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Datasheet for the decision of 22 October 2019

Case Number: T 0692/15 - 3.5.03

Application Number: 07749681.8

Publication Number: 1989600

IPC: G05B19/4065, G05B23/02

Language of the proceedings: EN

Title of invention:
ACTUATOR FREEPLAY MONITOR

Patent Proprietor:
The Boeing Company

Opponents:
Airbus SAS
Airbus Opérations SAS
Airbus Operations Limited
Airbus Operations GmbH
Airbus Operations S.L.

Headword:
Actuator freeplay monitor/BOEING

Relevant legal provisions:
EPC Art. 52(1), 56, 100(b), 111(1)

Keyword:
Sufficiency of disclosure - main request (yes)
Inventive step starting out from E1 - main request (yes)
Remittal to the department of first instance - (yes)

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Case Number: T 0692/15 - 3.5.03

D E C I S I O N
of Technical Board of Appeal 3.5.03
of 22 October 2019

Appellant: (Patent Proprietor)	The Boeing Company 100 North Riverside Plaza Chicago, IL 60606-1596 (US)
Representative:	Boult Wade Tennant LLP 5th Floor, Salisbury Square House 8, Salisbury Square London EC4Y 8AP (GB)
Respondents: (Opponents)	Airbus SAS 1 Rond-Point Maurice Bellonte 31700 Blagnac (FR) Airbus Opérations SAS 316, route de Bayonne 31060 Toulouse (FR) Airbus Operations Limited New Filton House Filton, Bristol, BS99 7AR (GB) Airbus Operations GmbH Kreetslag 10 21129 Hamburg (DE) Airbus Operations S.L. Avenida de John Lennon S/N Madrid (ES)
Representative:	Santarelli 49, avenue des Champs-Elysées 75008 Paris (FR)
Decision under appeal:	**Decision of the Opposition Division of the European Patent Office posted on 12 February 2015 revoking European patent No. 1989600 pursuant to Article 101(3)(b) EPC.**

Composition of the Board:

Chairman	F. van der Voort
Members:	J. Eraso Helguera
	J. Geschwind

Summary of Facts and Submissions

I. An appeal was lodged by the proprietor (henceforth, "appellant") against the decision of the opposition division revoking European patent No. 1 989 600 on the ground that the subject-matter of claim 1 of each of a main and first to sixth auxiliary requests did not involve an inventive step (Articles 52(1) and 56 EPC).

II. The opposition was based on the grounds for opposition pursuant to Article 100(a) and (b) EPC.

III. In its decision, the opposition division referred *inter alia* to the following prior art documents:

E1: C. S. Byington, P. Stoelting: "A Model-Based Approach to Prognostics and Health Management for Flight Control Actuators", 2004, IEEE Aerospace Conference Proceedings

E2: I. Schaefer, A. Kayser: "Smart EMA: An approach to avoid unscheduled maintenance", AIAA 5th Aviation, Technology, Integration, and Operation Conference, 26-28 September 2005, Arlington, Virginia

E3: US 5 881 971 A

IV. Below, reference will also be made to:

E1*: C. S. Byington, P. Stoelting: "A Model-Based Approach to Prognostics and Health Management for Flight Control Actuators", Paper submitted to the 2004 IEEE Aerospace Conference, March 6-13, Big Sky, MT

which was filed by the respondents in preparation for the oral proceedings before the board.

V. In its statement of grounds of appeal, the appellant requested that the decision under appeal be set aside and that the patent be maintained as granted or, in the alternative, be maintained in amended form on the basis of the claims of one of first to sixth auxiliary requests filed with the statement of grounds of appeal.

VI. In its reply to the appeal, the joint opponents (henceforth "respondents") requested that the appeal be dismissed.

VII. Both parties conditionally requested oral proceedings.

VIII. In a communication accompanying a summons to attend oral proceedings, the board indicated *inter alia* its preliminary opinion that the invention as defined in the main request was disclosed in a manner sufficiently clear for it to be carried out by a skilled person and that subject-matter of claim 1 involved an inventive step in view of E1 and the common general knowledge.

IX. Oral proceedings were held on 22 October 2019.

The appellant requested that the decision under appeal be set aside and that the opposition be rejected (main request) or, in the alternative, that the patent be maintained in amended form on the basis of the claims of one the first to sixth auxiliary requests filed with the statement of grounds of appeal.

The respondents requested that the appeal be dismissed.

At the end of the oral proceedings, the chairman announced the board's decision.

X. Claim 1 of the patent as granted (**main request**) reads as follows:

"A method for monitoring freeplay within an actuator (14) that controls movement of a control surface of the mobile platform, said method **characterized by**:

generating at least:
an actuator drive motor position signal comprising a plurality of motor position data indicative of a drive motor position (46) during a predetermined data collection period as the drive motor is commanded to repeatedly drive an actuator output ram between an extending direction and a retracting direction;
a drive motor velocity signal (58) comprising a plurality of motor velocity data indicative of the drive motor velocity during the data collection period, and
and *[sic]* an actuator output ram position signal (50) comprising a plurality of ram position data indicative of the actuator output ram position during the data collection period;
collecting a plurality of actuator parameter data sets during the data collection period, each actuator parameter data set comprising a motor position data value, a motor velocity data value and a ram position data value;
selectively isolating various sets of the plurality of actuator parameter data sets that include a motor position data value within a motor position range, a motor velocity data value within a motor velocity range and a ram position data value within a ram position range; and
computing an amount of freeplay value within the actuator for the data collection period based on the isolated actuator parameter data sets."

XI. In view of the board's decision, it is not necessary to reproduce the claims of the auxiliary requests.

Reasons for the Decision

1. *Main request - sufficiency of disclosure*

1.1 The board considers that the invention as defined in the main request is disclosed in a manner sufficiently clear for it to be carried out by a skilled person.

1.2 In particular, the board concurs with the opposition division that the isolating step can be implemented by: 1) determining an acceptable range of values for each parameter, 2) checking whether the values in the data set fall within the established range and 3) discarding the data set if any of the values is not within the established range. Each of these tasks is well within the skills of a person skilled in the art, who can use known software and/or hardware means to implement them.

1.3 The respondents submitted that the description of the patent only gave vague and uncertain indications about the execution of the step of selectively isolating.

1.4 The board disagrees. For instance, the skilled person can determine a range defined by an upper and a lower value for each parameter following the recommended operational ranges given by the manufacturer of the actuator and/or specific operational conditions which are known to provide noisy data. Checking and discarding can be implemented by comparing collected values to determined lower and upper thresholds, for example.

1.5 The board therefore concludes that the ground for opposition pursuant to Article 100(b) EPC does not prejudice the maintenance of the patent as granted.

2. Admission of E1 into the appeal proceedings*

2.1 The respondents filed E1* because Figure 2 was better legible and was allegedly the same as Figure 2 of E1.

The appellant requested not to admit E1* into the appeal proceedings, because of its late filing and because the new version was allegedly not identical to the original submission (E1), which was the conference proceedings publication. The new version had a header which read "Paper submitted to the 2004 IEEE Aerospace Conference, March 6-13, 2004, Big Sky, MT", and therefore raised doubts both as to the identity of content of the documents and as to its date of availability to the public. The appellant further requested that, if admitted, it should be considered as a different document, the publication date of which had to be established.

2.2 The board considered that the admission of E1* would not raise issues in connection with Figure 2, which the board or the other party could not reasonably be expected to deal with without adjournment of the oral proceedings. Exercising its discretion pursuant to Article 13(1) and (3) RPBA, the board therefore admitted E1* as further evidence useful for interpreting Figure 2 of E1.

3. Main request - inventive step in view of E1 and common general knowledge

3.1 For the sake of argument, the board will hereinafter assume that Figure 2 of E1 and E1*, respectively, are identical.

3.2 E1 discloses a method for monitoring freeplay within an actuator (Figs 1 and 11 and Table 2) that controls movement of a control surface of the mobile platform, the method, using the language of claim 1, including the steps of:

generating at least:
an actuator drive motor position signal comprising a plurality of motor position data indicative of a drive motor position (Fig. 2: Motor Position signal output by the Motor box) during a predetermined data collection period as the drive motor is commanded to repeatedly drive an actuator output ram between an extending direction and a retracting direction;
a drive motor velocity signal (page 8, right-hand column, first paragraph: *control/response data (**motor velocity**, motor torque, actuator velocity and actuator position) was collected at 5000 Hz*) comprising a plurality of motor velocity data indicative of the drive motor velocity during the data collection period, and
an actuator output ram position signal (page 8, right-hand column, first paragraph: *control/response data (motor velocity, motor torque, actuator velocity and **actuator position**) was collected at 5000 Hz*) comprising a plurality of ram position data indicative of the actuator output ram position during the data collection period; and

collecting a plurality of actuator parameter data sets during the data collection period, each actuator parameter data set comprising a motor velocity data value and a ram position data value (page 8, right-hand column, first paragraph: *control/response data (**motor velocity**, motor torque, actuator velocity and actuator position) was collected at 5000 Hz*).

3.3 E1 is concerned with fault detection and failure prediction. As in the claimed method, E1 relies on the collection of control/response data provided by the actuator. In particular, motor velocity, motor torque, actuator velocity, and actuator position are used to determine a set of model parameters (frictional damping coefficient, local gear stiffness, torque constant and motor temperature) which constitute estimates of physical properties representing the health of the actuator (see E1, page 9, left-hand column, last paragraph, and right-hand column, first paragraph). The model is trained with test data obtained from simulated faults, including gear slipping, so that different fault regions can be identified in the feature space defined by the parameters, each point of a fault region indicating a fault severity between 0 (healthy) to 1 (failure), which quantifies the likelihood of such fault happening. In order to perform diagnostics, control/response data is fed into the model and corresponding model parameters are obtained. The proximity of these model parameter values to the known fault patterns is computed in order to determine the likelihood of each failure mode occurring and the remaining useful life related to each component (see E1, page 9, right-hand column, second paragraph).

3.4 The subject-matter of claim 1 of the main request differs from the method known from E1 in that:

1) in the collecting step, each actuator parameter data set further comprises a motor position data value;

and in that the method further comprises the steps of:

2) selectively isolating various sets of the plurality of actuator parameter data sets that include a motor position data value within a motor position range, a motor velocity data value within a motor velocity range and a ram position data value within a ram position range; and

3) computing an amount of freeplay value within the actuator for the data collection period based on the isolated actuator parameter data sets.

3.5 The technical effect achieved by the first and the third distinguishing features in combination is that on the basis of the claimed actuator parameter data sets, they enable an assessment of actual freeplay in the actuator.

3.6 The second distinguishing feature, i.e. selectively isolating various sets of the plurality of actuator parameter data sets according to ranges, contributes to smoothing or filtering out of noise from each of the parameter data, thereby facilitating the collection of relevant data during operation of the actuator in the presence of noise sources. However, in the analysis below, irrespective of whether or not this isolating step may contribute to an inventive step, the board will concentrate on the technical effect achieved by the first and third distinguishing features.

3.7 The objective technical problem with reference to the first and third distinguishing features when starting out from E1 may thus be defined as how to provide an assessment of freeplay in the actuator.

3.8 A straight-forward solution for the skilled person confronted with this problem when starting out from E1 would be to train the model with additional test data, so as to define additional fault regions associated with different levels of freeplay. In order to generate such test data, and account being given to the fact that "motor position" is only mentioned in the context of the MATLAB Simulink model in order to simulate the interaction between motor and gearbox (see E1, Fig. 2), the skilled person would be prompted to simulate freeplay by adding another fault block in the model so as to generate test data according to different simulated levels of freeplay. There is no hint or motivation that would lead the skilled person starting out from E1 to actually compute an actual amount of freeplay value within the actuator for the data collection period based on actuator parameter data sets, each actuator parameter data set comprising a motor position data value, a motor velocity data value and a ram position data value.

3.9 Neither E3, which was cited by the respondents in the written procedure only in connection with the isolating step, nor the common general knowledge can supplement the teaching of E1 so as to prompt the skilled person to include the above-mentioned features.

3.10 The respondents acknowledged one distinguishing feature in claim 1, namely the step of isolating data sets, i.e. the above-mentioned second distinguishing feature (see point 3.4). As regards the above-mentioned first and third distinguishing features, the respondents argued that E1 disclosed on page 2, left-hand column, penultimate paragraph, that the sensors used for the control scheme and system monitors were also used for actuator prognostics and health management, and that these sensors generated a motor index signal and an actuator position signal in order to determine the correlation between motor index and actuator position cited on page 8, right-hand column, last paragraph, first sentence, and/or other signals such as motor velocity, motor torque, actuator velocity and actuator position, as referred to on page 8, right-hand column, first paragraph, last sentence. Furthermore, E1 disclosed the claimed step of computing, with reference to the PHM algorithm, mentioned on page 2, left-hand column, penultimate paragraph.

3.11 The board is not convinced by these arguments. Firstly, there is no evidence in E1 that a "motor position" or "motor index" signal from the actuator is actually collected. The last paragraph on page 8, right-hand column merely explains that a decrease in correlation between motor index and actuator position ultimately leads to a hard over and a loss of control of the surface. However, in the fault simulation disclosed in E1, there is no actual computation of an amount of freeplay. Instead thereof, by issuing a command of zero at specified radial positions, the control architecture is able to generate fault-to-failure data runs which simulate the effect of a broken tooth, i.e. the appearance of a "dead zone" in each turn of the gear, which leads to loss of correlation until the hard over occurs. Although in the simulation model, as shown in Fig. 2, the motor block supplies motor position (together with motor velocity and motor torque) to the gearbox block, this cannot be equated to the collection of a motor position signal from the actuator, since the "motor position" may also be generated internally within the model strictly for simulation purposes. Besides, motor position is not listed as part of the collected control/response data in what is understood by the board as an exhaustive list (see E1, page 8, right-hand column, first paragraph).

3.12 Secondly, the board does not agree that the computation of fault severity made by the PHM algorithm as it appears in Table 2 of E1 can be considered as a computation of an amount of freeplay. The board concedes that the occurrence of "gear slip" can be considered as implying the existence of freeplay, at least each time the gear reaches the "dead zone" and fails to engage, and, in this broad sense, the method of E1 may be considered to "monitor freeplay". However, the computation of severity achieved with the model merely gives an indication of the probability of a fault from a limited set of fault categories happening, which cannot be considered as quantifying freeplay by computing an amount of freeplay based on the parameter data sets comprising motor position data, motor velocity data and actuator position data, as in the claimed method.

3.13 The respondents further argued that, even if the step of computing were considered not disclosed in E1, when starting out from this document, the skilled person would be well aware of the advantages of monitoring actual wear of the actuator at an early stage, even before gear slip actually happens and that, in order to do that, it would be customary practice to measure an actual amount of freeplay, as taught for example in E2 for the calculation of transmission accuracy.

3.14 The board is not convinced by this line of argumentation either. E1 is based on a model-based reasoner which applies physical modeling and parametric identification techniques, along with a prognostics fault detection and failure prediction algorithm, in order to predict the time-to-failure for each of the critical competitive failure modes within the system (see E1, page 11, right-hand column, first paragraph). The goal of E1 is not to compute actual values of physical parameters of the system. To the contrary, the model-based reasoner is non-intrusive and operates only on command/response data which is fed into the model in order to obtain estimates of physically meaningful system parameters which are believed to characterise the system well enough to provide good prognostics.

3.15 The board therefore concludes that the subject-matter of claim 1 of the main request was not obvious to the skilled person when starting out from document E1 and taking into account E3 and/or the common general knowledge.

4. *Further procedure*

4.1 The reasons given in the decision under appeal are only based on E1 as the starting point for the examination of inventive step. The board notes that, already during the first instance proceedings, the respondents submitted further arguments starting out from at least document E2, which have not been considered in the decision under appeal. Therefore, the board deems it appropriate to remit the case to the opposition division for further prosecution (Article 111(1) EPC).

Order

For these reasons it is decided that:

The decision under appeal is set aside.

The case is remitted to the opposition division for further prosecution.

The Registrar: The Chairman:

G. Rauh F. van der Voort

Decision electronically authenticated