

# ISO19152 Land Administration Domain Model-oriented Niger River 3D Satellite Mapping

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- **Osaka Metropolitan University: Ramata Coulibaly; Bamako, Mali**
- **GeoNet, Inc. CEO: Hiroyuki Hasegawa; Osaka Pref., Japan**
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- **Bank of Ghana: Doe Rosemary Elikem; Accra, Ghana**

Key words:

ISO19152-Land Administration Domain Model, UTM map projection,  
Differential GPS 3D mapping, Satellite photogrammetry 3D mapping,  
4D Image Map Archive Designed Aerial Studies (IMADAS)

## Summary

This presentation will introduce the system configuration, survey map production regulations, and map creator training process for creating 3D cadastral maps in the Federal Republic of Nigeria and the Republic of Mali along Niger river in accordance with ISO19152-LADM (Land Administration Domain Model), based on the current state of cutting-edge fields in Japan and around the world.

According to the Land Survey Act and the Cadastral Survey Work Regulations, to create cadastral maps, the reference control point can be determined as the Japan basic triangulation point (electronic control point) of GNSS satellite surveying and the instrument point and backsight point of a total station surveying system that performs ground (one parcel) surveying from that alone, which is called the Japan single-point observation method, officially.

Osaka, a pioneer in cadastral surveying in Japan, completed 1/ 20,000 topographical map in 1910 (Meiji 43), and since 1952 has been able to display, measure, and store nationwide data for each paddy field plot using a unified coordinate system on a GIS system( UTM map projection). The creation of cadastral maps began with the Johri land administration system of the Taika Reforms in 645 A.D., and continued through Toyotomi Hideyoshi's "Taiko Land Survey" and "Shogun" Tokugawa Ieyasu's "National Map Creation," which crushed the Pope and the King of Spain's plans to occupy Japan and enslave the Japanese in the 1590s by expelling them and the Christians with the world's largest gun army,

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Rosemary Elikem (Ghana)

before leading to the land tax reform and cadastral map creation of the 1870s .

We propose, with the world-leading satellite surveying and photogrammetry, the followings ;

- (1) WGS84-UTM Zone -1/10,000 National Land Base Map Boundary Setting Method
- (2) DGPS Satellite Surveying - Large-Scale 3D Cadastral Mapping
- (3) Existing Aerial Photographs - Bundle Aerial Triangulation - 3D Topographic Mapping
- (4) High-Resolution Satellite Image Photogrammetry 3D Mapping

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## Introduction

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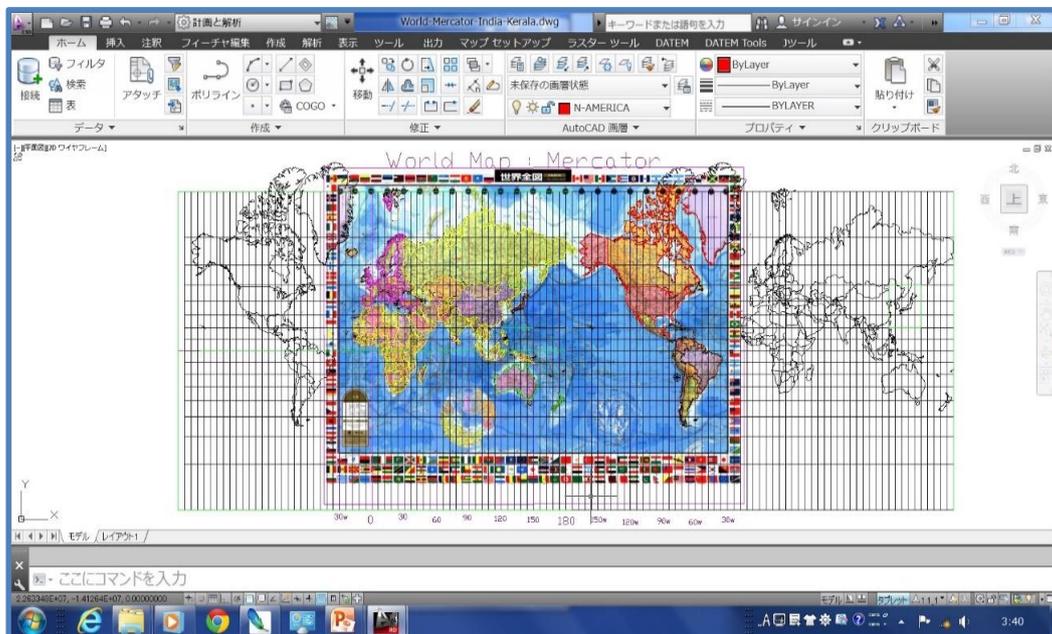
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## Chapter 1. WGS84-UTM Zone -1/10,000 National Land Base Map Grids Setting

Map projection and CAD globe that overcome cartography colonialism and the data copyright issues of Google Earth: with the invention of CAD globe, we propose a map projection method for creating basic national maps as a WGS84-based ellipsoid-UTM zone version, supported by GNSS satellites geodetic network adjustments, satellite image photogrammetry, bundle triangulation, and digital stereo plotter (AutoCAD version), which are the basis of ISO19152-Land Administration Domain Model as global standard. UTM map projection was originated from Gauss-Krueger conformal transverse cylindrical map projection and named after the book “Handbuch der Vermessungskunde, 1948”.

Cartography played a significant role in colonialism, functioning as a tool for claiming territory, imposing political control, and shaping public perception by framing colonized lands as empty or "discoverable" by European powers. Colonial maps served to dispossess Indigenous peoples, divide communities, overwrite local histories and languages with colonial ones, and establish artificial boundaries that continue to cause conflict in postcolonial nations. These maps were not neutral but were powerful mechanisms of domination that encoded power relations and served the interests of colonial empires. Cartography colonialism is thus criticized, as is the execrable political buzzword "labouring poor," which symbolizes the primitive accumulation of the capital accumulation process that is the essence of colonialism. In authentic 3D-DX (Digital Transformation initiative) cartography, economic entities are represented alongside 3D topography, to ensure Land Administration Property and Sovereignty.



**Fig. 1.01 Cartography Colonialism : World Map Mercator map projection**

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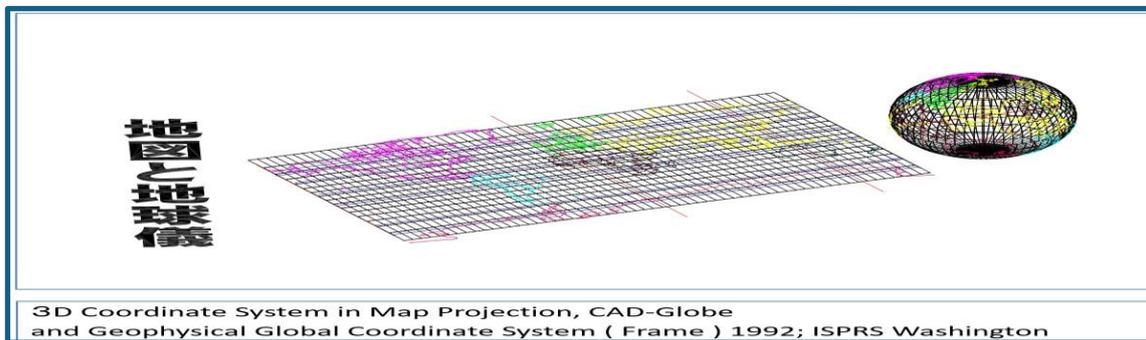
FIG Congress 2026

The Future We Want - The SDGs and Beyond

Cape Town, South Africa, 24–29 May 2026

## AutoCAD map image before CAD-Globe - 1992

CAD Globe was defined by Hiroyuki Hasegawa in 1992, at presentation in the International Society of Photogrammetry and Remote Sensing; ISPRS 1992 Washington congress.



**Fig. 1.02 CAD Globe -ISPRS Washington congress1992**

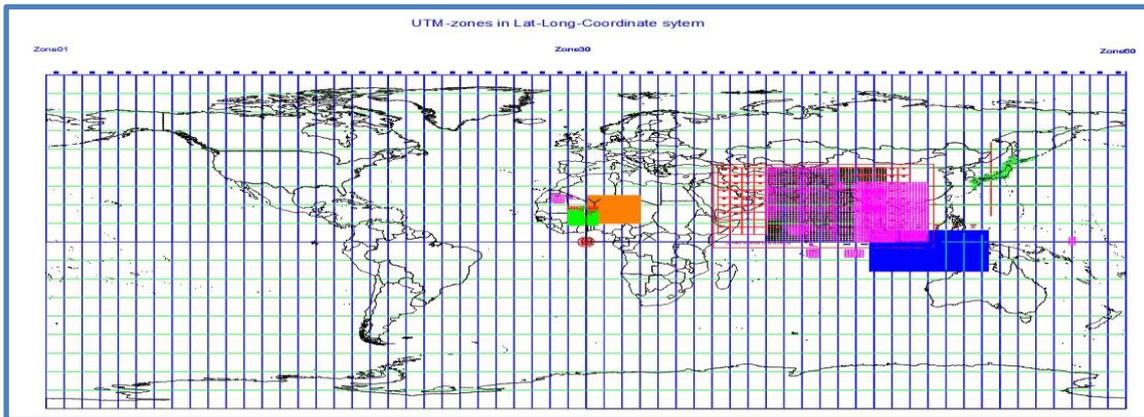
CAD Globe was exhibited on AutoCAD 3D coordinate systems with both maps and 3D ellipsoidal globe to be displayed in mm to the range of the whole solar system.

Since 2000, GNSS satellites as earth control points, defining the gravity center of the earth as the origin of earth rotary ellipsoid coordinate system, geodetic network adjustments have realized the ground accuracy of 1cm. If only small numbers of national reference stations derived from IGS (International GNSS data Service: JPL, USA) worldwide reference stations, we could configure the national reference GNSS stations in Nigeria, Ghana and Mali in 5G-6G internet, so safe and secure.

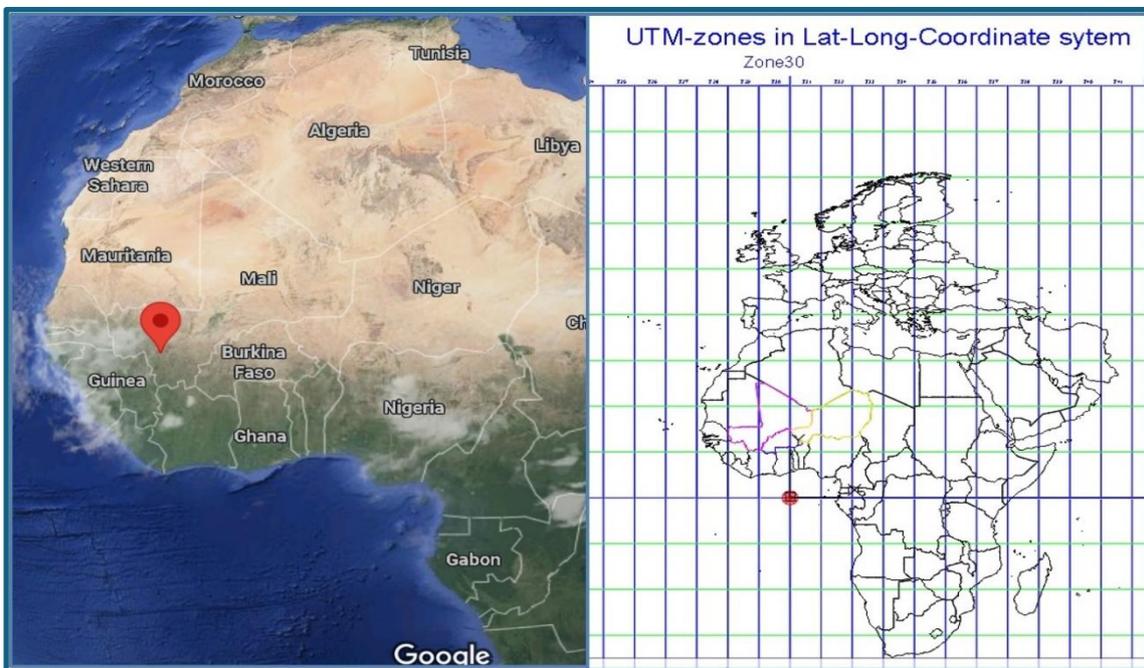
### 1.1 ISO19152-Land Administration Domain Model : Ghana – Mali 3D mapping

ISO19152-Land Administration Domain Model will be finalized in FIG2026 congress; Cape Town – South Africa. We refer to this world standard for Ghana-Mali 3D mapping.

UTM 60 zones are mapped as Latitude Longitude rectangle map projection in AutoCAD map projection module, transforming Survey of India map grids and Japan UTM map grids.



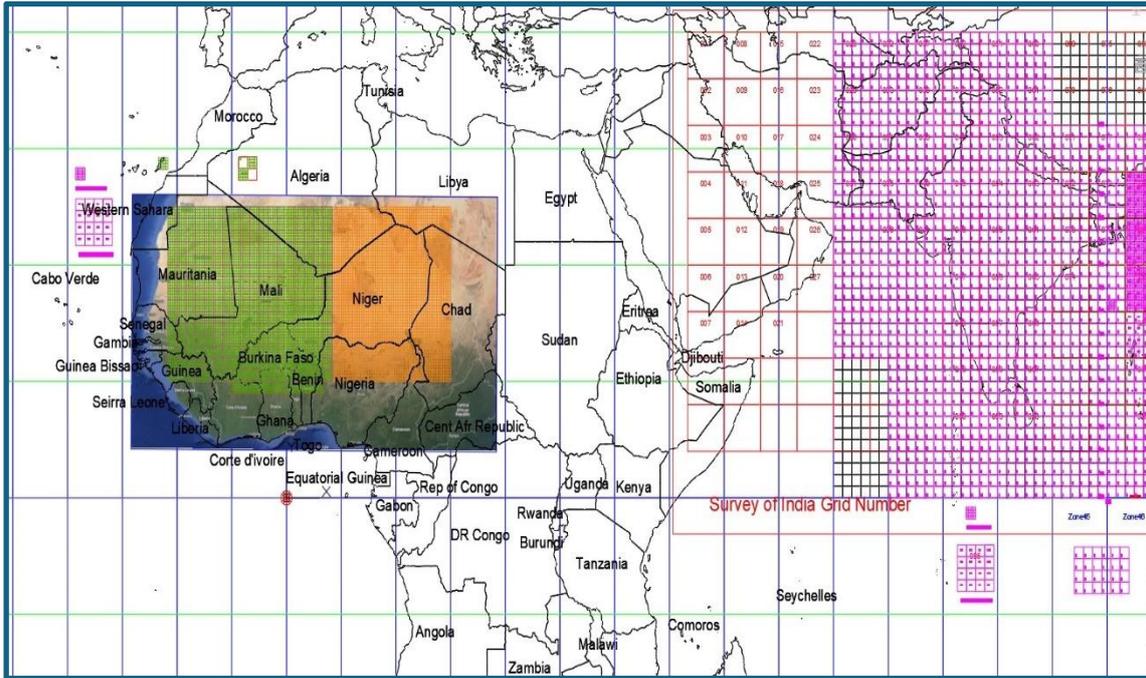
**Fig. 1.11 UTM 60 zones-Latitude Longitude rectangle map projection in AutoCAD map projection module**



**Fig. 1.12 Africa UTM zones in Latitude Longitude rectangle map projection**

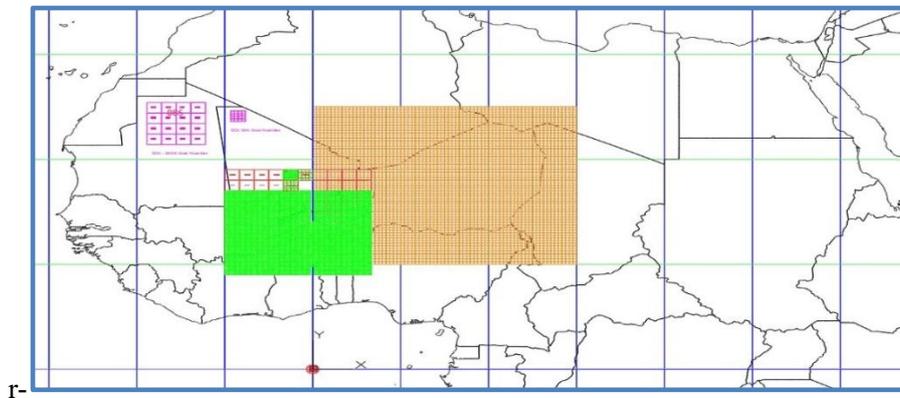
WGS84-LL84-Map Grids : Ghana- Burkina Faso-Mali-Niger-India have the followings;

- (1) Prime geodetic datum: WGS84 reference ellipsoid
- (2) Original map projection: Latitude-Longitude rectangle
- (3) Basic map projection: Universal Transverse Mercator 60 zones



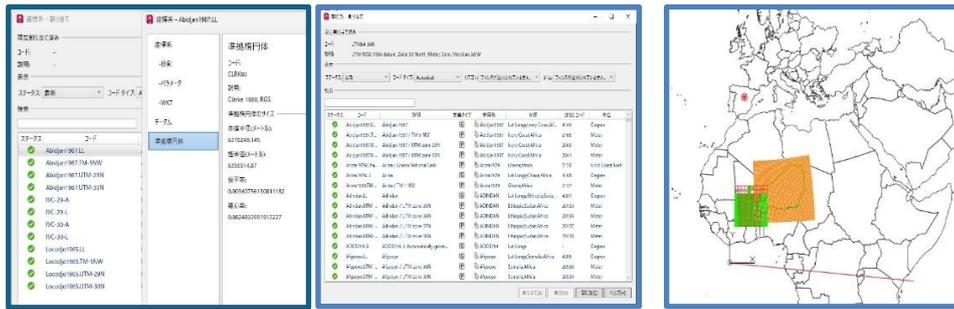
**Fig. 1.13 WGS84-LL84-Map Grids :Nigeria-Ghana- Burkina Faso-Mali-Niger-India**

UTM zones-Ghana-Burkina Faso-Mali and Niger-10K-mapgrids are divided into four zones, from 25K-mapgrids of 0.25 x 0.25 degree rectangle, according to classic grid numbering rule in 1960s.



**Fig. 1.13 UTM zones- 250K-50K-10K-mapgrids  
in Latitude Longitude rectangle map projection**

To achieve equal-area map projection, original map projection: Latitude-Longitude rectangle map projection is to be transformed (map projected) by AutoCAD map projection module in a rigorous way of map projection. We could start with the old map projection, like Abidjan-1987-LL-Clarke1880 for Ghana – Mali as follows;



**Fig. 1.14 Abidjan-1987-LL-Clarke1880**

**Fig. 1.15 WGS84-UTM30N-Ghana-Burkina Faso-Mali-Niger 2025**

**Fig. 1.16 UTM30N- Map Projection on AutoCAD Map : Ghana-Burkina Faso-Mali-Niger**

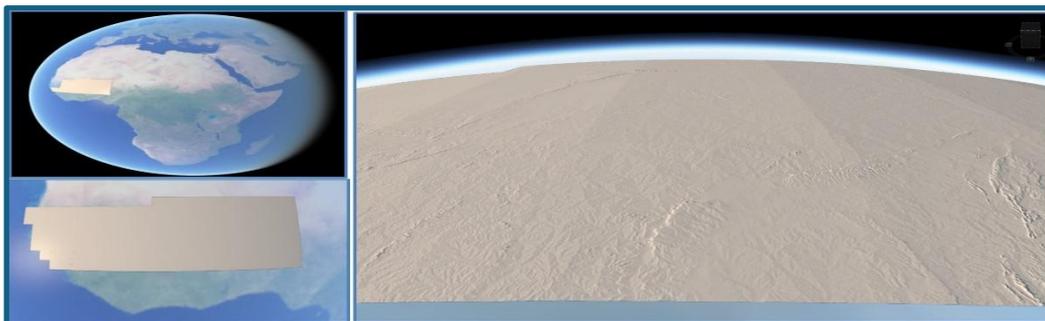
WGS84-UTM30N-Ghana-Burkina Faso-Mali is now the standard referenced map projection.

UTM30N-Ghana-Burkina Faso-Mali-Niger is now defined on AutoCAD image map.

To generate 3D maps, terrain heights could be expressed as either terrain grid spot height or TIN (Triangulated Irregular Network) surface terrain heights in 3D-CAD (like AutoCAD).

CAD Globe has the essential components of digital GEO tiff style map images with Digital Elevation Model, like NASA-JAXA world 3D- 30m grid spot heights.

NASA-JAXA-30m-DEM covers worldwide and downloads could be done for Ghana – Mali countries area, to be formed with GEOtiff style map images, according to the WGS84 UTM map projections.



**Fig. 1.18-1 NASA-JAXA-30m-DEM: Mali-Burkina Faso-Niger-Chad area**

Map images of Ghana-Burkina Faso-Mali area is now derived from University of Texas,Austin; Map Library as 250K map series as follows;



**Fig. 1.18-2 USA-2M maps in Abidjan-1987-LL-Clarke1880  
-Ghana-Mali-Burkina Faso-Niger-1973**



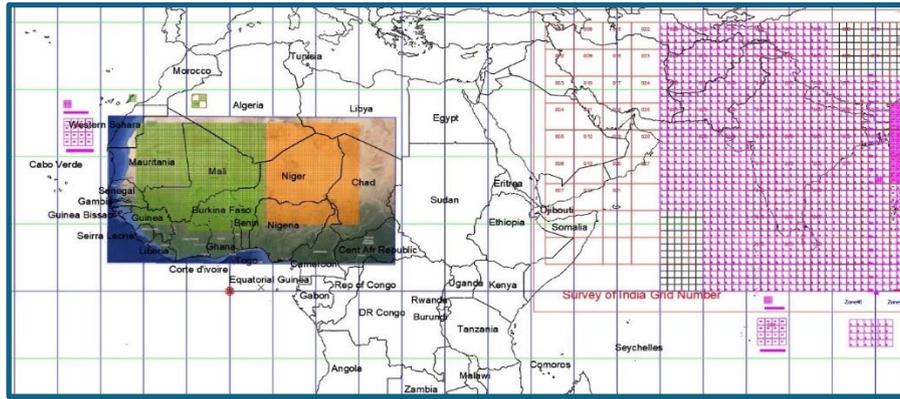
**Fig. 1.18-3 USA-1973- 2M- 6maps : 2M-africa\_index\_map**

USA-1973-2M-6maps are now unified and projected with 2M-africa\_index\_map. Also USA-1973-250K maps- Grids and Numbers are first defined in Abidjan-1987-LL-Clarke1880 map projection, and are to be transformed (projected) on WGS84-LL84 coordinate system in AutoCAD map module.

## **1.2 ISO19152-Land Administration Domain Model : Grids and Numbers**

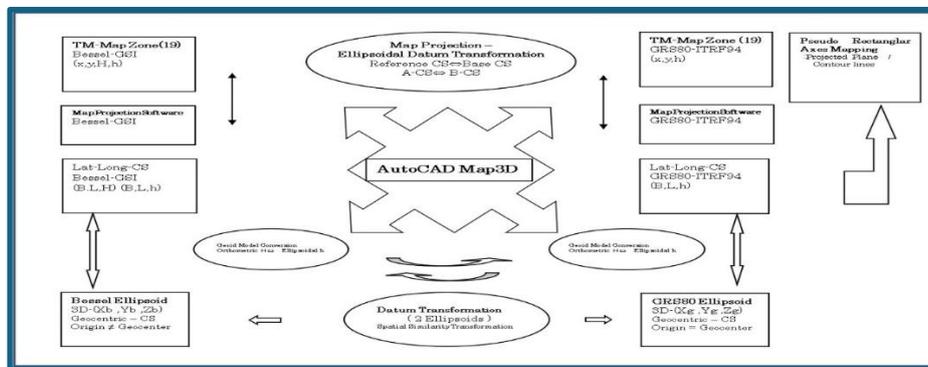
Classical map grids and numbers are started from Survey of India, based on the Indian “The Great trigonometrical Survey”, which began on 10th April 1802 with the survey of a baseline near Madras, and was completed in 1871.

The essence is the reference ellipsoid (spheroid) and map projection map corner grid’s latitude and longitude to be transformed and map projected in 3D CAD map projection module.



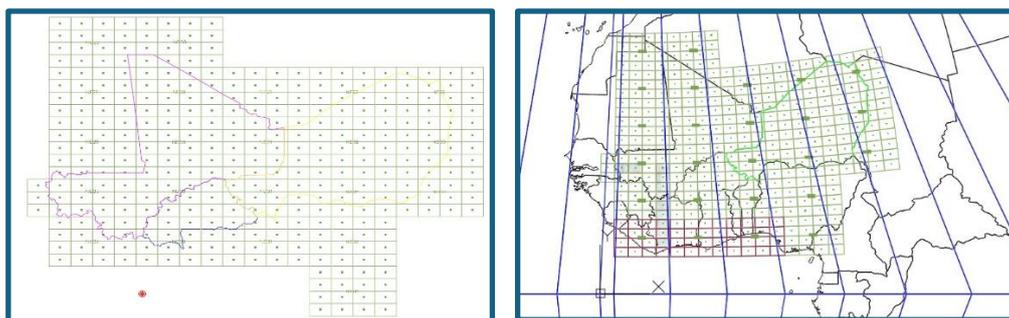
**Fig. 1.21 Ghana- Burkina Faso- Mali-Niger-3D-mapping  
- WGS84-UTM map projection zones**

Now we could use the traditional grid and numbering rules in 1970s, based on the rigorous transformation and map projection process as follows;



**Fig. 1.22 Map projection and Ellipsoidal DATUM Transformation in Japan  
Bessel1841 ellipsoid to GRS80 ellipsoid ( Geo-Centric coordinate datum)**

Ghana-Mali 3D mapping has the following map grid and numbering rules, according to USA mapping rule in 1970s, to be re-formalized in a rigorous way of map projection.



**Fig. 1.23 USA-1973-250K maps- Grids and Numbers**

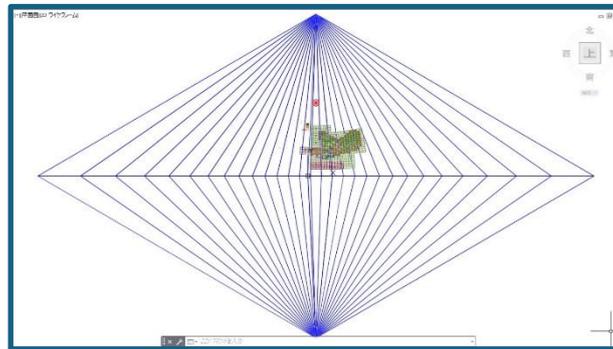
**Fig. 1.24 UTM29N-from Abidjan-1987-LL-Clarke1880**

UTM29N in WGS84 ellipsoid is transformed from Abidjan-1987-LL-Clarke1880 in Latitude

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Longitude rectangle map projection as follows, in AutoCAD map projection.

10K-numbering UTM29N is now defined on WGS84-LL84 map projection, to accept old and new grid and number rules for existing map sheets.



**Fig. 1.25 10K-numbering UTM29N**

### **1.3 Summary of current status:**

ISO19152-LADM-Ghana-Burkina Faso-Mali-Niger - 3D cadastral and agricultural mapping is to be proposed in FIG2026- Cape Town- South Africa – congress for the final standard.

We could summarize now the following items;

1. Land Administration Mapping is based on WGS84-UTM projection maps of 1/10,000.  
: **AutoCAD-Map projection module; to WGS84-UTM 60 zones**  
; **map scale 1/250,000 to 1/10,000**
2. Boundary points have geo-centric coordinates from GNSS geodetic networking  
, which has the origin at earth gravity center as the focus of an ellipse of GNSS trajectory.  
: **IGS global 500 stations combined national reference GNSS stations; 50kms interval**
3. Existing aerial photos are to be digitalized into high resolution images  
for bundle triangulation for 3D digital image models on 3D display with / without glasses.  
: **Instead satellite image stereo 3D mapping on Summit Evolution(AutoCAD) - 3D display**
4. For official archive, 3D digital image models and 3D image maps, as historical reality,  
are to be displayed on PC screen, measured and archived as title of land ownership.  
; **sustained by GNSS satellite networking, aerial / satellite photogrammetry**  
**and Least square adjustment based on map projections.**  
; **3D CAD mapping school in Osaka/ Ghana/Mali**
5. Map projections are based on USGS- Map projection working manual,  
and realized on 3D CAD/GIS systems, transforming ground accuracy of GNSS surveying.  
: **Ground unit in mm; Ground accuracy of GNSS geodetic networking in cm**

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6. CAD-Globe, Google Earth like presentation, is 3D diorama model maps for land design and construction on modern construction / forestry machines, as 3D mapper.  
**: Historical maps are to be transformed digitally to 3D DX maps, as Historical Reality, unified by 4D Image Map Archive Designed Aerial Studies (IMADAS).**

**Chapter 2. 3D DX(Forest) Map DGPS Satellite Survey  
 : 3D Diorama Model Creation Method**

3D Forest Map DGPS Satellite Survey for 3D Diorama Model Creation Method was conducted in Kyoto University Kamigamo Test Site, using Control Point 1 and Control Point 2.

DGPS-Garmin receiver and antenna on the roof of Suzuki Jimny-car took 1sec- GXGYGZ coordinates into AutoCAD-DXF files to 3D forest map.

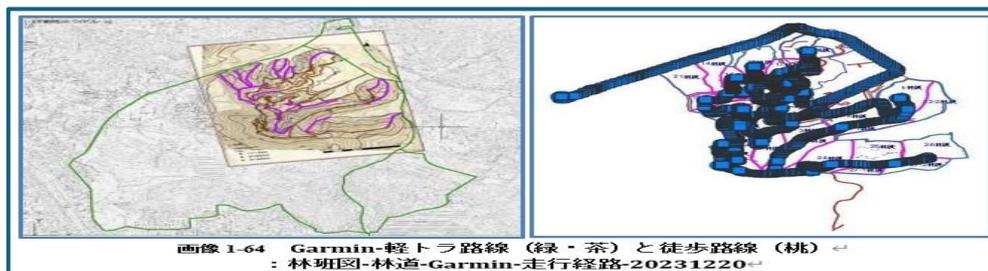


**Fig. 2.01 DGPS-3D mapping: Kyoto Univ. Kamigamo research forest**

**Fig. 2.02 DGPS satellite survey - forest compartment map - ortho image**

DGPS satellite survey - 3D topographical mapping in Kyoto University Kamigamo Research Forest was prepared with forest compartment map - ortho image.

For DGPS-3D topographical mapping in Kyoto University Kamigamo Research Forest, Forest compartment maps were unified into UTM map system, and DGPS-1 second-walking and Driving routes are projected in 3D forest map.



**Fig. 2.03 DGPS-3D topographical mapping**

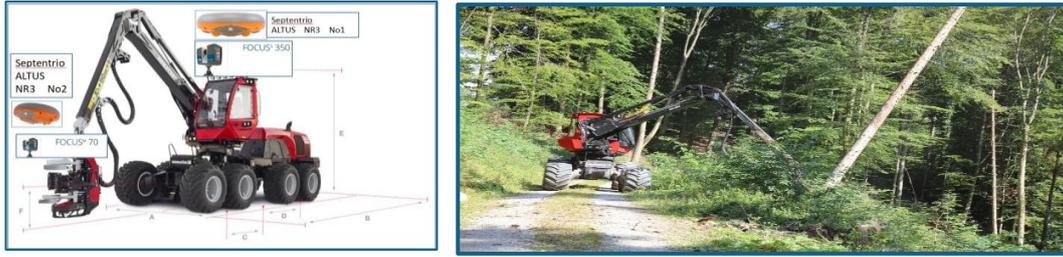
**-Kyoto University Kamigamo Research Forest**

**-Forest compartment map-DGPS-1 second-Driving route**

For 3D mapping, NASA-JAXA global 30m DEM is now introduced in AutoCAD Infraworks for CAD Globe presentation, to design the infrastructure and to drive(move) construction machines.

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**Fig. 2.04 Forestry vehicle 3D mapping : Komatsu harvester - GNSS-TLS**

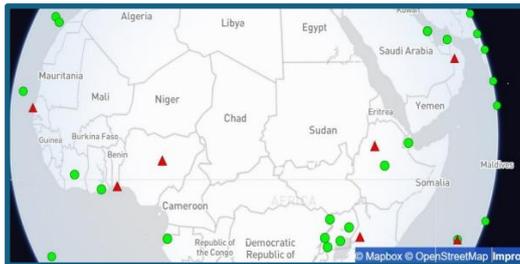
**Fig. 2.05 Komatsu Harvester-cutting Komatsu Forest : Singen excursion;2019.09.20**

3D-CAD map is well combined with forestry machines, and teaching operator is advanced in Japan.

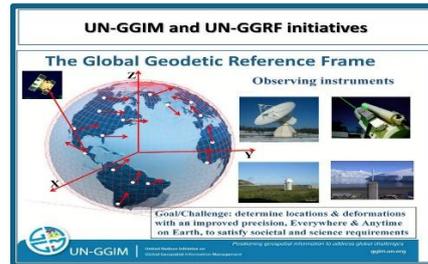
## 2.1 UN-GGIM and UN-GGRF oriented 3D mapping in Cambodia

Before Ghana – Mali 3D mapping, we investigated the current GNSS reference stations in the world, via IGS network in FIG2025 Working Week, Brisbane-Australia. For GNSS geodetic networking, we selected German standard software: “PANDA” as a candidate software of reference stations adjustment, since German official reports used this software as standard.

UN-GGIM and UN-GGRF have organized IGS-world-500 reference stations. So we could add more reference stations in Ghana and Mali and other countries.

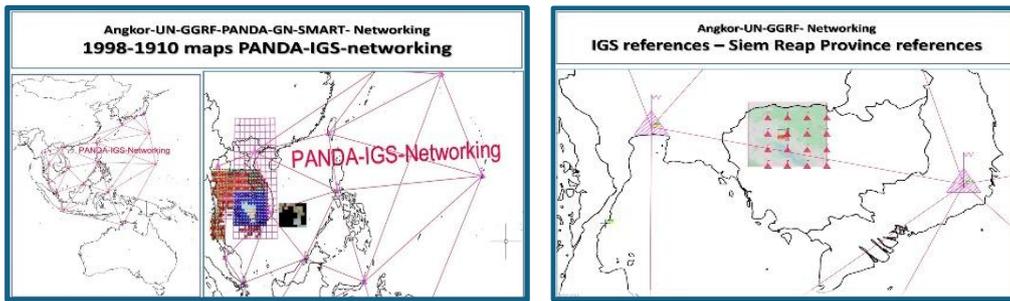


**Fig. 2.11 IGS-world-500 reference stations-in Africa**



**Fig. 2.12 UN-GGIM and UN-GGRF**

As a proposed example, Angkor-UN-GGRF geodetic networking was planned with PANDA and GN-SMART software for APSARA authority organization.



**Fig. 2.13 PANDA-IGS-networking**

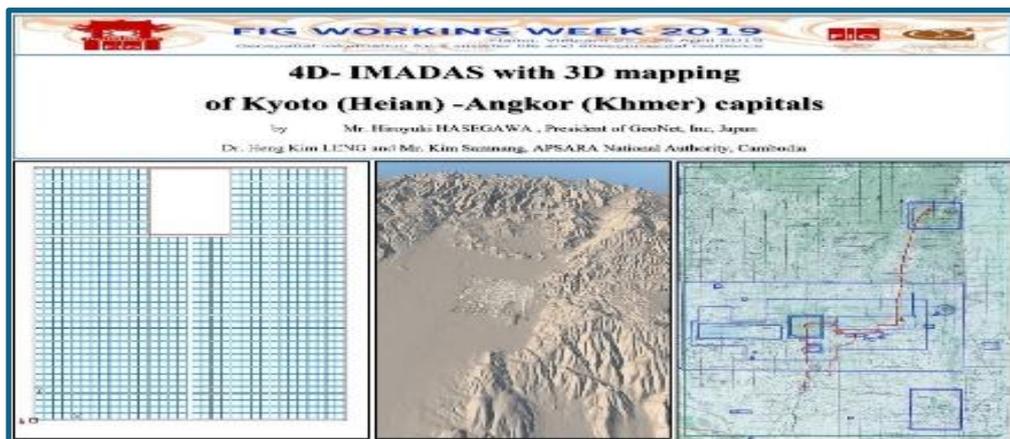
**Fig. 2.14 Siem Reap province networking**

**2.2 Large scale 3D cadastral mapping, using Differential GPS Surveying**

Parallel with the nationwide GNSS geodetic network adjustment, the first step of 3D large scale mapping of Ghana could be learned from the experience of Angkor DGPS mapping in 2016.

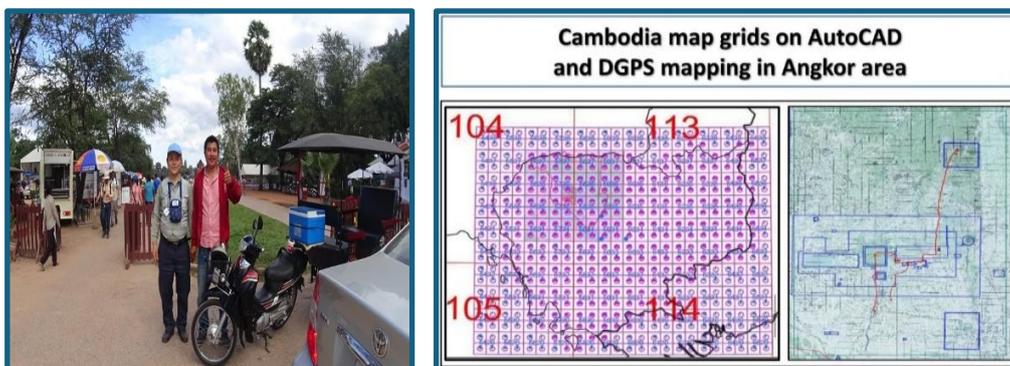
The process was presented in FIG Working Week 2019 Hanoi, Vietnam.

For 1/5,000 or larger map scales, we could use DGPS with the accuracy 2- 3m on the ground.



**Fig. 2.21 Heian(Japan)-Khmer(Cambodia)-palaces in 9th ce.**

**Fig. 2.23 Angkor DGPS mapping**



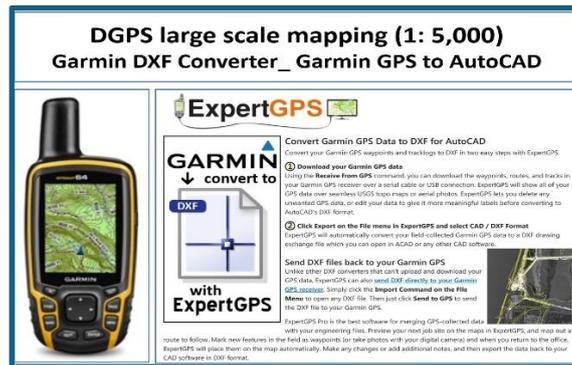


Fig. 2.24 DGPS mapping Cambodia Angkor Wat : (2016.11.30)

1 sec (GX / GY / GZ) coordinates to AutoCAD MapMobile Mapper/ Garmin DGPS mapper

Fig. 2.24 Garmin-DGPS-ExpertGPS

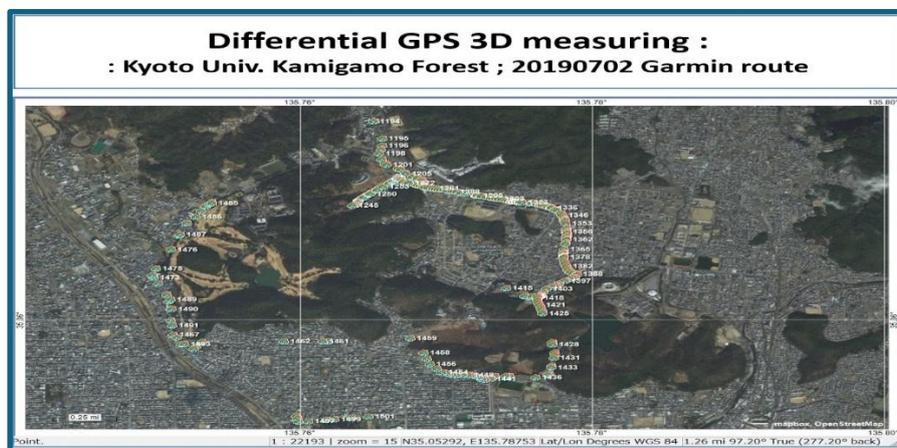
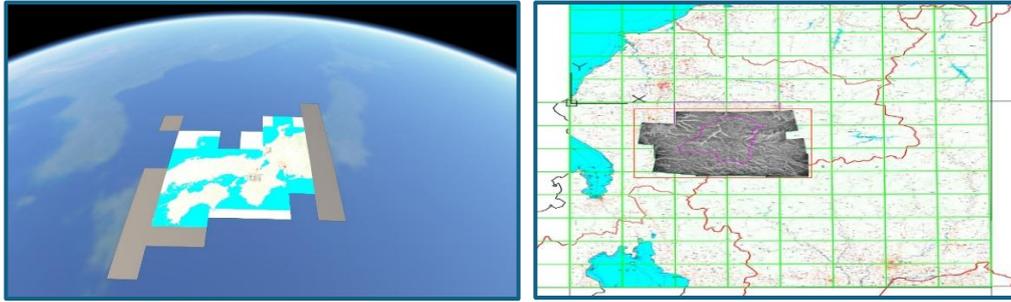


Fig. 2.25 Garmin-DGPS-ExpertGPS-Kyoto Univ

### Chapter 3. Vintage aerial photos(1970)

#### – automatic bundle triangulation of Fukui prefecture

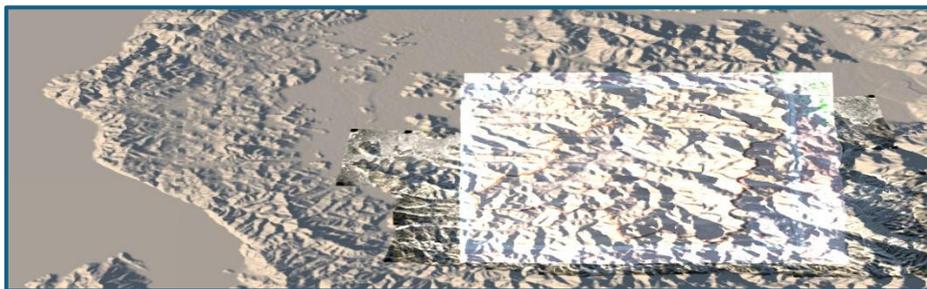
In 2000s, Kyoto University researchers asked GeoNet to generate 3D aerial photo model of Burkina Faso on digital stereo plotter: Summit Evolution. In FIG2025 Brisbane, the authors presented a paper on automatic bundle triangulation of Fukui prefecture in 1970.



**Fig. 3.01 CAD-Globe-JAXA-30mDEM-2000-200K map images**

**Fig. 3.02 Fukui prefecture- Ikeda town -1970 bundle triangulation**

Fukui prefecture forest basic maps are draped on JAXA 30m DEM for forestry boundary map and logging load designing as CAD Globe on AutoCAD-Infraworks show/measure/archive system.



**Fig. 3.03 Fukui prefecture- Ikeda town -CAD Globe- logging road design**

For the final target of 3D mapping in Land Administration, especially forest administration, the unit forest land parcels and individual trees are to be registered as inventory items with essential attributes in asset register on 3D-DX map ( 3D CAD map) as legitimate title of land registration. The most advanced institutes are University of Goettingen; Germany and Faculty of Forestry; University of British Columbia; Canada.

#### Chapter 4. Satellite photogrammetry

3D mapping for wide area in the world needs 3D image models from satellite photogrammetry.

We have already made 3D photogrammetric models on digital stereo plotter; Summit Evolution (AutoCAD version) with 3D display to be displayed/ measured/ archived as 3D CAD map.



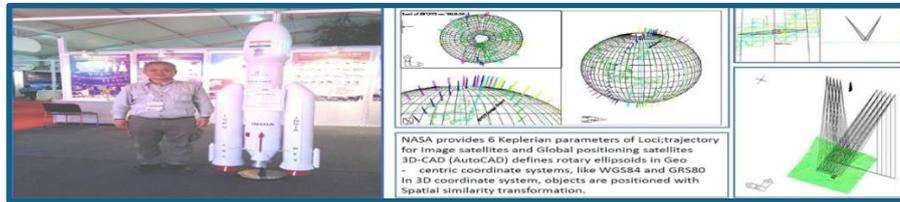
**Fig. 4.01 Satellite Photogrammetry of Kyoto University: ACRS2017-presentation**

**Fig. 4.02 TIN Surface modeling in AutoCAD-Civil3D : INPHO- 3D diorama**

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As the final product of 3D mapping, 3D diorama model on CAD Globe is produced. For satellite photogrammetry, we have been negotiating with the Survey of India for satellite stereo images worldwide. We have made SPOT, IKONOS, ALOS stereo images for accuracy evaluation, starting from 1995 Kobe earthquake research projects.



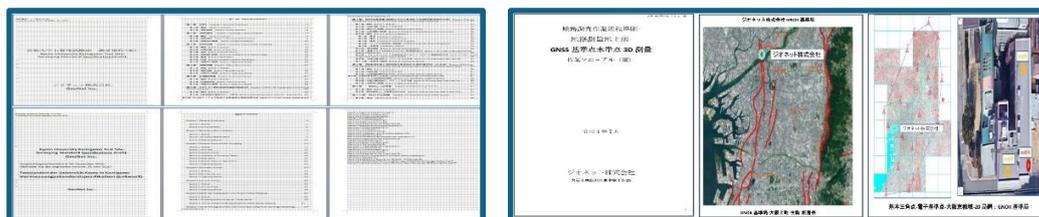
**Fig. 4.03 ACRS2017-Indian Satellite**

## Chapter 5. Regulations and Specifications (draft)

Since 2011, we have been preparing for practical regulations and specifications, negotiating with governmental authorities, based on Regulatory Exemption Regulations, starting from Land Survey Act and the Cadastral Survey Work Regulations, as follows;



**Fig. 5.01 Regulation-German-translated: Gauss bust (LGLN, Germany)**



**Fig. 5.02 Regulation-forestry-Japanese-English-German-draft**

**Fig. 5.03 3D mapping Regulation-draft: Osaka active faults, CORS and GNOK stations**

For 3D forest mapping, Forestry Agency - Measurement regulations, forest road regulations, map regulations are now introduced in AutoCAD mapping layer templates.

Layer Name	Color	Line Style	Symbol	Text Style	Layer Name	Color	Line Style	Symbol	Text Style	Layer Name	Color	Line Style	Symbol	Text Style	Layer Name	Color	Line Style	Symbol	Text Style	Layer Name	Color	Line Style	Symbol	Text Style	Layer Name	Color	Line Style	Symbol	Text Style	Layer Name	Color	Line Style	Symbol	Text Style	Layer Name	Color	Line Style	Symbol	Text Style																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
01	Red	Solid	Circle	Standard	02	Green	Solid	Square	Standard	03	Blue	Solid	Triangle	Standard	04	Yellow	Solid	Star	Standard	05	Magenta	Solid	Diamond	Standard	06	Cyan	Solid	Cross	Standard	07	Black	Solid	Circle	Standard	08	Red	Solid	Square	Standard	09	Green	Solid	Triangle	Standard	10	Blue	Solid	Star	Standard	11	Yellow	Solid	Star	Standard	12	Magenta	Solid	Diamond	Standard	13	Cyan	Solid	Cross	Standard	14	Black	Solid	Circle	Standard	15	Red	Solid	Square	Standard	16	Green	Solid	Triangle	Standard	17	Blue	Solid	Star	Standard	18	Yellow	Solid	Star	Standard	19	Magenta	Solid	Diamond	Standard	20	Cyan	Solid	Cross	Standard	21	Black	Solid	Circle	Standard	22	Red	Solid	Square	Standard	23	Green	Solid	Triangle	Standard	24	Blue	Solid	Star	Standard	25	Yellow	Solid	Star	Standard	26	Magenta	Solid	Diamond	Standard	27	Cyan	Solid	Cross	Standard	28	Black	Solid	Circle	Standard	29	Red	Solid	Square	Standard	30	Green	Solid	Triangle	Standard	31	Blue	Solid	Star	Standard	32	Yellow	Solid	Star	Standard	33	Magenta	Solid	Diamond	Standard	34	Cyan	Solid	Cross	Standard	35	Black	Solid	Circle	Standard	36	Red	Solid	Square	Standard	37	Green	Solid	Triangle	Standard	38	Blue	Solid	Star	Standard	39	Yellow	Solid	Star	Standard	40	Magenta	Solid	Diamond	Standard	41	Cyan	Solid	Cross	Standard	42	Black	Solid	Circle	Standard	43	Red	Solid	Square	Standard	44	Green	Solid	Triangle	Standard	45	Blue	Solid	Star	Standard	46	Yellow	Solid	Star	Standard	47	Magenta	Solid	Diamond	Standard	48	Cyan	Solid	Cross	Standard	49	Black	Solid	Circle	Standard	50	Red	Solid	Square	Standard	51	Green	Solid	Triangle	Standard	52	Blue	Solid	Star	Standard	53	Yellow	Solid	Star	Standard	54	Magenta	Solid	Diamond	Standard	55	Cyan	Solid	Cross	Standard	56	Black	Solid	Circle	Standard	57	Red	Solid	Square	Standard	58	Green	Solid	Triangle	Standard	59	Blue	Solid	Star	Standard	60	Yellow	Solid	Star	Standard	61	Magenta	Solid	Diamond	Standard	62	Cyan	Solid	Cross	Standard	63	Black	Solid	Circle	Standard	64	Red	Solid	Square	Standard	65	Green	Solid	Triangle	Standard	66	Blue	Solid	Star	Standard	67	Yellow	Solid	Star	Standard	68	Magenta	Solid	Diamond	Standard	69	Cyan	Solid	Cross	Standard	70	Black	Solid	Circle	Standard	71	Red	Solid	Square	Standard	72	Green	Solid	Triangle	Standard	73	Blue	Solid	Star	Standard	74	Yellow	Solid	Star	Standard	75	Magenta	Solid	Diamond	Standard	76	Cyan	Solid	Cross	Standard	77	Black	Solid	Circle	Standard	78	Red	Solid	Square	Standard	79	Green	Solid	Triangle	Standard	80	Blue	Solid	Star	Standard	81	Yellow	Solid	Star	Standard	82	Magenta	Solid	Diamond	Standard	83	Cyan	Solid	Cross	Standard	84	Black	Solid	Circle	Standard	85	Red	Solid	Square	Standard	86	Green	Solid	Triangle	Standard	87	Blue	Solid	Star	Standard	88	Yellow	Solid	Star	Standard	89	Magenta	Solid	Diamond	Standard	90	Cyan	Solid	Cross	Standard	91	Black	Solid	Circle	Standard	92	Red	Solid	Square	Standard	93	Green	Solid	Triangle	Standard	94	Blue	Solid	Star	Standard	95	Yellow	Solid	Star	Standard	96	Magenta	Solid	Diamond	Standard	97	Cyan	Solid	Cross	Standard	98	Black	Solid	Circle	Standard	99	Red	Solid	Square	Standard	100	Green	Solid	Triangle	Standard

Fig. 5.04 AutoCAD mapping layer template for 3D forest mapping

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**References: all are now translated in Japanese by the author.**

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ISO19152 Land Administration Domain Model-oriented Niger River 3D Satellite Mapping (13678)

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:Fukui City - 3D-Cadastral Map and Kyoto University - 3D-Forest Map

based on 4D-Image Map Archive Designed Aerial Survey

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