signal resulting from an anomalous differential global positioning system signal. The claim is considered new and inventive accordingly.

Consideration of the arguments of the Opponent

As indicated by the Opponent, AIME can also perform a pure inertial guidance mode (coasting) without GPS signals (D10, p. 1604, right column 2nd paragraph; D8 p. 685 text above fig. 2). The Opponent is of the opinion that when AIME switches to pure

IRS coasting mode, the filter states are reset and the bias and bias rate have been produced. This procedure would anticipate the new features of claims 1 and 3 of the fourth auxiliary request. In agreement with the arguments of the Patentee, the opposition division is of the opinion that D8 teaches away from the invention in that AIME stops to operate when switching to inertial mode. In particular, D8 (page 685, text above fig. 2) indicates clearly that the AIME system stops if the GPS signals are unavailable. Since no Kalman filter states will be recalculated, the IRS will coast without any valid or invalid GPS data. For this reason, AIME cannot reset, at this point in time, the Kalman filter states to filter states corresponding to the values at an earlier specified time period and use them for calculating the bias and bias rate at the time of switching. As a further difference, in the system according to claim 1, pure inertial guidance mode is entered every time an anomalous differential global positioning system signal is detected, whereas the AIME system excludes the defective satellite but continues operating with the signals of the safe satellites.

After deliberation of the opposition division,

- the chairman announced the following **decision**:

"Account being taken of the amendments made by the patent proprietor during the opposition proceedings, the patent and the invention to which it relates are found to meet the requirements of the European Patent Convention. The currently valid documents are those according to the forth auxiliary request."

Regarding the reasons for the decision, the chairman referred to:

Article 101(3)(a)EPC: Account being taken of the amendments made by the patent proprietor during the opposition proceedings, the patent and the invention to which it relates are found to meet the requirements of the European Patent Convention.Patent is maintained as amended.

The reason for the decision are provided in the decision

The chairman **closed the oral proceedings** on 24.03.2011 at 17:03 hours.

signed:

Mercier, Francois
. . . . . .
Chairman

signed:

Kern, Olivier
. . . . . .
Minute Writer

Enclosure(s):
Auxiliary request IV filed during oral proceedings
Form 2339.4

Documents for the maintenance of the patent as amended

Auxiliary request IV

In the text for the Contracting States:
DE FR GB

Description, Pages

2-3 of the patent specification

Claims, Numbers

1-4 of auxiliary request IV filed during oral proceedings on 24.03.2011

Drawings, Sheets

1/2, 2/2 of the patent specification

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Application No.: 02 079 013.5

Patent No.: EP-B-1 308 746

Minutes of the oral proceedings before the OPPOSITION DIVISION

The proceedings were public.

Proceedings opened on 24.03.2011 at 8:55 hours

Present as members of the opposition division:

Chairman:	Mercier, Francois
1st member:	Fanjul Caudevilla, J
2nd member:	Kern, Olivier
Minute writer:	Kern, Olivier

Present as or for the party or parties:

- For the Proprietor(s): The Boeing Company

  Land, Addick accompanied by de Baat, Michiel
- For the Opponent 1: Airbus SAS/AIRBUS FRANCE SAS/AIRBUS UK Limited/ AIRBUS DEUTSCHLAND GmbH/AIRBUS España S.L

  Le Tourneau, Augustin

The identity of the person/s (as well as, if applicable, that of the witness or witnesses) and, where necessary, the authorisation to represent/authority to act were checked.

Essentials of the discussion and possible relevant statements of the parties:

Submitted during oral proceedings March 24 2011

Auxiliary request ~~III~~ IV

Claims

1. An inertially augmented landing system comprising:

- a coasting filter receiving differential global positioning system position and velocity signals and receiving inertial reference unit velocity signals, said coasting filter identifying the bias and bias rate in the inertial reference unit velocity signals the coasting filter comprising a switch arranged to switch to pure inertial guidance mode upon an anomalous differential global positioning system signal being detected,

characterized by

- storing means storing coasting filter states for a specified time period and upon an anomalous differential global positioning system signal being detected, the coasting filter states ~~are~~ (x_1, x_2, x_3, x_4) reset to the coasting filter states corresponding to the values at the earlier specified time period to allow the bias and bias rate ~~in~~ of the inertial reference unit velocity signals to be determined based on the reset coasting filter states.

2. The system according to claim 1 wherein the specified time period is 6 seconds.

~~3. The system according to claim 1 or 2, wherein said filter comprises a complementary filter including two integrators for inertial and global positioning system~~

signals respectively to avoid corruption of the inertial reference unit velocity signal as a result of delayed detection of an anomalous differential global positioning system signal

3. A method for correcting the corruption of an inertial guidance signal resulting from an anomalous differential global positioning system signal, the method comprising receiving differential global positioning system positioning and velocity signals and an inertial reference unit velocity signal at a coasting filter to allow the coasting filter to identify the bias and bias rates in the inertial reference unit velocity signals, and switching to a pure inertial guidance mode upon detection of an anomalous differential global positioning system signal, characterized by

storing coasting filter states for a specified time period and upon an anomalous differential global positioning system signal being detected the coasting filter states are reset to the coasting filter states corresponding to the values at the earlier specified time period to allow the bias and bias rate of the inertial reference unit velocity signal to be determined based on the reset filter states.

4. The method of claim 3, wherein the specified time period is 6 seconds.

Resubmitted 24/3/2011

~~SKIPPING FILTER FOR INERTIALLY AUGMENTED LANDING SYSTEM~~

This invention relates to inertially augmented landing systems and more particularly methods and apparatus for overcoming delays in detection of GLS input signal errors essential to safe guidance in landing and rollout of an aircraft.

Since 1993, the industry has been working to develop automatic landing capability using differential GPS. This capability is known as the GNSS Landing System GLS). GLS developments to support CAT 1 operations are nearly complete. The industry is now working on standards and performance requirements for GLS to support CAT II/III operations. A key issue associated with GLS CAT II/III operations is the expected failure modes and effects of the GLS guidance system. It is anticipated that the most common failure mode for GLS will be a total loss of the signal for hundreds of seconds.

Key to this concept is the ability of the GLS groundstation to provide the aircraft systems with the information required to determine with certainty when the GLS guidance signals are unusable. The airborne multi-mode receiver (MMR) must respond rapidly to switch away from the faulty GLS signals to updated inertial guidance in order to prevent the inertial signals from becoming corrupted by the errors in the GLS signals. Unfortunately, the GLS groundstation cannot communicate the status of the guidance signals instantaneously, and therefore the likelihood of corruption exists.

WO 98/18016 describes a system for use with an inertial reference system and a global position receiver for calculating a position error after a loss of integrity by utilizing the global position system values for position and velocity at a time just before the loss of integrity.

1A →

U.S. Patent 6,178,363 B1 shows a GPS/Inertial filtering scheme to enable the airplane to continue to land and roll out after a total loss of GLS guidance below the alert height. U.S. Patent B1 US B1 6,178,363 discloses an inertially augmented landing system comprising a filter for receiving differential global positioning system, positioning and velocity signals and for receiving inertial reference unit velocity signals, said filter identifying the bias and bias rate in the inertial reference unit velocity signal.

The present invention has for its object to improve upon this known system, especially with respect to corrupted data, which may be a problem for the airplane landing performance.

→2

SUMMARY OF THE INVENTION

In accordance with an aspect of the present invention there is provided an inertially augmented landing system and a method according to the accompanying claims.

[0004] During a failure condition, it is possible for a differential GPS ground station to provide corrupted data for up to 3 seconds before raising an alarm. Furthermore, the airplane is allowed to continue to use the last data provided by the ground station for up to 3.5 seconds after the ground station stops transmitting data. Consequently, there could be a 3-6 second delay between GPS signal corruption and detection of the corruption by the airborne receiver. The present invention provides a means for correcting the integrated GPS/INS solution and protecting the airplane landing performance from any effects due to this potential for data corruption. A skipping filter in combination with a coasting filter shown in U.S. Patent 6,178,363B1 enables recovery from up to 6 seconds of corrupted GPS signal, thereby avoiding subsequent missguidance from the anomalous GPS signal.

BRIEF DESCRIPTION OF THE DRAWINGS

[0005] The foregoing aspects and many of the attendant advantages of this invention will become more readily appreciated as the same becomes better understood by reference to the following detailed description, when taken in conjunction with the accompanying drawings, wherein:

[0006] Fig.1 is a block diagram of a coasting filter as shown in U.S. Patent No. 6,178,363B1 issued January 23, 2001 to McIntyre et al. and assigned to The Boeing Company;

[0007] FIG.2 is a block diagram of a preferred embodiment of the present combination coasting filter and skipping filter;

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENT

Preferred Embodiment

[0008] Due to the requirements on the Ground Based Augmentation System (i.e., the differential GPS ground station supporting the GLS function) the detection of an anomalous GPS position or GPS velocity signal could require from 3 to 6 seconds. Consequently, the coasting filter is potentially exposed to up to 6 seconds of an error in progress before the guidance signal is flagged. Once the GPS anomaly is detected, the coasting filter switches to pure inertial guidance mode. However, due to this 3-6 second lag time to alarm, the landing guidance signal may be corrupted. It is necessary to find a means of avoiding guidance corruption due to the delay in GPS fault detection.

[0009] The solution to this problem is the hereinafter described signal skipping filter which separates the inertial guidance signal from the GPS guidance signal, and therefore avoids corruption caused by the delayed detection of the GLS signal loss.

[0010] The coasting filter of Fig. 1 is shown in U.S. Patent 6,178,363B1. The coasting filter of Fig. 1 receives GLS (differential GPS) position and velocity signals as shown. These high accuracy signals are used to identify the bias and bias-rate in the IRU (Inertial Reference Unit) velocity signal, shown. At the time of loss of GPS signal, the two switches go to open or "coast" position and the aircraft landing guidance is completed with IRU guidance alone. The IRU velocity and acceleration biases are estimated by integrator outputs x1 and x2. The IRU position offset is estimated by the output of integrator x3. The bias values for IRU velocity and acceleration are slowly varying quantities. They can be estimated with high accuracy (limited by the accuracy of GLS signals) during two or more minutes of landing approach. The IRU velocity and acceleration bias values are thus estimated for the subsequent coasting interval which can be up to one minute in duration.

[0011] Due to the time delay to alarm of the ground station, the coasting filter may be exposed to several seconds of corrupted GPS input before detection. In this case, after the switch to inertial mode, the complementary velocity and complementary position would have been corrupted and would therefore yield reduced accuracy

guidance. The skipping filter of Fig. 2 is directed to a solution for overcoming this problem.

[0012] The general concept of the present skipping filter is as follows: The states of the filters (along with any filter inputs if necessary;) are stored in a time buffer for 6 seconds. When the GLS guidance signal is lost and the switches are set to the "coast" position, the filter states are reset to the states from N seconds prior. Then the filter states are propagated forward in time by applying the filter information recorded over the last N seconds. In this manner, any corruption of the filter state due to GLS guidance failures in progress will be removed. The time period N depends on the exact conditions causing the coast mode to be entered.

[0013] A specific embodiment of the present skipping filter comprises a complementary filter. The skipping filter may be applied to any linear state space filter (including a Kalman Filter) implementation.

[0014] With the addition of two integrators it is possible to avoid corruption of the IRU guidance signal. Also, in order to avoid any unwanted effects of the anomalous 3-6 second GPS signal (either position or velocity), at the time coasting filter switches to inertial mode, the integrators x1, x2, x3, x4 are reset with stored values as follows: Assume the delayed signal detection interval is Δt seconds, and the values of the integrators just before the corrupted GLS signal are x1old, x2old, x3old and x4old. These old values of integrator outputs would be stored in MMR memory (up to 6 seconds). The current integrator values at the time of failure detection are x1now, x2now, x3now. When a GPS anomaly is detected the delay, Δt, will be estimated based on the failure mode. The velocity bias rate estimator x1 is replaced with the before-corruption value x1old. The velocity bias estimator x2 is replaced with the before-corruption value x2old + Δt x1old, and the "position-effect-of-velocity-bias" integrator x4 is replaced with the value x4old + Δt (x2old + Δt x 1old/2). The position bias estimator x3 is replaced with the before-corruption value x3old.

[0015] The IRU velocity/position information at integrator x5 is uncorrupted by the GLS signal fault and can be used without change.

[0016] It can thus be seen that the present skipping filter method allows the guidance error to recover immediately to its low pre-fault value with minor increase in filter complexity. This improvement in guidance accuracy is provided through utilization of two additional integrators and storage of a few values for integrators x1, x2 ~~and~~, x3, and x4.

[0017] In addition to recovering best estimates of IRU bias values when the coasting filter switches to coast mode, limiters are placed on the difference between GLS and IRU position/velocity to minimize temporary misguidance during delayed error detection. The error limiting is performed by the two limiters shown in Fig. 2. The error limit values will be chosen so that the required MMR guidance accuracy is achieved without interfering with normal mode filter operation.

[0018] The present skipping filter has been tested in simulations with the result that whereas a 6-second uncorrected delay in detecting GLS signal faults can increase final lateral position error on the runway from 23 ft rms to 42 ft rms, the hereinbefore described skipping filter allows the recovery of guidance accuracy to a 24 ft rms level.

[0019] The present improvement to the MMR (Multi-Mode Receiver) with GLS (differential GPS) will improve the availability of the aircraft landing system in the event of loss of GPS signal.

~~[0020] While the preferred embodiment of the invention has been illustrated and~~ described, it will be appreciated that various changes can be ~~made~~ therein without departing from the ~~spirit and~~ scope of the invention as defined by ~~the annexed claims~~.

CLAIMS

1. An inertially augmented landing system comprising:

- a filter receiving differential global positioning system positioning and velocity signals and receiving inertial reference unit velocity signals, said filter identifying the bias and bias rate in the inertial reference unit velocity signals; characterized by:

- storing means storing filter states for a specified time period and upon an anomalous differential global positioning system signal being detected the filter states are reset to the filter states corresponding to the values at the earlier specified time period to allow the bias and bias rate of the inertial reference unit velocity signals to be determined based on the reset filter states.

2. The system according to claim 1, wherein the specified time period is 6 seconds.

3. The system according to claim 1 or 2, wherein said filter comprises a complementary filter including two integrators to avoid corruption of the inertial reference unit velocity signal as a result in the delayed detection of an anomalous differential global positioning system signal.

4. A method for correcting the corruption of an inertial guidance signal resulting from an anomalous differential global positioning system signal, the method comprising receiving differential global positioning system positioning and velocity signals and an inertial reference unit velocity signal at a filter to allow the filter to identify the bias and bias rates in the inertial reference unit velocity signals characterized by storing filter states for a specified time period and upon an anomalous

differential global positioning system signal being detected the filter states are reset to the filter states corresponding to the values at the earlier specified time period to allow the bias and bias rate of the inertial reference unit velocity signal to be determined based on the reset filter states.

5. The method of claim 4, wherein the specified time period is 6 seconds.

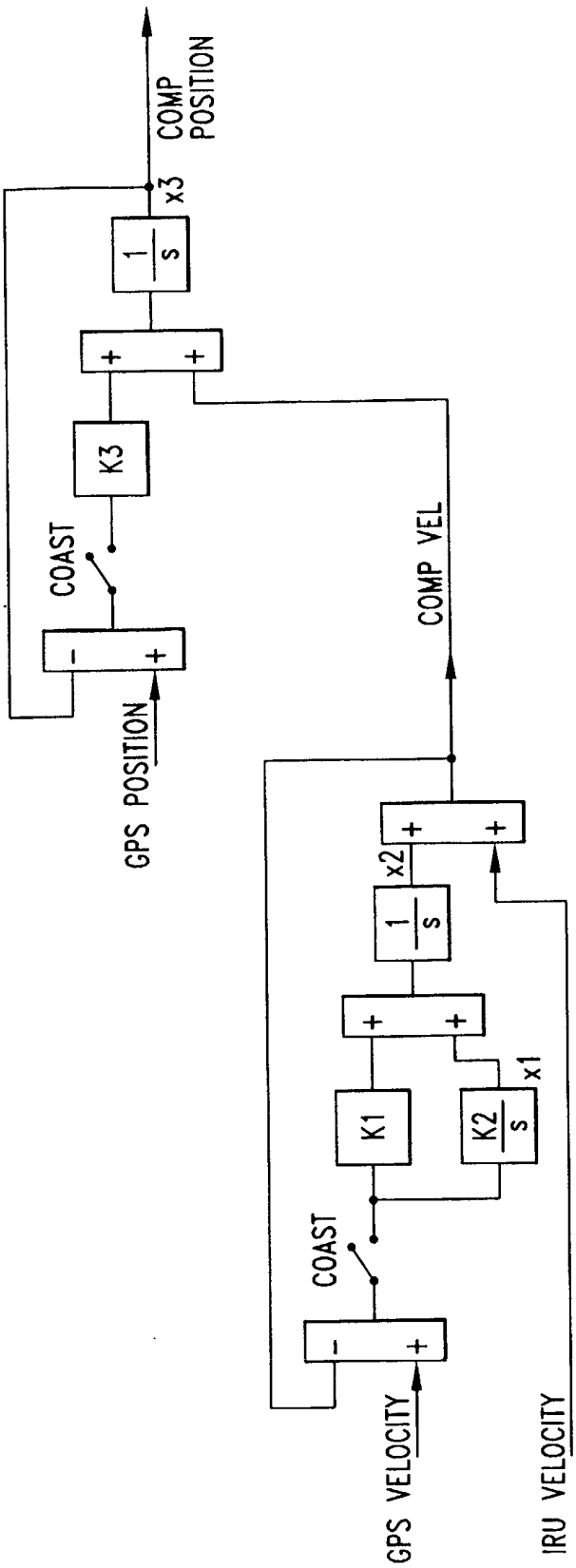

Fig. 1

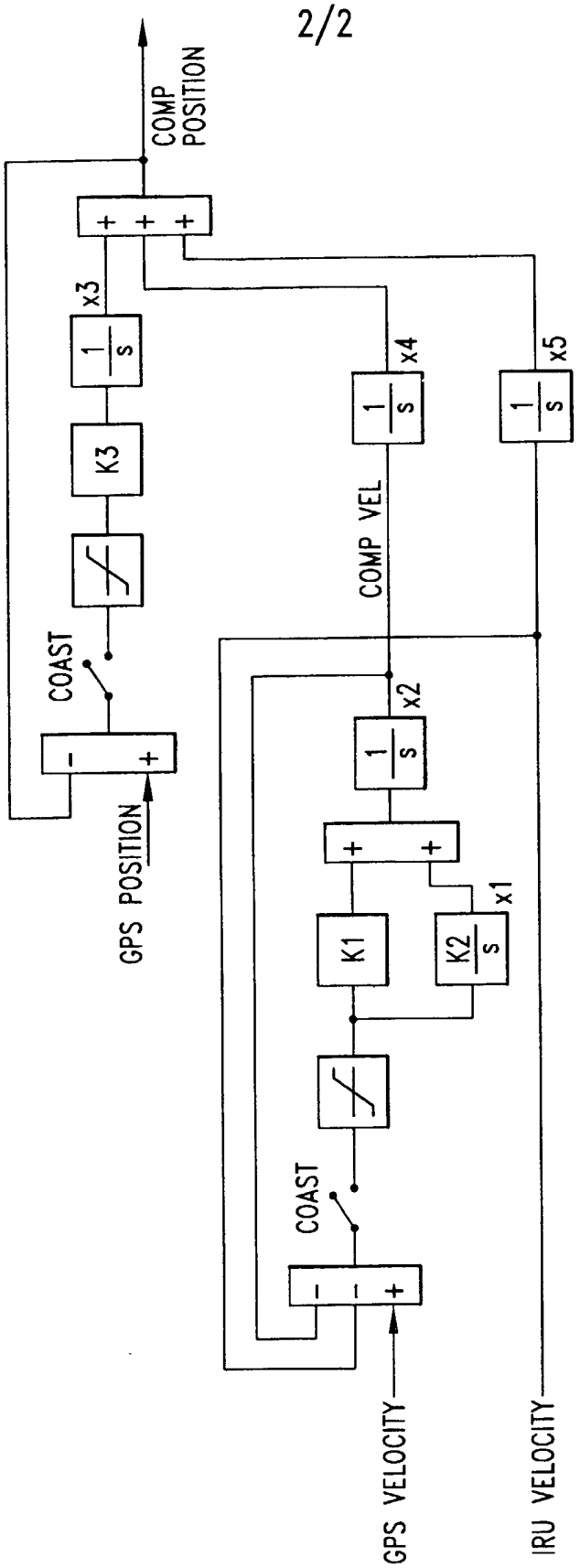
COMP POSITION
x3
1/s
K3
COAST
GPS POSITION
x4
1/s
COMP VEL
x5
1/s
x2
1/s
K1
K2/s
x1
COAST
GPS VELOCITY
IRU VELOCITY

Fig. 2