

The field of the invention is that of the displaying on a map background of objects identified in any way on the Earth's surface. A system such as described in the preamble of Claim 1 is known in the prior art, for example, through the document EP-A-0 242 050.

More precisely, the invention aims to make it possible to position, on a pre-existing set of map backgrounds, objects situated at any point on the Earth's surface. This positioning operation, according to the invention, is destined to be automated. Automation can thus be implemented in data processing machines allowing not only the locating of the object on the appropriate map background, but also processing operations related to the position of the object, for example measurements of distances or the like.

Preferably, but not limitingly, this displaying is carried out on a substantially flat surface, such as that of a cathode-ray screen.

The planar and cartesian representation of the Earth's surface is made difficult owing to the "sphericity" of the Earth. A mathematical study, carried out by Mercator in the 16th century, solves the problem in essence.

The representation principle developed by Mercator (UTM: Universal Transverse Mercator) consists in performing a projection of the Earth's surface onto a cylinder tangent to the equator. This representation is considered to exhibit acceptable distortion up to a latitude of plus or minus approximately 80°.

The cylindrical projection of the Earth's surface is broken down into 60 identical time-zones, 6° in longitude, their index numbers increasing from 1 to 60 on moving eastwards. A time-zone 10 is sketched in Figure 1. A squaring 11, making it possible to define terrestrial areas 12, 13 of smaller dimensions, which can themselves be broken down more finely into sub-areas, is carried out inside each time-zone.

Each time-zone 10 includes its own reference

system in cartesian coordinates (x, y). Conventionally, the central meridian 14 serves as ordinate axis y, and the equator 15 is used as abscissa axis.

5 The abscissa axis 15 is graduated such that the centre point of the time-zone 16 lies at an arbitrary value of 500 km: the abscissae decrease westwards, and increase eastwards, preserving values which are always positive in each time-zone.

10 The ordinate axis 14 is graduated such that the values of y increase in the Northern hemisphere from the value 0 km at the equator 15, and decrease in the Southern hemisphere from the value 10,000 km also at the equator. The ordinates x are therefore also always positive in each time-zone.

15 Such a type of planar representation and of squaring of the Earth's surface is homogeneous inside each zone. On the other hand, a problem of break in numbering and in squaring is clearly encountered whenever there is a change of time-zone. This difficulty is illustrated in Figure 2.

20 Figure 2 represents the UTM squaring of Europe, and more particularly of the portion included between 6°W and 24°E in longitude, and 40°N to 56°N in latitude. The squaring is performed with squares 21 of side 100 km, identified with the reference letters of the GEOREF world geographical standard. Squaring rotation can be identified with each crossing from one time-zone to another, in the form of the latitude-dependent variable-aperture angles 22.

30 The rotation of the squaring from one time-zone to another singularly complicates the task of the cartographer when he wishes to measure for example the distance separating two geographical points 23, 24 belonging to different time-zones, each of the points 23, 24 being identified in its particular time-zone.

35 Hitherto, the method employed consists in expressing one of the points 24 in the cartesian reference system of the other point 23, by performing a coordinate conversion. Conversion matrices corresponding to each of

the specific cases liable to occur have thus been constructed in order to make this method easier to employ.

It is nevertheless conceded that the systematization of such a method, especially in the case in which it is desired to be able to deal automatically and simultaneously with points belonging not only to two adjacent zones but also points scattered anywhere on the surface of the globe, demands considerable storage capacities which are relatively unwieldy to manage.

The management of this method is moreover made additionally unwieldy when it is desired to produce compatibility on the one hand with other systems of representation, such as those used in regard to sea areas (expressions in nautical miles), or on the other hand with radiation measurements (the locating of a point in polar coordinates: bearings, distances and elevations).

Finally, in order to produce a truly universal display system, it is also paramount to be able to manage simultaneously points belonging to distinct spheroids. The determination of several terrestrial spheroids onto which to map the Mercator cylindrical projection results from the irregular shape of the Earth's surface and from the date at which the studies were conducted. Figure 3 sketches symbolically the areas of relevance of the five main spheroids. These spheroids are those of Clarke 1866 (31), Clarke 1880 (32), Everest (33), Bessel (34), and the international spheroid (35). Each of the spheroids associated with a terrestrial area is such that the distortion resulting from application of the UTM system does not exceed 4 per thousand.

The multiplicity of parameters to be taken into account in the production of a universal display system therefore makes the existing methods unsuitable for operational automation.

The purpose of the invention is to remedy this unsuitability.

More precisely, a first purpose of the invention is to provide a fully universal map display system which can be installed on an automated machine, allowing the

locating on a determined and appropriate map background of any point identified in any manner, on the Earth's surface.

5 A further purpose of the invention is to provide such a universal display system which is compatible with all the functions and all the processing operations required by military mapping, especially the graphical representation of a deployment of units superimposed on a map background.

10 Another purpose of the invention is to provide such a system allowing display of objects superimposed on a map background according to the principle of Mercator cylindrical projection, whilst exhibiting configurable parameters such as in particular the time-zone width, the
15 numbering conventions for the reference system of each time-zone, or else the terrestrial spheroids used.

The purpose of the invention is also to allow the positioning and display of a given object on map back-
grounds produced according to different referencing
20 systems.

These purposes as well as others which will emerge below are achieved with the aid of a universal map display system, of the type intended to allow in particular the depiction of an object identified in any manner
25 on the Earth's surface, on a corresponding map background, the said depiction being carried out for example on a cathode-ray screen, the said system including means for storing a map background, and characterized in that it includes:

- 30 • means for assigning a universal identifier to each of the said identified objects;
• means for initializing the display of the said points superimposed on an appropriate map background;
• means for converting the said universal identifier of
35 each of the said points into the characteristic cartesian coordinates of the said appropriate depiction map background.

Advantageously, the said means for storing the said map backgrounds are organized in such a way as to

reference each map background by a unique identification, spheroid, hemisphere, a base point in cartesian coordinates, and a representation scale.

According to the invention, the said means for
5 assigning a universal identifier to each of the said identified points are preferably organized in such a way as to associate with each identified point on the one hand an identifier in geographical coordinates and on the other hand an identifier in UTM cartesian coordinates,
10 with hemisphere and spheroid information.

According to a characteristic of the invention, the system includes a first chain for converting the objects and/or the map backgrounds initially identified into UTM coordinates, in such a way as to associate with
15 them the universal identifier of the invention and a second chain for converting the objects identified initially into geographical coordinates, in such a way as to associate with them also the universal identifier of the invention.

20 Each of the said conversion chains comprises a module for testing the consistency of the initial coordinates of the object and of the map background respectively.

Advantageously, the said means for controlling
25 the display of the said points comprise means for the selection of an appropriate map background and of an appropriate UTM cartesian reference representation system.

Moreover, the said means for converting the
30 universal identifier of each object into the cartesian coordinates of the depiction map background preferably comprise:

- means for converting the universal identifier into the said cartesian coordinates of the map background;
- 35 • means for calculating the references of the said object in the conventional squaring of the said map background;
- means for calculating the coordinates of the said object in the display screen.

Advantageously, the said means for converting the

said universal identifier of each point into cartesian coordinates for displaying the appropriate map background comprise means for testing the consistency of the coordinates of the object with the map background.

5 Other characteristics and advantages of the invention will emerge on reading the following description given by way of non-limiting illustration, of a particular embodiment of the invention, and the appended drawings in which:

10 . Figure 1 sketches the conformation and parameterization of a UTM time-zone according to the Mercator system;

 . Figure 2 represents the configuration of the squaring of the European continent in the UTM system;

15 . Figure 3 illustrates the approximate terrestrial areas corresponding to the five main spheroids mentioned;

 . Figure 4 is a block diagram illustrating the main functional modules of a universal map display system according to the invention;

20 . Figures 5, 6 and 7 are flowcharts detailing the processing chains corresponding to the conversion of geographical coordinates into UTM cartesian coordinates, such as implemented in the map display system of the invention.

25 . Figure 8 represents the flowchart of a subroutine for calculating radiation compatible with the map display system of the invention.

 Figure 4 illustrates the main functional modules of a universal map display system according to the invention.

30 The system represented is composed of input circuits 41 comprising two parallel conversion chains 42, 43, of means 44 for storing the universal identifier of the map backgrounds and of the objects to be displayed, of the means 45 for controlling depiction, and a chain 46 for depiction proper on a screen 47.

35 According to the invention, the memory 44 stores the map backgrounds, referencing each of them with a specific identification, as well as a base point in cartesian coordinates and a scale. This referencing system makes it possible on the one hand to position each

object to be displayed with respect to the base point, and on the other hand to display the map background in accordance with any desired scale.

5 It may moreover be advantageous to store the base point of each map background according to the universal identifier used for the objects to be displayed, so as to allow representation of the same map background on several reference systems. In this case, all the points of the map background have also to be able to be
10 converted.

According to an essential characteristic of the invention, all the objects to be displayed are stored together with a universal identifier. The universal identifier consists of the concatenation on the one hand
15 of an identifier in geographical coordinates, and on the other hand of an identifier in UTM cartesian coordinates of the object (or of a base point of the object).

Storage of the geographical coordinates of the object ensures the universality of its identifier, and especially the independence of the identifier with
20 respect to the spheroid used, and to the projection time-zone.

Storage of the cartesian coordinates is added so as to allow immediate graphical representation on the
25 conventional pencil drawn up on the basis of the conventional spheroid corresponding to the geographical locating of the object. The representation of the object according to these conventional coordinates is in fact statistically the most probable.

30 Nevertheless, in all cases in which the object shall have to be displayed on a screen background referenced according to a system other than the conventional system, for example according to the coordinates of an adjacent time-zone, or even an adjacent spheroid, a
35 conversion will be performed from the geographical coordinates stored for the said object.

Finally, each object stored in the memory 44 also includes a hemisphere information item (Northern hemisphere or Southern hemisphere) as well as an identifier

of the spheroid corresponding to the UTM cartesian coordinates.

It will be noted that the universal identifier thus defined by the concatenation of geographical
5 coordinates and of cartesian coordinates together with hemisphere and spheroid information, constitutes a redundant identifying system. This redundant system is designed to be optimal from the point of view of the three combined criteria of universality, speed of display
10 and security.

The storage means 44 are supplied from two conversion chains 42, 43.

The conversion chain 42 carries out formation of the universal identifying information for the objects 48
15 entered as UTM coordinates, as well as for each map background 49 generally expressed in the UTM cartesian coordinates of the time-zone to which it belongs.

A first module 81 of the conversion chain 42 plays the role of tester of consistency of the
20 coordinates 48, 49 introduced. In the event of inconsistency, for example following an input error, the tester module 81 activates an interrupt and alert module 82.

After confirmation of consistency in the tester module 81, the data 48, 49 are introduced into the
25 converter module 83 which then calculates the universal geographical coordinates of the object and/or of the map background introduced, and concatenates the geographical coordinates with the UTM coordinates in order to construct the universal identifying information stored in
30 the storage means 44.

The conversion chain 43 exhibits an architecture symmetrical with the chain 42 which has just been described.

The input data 84 consist of the geographical
35 coordinates of objects to be displayed. These geographical coordinates are tested firstly in a module 85 testing the consistency of the coordinates introduced. In the event of inconsistency, the interrupt and alert module 82 is activated.

After confirmation of consistency by the tester module 85, the data are introduced into the conversion module 86 for calculating the UTM cartesian coordinates corresponding to the geographical coordinates 84 introduced and for concatenating the UTM coordinates with the geographical coordinates in order to form the universal identifying information stored in the storage means 44.

The depiction control module 45 initializes and pilots the operation of the depiction chain 46 through the storage means 44.

The control module 45 selects, manually or automatically, the map background to be displayed, and the reference cartesian coordinates of the map background. It also activates the depiction circuits 46 for the positioning and display of the objects identified and stored in the storage means 44, on the corresponding map background.

The depiction chain 46 comprises three consecutive modules 87, 88, 89 which, at the end of the chain, provide a signal displayable on the screen 47.

The module 87 is a module for converting the universal identifying information for the object stored in memory 34 [sic] into the UTM cartesian references of the map background displayed. The conversion module 87 includes consistency testing means which enable an interrupt and alert module 90 to be activated in the event of inaptness of the map background in respect of the object undergoing processing.

In the event of aptness, the conversion module provides a second conversion module 88 with the calculated cartesian coordinates. This second conversion module 88 has the function of positioning the object in the coordinates specific to the time-zone to which it belongs.

Finally, the information obtained at the output of the second conversion module 88 is transmitted to a module 89 for calculating the positioning of the object undergoing processing on the depiction screen, as a function of the scale of representation selected.

The scale of representation is advantageously determined by the control module 45, either automatically as a function of the set of objects which it is desired to see displayed simultaneously, or manually.

5 The detail of the processing chains 42, 43 of the input circuits 41 will now be presented.

 It will be noted that the geographical/UTM conversion module 86, which will be presented first, of the processing chain 43 corresponds in substance to the
10 conversion module 88 of the depiction chain.

 The following notational conventions will be adopted hereafter:

Wid: width of the time-zone in degrees

Znw: time-zone west of Greenwich

15 Zne: time-zone east of Greenwich

EO: central abscissa of the time-zone (500 000)

NN: ordinate of the equator in the Northern hemisphere
(0)

NS: ordinate of the equator in the Southern hemisphere
20 (10 000 000).

 The tester module 85 checks the input data:

if we put:

. latitude: deglat/minlat/seclat/Hem (variables representing respectively the degree, minute, second and nature
25 of the hemisphere of the object considered).

. longitude: deglong/minlong/seclong/Hem (variables representing respectively the degree, minute, second and nature of the hemisphere of the object considered)

we must have:

30 $0 \leq \text{deglat} \leq 80$

$0 \leq \text{minlat} \leq 59$

$0 \leq \text{seclat} \leq 59$

Hem = "N" or Hem = "S" (Northern or Southern hemisphere)

$0 \leq \text{deglong} \leq 180$

35 $0 \leq \text{minlong} \leq 59$

$0 \leq \text{seclong} \leq 59$

Semg = "W" or Semg = "E" (western or eastern geographical semi-globe)

latsec = ((Deglat* 3600)+(Minlat* 60)+(Seclat)) $\leq$ 288 000

$\text{longsec} = ((\text{Deglong} * 3600) + (\text{Minlong} * 60) + (\text{Seclong})) \leq 648\ 000.$

In the event that one of these conditions is not satisfied, the interrupt and alert module 82 is activated.

5 The conversion operation proper, implemented in the module 86, or in the module 88, amounts firstly to searching for the time-zone to which the object undergoing processing belongs. Naturally, the corresponding projection spheroid has been determined beforehand.

10 Determination of the appropriate time-zone amounts to searching for the time-zone number (area number zn) whose centre 16 (Fig. 1) lies less than half a time-zone width longitudinally from the base point of the object undergoing processing.

15 An example implementational flowchart is represented in Figure 5.

Step 50 converts the longitude of the point undergoing processing into degrees. Step 51 calculates the half-value (cent) of a pencil width (wid) which will
20 be used later for the interactive incrementation of the coordinates of the centre of each pencil.

Step 52 introduces the initialization 53, 54 of the time-zone numbers (zn), and of the increment/decrement dz of the time-zone number used in the
25 iterative procedure 55. Steering towards one or other of the initialization modules 53, 54 is performed by the module 52 by determining whether the point undergoing processing lies in the western or eastern geographical semi-globe (semg), respectively.

30 The iterative module 55 consists in incrementing the pencil number (56) and the corresponding abscissa of the centre of the pencil (57) so long as the current time-zone centre does not lie less than half a time-zone width longitudinally from the point undergoing processing
35 (58).

When the time-zone number zn is determined, the abscissa and the ordinate of the object undergoing processing are calculated in the ordinates of the time-zone.

The chain of instructions for calculating the cartesian coordinates is advantageously as follows (the names of variables used have no particular significance, and correspond merely to intermediate variables):

```

5  Centsec = (cent * 3600)
   . P = Abs(longsec - centsec)* (10-4)
   . JO = latsec*Pi/3600/180
   . Aa = Sin (JO)
   . Bb = Cos (JO)
10  . Cc = Tan (JO)
   . Dd = Sin(Pi/180/3600) : sine 1 second

   . V = Aa * Bb
   . U = (Bb2)
   . J2 = JO + V
15  . J4 = ((3*J2) + (2*U*V))/4
   . J6 = ((5*J4) + (2*V*(U2)))/3
   . J8 = ((7*J6) + (4*V*(U3)))/8
   RO = ((A*(1 - (Ee2))/(1 - (Ee2)*(Aa2)))(3/2))
   NU = RO * (1 + ((Ep2) * (Bb2)))
20  Q1 = KO * C * (JO - (Alpha * J2) + (Béta * J4) -
      (Gamma * J6) + (Delta * J8)
   Q2 = (NU*Aa*Bb*(Dd2)* KO * (108))/2
   Q3 = ((Dd4) * NU * Aa * (Bb3) * (5 - (Cc2) +
      (9 * (Ep2) * (Bb2)))
25  Q4 = NU x Bb * Dd * KO * (104)
   Q5 = (Dd3) * NU * (Bb3) * (1 - (Cc2) + ((Ep2) *
      (Bb2))) * KO * (1012)/6

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These intermediate variables make it possible to calculate the abscissa difference De of the relevant point with respect to the central meridian of the time-zone:

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30  De = (P * Q4) + ((P3) * Q5)
   and the ordinate difference Dn with respect to the
   equator:
35  Dn = (Q1 + (Q2 * (P2)) + (Q3 * (P4)))

```

The flowcharts of Figures 6 and 7 show the logic for calculating the absolute abscissae and absolute ordinates respectively, of the point undergoing processing, from the abscissa difference De and ordinate

difference D_n calculated above.

The modules 61, 62 and 63 (semi-globe of membership, and semi-time-zone of membership) enable a negative sign (64) to be assigned or not to the abscissa difference D_e . The abscissa difference D_e thus endowed with a sign is next added to the central abscissa of the time-zone E_0 , in the module 65, to obtain the absolute abscissa E of the point undergoing processing.

This flowchart makes it possible to solve the problem of the growth of the longitude with respect to the central meridian of the time-zone, which is manifested either by a reduction in the abscissa with respect to E_0 when travelling westwards ($semg = W$), or by an increase in this abscissa with respect to E_0 when travelling eastwards ($semg = E$).

The flowchart of Figure 7 makes it possible to calculate the absolute ordinate n of the point undergoing processing, from the ordinate difference dn with respect to the ordinate of the equator. The module 71 carries out this function by taking account of the hemisphere hem of membership of the current point (73).

The module 72 checks whether the ordinate n thus calculated oversteps the boundaries of the relevant hemisphere; this would be manifested by an inconsistency in the value of the ordinate owing to the conventions adopted. This test operation is performed on the integer value of the absolute ordinate n , effected beforehand in the module 74.

The processing chain 42 calculates the UTM cartesian coordinates of the objects and/or of the map backgrounds introduced in geographical coordinates. Means for carrying out this function are presented below.

The notational conventions are the same as those employed hitherto.

In order to resolve the ambiguities regarding the working hemisphere, the operator should, during initialization thereof, specify a priori whether he will be working:

. in the Northern hemisphere $Hemb = "N"$

- . in the Southern hemisphere Hemb = "S"
- . straddling the equator Hemb = "B"

The tester module 81 checks the input data:

5 Consider the initial cartesian coordinates: area
number/abscissa/ordinate.

The area number zn must satisfy:

$$(ZNW + 1) - (180/wid) \leq ZN \leq (ZNE - 1) + (180/wid)$$

The abscissa (Eastg) must satisfy:

$$EO - geoutm(0, wid/2) \leq EO + geoutm(0, wid/2)$$

10 (This is a first-order check. When the latitude
is calculated, a second-order check should be performed.

The ordinate (Northg) must satisfy, as
appropriate:

- . if Hemb = "N":
15 Northg $\geq$ NN then Hem = Hemb
- . if Hemb = "S", we must have:
 Northg $\leq$ NS then Hem = Hemb
- . if Hemb = "B" then:
 - if Northg $\leq$ NN + $\frac{1}{2}$ (NS - NN) Hem = "N"
20 - if Northg $<$ NS - $\frac{1}{2}$ (NS - NN) Hem = "S"

In the event that one of these conditions is not
satisfied, there is a calculation abort with error
diagnostic (module 82).

25 Actual calculation of the geographical
coordinates includes the following steps:

Calculation of the longitude of the central
meridian of the time-zone:

- . if ZN $\leq$ ZNW ZNb = ZNW Demg = "W"
- . if ZN $\geq$ ZNE ZNb = ZNE Demg = "E"
- 30 long cendeg = ((|ZN - ZNb| * wid) + wid/2)
- long censec = long cendeg * 3600

Calculate the ordinate differential

- . if Hem = "N" then Delta Y = Northg - NN
- . if Hem = "S" then Delta Y = NS - Northg

35 Calculate the latitude:

this calculation proceeds via inversion of the function:

$$Q1 : \Delta Y = f(lat)$$

It is recommended to proceed via a recurrent
method which is particularly well suited to the operation

of computers and which gives sufficient accuracy within reasonable time periods (from 3 to 5 passes).

Invert Q1:

```

Q = 0, P = 0
5 YY = Delta Y
  Start:
    Phi p = YY/C/KO
    Aa = SIN (Phi p)
    Bb = COS (Phi p)
10 Cc = TAN (Phi p)
    V = Aa * Bb
    J2 = Phi p + V
    J4 = ((3 * J2) + (2 * V * U))/4
    J6 = ((5 * J4) + (2 * V * (U2)))/3
15 J8 = ((7 * J6) + (4 * V * (U3)))/8
    Q1 = KO*C*(Phi p - (Alpha*J2) + (Beta*J4) - (Gamma*J6) +
      (Delta*J8))
    If | Delta Y - Q1 | > 0,005
      then YY = YY + Delta Y - Q1, goto start:
20 else FIN.

```

Actual calculation:

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Q = |(eastg - EO) * (10-6)|
YY = Delta Y
  Start:
25 Phi p = YY/C/KO
    Aa = SIN (Phi p)
    Bb = COS (Phi p)
    Cc = TAN (Phi p)
    RO = ((A * (1 - (Ee2))/(1 - ((Ee2) * (Aa2)))(3/2)))
30 Nu = RO * (1 + ((Ep2) * (Bb2)))
    Q7 = (Cc * (1 + ((Ep2) * (Bb2))) * (1012))/(2*(Nu2)
      * Dd * (KO2))
    Q8 = (Cc * (5 * (3 * (Cc2)) + (6 * (Ep2) * (Bb2))
      - (6 * (Ep2) * (Aa2)) - (3 * (Ep4) * (Bb4))
35 - (9 * (Ep4) * (Aa2) * (Bb2))) * (1024))/
      (24 * (Nu4) * Dd * (KO4))
    Q9 = (106)/(Bb * Nu * Dd * KO)
    Q10 = (1 + (2 * (Cc2)) + ((Ep2) * (Bb2))) * (1018)/6
      /(Nu3) / Dd / (KO3) / Bb

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Delta long = ((Q9 * Q) - (Q10 * (Q3)))
P = |Delta long * (10-4)|
Phi = (Phi p * 180/Pi * 3600) - (Q7 * (Q2)) + (Q8 *
      (Q4))
5  JO = Phi * Pi/180/3600
   V = SIN(JO) * COS(JO)
   U = (COS (JO)2)
   J2 = JO + V
   J4 = ((3 * J2) + (2 * V * U))/4
10  J6 = ((5 * J4) + (2 * V * (U2)))/3
   J8 = ((7 * J6) + (4 * V * (U3)))/8
   Aaa = SIN (JO)
   Bbb = COS (JO)
   Ccc = TAN (JO)
15  RO = ((A * (1 - (Ee2))/(1 - ((Ee2) * (Aaa2)))(3/2)))
   Nu = RO * (1 + ((Ep2) * (Bbb2)))
   Q1 = KO * C * (JO - (Alpha * J2) + (Beta * J4) -
      (Gamma * J6) + (Delta * J8))
20  Q2 = (Nu * Aaa * Bbb * (Db2) * KO * (108))/2
   Q3 = ((Dd4) * Nu * Aaa * (Bbb3) * (5 - (Ccc2) +
      (9 * (Ep2) * (Bbb2)) + 4 * (Ep4) * (Bbb4))) *
      KO * (1016))/24
25  Dn = Q1 = (Q2 * (P2)) + Q3 * (P0-4)

If | Delta Y - Dn| ≥ 0,0005
then: YY = YY - Delta Y - Dn      goto start
30 else: **
      If |Deltalong|>10 800 eastings error (second-
order check).
deglat = INT (Phi/3600)
minlat = INT ((Phi - deglat * 3600)/60)
35 seclat = INT (Phi-(deglat * 3600) - (minlat * 60)+0,5)
. If seclat ≥ 60 then seclat = (seclat - 60)
  and minlat = (minlat + 1)
. If minlat ≥ 60 then (minlat - 60)
  and deglat = deglat + 1)

```

. If Demg = "W" and E ≥ E0
then Delta long = - Delta long
seclong = longcensec + Delta long
deglong = INT (seclong - (deglong * 3600))/60
5 seclong = INT (seclong - (deglong * 3600)
- (minlong * 60) + 0,5)
. If seclong ≥ 60 then seclong = (seclong - 60) and
minlong = (Minlong + 1)
. If minlong ≥ 60 then minlong = (minlong - 60) and
10 deglong = (deglong + 1)
The result is therefore;
deglat/minlat/seclat/hem, on the one hand (geographical
latitude) and
deglong/minlong/seclong/Demg, on the other hand
15 (geographical longitude).

Before displaying the object on the map back-
ground, it is necessary to determine whether the object
actually belongs to the map background such as repre-
sented. This is advantageously carried out by ascertain-
20 ing whether the base point of the object lies inside the
screen with respect to the base point of the map back-
ground. In other words, if Delta X and Delta Y represent
the abscissa and ordinate distances of the object from
the base point of the map background, and e the on-screen
25 map background display scale, the two expressions
e*Delta X and e*Delta Y must be less than or equal to the
maximum size of the graphic.

The values Delta X and Delta Y can advantageously
be calculated on the basis of two subroutines:
30 . a subroutine for calculating polar coordinates,
enabling the base point of the object to be expressed in
polar coordinates with respect to the base point of the
map background, starting from the cartesian coordinates
of the two points;
35 . a subroutine for calculating radiation, enabling the
cartesian coordinates of a point to be obtained knowing
the cartesian coordinates of another point, the pole (for
example the base point of the map background), and the
polar coordinates of the point sighted from the pole.

These subroutines may serve, more generally, to perform processing operations between displayed points (calculation of distances, depiction of points of impact of ballistic objects, etc.).

5 As will be seen below, these routines embrace steps for checking the location of the object, which is generally identified with respect to the base point of the map background. This checking pertains to the nature of the hemisphere to which it belongs, its membership or
10 not of the UTM latitudinal boundaries, as well as its time-zone of membership.

Figure 8 is a flowchart illustrating the subroutine for calculating radiation.

This subroutine amounts in substance to executing
15 the function:

(ZN, Esatg [sic], Northg, Alt) = TRA ((Zn, Eastg, Northg, Alt), (Brg, Dist, A/S))

where:

Brg = Bearing

20 Dist = Distance

A/S = Angle of Site (elevation)

The other variables correspond to notations already explained.

The module 101 for checking the input values
25 carries out the following operations:

Check of the area number, ZN:

$(ZNW + 1) - (180/\text{width}) \leq ZN \leq (ZNE - 1) + (180/\text{wid})$

Check of the ordinate, Northg:

30 . if Hemb = "N" we must have Northg $\geq$ NN
 . if Hemb = "S" we must have Northg $\leq$ NS
 . if Hemb = "B" we must have NS $\geq$ Northg $\geq$ NN

Check of the altitude, Alt:

- 500 < + Alt < + 9000

Check of the bearing, Brg:

35 0 $\leq$ Brg $\leq$ 6400

Check of the elevation, A/S:

- 1599 $\leq$ A/S $\leq$ 1599

The step 012 for calculating the differential coordinates includes:

. Calculation of the topographical distance, TD:

$TD = Dist * \cos((A/S) * \pi/3200)$

(the elevation is converted into radians).

. Abscissa differential: Delta X

5 $\Delta X = TD * \sin(-(BRG - 1600) * \pi/3200)$

(The bearing is converted into a trigonometric angle expressed in radians.)

. Ordinate differential, Delta Y:

$\Delta Y = TD * \cos(-(BRG - 1600) * \pi/3200)$

10 The bearing is converted into a trigonometric angle expressed in radians.

. Altitude differential, Delta Z:

$\Delta A = Dist * \sin((A/S) * \pi/3200)$

The elevation is expressed in radians.

15 Step 103 for calculating the absolute coordinates is performed simply by addition to the cartesian coordinates of the pole:

$ZZ = ZN$

$XX = Eastg + \Delta X$

20 $YY = Northg + \Delta Y$

$AA = Alt + \Delta A$

The step for checking the coordinates which is [sic] obtained includes three phases 104, 105, 106.

. Phase 104: check of the hemisphere

25 If hemb = "N" and $YY < NN$

then $YY = NS - (NN - YY)$

If hemb = "S" and $YY > NS$

then $YY = NN + (YY - NS)$

If hemb = "B" and $YY > NS$

30 error

or $YY < NN$

. Phase 105: UTM boundaries

To check whether the point is not outside the UTM boundaries, namely 80°N and 80°S in latitude, it is necessary
35 to calculate its latitude with the UTM/geographical conversion routine.

. Phase 106: time-zone of membership

To check whether the point is not in the neighbouring time-zone, the same UTM/geographical conversion

calculation provides Delta long (longitude differential).
In the case of time-zones with 6° of longitude, if
|Delta long| ≤ 3°, the point is in the same time-zone as
the reference base point. Otherwise, having obtained the
5 geographical coordinates of the point, the cartesian
coordinates of the resulting point should next be calculated
in the correct time-zone, by means of a
geographical/UTM conversion routine detailed earlier.

The sub-routine for calculating polar coordinates
10 can be expressed in the form of the function RTP:
(Brg, Dist, A/S) = rtp ((ZN1, Eastg1, Northg1, Alt1),
(ZN2, Eastg2, Northg2, Alt2))

It advantageously comprises a step of checking
the values at input. The check of the area numbers ZN1,
15 ZN2 of each of the points must satisfy:
(ZnW + 1) - (180/wid) < ZN1 < (ZnE - 1) + (180/wid) and
(ZnW + 1) - (180/wid) ≤ ZN2 ≤ (ZnE - 1) + (180/wid) and
ZN1 = ZN2 or |ZN2 - ZN1| = 1

or ZN1 = (ZnW + 1) - (180/wid)
20 and ZN2 = (ZnE - 1) + (180/wid)
or ZN2 = (ZnW + 1) - (180/wid)
and ZN1 = (ZnE - 1) + 180/wid

In other words, the two points must be in the
same time-zone or in two neighbouring time-zones (taking
25 into account the break in numbering at the Greenwich
antipodes).

Checking of the ordinates and altitudes is
performed in the same way as for the subroutine for
calculating radiation.

30 Calculation of the polar coordinates requires,
firstly, the expressing of the two points in a single
time-zone, that of the pole, and then the performing of
the inverse calculation of the radiation.

. If ZN1 = ZN2, not applicable

35 . Else:

the UTM/geographical conversion routine makes it possible
to obtain the geographical coordinates of the point 2.

. If |ZN1 - ZN2| = 1

then if ZN2 > ZN1 the geographical/UTM conversion routine

is applied, setting (cent) to (cent + wid).

. If $ZN2 < ZN1$ the geographical/UTM conversion routine is applied, setting (cent) to (cent - wid).

. If $ZN2 = (ZNW + 1) - (180/wid) \rightarrow ZN2 > ZN1$

5 . If $ZN2 = (ZNE - 1) + (180/wid) \rightarrow ZN2 < ZN1$

At the end of the calculation, we have the coordinates of the points, expressed in the time-zone $ZN1$.

$ZN1 / Eastg1 / Northg1 / Alt 1$

10 $ZN1 / XX / YY / Alt2$

It will be noted that if $ZN1 = ZN2$: $XX = Eastg2$ and $YY = Northg2$ it is then possible to calculate the topo distance, TD:

$$TD = ((XX - Eastg1)^2 + (YY - Northg1)^2)^{1/2}$$

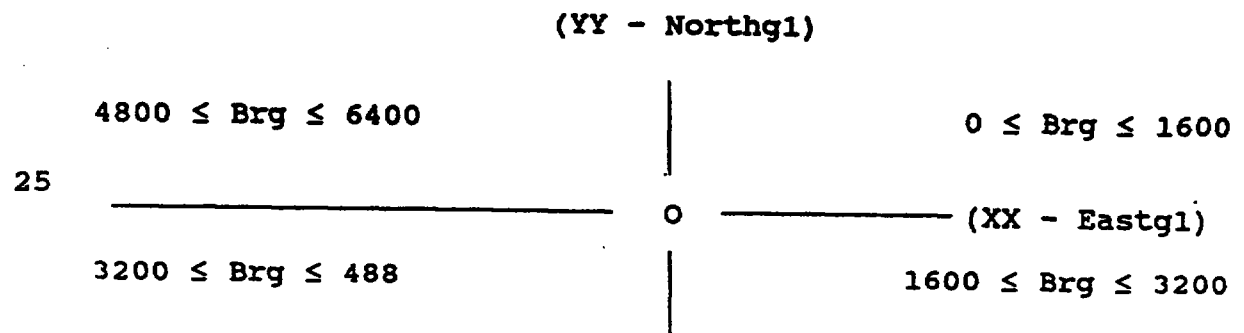
15 . If $TD = 0$ then $Brg = 0$ Dist = 0 A/S = 0, the two points coincide.

Calculation of the bearing, Brg, is achieved via:

$$Brg = 3200/Pi * Asin ((XX - Eastg1)/DT)$$

Brg satisfies the double inequality $0 \leq Brg \leq 6400$

20 the final values correspond to the following quadrants:



30 The elevation is expressed as:

$$A/S = Atan((AA - Alt1)/TD) * 3200/Pi$$



CLAIMS

1. Universal map display system, of the type intended to allow in particular the depiction of an object identified in any manner on the Earth's surface,
5 on a corresponding map background, the said depiction being carried out for example on a cathode-ray screen, the said system including means (44) for storing map backgrounds, and characterized in that it includes:
 - means (42, 43) for assigning a UTM universal identifier
10 to each of the said identified objects;
 - means (45) for initializing the display of the said points superimposed on an appropriate map background;
 - means (46) for converting the said UTM universal
15 identifier of each of the said points into the characteristic cartesian coordinates of the said appropriate depiction map background.
2. System according to Claim 1, characterized in that the said means (44) for storing the said map backgrounds are organized in such a way as to reference each
20 map background by a unique identification, spheroid, hemisphere, a base point in cartesian coordinates, and a representation scale.
3. System according to Claim 1, characterized in that the said means (42, 43) for assigning a universal
25 identifier to each of the said identified points are organized in such a way as to associate with each identified point on the one hand an identifier in geographical coordinates and on the other hand an identifier in UTM cartesian coordinates, with hemisphere and spheroid
30 information.
4. System according to one of Claims 1 to 3, characterized in that the map background storage means (44) also comprise sectors for storing the said identified points furnished with their universal identifier.
35
5. System according to Claim 3, characterized in that it includes a chain (42) for converting the objects (48) and/or the map backgrounds (49) initially identified into UTM coordinates, in such a way as to associate the



said universal identifier with them.

6. System according to Claim 3, characterized in that it includes a chain (43) for converting the objects (84) identified initially into geographical coordinates, in such a way as to associate with them the said universal identifier.

7. System according to Claim 5 or 6, characterized in that the said conversion chain (42, 43) comprises a module (81, 85) for testing the consistency of the initial coordinates of the object (48, 84), and of the map background (49) respectively.

8. System according to Claim 1, characterized in that the said means (45) for controlling the display of the said points comprise means for the selection of an appropriate map background and of an appropriate UTM cartesian reference representation system.

9. System according to Claim 1, characterized in that the means for converting the universal identifier of each object into the cartesian coordinates of the depiction map background comprise:

- means (87) for converting the universal identifier into the said cartesian coordinates of the map background;
- means (88) for calculating the references of the said object in the conventional squaring of the said map background;
- means (89) for calculating the coordinates of the said object in the display screen.

10. System according to Claim 9, characterized in that the said means (87) for converting the said universal identifier of each point into cartesian coordinates for displaying the appropriate map background comprise means for testing the consistency of the coordinates of the object with the map background.

11. System according to Claim 1, characterized in that it comprises means for checking an object's membership of the said depicted map background, the said checking means including means for identifying the hemisphere and/or the spheroid and/or the time-zone of membership of each of the two points.



12. System according to Claim 11, characterized in that the said checking means co-operate with means for calculating the cartesian coordinates of each of the said points in its time-zone of membership, from the said
5 universal identifier assigned to the said point.