# DIGEST Support Document


# Part 1 — Geodesy Background Notes

DIGEST Support Document is module-based, and is designed to provide additional information to users of DIGEST Edition 2.1 where required.

Part 1 is produced and issued under the direction of Defence Geographic and Imagery Intelligence Agency (DGIA), UK, on behalf of the Digital Geographic Information Working Group.

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# 1 Geodesy Background Notes



## 1.1 Scope

For Editions 2.0 onwards, DIGEST has used Part 3 Clause 6 to provide geodetic codes and parameters. The DGIWG DIGEST Working Party has updated and expanded the tables given in previous editions. These notes make available some of the background information compiled during the restructuring and subsequent maintenance of that Clause.

Ellipsoids, datums, projections and grids included in these notes are listed in alphabetic order of name (rather than code). Entries are marked with asterisks in the following cases:

A single asterisk (*) indicates “added to DIGEST for Edition 2.1”.

A double asterisk (**) indicates “replaced or corrected an existing entry in DIGEST for Edition 2.1”.

A triple asterisk (***) indicates “removed from DIGEST for Edition 2.1”.

## 1.2 References

Lists produced by US National Imagery and Mapping Agency (NIMA) lists are normative in the sense that DGIWG decided at an early stage to be as consistent as possible with codes used by NIMA sources. Codes used by UK Defence Geographic and Imagery Intelligence Agency (DGIA) are broadly consistent with NIMA codes, so DGIA lists have sometimes been used as an additional source of codes.

The following sources of geodetic information have been used in the maintenance of DIGEST’s Geodetic Clause since DIGEST 1.2.

CGI, France, Tables of Ellipsoids & Datums.

EPSG Geodetic Database, which is updated twice per year. The WWW site http://www.epsg.org can be used to access the database.

UK DGIA’s lists of Ellipsoids, Datums, Projections & Grids.

US NIMA Technical Report 8350.2 (originally DMA Technical Report 8350.2)

"Department of Defense World Geodetic System 1984" (Third Edition dated 4 July 1997).

US NIMA's lists of Ellipsoids, Datums, Projections & Grids.

Snyder, John P: "Map Projections - A Working Manual" (US Geological Survey Professional Paper 1395, 1987).

S-57, also known as "IHO Transfer Standard for Digital Hydrographic Data, Special Publication 57" (published by International Hydrographic Bureau) (Edition 3 dated November 1996).

USGS: "Content Standards for Digital Geospatial Metadata" (particularly Section 4, "Spatial Reference Information") endorsed by the (US) Federal Geographic Data Committee.

## 1.3 Ellipsoids

The ellipsoids included in DIGEST are mostly those on the ellipsoid lists used by DGIA (UK) and NIMA (US). A few ellipsoids were not on the NIMA list when DIGEST 2.0 was being finalized. These have been given "spare" codes, that is to say codes not already assigned by NIMA.

There are several ways of defining an ellipsoid. One way is to specify a and 1/f, for which values are given in Table 6.1. Where 1/f is padded out to 7 decimal places by 3 or more zeroes, the probability is that 1/f is one of the original defining parameters. Sometimes 1/f is a "derived" parameter evaluated to 10 figures (sufficient for all practical purposes), as happens when ellipsoid axes a and b are the defining parameters. Where the value of a in metres has non-zero decimal figures, the probability is that it was originally defined in different units.

The following notes describe such cases as:

Ellipsoids associated with datums of current importance, despite being omitted from some published lists.

Ellipsoids for which parameters are not widely known.

Ellipsoids for which the parameters differ from some sources.

Ellipsoids for which additional information was obtained too late for inclusion in the current edition of DIGEST.

Airy.** For Editions 2.1 onwards, DIGEST gives 1/f = 299.3249646 (based on the original values of a and b in feet). DIGEST 2.0 had 7 as the final digit.

Airy Modified.** For Editions 2.1 onwards, DIGEST gives 1/f = 299.3249646 (because Airy Modified has identical flattening to Airy). DIGEST 2.0 had 7 as the final digit.

Average Terrestrial System 1977. The ellipsoid of the datum of the same name (refer to

Datums). Parameters are a = 6378135 & 1/f = 298.257. (Source: ATS77 specification dated November 1993 supplied by the Canadian Hydrographic Service) The ellipsoid is not on the NIMA list, but "AP" is a spare code.

Bessel (Modified).** Included in DIGEST Editions 2.0 onwards. For Editions 2.1 onwards, DIGEST gives 1/f = 299.1528128. (Source: Norwegian Mapping Authority.) DIGEST 2.0 had 000 as the final three digits.

Clarke 1880 (IGN).** Included in DIGEST Editions 2.0 onwards. For Editions 2.1 onwards, DIGEST gives 1/f = 293.4660213 (based on the original values of a and b in feet). DIGEST 2.0 had 08 as the final two digits.

Everest (India). Included in DIGEST Editions 2.0 onwards. The published parameters of Everest 1830 are: a = 20922931.80 Indian feet, b = 20853374.58 Indian feet and 1/f = 300.8017 [Source: Georg Strasser's "Ellipsoidische Parameter der Erdfigur (1800-1950)"]. The parameters are not totally consistent, because the value of 1/f derived from a and b is 300.8017255 (to 7 decimal places). The effect of the different values of 1/f is very small (0.0018m in the value of b).

Geodetic Reference System 1980. For practical purposes, this is the same ellipsoid as the WGS 84 ellipsoid. The values of a are the same, and the values of b differ by only 0.0001m.

IAG Best Estimate 1975. Included in DIGEST Editions 2.0 onwards, as the name of the ellipsoid used by the datum GDZ80. Its parameters are: a = 6378140, 1/f = 298.257. The ellipsoid is called "Best estimate" in the Fourth Edition of G Bomford's "Geodesy" (1980). In 1975, it was recommended by the IAG Special Study Group 5.39 examining "Fundamental Geodetic Constants", hence the name adopted by DIGEST. H Moritz's paper in Travaux L'Association Internationale de Géodésie 25, pages 411-418, admits that one reason for the group choosing a semi-major axis of 6378140 rather than 6378135 was that the former was a round number. It is not on the NIMA list, but "IA" is a spare code.

Soviet Geodetic System 1985. Included in DIGEST Editions 2.0 onwards. Datum and ellipsoid used by GLONASS until 1993. Ellipsoid parameters are: a = 6378136, 1/f = 298.257. (Source: senior Geodesy staff at NIMA.) The NIMA datum code is "SGA".

Soviet Geodetic System 1990 (PZ-90). Included in DIGEST Editions 2.0 onwards. Datum and ellipsoid used by GLONASS from November 1993. Ellipsoid parameters are: a = 6378136, 1/f = 298.2578393. (Source: Russian Bulletin Board). The NIMA datum code is "SGB".

World Geodetic System 1984. The datum and ellipsoid are not affected by the change (in 1997) in the way WGS 84 was defined. The value of 1/f, which was originally derived from physical constants, is now a defining parameter.

## 1.4 Geodetic Datums

The datums included in DIGEST are mostly those on the datum lists used by DGIA (UK) and NIMA (US), also some have been supplied by other mapping agencies. A few datums were not on the NIMA list when DIGEST 2.0 was being finalized. These have been given "spare" codes, that is to say codes not already assigned by NIMA.

Not all datums on the US NIMA/UK DGIA code lists are included. Those that are in DIGEST Editions 2.0 onwards include all those in NIMA Technical Report 8350.2. Others were included, for example, if those datums occurred on a significant number of UK-held map sheets.

The following notes describe such cases as:

> Datums of current importance which are not always found in published lists.
>
> Datums whose details differ from those given in some published sources, including DIGEST 1.2.
>
> Datums for which additional information was obtained too late for inclusion in the current edition of DIGEST.
>
> Items omitted from the latest DIGEST datum list which are described as datums in other sources (for example DIGEST 1.2 and S-57 Edition 3.0).

Astro DOS 71/4 (St Helena Island).** For Editions 2.1 onwards, DIGEST has "DOS" in capitals (replacing "Dos") because DOS is the acronym for the survey organization.

Average Terrestrial System (Atlantic Datum) 1997. Included in DIGEST 1.2, but omitted from Editions 2.0 onwards. No evidence has been found for the datum's existence; at least, not with that date. The Canadian Hydrographic Service regards it as a miscopy of Average Terrestrial System 1977. The code given in DIGEST 1.2, "ATS", is used by NIMA for a different datum.

Average Terrestrial System 1977, New Brunswick, Nova Scotia, Prince Edward Island.** Included in S-57 Edition 3.0. According to the Canadian Hydrographic Service, it came into existence in 1979, superseding NAD 27 as used in the province of New Brunswick. New Brunswick will be adopting NAD 83 "some time during the mid-1990s" according to an ATS77 specification dated November 1993. The ellipsoid is ATS 77. This datum could be regarded as a correction to "Average Terrestrial System 1997" in DIGEST 1.2. The datum is not on the NIMA list but "ATX" is a spare code. This replaces the code "ATS" used in DIGEST 1.2 for the incorrectly dated system. For Editions 2.1 onwards, DIGEST includes Nova Scotia and Prince Edward Island in the name of the datum (on advice from Canada).

Belgium 1950 System (Lommel Signal). Included in DIGEST Editions 2.0 onwards. The Department of Geodesy, Belgian National Geographic Institute, confirms that Lommel Signal is the fundamental datum point and that Greenwich is the zero meridian. The Belgium 1950 System has been replaced by Belgium 1972; thus if any data still exists on Belgium 1950, it is definitely old data. The NIMA code for Belgium 1950 is "BEL" (although, in an apparent duplication, the NIMA datum list also includes "Lommel Signal" with code LOD).

Belgium 1972 (Observatoire d'Uccle). Included in DIGEST Editions 2.0 onwards. The Department of Geodesy, Belgian National Geographic Institute, confirms that Observatoire d'Uccle is the fundamental datum point and that the zero meridian is Greenwich. Its NIMA code is "ODU".

BJZ54 (A954 Beijing Coordinates). Included in DIGEST Editions 2.0 onwards for alignment

with S-57 Edition 3.0. According to the UK Hydrographic Office, the ellipsoid is Krassovsky. The datum is not on the NIMA list, but "BJZ" is a spare code.

Bukit Rimah (Bangka & Belitung Islands). DIGEST 1.2a had this datum twice with different codes: "BUR" (the NIMA code) and "BOR" (the NIMA code for a different datum). For Editions 2.0 onwards, DIGEST has the datum once with its NIMA code "BUR".

Canton Astro 1966 (Phoenix Islands). For Editions 2.0 onwards, DIGEST uses the NIMA code "CAO". DIGEST 1.2a had the code misprinted as "CA0" (i.e. 3rd character zero).

Cape (South Africa). For Editions 2.0 onwards, DIGEST gives the ellipsoid as Clarke 1880 (Cape) whereas NIMA Technical Report 8350.2 gives the ellipsoid as Clarke 1880. The difference between the ellipsoids is small (zero between the semi-major axes and less than 0.1 metres between the semi-minor axes). In the context of datum transformations to WGS 84 (which is what NIMA Technical Report 8350.2 is concerned with), the difference is negligible.

Carthage (Tunisia). For Editions 2.0 onwards, DIGEST gives the ellipsoid as Clarke 1880 (IGN) whereas NIMA Technical Report 8350.2 gives the ellipsoid as Clarke 1880. The difference between the ellipsoids is small (less than 0.1 metres between the semi-major axes and less than 0.1 metres between the semi-minor axes). In the context of datum transformations to WGS 84 (which is what NIMA Technical Report 8350.2 is concerned with), the difference is negligible.

Chua Astro (Paraguay).** DIGEST 1.2a had this datum twice with different codes: "CHU" (the NIMA code) and "CHG" (the NIMA code for a different datum). For Editions 2.0 onwards, DIGEST has the datum once with its NIMA code "CHU", omitting the duplicate entry with a different code ("CHG") which appeared in earlier editions. For Editions 2.1 onwards, DIGEST has included the associated ellipsoid code "IN".

Compensation Géodésique du Québec 1977.** Included in DIGEST Editions 2.0 onwards for alignment with S-57 Edition 3.0. The Canadian Hydrographic Service advised that it is really a recomputation of NAD27 values. The ellipsoid is Clarke 1866. It is not on the NIMA list but "CGX" is a spare code. For Editions 2.1 onwards, DIGEST has "Géodésique" with an "s". DIGEST 2.0 incorrectly had a "t".

Djakarta (Batavia).** Included in DIGEST Editions 2.0 onwards. For Editions 2.1 onwards, DIGEST gives "BR" as the associated ellipsoid code for each of the two Djakarta datums. DIGEST 2.0 incorrectly had "BN".

European 1979. Included in DIGEST Editions 2.0 onwards, replacing "European 79". The code used in DIGEST 1.2, "EUQ", has been amended in DIGEST to the NIMA code "EUS" (For Editions 2.0 onwards).

European Terrestrial Reference System 1989 (ETRS89). Included in DIGEST Editions 2.0 onwards. The datum due to supersede European 1950 for European mapping. It is not in S-57 or DIGEST 1.2, nor is it on the NIMA list, although "EUT" is a spare code. The ellipsoid is GRS 1980. The datum is called "European Terrestrial Reference Frame 1989 (ETRF89)" in some sources. UK Hydrographic Office advised DIGEST WP that some nations are using national versions for mapping rather than ETRS89 itself.

Finnish (KKJ). See "KKJ, Finland".

Gan 1970. Incorrectly shown in DIGEST 1.2 as GAN 1970. Gan is actually a place. The corrected datum name is supported by NIMA Technical Report 8350.2.

GDZ80. Included in DIGEST Editions 2.0 onwards for alignment with S-57 Edition 3.0. According to the UK Hydrographic Office, it is used by China, and its ellipsoid parameters are a = 6378140 and 1/f = 298.257. (See notes on the ellipsoid "IAG Best Estimate 1975)". Professor Alan Dodson, Nottingham University advised DIGEST WP that the origin of the datum is Xian, China, and that the best English translation of the datum name is "National Geodetic Reference System 1980". It is not on the NIMA list, but "GDZ" is a spare code.

Geocentric Datum Of Australia (GDA). Included in DIGEST Editions 2.0 onwards for alignment with S-57 Edition 3.0. It is not on the NIMA list, but "GDS" is a spare code.

German Datum. Included in DIGEST 1.2, but omitted from Editions 2.0 onwards. The reason is that there are several German datums, none of them called "German Datum". The ones in the NIMA list are Potsdam or Helmertturm (NIMA code PDM, ellipsoid International), Rauenberg (Berlin) (NIMA code RAU, ellipsoid Bessel 1841), Tübingen (NIMA code TUB) and Mannheim (NIMA code MNN). FAFGO recommended exclusion of Mannheim and Tübingen.

GGRS 76 (Greece). Included in S-57 Edition 3.0 but omitted from DIGEST. Professor George Veiss, National Technical University of Athens, confirmed that this is a misidentification of Greek Geodetic Reference System 1987 (GGRS 87).

Ghana. Included in DIGEST 1.2, but omitted from DIGEST for Editions 2.0 onwards. It has been superseded by Leigon with code "LEH".

Greek Datum, Greece. Included in DIGEST for Editions 1.2a onwards. Professor George Veiss, National Technical University of Athens, stated that "the so-called (old) Greek Datum [was] established in the 1890s on Bessel's ellipsoid". Separate DGIA records confirm the ellipsoid as Bessel 1841 (Revised).

Greek Geodetic Reference System 1987 (GGRS 87). Included in DIGEST Editions 2.0 onwards. GGRS 87 was established under the supervision of Professor George Veiss, National Technical University of Athens, using a combination of terrestrial and satellite data. The ellipsoid is GRS 1980. In 1994, Professor Veiss advised the UK Hydrographic Office that all future geodetic, topographic, cadastral and cartographic work would be expressed in GGRS 87.

Guadeloupe Ste Anne. Included in DIGEST 1.2a with a code "GUD" which NIMA uses for a different datum. For Editions 2.0 onwards, the datum appears in DIGEST as "Sainte Anne I 1984 (Guadeloupe)" with code "SAG".

Guyana CSG67.** The datum is not on the NIMA list, but "CSG" is a spare code. For Editions 2.1 onwards, DIGEST has included the code of the associated ellipsoid, "IN" (on the basis of information supplied by CGI, France).

Helsinki (Finnish Chart Datum) Finland. Considered for inclusion in DIGEST (Editions 2.0

onwards), but not included. This has a NIMA code "HEL". UK Hydrographic Office says that it is a much older datum than KKJ.

Hungarian Datum 1972. Included in DIGEST Editions 2.0 onwards. Its ellipsoid is GRS 67, not "International 1967" as given in the EPSG Geodetic Database of 1996. Confirmation can be found in "Description Directory of the Hungarian Geodetic References" compiled by Dr Sz Mihály, published August 1994. NIMA is to add the datum to its list with code "HUY".

Indian. This datum, whose NIMA code is "IND", is the only case in DIGEST where the datum has different ellipsoid codes for different regions. The ellipsoids only differ in the value-in-metres of the semi-major axis. This is due to different foot-to-metre conversion factors.

Ireland 1965 (Ireland and Northern Ireland). DIGEST 1.2a had this datum twice with different codes: "IRL" (the NIMA code) and "IRE". For Editions 2.0 onwards, DIGEST has the datum once with its NIMA code "IRL".

Ireland 1975. Considered for inclusion in DIGEST (Edition 2.0 onwards), but not included. Ordnance Survey of Ireland confirms that it is not a separate datum from Ireland 1965, but a clarification based on a re-adjustment. The name of the datum is still Ireland 1965.

Italian Datum. Included in DIGEST 1.2 but not in Editions 2.0 onwards. There is only one Italian datum, but its correct name is Rome 1940 or Rome Monte Mario. (Source: Italian Military Geographic Institute.)

Kertau 1948. Included in S-57 Edition 3.0 as "Revised Kertau". UK DGIA's Geodetic Branch confirms this is the same as Kertau 1948. The full name in the NIMA listing is "Kertau 1948 (West Malaysia and Singapore (Malayan Revised Triangulation 1948))", and its NIMA/DIGEST code is "KEA". UK Hydrographic Office informed DIGEST WP that Revised Kertau uses Revised Everest ellipsoid (a = 6377304.063, 1/f = 300.8017) which is also known as "Everest (Malaya RKT)".

KKJ, Finland. Included in DIGEST Editions 2.0 onwards for alignment with S-57 Edition 3.0 as "Finnish (KKJ)". According to the UK Hydrographic Office, KKJ stands for Kartastokoordinaattijarjestelma. It is a variation on European Datum 1950, and its ellipsoid is International. The datum is not on the NIMA list, but "KKX" is a spare code.

Leigon (Ghana).** DIGEST 2.0 incorrectly had "CG" as the associated ellipsoid code. For Editions 2.1 onwards, DIGEST has "CD". (Sources: Geodetic Branch, UK DGIA and ESPG Geodetic Database).

Mannheim (Germany). See German Datum.

Mayotte Combani. Included in DIGEST for Editions 1.2 onwards. CGI, France, provided the following details: the datum is used by Mayotte (an island in the Indian Ocean), and Combani is the village where the fundamental datum point is located. The ellipsoid is International 1924, and its zero meridian is Greenwich. The change of code, "MAY" in DIGEST 1.2 to "MCX" in DIGEST 2.0 onwards, was made to avoid conflict with the NIMA list (which omitted this datum but used the code MAY for another).

Merchich (Morocco). For Editions 2.0 onwards, DIGEST gives the ellipsoid as Clarke 1880 (IGN) whereas NIMA Technical Report 8350.2 gives the ellipsoid as Clarke 1880. The difference between the ellipsoids is small (less than 0.1 metres between the semi-major axes and less than 0.1 metres between the semi-minor axes). In the context of datum transformations to WGS 84 (which is what NIMA Technical Report 8350.2 is concerned with), the difference is negligible.

Modified BJZ54. Included in DIGEST Editions 2.0 onwards for alignment with S-57 Edition 3.0. According to the UK Hydrographic Office, the ellipsoid is Krassovsky. The datum is not on the NIMA list, but "BJM" is a spare code.

Mount Dillon (Tobago). Included in DIGEST Editions 2.0 onwards. Not in S-57 or on NIMA list. It is the datum used for Tobago grid and UK DGIA had given it the code "MDT" (which is not used by the NIMA list). The ellipsoid is Clarke 1858 (Modified) with parameters a = 6378293.645 & $e^2$ = 0.00678516157 (equivalent to 1/f = 294.26). (Source: UK Hydrographic Office and UK DGIA)

M'Poraloko (Gabon). Included in DIGEST Editions 2.0 onwards for alignment with S-57 Edition 3.0 and NIMA Technical Report 8350.2. Its NIMA code is MPO.

Nigeria. Included in DIGEST 1.2, but omitted from DIGEST Editions 2.0 onwards. It has been superseded by Minna with code "MIN". Note that "Minna (Nigeria)" is one of two regional solutions of Minna.

North American 1983. DIGEST 1.2 used the code "NAX". For Editions 2.0 onwards, DIGEST has used the NIMA code "NAR".

Nouvelle Triangulation Française (NTF). Sometimes called "New French (Pantheon, Paris)". The NIMA code is "NFR". The datum is only used with zero meridian Paris, according to CGI, France (hence the NFR**1** in DIGEST). There is a theoretical NTF-Greenwich which has Greenwich as Zero Meridian. NTF-Paris is related to NTF-Greenwich by a longitude shift. Paris is 2°20′14.0250″ east of Greenwich.

Ordnance Survey of Ireland. Mistakenly included in the datum list of S-57 Edition 3.0. The Ordnance Survey of Ireland is an organization, not a datum. The advice from that organization is to regard "Ireland 1965" as the only Irish datum.

Oslo Observatory (Old), Norway.** This is better known as NGO1948, although its fundamental point is Oslo Observatory. DIGEST 2.0 incorrectly had "BR" as the associated ellipsoid code. For Editions 2.1 onwards, DIGEST has "BM". From 1997, ETRS89 is replacing NGO1948 as Norway's national geodetic horizontal datum. (Source: Norwegian Mapping Authority.)

Potsdam Or Helmertturm (Germany). Included in DIGEST Editions 2.0 onwards. The ellipsoid is International. The NIMA code is "PDM".

Rauenberg (Berlin, Germany). Included in DIGEST Editions 2.0 onwards. The ellipsoid is Bessel (1841) Revised. The NIMA code is "RAU".

Revised Kertau. See "Kertau 1948".

Revised Nahrwan. Included in DIGEST Editions 2.0 onwards for alignment with S-57 Edition 3.0. According to the UK Hydrographic Office, it is also known as GO66 or GO67. Its ellipsoid is Clarke 1880 Modified. The datum is not on the NIMA list, but "NAX" is a spare code.

Rome 1940 or Rome Monte Mario. The Italian Military Geographic Institute recommended that "(Sardinia Island)" should be omitted from the name as given in DIGEST 1.2, hence the absence of "(Sardinia Island)" from DIGEST for Editions 2.0 onwards.

RT90, Stockholm, Sweden. Included in DIGEST Editions 2.0 onwards for alignment with S-57 Edition 3.0. UK Hydrographic Office says its ellipsoid is Bessel 1841 (Revised); RT38 also uses that ellipsoid. The NIMA code is "RTS".

Saint Anne I 1984 (Guadeloupe). For DIGEST Editions 2.0 onwards, this entry, with NIMA code "SAG", replaces Guadeloupe in DIGEST 1.2a.

St Pierre et Miquelon 1950. CGI, France, advised that its ellipsoid is Clarke 1866. The change of code, "STP" in DIGEST 1.2 to "STX" in DIGEST 2.0 onwards, was made to avoid conflict with the NIMA list (which omitted this datum but used the code STP for another).

Soviet Geodetic System 1985. Included in DIGEST Editions 2.0 onwards. Datum and ellipsoid used by GLONASS until 1993. Ellipsoid parameters are: a = 6378136, 1/f = 298.257. (Source: Senior Geodesy Staff at NIMA.) The NIMA datum code is "SGA".

Soviet Geodetic System 1990 (PZ-90). Included in DIGEST Editions 2.0 onwards. Datum and ellipsoid used by GLONASS from November 1993. Ellipsoid parameters are: a = 6378136, 1/f = 298.2578393. (Source: Russian Bulletin Board.) The NIMA code is "SGB".

S-JTSK (Czechoslovakia Prior to 1 Jan 1993).** Included in DIGEST Editions 2.0 onwards. Its NIMA code is "CCD". For Editions 2.1 onwards, DIGEST gives "BR" as the associated ellipsoid code. DIGEST 2.0 incorrectly had "BN".

S-JYSK. Not a datum. "S-JYSK" in S-57 Edition 3.0 is a misspelling of "S-JTSK".

Timbalai 1968.** Its NIMA code is "TIN". For Editions 2.1 onwards, DIGEST has spelt the name as "Timbalai" (replacing the incorrect "Timbali") and has included the associated ellipsoid code "BR".

Tokyo. The change of code, "TOK" in DIGEST 1.2 to "TOY" in DIGEST 2.0 onwards, preserves alignment with NIMA codes.

Tübingen (Germany). See German Datum.

Wake Island Astro 1952.** Included in DIGEST Editions 2.0 onwards. Its NIMA code is "WAK". For Editions 2.1 onwards, DIGEST has included the associated ellipsoid code "IN".

Voirol 1875. The date has been added to the entry in DIGEST 1.2. The NIMA list omits the

date. EPSG includes the date.

Voirol 1950. Mistakenly included in S-57 Edition 3.0. CGI, France, has advised that it does not exist.

Voirol 1960 (Algeria).*** For Editions 2.1 onwards, DIGEST has omitted this from the list of datums. Although it has been on the NIMA list (with code "VOR"), it is actually a grid. There is no alternative version with Zero Meridian Paris.

World Geodetic System 1984. The datum and ellipsoid are not affected by the change (in 1997) in the way WGS 84 was defined. The value of 1/f, which was originally derived from physical constants, is now a defining parameter.

## 1.5 Datum Transformations

Datum transformations exist between most datums and WGS 84. However, the following points should be noted.

Datum transformations are not exact. They are "best fit" mathematical models.

The most widely used transformation is the 3-parameter transformation. The 3 parameters are shifts representing components of distance DeltaX, DeltaY, DeltaZ between the centres of the 2 ellipsoids. These are added to the Cartesian coordinates X, Y, Z in the local datum to give Cartesian coordinates X, Y, Z with respect to WGS 84.

A transformation between a local datum and WGS 84 should only be applied within the territory covered by the local datum. Transformations based on regional solutions of a particular datum are generally more accurate in the indicated region than a transformation based on a "mean value".

A local datum with a Zero Meridian other than Greenwich should not be transformed to WGS 84 directly. The local datum should first be transformed to the Greenwich version of the local datum by a block shift in longitude. The transformation between the Greenwich version of the local datum and WGS 84 can then be applied.

The Metadata section of DIGEST 2.1 includes polynomial transformation formulae between datums. See under METRIC SUPPORT PARAMETERS in 10.1.3.1 in Part 2. Latitude and longitude are "normalized" in the region common to both datums, so that their values in the formulae are generally in the range –1 to 1. If the formulae are Multiple Regression Equations (MREs), they may be more accurate than 3-parameter transformations. Where they are simply a derived approximation to the 3-parameter transformation, they are less accurate.

### 1.5.1 Datum Transformations Published By NIMA

Over 200 three-parameter datum transformations between local geodetic datums and WGS 84 have been published in NIMA Technical Report 8350.2. The most up-to-date version of the NIMA transformations can be found in:

http://164.214.2.59/GandG/wgs84dt

### 1.5.2 Datum Transformations From Other Sources

The following transformations to WGS 84 are not listed in NIMA Technical Report 8350.2, but have been supplied to DIGEST WP by other organizations.

Mayotte Combani. The transformation parameters to WGS 84 are:
-382m in X, -59m in Y, -262m in Z. (Source: CGI, France)

NTF. The transformation parameters from NTF-Greenwich to WGS 84 are:
-168m in X, -60m in Y, +320m in Z. (Source: CGI, France)

St Pierre et Miquelon 1950. The transformation parameters to WGS 84 are:
+30m in X, +430m in Y, +368m in Z. (Source: CGI, France)

Timbalai 1968. The transformation parameters to WGS 84 are:
-615m in X, +537 in Y, -35m in Z. (Source: Geodetic Branch, UK DGIA)

## 1.6 Projections

The projections included in DIGEST are mostly those on the projection lists used by DGIA (UK) and NIMA (US), although a significant number have been supplied by USGS (US). A few projections were not on the NIMA list when DIGEST 2.0 was being finalized. These have been given "spare" codes, that is to say codes not already assigned by NIMA.

According to senior Geodesists at NIMA, NIMA realised in 1996 that it had more than one list of projection codes, and that they needed to be harmonized. A definitive NIMA list was scheduled to appear in the Second Edition of NIMA Technical Manual 8358.1. However, the list was still in preparation when DIGEST 2.0 and DIGEST 2.1 were being prepared.

The projections all have their own methods of converting latitude and longitude to easting and northing, and vice-versa. Several of the methods are described in Snyder 1987. The method mentioned in DIGEST 2.1 under ARC SYSTEM METRIC SUPPORT PARAMETERS (the formulae for NN and EN in 10.1.3.1 of Part 2) can be used to approximate projection formulae if suitable constants have been computed.

The following notes describe such cases as:

> Projections whose parameters appear to differ from those given in other projection lists, such as the one in DIGEST 1.2 and the one used by USGS.
>
> Projections treated in DIGEST as single types (such as Lambert Conformal Conic, Space Oblique Mercator) but which appear as two or more types in other projection lists.
>
> Items omitted from the DIGEST projection list (such as ARC, Gauss-Krüger, UTM) which are described as "projections" in other sources.

ARC. This is omitted because it is not a projection. It is a system of representing geographic coordinates in a raster image, although it is based on two simple projections (Equirectangular

and Azimuthal Equidistant). The system is documented in Part 3 of DIGEST Support Document.

Bonne.** For Editions 2.1 onwards, DIGEST omits "scale factor at projection origin" because the method does not use a scale factor.

Cylindrical Equal Area.* According to Snyder, this is also known as "Lambert Cylindrical Equal-Area". "LI" is the code used by UK DGIA.

Conic Equidistant. See Equidistant Conic.

Eckert IV.* "EF" is the code used by UK DGIA. DIGEST gives the second parameter as "Radius of Sphere", but allows it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. USGS omits the Radius-of-Sphere parameter on the assumption that the sphere is defined in that way.

Eckert VI.* "ED" is the code used by UK DGIA. DIGEST gives the second parameter as "Radius of Sphere", but allows it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. USGS omits the Radius-of-Sphere parameter on the assumption that the sphere is defined in that way.

Equidistant Conic with 1 Standard Parallel.** From Edition 2.1 onwards, DIGEST has the NIMA code "CC". This is a correction to DIGEST 2.0. The projection is also known as "Conic(al) Equidistant with one Standard Parallel".

Equidistant Conic with 2 Standard Parallels. Some lists contain several versions of this projection, but they only differ in the criteria for selecting the 2 standard parallels. (Source: Snyder, 1987.) The DIGEST version should be regarded as the most generic, although it is usual for the standard parallels to be chosen to minimise error. For Editions 2.0 onwards, DIGEST has the code "KA" which NIMA uses for Kavraiskiy Minimum-Error Equidistant Conical with 2 Standard Parallels.

Equidistant Cylindrical. See Equirectangular.

Equirectangular (La Carte Parallélogrammatique).** From Edition 2.1 onwards, DIGEST has the NIMA code "CP" and gives the third parameter as "Radius of Sphere", allowing it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. These (and the "mm" in "Parallélogrammatique") are corrections to DIGEST 2.0. There are several other names for the projection, including "Equidistant Cylindrical". (Source: Snyder, 1987.)

Gauss-Krüger. Omitted from the projections in DIGEST because it is a special case of another projection, namely Transverse Mercator. Usually Gauss-Krüger means Transverse Mercator with the Scale Factor set to 1.

General Vertical Near-Side Perspective. This projection, included in DIGEST Editions 2.0 onwards, is not on the NIMA list, but "VX" is a spare code.

Hotine Oblique Mercator based on 2 Points. This projection, included in DIGEST Editions 2.0 onwards, is not on the NIMA list, but "HX" is a spare code. It is possible to convert the 6

parameters of this projection into the 4 parameters of Hotine Oblique Mercator (Rectified Skew Orthomorphic). Details can be found in Snyder (1987).

Laborde.** For Editions 2.1 onwards, there is a fourth parameter "Azimuth at origin of axis of constant scale". Some sources omit this, preferring to treat the azimuth used in the Madagascar Laborde grid (018.9°) as part of the projection mathematics.

Lambert Conformal Conic. The version in DIGEST assumes 2 standard parallels rather than 1 standard parallel with a scale factor. Procedures for converting the 1-standard-parallel case into 2 are established and are being applied where needed. (Source: CGI, France, although UK DGIA also has conversion formulae).

Lambert Cylindrical Equal Area.* See Cylindrical Equal Area.

Mercator.** DIGEST 1.2 included "Parallel of Origin" as the third parameter. DIGEST 2.0 omitted it, because it is usual to regard the parallel of origin as the Equator. For Edition 2.1 onwards, DIGEST has a third parameter "Latitude of Reference Origin" (meaning the latitude where Northing False Origin is defined) which can be omitted if it is the Equator.

Miller Cylindrical. Included in DIGEST Editions 2.0 onwards. DIGEST gives the second parameter as "Radius of Sphere", but allows it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. USGS omits the Radius-of-Sphere parameter on the assumption that the sphere is defined in that way.

Mollweide.* UK DGIA uses the code "MP". DIGEST gives the second parameter as "Radius of Sphere", but allows it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. USGS omits the Radius-of-Sphere parameter on the assumption that the sphere is defined in that way.

New Zealand Map Grid. Included in DIGEST Editions 2.0 onwards. The New Zealand Map Grid Projection can only be used for the New Zealand Map Grid. The formulae use constants which would have been different if derived from a different-shaped area in a different part of the world.

Oblique Mercator.** For Editions 2.1 onwards, DIGEST includes a fourth parameter, "Radius of Sphere", but allows it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. USGS omits the Radius-of-Sphere parameter on the assumption that the sphere is defined in that way.

Orthographic.** For Editions 2.1 onwards, DIGEST includes a third parameter, "Radius of Sphere", but allows it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. USGS omits the Radius-of-Sphere parameter on the assumption that the sphere is defined in that way.

Polar Stereographic. Although zone number exists to indicate whether the polar zone is north or south, this can also be deduced from the parameter "Latitude of true scale". The Central Meridian is clarified as the "Longitude straight down from Pole on map" which can also be regarded as the downward Y-axis.

Relative Coordinates.*** For Editions 2.0 onwards, this has been omitted from DIGEST because it is a coordinate system, not a projection. The projection which has plane coordinates based on relative latitude and relative longitude is "Equirectangular".

Robinson. Included in DIGEST Editions 2.0 onwards. This appears on one NIMA list with code "RC" which DIGEST had assigned to "Relative Coordinates". "RX" is a spare code. For Editions 2.0 onwards, DIGEST gives the second parameter as "Radius of Sphere", but allows it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. USGS omits the Radius-of-Sphere parameter on the assumption that the sphere is defined in that way.

Sinusoidal. Included in DIGEST Editions 2.0 onwards. DIGEST gives the second parameter as "Radius of Sphere", but allows it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. USGS omits the Radius-of-Sphere parameter on the assumption that the sphere is defined in that way.

Space Oblique Mercator. Included in DIGEST Editions 2.0 onwards. USGS has two versions of this projection, one called "Space Oblique Mercator", the other called "EOSAT SOM". USGS has Vehicle Number and Orbital Path Number as the parameters in each case, since the mathematical constants depend solely on these. ERDAS has advised that the 2 projections are theoretically the same and that the only difference is that EOSAT has swapped the X and Y axes. The decision to use "Application Code" as a parameter to distinguish between the 2 versions (which are both linked to LANDSAT) also allows for the possibility of a future version based on a satellite other than LANDSAT. The projection is not on the NIMA list, but "SX" is a spare code.

Transverse Cylindrical Equal Area.* NIMA has no code for this projection, so the spare code "TX" has been assigned.

Universal Polar Stereographic. Omitted from the projections in DIGEST because it is a special case of Polar Stereographic.

Universal Transverse Mercator. Omitted from the projections in DIGEST because it is a special case of another projection: Transverse Mercator, with Central Scale Factor set to 0.9996, applied to a set of 120 zones.

Van der Grinten. Included in DIGEST Editions 2.0 onwards. DIGEST gives the second parameter as "Radius of Sphere", but allows it to be omitted if the chosen sphere has the same surface area as the chosen ellipsoid. USGS omits the Radius-of-Sphere parameter on the assumption that the sphere is defined in that way.

Note 2.** The formula for Qp was mathematically correct in DIGEST 2.0, but not expressed in the best way. The version in Edition 2.1 is incorrect. It should read

$$Qp = 1 + ((1-e^2)/(2*e)*Ln((1+e)/(1-e)).$$

Note 6.* See Mercator.

## 1.7 Grids

The grids included in DIGEST are mostly those on the grid lists used by DGIA (UK) and NIMA

(US). A few grids were not on the NIMA list when DIGEST 2.0 was being finalized. These have been given "spare" codes, that is to say codes not already assigned by NIMA.

Some "grids" are grid categories, being multi-zone, multi-datum or both.

The following notes describe such cases as:

> Grid categories which have zones that do not use the same projection.
>
> Grid categories where the system of zones differs between datums.
>
> Grids of current importance which are not always found in published lists.
>
> Grids for which additional information was obtained too late for inclusion in the current edition of DIGEST.
>
> Items omitted from the current DIGEST grid list which are described as "grids" in other sources (for example DIGEST 1.2).

Alaska Coordinate System. Zone 1 uses the Hotine Oblique Mercator projection. Zone 10 uses the Lambert Conformal Conic Projection. The remaining zones (Zones 2 to 9) use the Transverse Mercator projection. (Source: Snyder, 1987.)

American Samoa Coordinate System. This is part of the NAD27 State Plane coordinate system, but not part of the NAD83 State Plane coordinate system (see, for example, Snyder, 1987). UK DGIA has maps on that grid for which the datum is American Samoa Datum 1962. That datum is assumed to be the reason why the grid is not part of the NAD83 State Plane coordinate system.

Australian Map Grid. The datum is given as "Australian Geodetic Datum" without any indication whether the year is 1966 or 1984. However, the ellipsoid is confirmed as Australian National.

Baltic Region Transverse Mercator Grid. Included in DIGEST Editions 2.0 onwards. One of the grids to take advantage of the datum ETRS89. It is sometimes referred to as TM-BALTI. It is not on the NIMA list, but "BD" is a spare code. (Source: UK DGIA)

Borneo Rectified Skew Orthomorphic Grid. This has been used with different Timbalai datums, but the ellipsoid is always Everest (Borneo). (Source: UK DGIA)

California Coordinate System. In the NAD27 State Plane coordinate system, this has 7 zones (I, II, II, IV, V, VI, VII). In the NAD83 State Plane coordinate system, it has 6 zones (1 to 6), Zone 7 having been deleted. (Source: Snyder, 1987.)

Czechoslovak Military Grid.** DIGEST 2.0 included an invalid projection code for this grid. The projection used for the grid is an oblique conformal conic projection, for which DIGEST has no code. In DIGEST Editions 2.1 onwards, the grid has a blank entry in the final column.

Denmark Geodetic Institute System 1934.** For Editions 2.0 onwards, DIGEST has the date

1934. This is a correction to the date 1924 given in DIGEST 1.2. DIGEST 2.0 included an invalid projection code for this grid. The projection used for the grid is the Buchwald projection, for which DIGEST has no code. In DIGEST Editions 2.1 onwards, the grid has a blank entry in the final column.

Geodetic Grid. This was an entry in DIGEST 1.2 which has been omitted from DIGEST Editions 2.0 onwards. It does not identify a particular grid, and the reason for its earlier inclusion is unknown.

Geographic Reference System (GEOREF). Although retained in DIGEST for Editions 2.0 onwards, this is not a grid. It is a method of expressing geographical coordinates in a character string. The code "GR" in DIGEST 1.2 has been replaced by the NIMA code "GE" in DIGEST for Editions 2.0 onwards.

Greece Conical Meckleburg Coordinates (New Numbering). The code "GM" in DIGEST 1.2 has been replaced by the NIMA code "GR" in DIGEST for Editions 2.0 onwards.

Estonia Lambert Conformal Conic Grid.** Included in DIGEST Editions 2.0 onwards. One of the grids to take advantage of the datum ETRS89. It is sometimes referred to LAMBERT.EST. It is not on the NIMA list, but "EL" is a spare code. (Source: UK DGIA.) For Edition 2.1 onwards, DIGEST has "Estonia", which is a correction of "Estonial" in DIGEST 2.0.

Florida Coordinate System. The East and West Zones both use the Transverse Mercator projection. However, there is also a North Zone which uses the Lambert Conformal Conic projection. (Source: Snyder, 1987.)

Lithuanian LKS-94 Grid. Included in DIGEST Editions 2.0 onwards. One of the grids to take advantage of the datum ETRS89. A more complete version of the name is Lietuvos Koordinaciu Sistema 1994. It is not on the NIMA list, but "LK" is a spare code. It uses the Transverse Mercator projection. (Source: UK DGIA)

Map Grid of Australia 1994 (MGA94). Included in DIGEST Editions 2.0 onwards. This is a grid category (in the sense of having several zones) which goes with the Geocentric Datum of Australia. MGA94 is not on the NIMA list, but "AT" is a spare code which UK has already started to use for the grid.

Military Grid Reference System. Not a grid system as defined in DIGEST 2.1. Although included in DIGEST 1.2a with code "MGRS", it has been omitted from DIGEST for Editions 2.0 onwards. Military Grid References are related to Universal Transverse Mercator in the sense that they are a mechanism for expressing UTM coordinates.

Montana Coordinate System. In the NAD27 State Plane coordinate system, this has 3 zones (North, Central, South). In the NAD83 State Plane coordinate system, it has only 1 zone. (Source: Snyder, 1987.)

Nebraska Coordinate System. In the NAD27 State Plane coordinate system, this has 2 zones (North, South). In the NAD83 State Plane coordinate system, it has only 1 zone. (Source: Snyder, 1987.)

New York Coordinate System. This has 3 zones which use the Transverse Mercator projection (East, Central, West) and one that uses the Lambert Conformal Conic projection (Long Island). (Source: Snyder, 1987.)

Polish PSWG 1992 Grid. Included in DIGEST Editions 2.0 onwards. One of the grids to take advantage of the datum ETRS89. It is not on the NIMA list, but "PG" is a spare code. It uses the Transverse Mercator projection. (Source: Institute of Geodesy and Geodetic Astronomy, Warsaw University of Technology)

South Carolina Coordinate System. In the NAD27 State Plane coordinate system, this has 2 zones (North, South). In the NAD83 State Plane coordinate system, it has only 1 zone. (Source: Snyder, 1987)

Switzerland Conformal Oblique Cylindrical Grid. This grid uses a unique projection, including constants that would have been different in another part of the world. The ellipsoid parameters [from Bessel (1841) Revised] are actually built into the constants. There are different versions of the grid depending on whether the new or old centre of Berne Observatory is the origin. A third version treats Berne Observatory as the zero meridian.

Universal Polar Stereographic System. This has a North Polar Zone and a South Polar Zone. It is used with various datums. DIGEST recommends the use of zone numbers 61 and -61 respectively. The DIGEST system of zone numbering follows that of the UTM/UPS Standard Raster Product, in which zones -61 to 61 (excluding 0) cover the entire Earth. The Central Meridian, in the sense of Longitude straight down from Pole on Map, is 0°E in the North Polar Zone and 180°E in the South Polar Zone.

Universal Transverse Mercator. A worldwide system used in the latitude range 84°N to 80°S with various datums. Often regarded as having 60 zones, although it actually has 120: zones 1N to 60N (with a false northing origin of zero) and zones 1S to 60S (with a false northing origin of 10 million). For Editions 2.0 onwards, DIGEST recommends the use of zone numbers 1 to 60 for the northern zones and -1 to -60 for the southern zones.

Voirol 60 Zone.* For Edition 2.1 onwards, DIGEST includes this as a grid system. It has two zones, uses the French Lambert projection, and is based on the North Sahara Datum 1959. (Source: UK DGIA, EPSG.) Some sources incorrectly identify this grid as a datum.