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| 62/408,265 | 14 October 2016 (14.10.2016)  | US |
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| 62/408,264 | 14 October 2016 (14.10.2016)  | US |
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(81) **Designated States** (unless otherwise indicated, for every kind of national protection available): AE, AG, AL, AM, AO, AT, AU, AZ, BA, BB, BG, BH, BN, BR, BW, BY, BZ, CA, CH, CL, CN, CO, CR, CU, CZ, DE, DJ, DK, DM, DO, DZ, EC, EE, EG, ES, FI, GB, GD, GE, GH, GM, GT, HN, HR, HU, ID, IL, IN, IR, IS, JO, JP, KE, KG, KH, KN, KP, KR, KW, KZ, LA, LC, LK, LR, LS, LU, LY, MA, MD, ME, MG, MK, MN, MW, MX, MY, MZ, NA, NG, NI, NO, NZ, OM, PA, PE, PG, PH, PL, PT, QA, RO, RS, RU, RW, SA, SC, SD, SE, SG, SK, SL, SM, ST, SV, SY, TH, TJ, TM, TN, TR, TT, TZ, UA, UG, US, UZ, VC, VN, ZA, ZM, ZW.

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(54) **Title:** SYSTEMS AND METHODS TO DETERMINE A LOCATION OF A MOBILE DEVICE

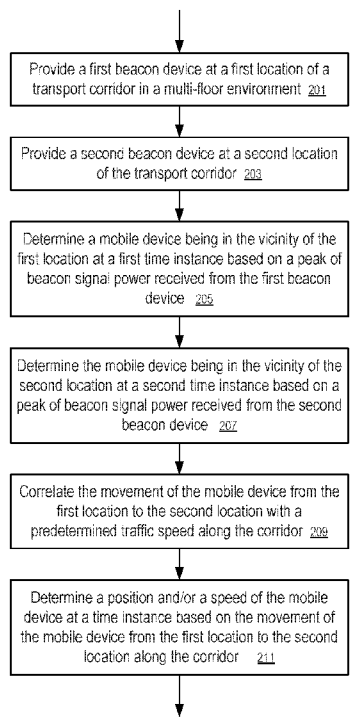


FIG. 3

(57) **Abstract:** Systems and methods to determine a location of a mobile device by combining a radio frequency navigation system and an inertial navigation system, where the radio frequency navigation system determines a location of the mobile device in reference to a map of radio frequency signals and the inertial navigation system based on dead reckoning the position of the mobile device based on measurements from motion sensors and/or magnetic field sensors. The mobile device combines the position determination results from the radio frequency navigation system and the inertial navigation system to determine two successive locations. A heading of the user of the mobile device is computed from the two successive locations without using the orientation of the mobile device.



**Published:**

- *with international search report (Art. 21(3))*
- *before the expiration of the time limit for amending the claims and to be republished in the event of receipt of amendments (Rule 48.2(h))*

**(88) Date of publication of the international search report:**

31 May 2018 (31.05.2018)

# INTERNATIONAL SEARCH REPORT

International application No.  
PCT/US2017/056535

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

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

1.  Claims Nos.:  
because they relate to subject matter not required to be searched by this Authority, namely:
  
2.  Claims Nos.:  
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:
  
3.  Claims Nos.:  
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

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

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

see additional sheet

1.  As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
  
2.  As all searchable claims could be searched without effort justifying an additional fees, this Authority did not invite payment of additional fees.
  
3.  As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:
  
4.  No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:  
  
1-10, 30

### Remark on Protest

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

**INTERNATIONAL SEARCH REPORT**

International application No  
PCT/US2017/056535

**A. CLASSIFICATION OF SUBJECT MATTER**  
 INV. H04W64/00  
 ADD. G01S5/02

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

**B. FIELDS SEARCHED**

Minimum documentation searched (classification system followed by classification symbols)  
 H04W G01S

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

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)  
 EPO-Internal, WPI Data

**C. DOCUMENTS CONSIDERED TO BE RELEVANT**

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|-----------|--|-----------------------|
| X         | US 2014/308976 A1 (GARIN LIONEL JACQUES [US] ET AL) 16 October 2014 (2014-10-16)   | 30                    |
| Y         | paragraphs [0002] - [0013], [0101], [0111], [0116], [119123] - [0124]              | 1-10                  |
| Y         | US 2007/247366 A1 (SMITH DEREK M [US] ET AL) 25 October 2007 (2007-10-25)          | 1-6                   |
| Y         | paragraphs [0003] - [0014], [0044], [0109], [0160] - [0170], [0187] - [0192]       | 1,7-10                |
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|           | paragraphs [0014] - [0021]   |                       |

Further documents are listed in the continuation of Box C.

See patent family annex.

\* Special categories of cited documents :

- "A" document defining the general state of the art which is not considered to be of particular relevance
- "E" earlier application or patent but published on or after the international filing date
- "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)
- "O" document referring to an oral disclosure, use, exhibition or other means
- "P" document published prior to the international filing date but later than the priority date claimed

- "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
- "X" document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
- "Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
- "&" document member of the same patent family

Date of the actual completion of the international search

27 February 2018

Date of mailing of the international search report

02/05/2018

Name and mailing address of the ISA/

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Authorized officer

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# INTERNATIONAL SEARCH REPORT

Information on patent family members

International application No

PCT/US2017/056535

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**FURTHER INFORMATION CONTINUED FROM PCT/ISA/ 210**

This International Searching Authority found multiple (groups of) inventions in this international application, as follows:

1. claims: 1-10, 30

Location of a mobile terminal using a combination of RF Map and Inertial methods

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2. claims: 11-19

A mobile device with means to implement a method to determine a heading based on successive location determinations

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3. claims: 20-27

Initialisation of an inertial location system using initial location determined by RF Map based method

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4. claims: 28, 29, 31-36

Determination of pattern(s) in a series of RF MAP based locations.

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5. claims: 37-40

Determination of location using inertial method and discarding of successive measurements

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