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“More on the UTM Grid system”

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More on the UTM Grid system – international aspects

John L Cruickshank



In *Sheetlines* 96 and 98 Mike Nolan presented what he termed a ‘short note’ on the introduction of the Universal Transverse Mercator (UTM) Grid on military maps.¹ His note is in fact a very substantial one, but concentrates almost exclusively on the process of the application of the new grid system to British military maps as revealed by the associated implementation documentation.

It is worth appreciating, however, that because the UTM grid was initially introduced by the United States Army, and was only subsequently adopted as a NATO (and so British) worldwide standard, the process of introducing the grid was less linear than Mike’s account might suggest. Furthermore documentation was produced and distributed by NATO countries other than Britain,² and also by countries outside NATO, particularly those of the Warsaw Pact. The present note is firstly intended to draw preliminary attention to some elements of this additional documentation that exist and may be encountered in libraries and collections, and secondly to point out their wider significance.

The need for unified worldwide grid systems became starkly clear in the final months of the Second World War (WWII) and early years of the Cold War. Put briefly, the grids of WWII were designed for use in targeting conventional artillery. For such weapons, the presence of a grid junction is a nuisance, but can be dealt with by constructing overlap areas at the junctions of grids. The vastly greater ranges of the V2 rocket and all its successors made such expedients unworkable. Targeting intercontinental ballistic missiles depended crucially on accurate worldwide geodetic data, and the construction of worldwide reference systems. In the USSR, the reference system used was based on their 1942 System of Gauß-Krüger grids, constructed using Krassovsky’s newly-calculated figure of the Earth (1940) and introduced into service in 1946. The geodetic calculations underpinning this had originally been intended merely to unify the hitherto incompatible geodetic systems of the USSR, and to establish a single geodetic framework spanning the vast extent of that country from Central Europe to the Bering Strait. However the size of the USSR was such that subsequent extension of this system around the remainder of the globe required no fundamental change.³ The USA and its allies seem to have been slower off the mark, perhaps

¹ Mike Nolan, ‘The introduction of the Universal Transverse Mercator (UTM) grid on military maps: a sixty year retrospect’, *Sheetlines*, 96 (2013), 20-29. Mike Nolan, ‘The introduction of the Universal Transverse Mercator (UTM) grid’, *Sheetlines*, 98 (2013), 52-53.

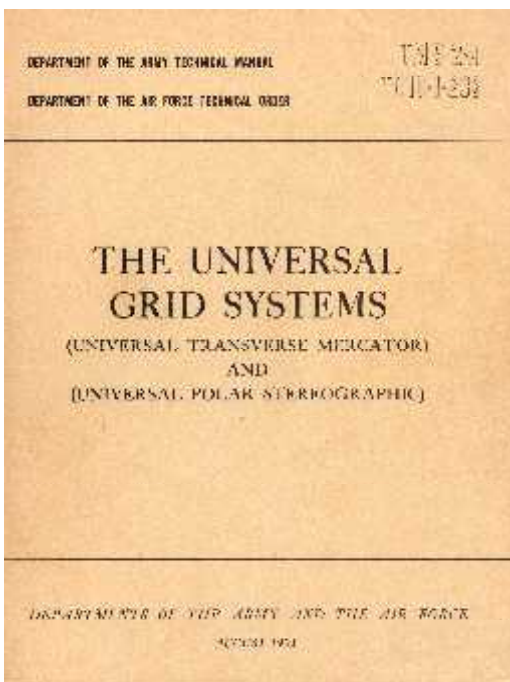
² The NATO Treaty was signed on 4 April 1949.

³ Resolution of the Council of Ministers of the USSR of 7 April 1946, N 760, [On the Introduction of a Unified System of Geodetic Coordinates and Heights on the Territory of the USSR]. SG Sudakov, ‘Osnovnie topografo-geodezicheskie raboti za 50 let Sovetskoi vlasti’, (in) AN Baranov & MK Kudryavtsev (eds.), *50 let sovetskoi geodezii i kartografii*, Moscow: Nedra,

because for them WWII was experienced as a conflict fought in a number of quite separate theatres of action. Many of these theatres were covered by various existing British grids (and map projections), which had been adopted unchanged by all the allied powers where they existed.⁴

Geodetic systems and map projections within the Continental USA and elsewhere in the Americas had developed in isolation from each other and were often incompatible. Following the First World War the United States Army had introduced a series of Lambert Polyconic projections with two standard parallels to be their standard within the USA, and had based their grid system on this projection. The USGS and the USCGS used their own projections and reference systems. From 1936 these had been coordinated such that the Polyconic projection was used for some scales and what became known as the Transverse Mercator was used for others. Individual Polyconic grids were established for each individual state of the Union and for the Panama Canal Zone, Hawaii and the Philippines. As an expedient during WWII this grid system was extended, as the World Polyconic Grid, to combat areas for which British grids had not been established, but was soon recognised to be unsatisfactory.⁵

Following WWII the US Army and Air Force thus worked to develop new ‘universal grid systems’. Mike Nolan quoted (from a 1952 US manual) a description of the adoption in 1947 of the Transverse Mercator Projection with UTM grid as a standard ‘for use in US joint Army-Navy-Air operations involving close contact with the enemy’. The very specificity of this definition of the applicable operations clearly indicates that at that date application of the system was still limited. The general introduction of the UTM grid system can however be dated to 8 August 1951 when the manual *The Universal Grid Systems (Universal Transverse Mercator) and (Universal Polar Stereographic)* was published (*left*). After some introductory text, the bulk of this fat volume (324 pp) comprises sets of tables of numerical values for the construction of UTM grids based on the Clarke 1866 spheroid. The



The 1951 US manual TM 5-241 The Universal Grid Systems

1967, 21-90, esp 69-72. It should be noted that a Gauß-Krüger projection is essentially similar to a Transverse Mercator projection.

⁴ See AB Clough, *Maps and Survey*, London: War Office, 1952, chapter IV, 43-48, for a discussion of the relevant war-time Anglo-American agreements.

⁵ The clearest summary that I know of this complex topic is unfortunately in Russian: AM Komkov, *Gosudarstvennaya Kartografiya SShA*, Moscow: Geodezizdat, 1961, see especially chapter II, section 13, 56-61. There is an extensive English-language bibliography to this work.

section on the construction of the Polar Stereographic Projection is much shorter, as this projection was intended only for use between 80° and 90° North and South. The novelty of this publication is emphasised by the fact that *Changes No. 1* to this manual, issued in August 1952 (just twelve months after the first publication), included a complete rewriting of an introductory section headed 'The Basic Structure of Military Mapping' as well as several other significant changes.⁶

And furthermore, notwithstanding the publication of this manual, a unified worldwide reference system for the western powers had still not been achieved. What now seems jaw-dropping is that five different spheroids were still to be used for different parts of the globe, reflecting the different spheroids historically used in the construction of the then existing mapping. Appendix II of the 1951 manual is a diagram showing the patchwork of areas of the world to be gridded using different spheroids. The grid values for the Clarke 1866 spheroid tabulated in the manual were thus only applicable to the North American continent, Greenland and the Philippines. Several of the boundaries between areas with different spheroids seem to have been chosen to cause confusion and incompatibility. For example the international spheroid was to be used for western and central Europe, including the USSR west of the Leningrad meridian, while the Bessel spheroid was to be used for the rest of the USSR together with Norwegian Svalbard. Revision of the boundaries of these areas was clearly inevitable.

In fact, the use of these multiple spheroids by the western powers was unavoidable at that time. Unlike the Soviet Union, which had a continuous geodetic triangulation chain from the Baltic and Black Seas to the Pacific Ocean, augmented with complementary astronomical observation data, the western powers had no equivalent data set from which to recalculate the figure of the earth. Not until techniques of geodetic measurement using orbital satellites could be developed (from October 1957 onwards) was it possible for the western powers, including the United States, to adjust all their separate geodetic triangulation nets and bring them into conformity on a single spheroid.⁷ Even then, the practical computation of such adjustments also required the development of electronic computing technology.

Nevertheless it can be seen that the introduction of UTM grids on British military maps from 1952, in accordance with the *Army Council Instructions* described by Mike Nolan, formed part of a sequence of events triggered by the

⁶ Department of the Army Technical Manual *TM 5-242* / Department of the Air Force Technical Order *TO 16-1-233, The Universal Grid Systems (Universal Transverse Mercator) and (Universal Polar Stereographic)*, Washington DC: Department of the Army and Department of the Air Force, 8 August 1951.

⁷ The immediate impact of the launch of Sputnik I on the geodetic work of the Ordnance Survey is mentioned in a chapter on geodetic developments in WA Seymour, *A History of the Ordnance Survey*, Folkstone: Dawson, 1980, chapter 34, especially p 346. It is however now obvious that the content of this chapter was substantially constrained by security restrictions; the topic thus requires re-evaluation.

publication of the 1951 American manual, which in turn arose from the experience of WWII and the development of long-range ballistic missiles.

In a further *Sheetlines* article Mike has illustrated the complex patchwork of grids used within Europe and North Africa by the western powers before the introduction of the UTM system.⁸ Historically this pattern had arisen quite simply because different countries had constructed their geodetic nets using independent datums and different spheroids, and had constructed their maps using different projections. The existing grids had subsequently been established on the basis of the existing maps. Not until WWII, when warfare and conquest swept across both much of continental Europe and Africa north of the Sahara, did the necessity to unify all these different systems appear. Nor indeed was it possible to do so before conquest had led to the sharing of geodetic data that had previously remained unpublished in national geodetic archives. Following the German conquest of much of Europe, which included the taking over of many geodetic offices and archives, members of the German General-Staff *Kriegskarten- und Vermessungswesen* organisation began the process of collecting and unifying the geodetic data of the continent.⁹ After the eventual German defeat and organisational degradation, many of the same individuals were once more recruited to continue the same work (with allied encouragement) as part of the *Institut für Angewandte Geodäsie* (IfAG, the Institute for Applied Geodesy), in Frankfurt am Main. The *Army Council Instruction* of January 1952 pictured in *Sheetlines* 96 refers to ‘the recently completed adjustment of European national triangulations’.¹⁰ In a very real sense this British *Army Council Instruction* represents the culmination, and indeed fulfilment, of a German wartime project initiated a decade before. However it should of course be appreciated that the Army Council, in their *Instruction*, silently excluded Britain from Europe. According to Seymour, the incorporation of the Ordnance Survey’s triangulation network into this adjustment did not take place until more than a decade later.¹¹

Mike has also shown that the process of substituting UTM grids for the pre-existing British grids was a very drawn-out one, extending over at least two decades. This was reflected in American manuals, for example a 1955 manual on the compilation of maps specifies that between 80° North and 80° South the major grid indicated should be the UTM grid ‘except in areas for which British grids are prescribed’.¹² It is also reflected in the continued acceptance for use by NATO forces within this country of the Ordnance Survey’s National Grid, which although a transverse mercator grid does not conform to the UTM standard.

⁸ Mike Nolan, ‘Grid colours on military maps’, *Sheetlines*, 98 (2013), 34-37.

⁹ Max Kneissl, *Generalleutnant Gerlach Hemmerich, sein Werk und Wirken*, München: Deutsche Geodätische Kommission, Reihe E, Heft 8, 1969, 14-17 and 26-30.

¹⁰ *Sheetlines*, 96, 28.

¹¹ The British and French triangulations were linked in 1963. The time taken for the subsequent adjustment is not mentioned. WA Seymour, *op. cit.*, 345-346.

¹² *TM 5-240 A Guide to the Compilation and Revision of Maps*, Washington, DC: Department of the Army, 1 September 1955, 17.

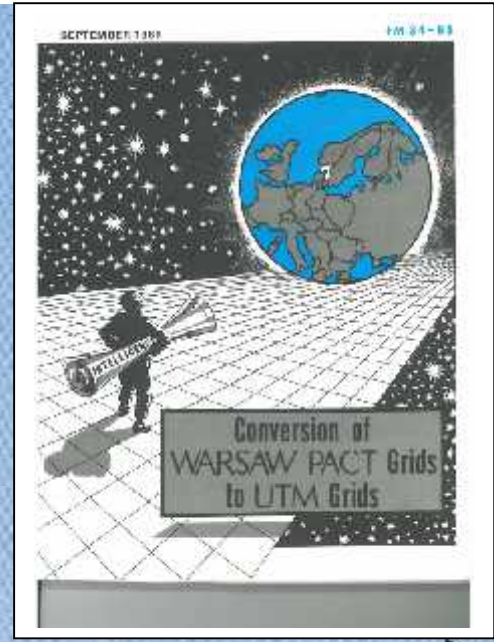
ZONE 1	(42-54N)	N .9996X + 47
		E .9996Y + 157
ZONE 2	(42-57N)	N .9996X + 52
		E .9996Y + 147
ZONE 3	(42-57N)	N .9996X + 55
		E .9996Y - 137
ZONE 4	(40-60N)	N .9996X + 61
		E .9996Y + 129
ZONE 5	(40-60N)	N .9996X + 67
		E .9996Y + 120

(NORWAY)

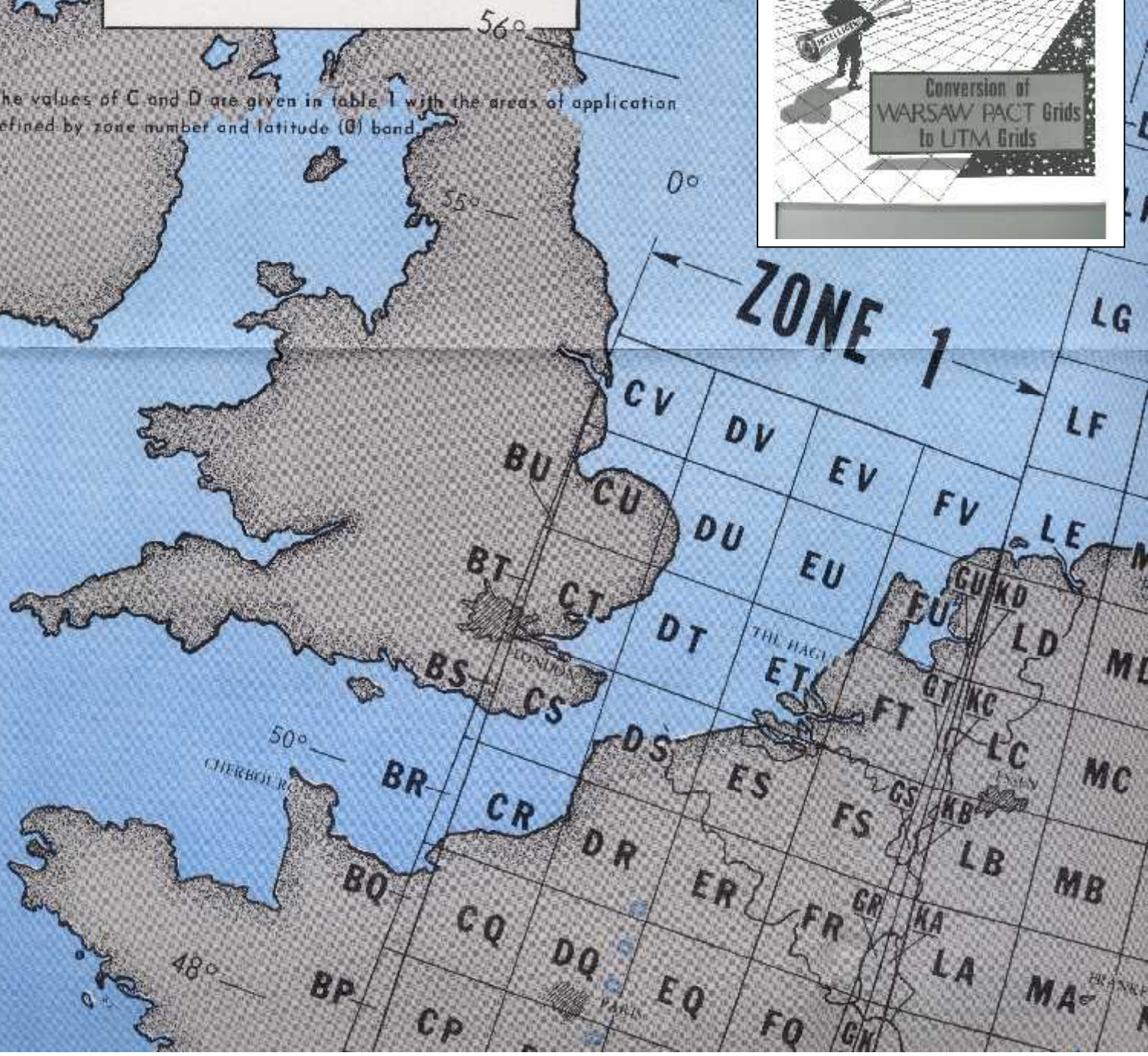
ZONE 4	(69-71N)	N .9996X + 64
		E .9996Y + 134
ZONE 5	(69-71N)	N .9996X + 70
		E .9996Y + 126

Extract from fold-out diagram in FM-84-35 showing Gauß-Krüger grid zones in Western and Central Europe. Note that while the grid-zone boundaries are formed by the same meridians as used for UTM grid zones, the G-K zone to the east of the Greenwich Meridian is grid zone 1, while in the UTM system this is grid zone 31

Inset: Cover of FM-84-35, dated September 1981



The values of C and D are given in table 1 with the areas of application defined by zone number and latitude (Ø) band.



The introduction and extension of UTM gridding by the NATO armed forces was of course noticed by the intelligence services of the Warsaw Pact nations.¹³ During the Cold War each side watched the other's technological developments closely, both to assess where they themselves were ahead, and to plagiarise or replicate significant innovations by the other side. Geodesy was most certainly a topic of interest to both sides, not only because of its central role in the targeting of intercontinental ballistic missiles, and later of cruise missiles, but also because each side needed an accurate locational framework within which to place satellite imagery and other remote sensing data. An example of the Warsaw Pact response to the introduction of UTM grids is the creation and issue by the East-German *Militär-Topographische Dienst* of an entire series of 1:200,000 military topographic maps, covering the expected central and western European battlefield, carrying both their usual Soviet System 1942 Gauß-Krüger grids and an overprinted UTM grid. These were clearly intended for use in interpreting intercepted signals and other intelligence material. Examples of a provisional edition of this series are known from 1960-1961, but a more developed form of the series extending as far as the English Channel was issued in 1985. This incorporated not only both grids, but also placenames and marginal information in both the Russian and German languages.¹⁴ To date I have not seen an analogous purely-Russian series produced

by the Soviet Military Topographic Service, but it surely must exist.

Likewise US Army Intelligence officers needed to be able to interpret intercepts. An intelligence field manual *FM 34-85 Conversion of Warsaw Pact Grids to UTM Grids* was produced, with supplementary manuals giving detailed conversion tables for particular parts of the globe. Thus *FM 34-85-1 GK Conversion (Mideast)* was issued in February 1983 (left).¹⁵ Unlike earlier US Army manuals, these have attractive graphics on the front cover, although rather than using Soviet-pattern dividers (which are very distinctive) the Russian bear is shown using a western-style instrument to measure part of northern Iran. The prospect of changes in the spheroids used for different areas of the globe within the UTM system was mentioned above. Whereas in 1951 the Middle East had been a meeting point of mapping and grids with four



The cover of M 34-85-1 GK Conversion (Mideast), Feb 1983

¹³ See AM Komkov, *op. cit.*

¹⁴ Kartenart 05.6. UTM-gridded maps were also produced at 1:500,000 and 1:1M (Kartenarten 05.7 and 05.8).

¹⁵ *FM 34-85-1 GK Conversion (Mideast)*, Washington DC: Department of the Army, 2 February 1983. The parent manual is *FM 34-85 Conversion of Warsaw Pact Grids to UTM Grids*, Washington DC: Department of the Army, 25 September 1981.

different spheroids, in the 1983 manual the whole area was referred to the European Datum and International Spheroid. Nevertheless the foldout map at the back of the manual carries a note that yet further changes were pending in the boundaries between spheroids, particularly as they concerned Afghanistan, Saudi Arabia, and Kuwait (all of them areas of Soviet and/or NATO military interest). One is left wondering whether this represents disinformation, since by this time the transition to a unified worldwide system based on satellite data had become both possible and imminent. It became an actuality the following year with the introduction of the World Geodetic System (WGS 84).

Even so, while WGS 84 still remains the standard to which the American Global Positioning System (GPS) relates, in the decades since its introduction it has undergone minor revisions, including revisions to its ellipsoid. Similarly the Soviet (and now Russian) parameters of the earth have also been updated to achieve progressively greater accuracy and precision, new values being established in 1977, 1985, and 1990.¹⁶

Mike Nolan's 'short note' should thus be seen as opening a door into a broader history of the development of modern geodesy. In our small islands off the coast of western Europe we have tended to take geodesy for granted, or even to regard it as a nasty habit that foreigners indulge in, yet GPS, GLONASS and Google Maps are now ubiquitous in our lives and in the economy of our country, as well as in the rest of the world. Ordnance Survey practice and procedure have certainly been transformed. While the most visible indication of this transformation may be the dramatic reduction in the number of trig points and pillars to be maintained, this is merely a reflection of rather more fundamental changes which seem overdue for description. Indeed, despite some important recent essays,¹⁷ a comprehensive historical account of the development of modern geodesy and its impact on our lives is still awaited.

¹⁶ Valerii V Glushkov, 'Otechestvennie kosmicheskie geodezicheskie kompleksi: istoriya i perspektivi', (in) *Godochnaya Nauknaya Konferentsiya 2007g. Instituta Istorii Estestvoznaniya i Tekhniki Imeni S.I. Vavilova*, Moscow: Akademiya Nauk, 2008, 524-530.

¹⁷ Examples include: John Cloud, 'American Cartographic Transformations during the Cold War', *Cartography and Geographic Information Science*, 29 (2002), 262-282 (available on-line at <http://www.geography.wisc.edu/histcart/v6initiative/11cloud.pdf>); John Cloud, 'Crossing the Olentangy River: The Figure of the Earth and the Military-Industrial-Academic Complex, 1947-1972', *Studies in the History and Philosophy of Modern Physics*, 31 (2000), 371-404; Valerii V Glushkov, *op. cit.* (2008); Gerry Brotton, 'Information; Google Earth 2012', (in) Gerry Brotton, *A History of the World in Twelve Maps*, London: Allen Lane, 2012, 405-436; Ed Parsons, 'The Map of the Future May Not be a Map!', *The Cartographic Journal*, 50 (2013), 182-186.