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Datasheet for the decision of 5 November 2015

Case Number: T 2389/11 - 3.4.02

Application Number: 03018559.9

Publication Number: 1508776

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Language of the proceedings: EN

Title of invention:
Autonomous velocity estimation and navigation

Applicant:
SAAB AB

Headword:

Relevant legal provisions:
EPC 1973 Art. 83

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Sufficiency of disclosure - enabling disclosure (no)

Decisions cited:

Catchword:

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Case Number: T 2389/11 - 3.4.02

D E C I S I O N
of Technical Board of Appeal 3.4.02
of 5 November 2015

Appellant: (Applicant)	SAAB AB 581 88 Linköping (SE)
Representative:	Holmberg, Magnus Zacco Sweden AB Box 5581 114 85 Stockholm (SE)
Decision under appeal:	**Decision of the Examining Division of the European Patent Office posted on 29 June 2011 refusing European patent application No. 03018559.9 pursuant to Article 97(2) EPC.**

Composition of the Board:

Chairman	B. Müller
Members:	A. Hornung
	F. J. Narganes-Quijano

Summary of Facts and Submissions

I. The applicant (appellant) appealed against the decision of the examining division refusing European patent application No. 03018559.9 on the basis of Article 83 and 84 EPC.

II. In reply to a summons to oral proceedings, the appellant filed, with a letter dated 5 October 2015, new sets of claims amended according to a new main request and new first and second auxiliary requests. Upon filing the appeal and statement of grounds of appeal it had requested that the appealed decision be set aside and a patent be granted on the basis of the respective claims of those main requests that were then pending.

The appellant informed the board with a letter dated 3 November 2015 that it would not attend the oral proceedings. Oral proceedings were held on 5 November 2015 in the absence of the appellant. At the end of the oral proceedings the chairman announced the decision of the board.

III. Independent claim 1 according to the main request reads as follows:

"1. A spatial velocity meter (200) adapted to be mounted on a craft comprising:

an inertial measurement unit (210) adapted to register force parameters (f_x, f_y, f_z, a) and angular velocity parameters (ω) in three dimensions (x, y, z);

a direction-sensing module (220) which is adapted to register a natural reference signal (R), wherein the direction-sensing module (220) comprises a magnetic measurement unit which is adapted to register a field vector (B) of the terrestrial

magnetic field to represent the natural reference signal (R), and

a velocity processor (230) adapted to receive the force parameters (f_x, f_y, f_z, a), the angular velocity parameters (ω) and the field vector (B);

characterized in that

the velocity processor (230) is arranged to calculate a relationship between the force parameters (f_x, f_y, f_z, a) and the angular velocities parameters (ω) in respect of an axis (x) being parallel to a longitudinal body axis of the craft (110) based on an estimation procedure and to derive the velocity vector (v_x, v_y, v_z) in relation to the earth based on said relationship and based on the field vector (B), wherein

the estimation procedure is arranged to repeatedly calculate attitude transformation errors (dΦ, dθ), velocity data (v) and acceleration data $(\dot{v})$ from an equation system, wherein

$$\begin{bmatrix} f_x \\ f_y \\ f_z \end{bmatrix} + \begin{bmatrix} g \cdot c_{13} \\ g \cdot c_{23} \\ g \cdot c_{33} \end{bmatrix} = \begin{bmatrix} g \cdot c_{11} & -g \cdot c_{12} & 0 & 1 \\ g \cdot c_{21} & -g \cdot c_{22} & \omega_z & 0 \\ g \cdot c_{31} & -g \cdot c_{32} & -\omega_y & 0 \end{bmatrix} \cdot \begin{bmatrix} d\theta \\ d\phi \\ v \\ \dot{v} \end{bmatrix} \text{ where}$$

g is gravitation,
f_x, f_y and f_z represent the registered force parameters from the inertial measurement unit, ω_z and ω_y represent the angular velocity parameters (ω) from the inertial measurement

unit, c_{11}, c_{12}, c_{13}, c_{21}, c_{22}, c_{23}, c_{31}, c_{32}, c_{33} represent components of a body attitude transformation matrix c_n^b."

Independent claim 1 according to the first auxiliary request comprises, with respect to claim 1 of the main request, the additional feature:

"wherein the velocity processor comprises a plumb-bob module (231) adapted to receive the force parameters (f_x, f_y, f_z, a) and in response thereto produce a set of initial attitude parameters ($\{A_j\}$) and comprises an attitude updating module (232) adapted to receive the set of initial attitude parameters ($\{A_j\}$), receive the angular velocity parameter (ω) and based thereon produce a set of updated attitude parameters ($\{A\}$)."

Independent claim 1 according to the second auxiliary request comprises, with respect to claim 1 of the first auxiliary request, the additional feature specifying the relationship between ($\{A\}$) and c_n^b:

"a set of updated attitude parameters ($\{A\}$) representing the components c_{11}, c_{12}, c_{13}, c_{21}, c_{22}, c_{23}, c_{31}, c_{32}, c_{33} of the body attitude transformation matrix c_n^b."

Reasons for the Decision

1. Main request - Sufficiency of disclosure

The application does not disclose the subject-matter of claim 1 in a manner sufficiently clear and complete for it to be carried out by a person skilled in the art (Article 83 EPC 1973).

1.1 Centrifugal force

1.1.1 According to claim 1, the inertial measurement unit is adapted to register force parameters (f_x, f_y, f_z, a) and angular velocity parameters (ω). The velocity processor of claim 1 is arranged to calculate a relationship between the force parameters and the angular velocity parameters and to derive therefrom the velocity vector (v_x, v_y, v_z). Central to the calculation of the velocity vector is the mathematical expression of the specific force vector f_s^b on page 7, line 15 of the description and, derived therefrom, equation system (2) on page 8 of the description, incorporated in present claim 1. As already objected by the examining division in the decision under appeal, however, the mathematical expression of the specific force f_s^b, composed of the three terms $-g^b$, $(\dot{v})$ and ω^b x v^b, misses a term for the centrifugal force. Consequently, the mentioned mathematical expression and, therefore, also the resulting linearized equation system (2) on page 8 of the description, incorporated in present claim 1, are necessarily incomplete, with the result that an undue burden is placed on the skilled person wishing to carry out the invention.

1.1.2 In its statement setting out the grounds of appeal, the applicant contended that the effect of the centrifugal force was actually included in the expression of the specific force f_s^b. The third term of this expression represented Coriolis force due to body frame rotation with respect to inertial space, including earth rate and body rates with respect to the earth. The third term was the contribution to the total acceleration with respect to inertial space caused by a velocity vector defined in a coordinate system that was rotating with respect to inertial space. This rotation was composed of a first rotation of an earth referenced frame with respect to inertial space and of a second rotation of

the body frame of the craft with respect to the earth, the second rotation including the effect of the centrifugal force.

The appellant's argument is not found convincing by the board because the third term of the mathematical expression of the specific force f_s^b, i.e. ω^b x v^b, represents the Coriolis force which depends linearly on the velocity v^b and is independent of position, whereas the centrifugal force does not depend on the velocity v^b but on the position vector.

In response to the annex to the summons to oral proceedings, the applicant provided no additional argument in support of its contention that the effect of the centrifugal force is included in the equation system as originally filed.

1.2 Derivation of the velocity vector

1.2.1 According to claim 1, a velocity vector (v_x, v_y, v_z) is derived *inter alia* from the equation system (2) mentioned on page 8 of the description and recited in claim 1. This equation system (2) forms a system of three equations with four unknown parameters dθ, dΦ, v and $(\dot{v})$. According to the description, page 9, lines 14 to 18, the four unknown parameters "are calculated repeatedly by means of an estimation function, which may be implemented as a Kalman filter". The description, page 9, line 26 to page 11, line 14, further refers to figures 2 to 5 to explain how the spatial velocity is calculated. However, these figures merely show general block diagrams and general flow diagrams without technical details as to how parameters are sensed and how the calculation based on the sensed parameters is actually carried out.

While Kalman filtering is generally known in the art, the application documents as originally filed do not disclose any

concrete details about how the Kalman filtering is applied to the case at stake so as to provide a satisfactory estimation of the four unknown parameters (e.g. generation or estimation of a first or initial value of the parameter to be determined, criteria for carrying out the iterative or adaptive estimation process, etc.).

Moreover, even if the four parameters were determined at a certain point in time at which assumingly $v_y = v_z = 0$, it is not clear from the original application documents how the three components of the velocity vector v can be determined at any other point in time, as required by claim 1.

1.2.2 The appellant agrees that the set of three equations cannot be solved uniquely for four unknowns. However, in its view, this is not a problem. The equations related to a dynamic system with observable parameters and the skilled person was familiar with numerous ways of estimating the unknown parameters in such an equation system, such as using adaptive Kalman filtering. The appellant refers to related information available at the internet sites of wikipedia.org and mathworks.se.

The board acknowledges that mathematical techniques for finding solutions to an underdetermined system of equations are known in the art. However, these methods merely provide some solutions among all possible mathematical solutions - generally an infinite number - and not all possible solutions constitute a realistic or technically meaningful solution to the underlying physical problem. In any case, the different methods generally provide different, non-equivalent "best" or "unique" solutions. The application as originally filed does not provide sufficiently clear and complete guidance on how to implement these mathematical methods to the equation system of claim 1, in particular, how to obtain and select

the initial values of the unknown parameters and how to concretely update them.

1.2.3 Concerning the determination of the three components of the velocity vector, the appellant explains that the spatial velocity meter is mounted on crafts maneuvering in a manner such that it is realistic to assume that the main velocity component is aligned with the body axis and that, therefore, the determination of the velocity when the main velocity component is not aligned with the body axis is not the subject of the present disclosure.

The board cannot follow this argument because the application is silent about any specific manner of mounting the velocity meter on any crafts maneuvering in a specific manner. Claim 1 is also not so limited since the claimed velocity processor is adapted to derive a general velocity vector (v_x, v_y, v_z).

1.2.4 In response to the summons to oral proceedings, the appellant, in its letter dated 5 October 2015, provided some new information about how and under which circumstances the plumb-bob module mentioned on page 10 of the description, lines 17 to 27, contributes to produce the set of initial and updated attitude parameters. Some new information was also provided about how and under which circumstances (e.g. the craft can at occasion be assumed to travel at a constant velocity) the equation system of claim 1 could be solved in a satisfactory manner.

Irrespective of the technical merits of this additional information, the board is of the opinion that this information is neither implicitly nor explicitly disclosed in the application as originally filed, nor can it be assumed that it belonged to the common general knowledge of the person skilled in the art at the relevant date of the application. The board notes that the appellant did not

provide any evidence that it belonged to the common general knowledge.

1.3 It follows that the claimed subject-matter is not disclosed in a manner sufficiently clear and complete contrary to the requirement of Article 83 EPC 1973.

2. First and second auxiliary requests

2.1 Claim 1 of the first auxiliary request clarifies that a plumb-bob module produces a set of initial attitude parameters ($\{A_j\}$) and that an attitude updating module produces a set of updated attitude parameters ($\{A\}$).

Claim 1 of the second auxiliary request further clarifies that the set of updated attitude parameters ($\{A\}$) represents the components of the body attitude transformation matrix.

However, these amendments are insufficient to overcome the objections raised with regard to claim 1 of the main request and relating to the question of how the claimed spatial velocity meter takes into account the centrifugal force and how it effectively derives the velocity vector.

Indeed, there is no apparent link between the two modules of the spatial velocity meter and the centrifugal force. Since these two modules are defined in general functional terms only, without disclosing any concrete technical features, it is also not apparent which enabling information they provide about how to derive the velocity vector. In addition, as already noted by the board in the annex to the summons to oral proceedings, in the absence of appropriate evidence the board cannot accept that the implementation of the features of the plumb-bob and the attitude-updating modules now required by the claims of the first and the second auxiliary requests was common general knowledge at the relevant date of

the application. Finally, the added feature of claim 1 of the second auxiliary request does not seem to limit at all the scope of the claim since it merely states that the components of the body attitude transformation matrix are updated.

The appellant furthermore relied on the arguments it provided in favour of the sufficiency of disclosure of the main request.

2.2 Therefore, for the reasons given in points 1. and 2.1 above, the invention defined in claim 1 of the first and the second auxiliary requests is not sufficiently disclosed (Article 83 EPC 1973).

Order

For these reasons it is decided that:

The appeal is dismissed.

The Registrar: The Chairman:

M. Kiehl B. Müller

Decision electronically authenticated