RESURVEY OF CADAstral Maps

ORSAC
ODISHA SPACE APPLICATIONS CENTRE
BHUBANESWAR
MAPPING LAND PARCELS
Methodologies Recommended by NLRMP

1. GROUND METHOD
2. AERIAL PHOTOGRAMMETRY
3. HIGH RESOLUTION SATELLITE IMAGERY
What is Photogrammetry

- **Photogrammetry** is the art and science of making accurate measurements by means of aerial photography:
  - Analog photogrammetry (using films: hard-copy photos)
  - Digital photogrammetry (digital images)

- Aerial photographs were the first form of remote sensing imagery.

- Differences between photogrammetry and Remote Sensing are that photographs are:
  - Black and white (1 band) or color (blue, green, red, and IR)
  - Wavelength range of 0.3-1.0 μm
  - Use cameras
  - One type of remote sensing imagery
Types of vantage points to acquire photographs

- **Vertical** vantage points
- **Low-oblique** vantage points
- **High-oblique** vantage points
Most are vertical aerial photography
Low-oblique Aerial Photography

Low-Oblique Aerial Photograph Over Flat Terrain

90°

field of view

Optical axis

Horizon is not shown in photograph

Jensen, 2000

Low-oblique photograph of a bridge on the Congaree River near Columbia, SC.
High-oblique Aerial Photography

High-oblique photograph of the grand Coulee Dam in Washington in 1940

Jensen, 2000

Horizon is shown in the photograph

Optical axis

90°
Color Science

- Additive primary colors:
  - Blue, Green, and Red

- Subtractive primary colors (or complementary colors):
  - Yellow, Magenta, and Cyan

- Filters (subtract or absorb some colors before the light reaches the camera):
  - Red filter (absorbs green and blue, you can see red)
  - Yellow (or minus-blue) filter (absorbs blue, allows green and red to be transmitted, which is yellow)
  - Haze filter (absorbs UV)
Types of photographs

• **Black and white photographs**
  – Panchromatic *(minus-blue)* filter used to eliminate UV and blue wavelengths
  – IR (IR-sensitive film and **IR only** filter used to acquire photographs at 0.7-1.0 μm)
  – UV (at 0.3-0.4 μm, low contrast and poor spatial resolution due to serious atmospheric scattering)

• **Color photographs**
  – Normal color *(Haze filter)* used to absorb UV and create true color 0.4-0.7 μm, or blue, green, red
  – IR color *(Yellow filter)* used to eliminate blue and create IR color (or false-color infrared) of 0.5-1.0 μm, or green, red, and IR
  – 4 bands (blue, green, red, and IR)
Normal color

False-color infrared
Scale of photographs

- **Image size/ real world size:**
  - $S = \frac{ab}{AB}$

- **Focal length/ altitude above ground:**
  - $S = \frac{f}{H}$
Scale (2)

1′ = 12 ”

S = 0.012/ (6 x 12) = 1/6000

S = f / (H-h)

Max scale, minimum scale, and average or nominal scale
Digital Cameras

- Use an area array of solid-state charge-coupled-device (CCD) detectors. The detectors are arranged in a matrix format with \( m \) columns and \( n \) rows.
- Analog (continuous) signals (voltage) are converted into (discrete) digital brightness value (DN)
Orthophotographs and digital orthoimagery

• An aerial photograph that has all the distortions due to camera tilt, scale, oblique, and surface relief.

• Photograph after corrected by ground control points \((x, y, z)\) or digital elevation model (DEM), namely orthorectification, called orthophotograph, orthophoto, or digital orthoimagery.

• Not as photographs, they have different scales in different terrain relief, orthophotos have only one scale, no distortion, and have true distance, angle, and area. Orthophotos can be directly input into GIS as basemap or for interpretation.
Orthorectification
a. Uncorrected vertical aerial photograph

b. Orthophotograph
Extraction of Building Infrastructure based on orthophotographs
Orthophotograph draped over a DEM
Orthorectification of SIMBA camera photos in assisting ASPeCt sea ice observations

PhD student Blake Weissling in SIMBA Oct-Nov. 2007

Orthorectified photo

Blake et al. to be submitted
Satellite photographs

- Extensive collections of photographs have been acquired from manned and unmanned Earth or Mars-orbiting satellites.
  - Beginning in 1962, USA acquired photographs of moon for Apollo mission
  - 1995, USA declassified intelligence satellites photographs of Sino-Soviet acquired 1960-1972 at 2-8 m resolution.
  - 2000, Russia launched satellites acquired photographs of 2 meter resolution
  - 1999, Mars Orbiter Camera (MOC) onboard the Mars Global Surveyor (MGS) of NASA acquires Mars photographs with 1.2 – 12 m resolution
  - 2003, High Resolution Stereo Camera (HRSC) on board the ESA Mars Express acquires Mars photographs with 10 m resolution, selected areas will be imaged at 2 meters resolution.
  - 2005, High Resolution Imaging Science Experiment (HiRISE) on board NASA MRO (Mars Reconnaissance Orbiter) acquires Mars photographs with up to 25 cm resolution.
NECESSITY OF CADAstral RESURVEY

Cadastral maps were prepared in different periods during various settlements.

Cadastral maps of Odisha of different villages were prepared during and are being used


These maps are being used as Hall Maps.

Parcel geometry changes due to: division of plots, sale & mutation, natural process recourse, land use pattern etc.

These changes are not depicted in the Cadastral Map till the next Settlement

The settlement operations by conventional methods are highly time consuming
CADAstral Resurvey

By Using

Ortho Image Data Products, DGPS, ETS and Ground Validation
<table>
<thead>
<tr>
<th></th>
<th>STEPS FOR RESURVEY</th>
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</thead>
<tbody>
<tr>
<td>1</td>
<td><strong>GROUND CONTROL POINT (GCP) ESTABLISHMENT - MONUMENTATION</strong></td>
</tr>
<tr>
<td>2</td>
<td><strong>TASKING AND ACQUISITION OF WORLDVIEW II STEREO SATELLITE DATA, EXISTING DIGITAL CADAstral MAPS AND AUTHENTICATED UP-TO-DATE RECORD OF RIGHTS (ROR)</strong></td>
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<tr>
<td>3</td>
<td><strong>ORTHOIMAGE GENERATION AND GROUND VALIDATION</strong></td>
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<td>4</td>
<td><strong>GEOREFERENCING OF CADAstral MAP FOR VILLAGE BOUNDARY AND AREA CONFIRMATION</strong></td>
</tr>
<tr>
<td>5</td>
<td><strong>PARCEL VECTOR GENERATION FROM ORTHOIMAGE</strong></td>
</tr>
<tr>
<td>6</td>
<td><strong>FIELD VALIDATION OF IMAGE DERIVED PARCEL VECTOR</strong></td>
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<tr>
<td>7</td>
<td><strong>OBSCURED AREA SURVEY</strong></td>
</tr>
<tr>
<td>8</td>
<td><strong>INTEGRATION OF FIELD SURVEY VECTOR WITH IMAGE DERIVED VECTOR TO GENERATE THE DRAFT CADAstral MAP</strong></td>
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<td>9</td>
<td><strong>GENERATION &amp; LINKING OF ROR DATA</strong></td>
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<tr>
<td>10</td>
<td><strong>VECTORISATION AND INTEGRATION OF MUTATION DATA UP TO THE DATE OF SURVEY NOTIFICATION</strong></td>
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<tr>
<td>11</td>
<td><strong>FINALISATION OF DRAFT CADAstral MAP</strong></td>
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GROUND CONTROL POINT (GCP) ESTABLISHMENT - MONUMENTATION

MONUMENTATION PLANNING OF PRIMARY/SECONDARY GROUND CONTROL POINTS (GCPs)

PRIMARY (16 km x 16 km grid)

SECONDARY (4 Km x 4km grid)
GCP AS SEEN ON THE SATELLITE IMAGE/ FIELD
GROUND CONTROL POINT NETWORK
The ortho-rectification is the process of reducing geometric errors inherent within photography and imagery. The variables contributing to geometric errors include:

- Camera and sensor orientation
- Systematic error associated with the camera or sensor
- Topographic relief displacement
- Earth curvature

The orthographic image is constructed by resampling the original image pixels into their new Orthorectified positions.
PREPARATION OF MOSAIC OF ORTHO IMAGE DISTRICT WISE
VALIDATION OF ORTHO IMAGE AND QUALITY CHECKING

ONE SHEET OF HIGH RESOLUTION SATELLITE IMAGE (WV II) COVERS APPROXIMATELY 200 SQ KM AREA

TIE-LINES OF DIFFERENT LENGTHS ARE MEASURED IN THE FIELD AT 4 TO 5 LOCATIONS OF EACH ORTHO IMAGE SCENE.

LENGTHS OF CORRESPONDING TIE-LINES ARE MEASURED FROM ORTHO-IMAGE AND COMPARED.

TOLERANCE LIMIT IS 20 CM.
VALIDATION OF ORTHOIMAGE BY GROUND MEASUREMENT

LENGTH MEASUREMENT FROM IMAGE (SYSTEM GENERATED)
VERTEX TO VERTEX MEASUREMENT (ETS)
GEOREFERENCING OF CADAstral MAP FOR VILLAGE BOUNDARY AND AREA CONFIRMATION

MOSAICING OF EXISTING CADAstral MAP

IDENTIFICATION OF BIJUNCTION / TRIJUNCTION POINTS

COLLECTION OF DGPS COORDINATES OF JUNCTION POINTS

GEO-REFERENCING OF MOSAICED VILLAGE MAP

SUPERIMPOSITION OF GEO-REFERENCED VILLAGE MAP ON ORTHO-IMAGE

EDGE ADJUSTMENT FOR DELINEATION OF VILLAGE BOUNDARY
MOSAIC OF DIGITISED CADASTRAL MAPS

The vendor is provided scanned cadastral sheets, digitized cadastral layer in the form of AutoCAD .dwg as well for the individual mouza by DOLR&S / ORSAC.
IDENTIFICATION OF COMMON FEATURES ON DIGITAL CADASTRAL MAP AND ORTHOIMAGE
DELINEATION & CONFIRMATION OF VILLAGE BOUNDARY WITH ADJACENT VILLAGES ON ORTHOIMAGE

CADASTRAL MAPS OF 7 VILLAGES OF ATHAGAD TAHASIL GEO-REFERENCED
VILLAGE BOUNDARY EXTRACTED FROM OLD CADASTRAL GEOREFERENCED MAPS FOR RESURVEY WORK
ETS/ DGPS SURVEY OF GHARBARI AREA AND BOUNDARY (CONFIRMATION) FOR
RESURVEY WORK
GHARBARI PLOTS INTEGRATED TO VILLAGE MAP AND FURTHER INDIVIDUAL PLOT DELINEATION FOR RESURVEY WORK
VILLAGE MAP (CADASTRAL) OF BIJEPADMANAVPUR ON ORTHOIMAGE
TOTAL VILLAGE AREA CALCULATED AFTER GEOREFERENCING SHOULD NOT VARY BEYOND 2% OF THE SUM TOTAL AREA OF THE RoR/NOTIFIED VILLAGE AREA. IF THE DIFFERENCE IS BEYOND 2% THE BOUNDARY WILL BE DEMARCATED THROUGH FIELD OBSERVATION USING DGPS/ETS WITH THE HELP OF CONCERNED TAHASIL OFFICIALS
Geo-referenced Cadastral vector of Nuasasan village (1952-53), Athagad Tahasil, Cuttack.
Anantpur village (1952-53), Athagad Tahasil, Cuttack

Anantpur village resurvey map
Change of Parcels (Plots)
Change of Land use
Cadastral Map Problems

Consolidation
VILLAGE AREA CONFIRMATION

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<tr>
<th>SL.NO.</th>
<th>VILL_NAME</th>
<th>ROR (Ac.)</th>
<th>AREA</th>
<th>CADASTRAL_MAP (Ac.)</th>
<th>IMG (Ac.)</th>
<th>AREA</th>
<th>% DIFF (IMG-ROR)</th>
<th>% DIFF (IMG-CAD)</th>
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VILLAGE AREA FROM THE IMAGE SHOULD NOT VARY ±2% WITH THE TOTAL ROR AREA.
8. QUALITY CHECKING OF VILLAGE BOUNDARY BY ORSAC

Georeferencing of digitised village Cadastral maps with image. Boundary adjusted to field bunds of the image and boundary confirmed.
Boundary adjusted to field bunds of the image and boundary confirmed
Advised for plot generation by mirror image principle
Digitised cadastral maps of one tahasil georeferenced and verified by ArcGIS environment: For QC
Seamless Village boundaries confirmed after QC
Mosaic Village boundaries of Baliana Tahasil from georeferenced Cadastral maps
Problems found:
Common plots appearing in adjacent villages in properly georeferenced map
Referred for field verification by the help of Tahasil officials
Problems found:
Geometry of plots changed in adjacent villages in properly georeferenced map
Referred for field verification by the help of Tahasil officials
Problems found:
Common plots appearing in adjacent villages in properly georeferenced map
Referred for field verification by the help of Tahasil officials
### A Few Observations During Quality Checking

#### Area Variation

<table>
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<tr>
<th>DISTRICT_NAME</th>
<th>TAHESIL_NAME</th>
<th>VILL_NAME</th>
<th>ORIGINAL DWG_AREA (in acre)</th>
<th>DELINIA TED_VILL_BOUN DARY_AREA (in acre)</th>
<th>ROR_AR EA (in acre)</th>
<th>NO. OF PLOTS IN ROR</th>
<th>NO. OF PLOTS IN CADASTRAL</th>
<th>DIFFERENCE (in acre)</th>
<th>VARIATION (%)</th>
<th>REMARKS</th>
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<td>CUTTACK SA</td>
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<td>505</td>
<td>147.75</td>
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<td>Georef ok, adjacent bound ok, ROR area not matching</td>
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</table>
A FEW OBSERVATIONS DURING QUALITY CHECKING

Problems found in RoR
Total Village Area variation
PARCEL VECTORISATION

DELINEATION AND EXTRACTION OF CULTURAL FEATURES

SELECTION OF SEGMENT

PARCEL VECTOR EXTRACTION IN EACH SEGMENT

TRANSFER OF OLD PLOT NOS TO NEW PARCELS

SELECTION OF OBSCURED AREA FOR FIELD MEASUREMENT
PLOT LEVEL VECTORISATION AND MAP GENERATION FROM ORTHOIMAGE

PARCEL BOUNDARY VECTORISATION WILL BE DONE ACCORDING TO MIRROR IMAGE PRINCIPLE BY ONSCREEN DIGITISATION METHOD

PARCEL BOUNDARY VECTORISATION WILL BE DONE ADOPTING WHOLE TO PART APPROACH

THE PARCEL BOUNDARY WILL BE DRAWN ALONG THE CENTRE LINE OF THE BUND AS SEEN ON THE IMAGE
Vectorisation of plots by onscreen digitisation method
PLOT VECTORISATION AND MAP GENERATION FROM ORTHO IMAGE

PLOT VECTOR EXTRACTED FROM IMAGE WITH PLOT NUMBER FROM ROR
FIELD VALIDATION OF IMAGE DERIVED PARCEL VECTOR

• AFTER THE COMPLETION OF VECTORISATION, GROUND TRUTHING WILL BE UNDERTAKEN IN 5% OF TOTAL NUMBER OF PLOTS FOR EACH VILLAGE

• THE FIELD BUND DIMENSIONS WILL BE MEASURED BY THE VENDOR ENGAGED FOR THE VECTORISATION WORK USING DGPS AND ETS

• THE MEASUREMENTS WILL BE DONE ON RANDOMLY SELECTED PLOTS DISTRIBUTED THROUGHOUT THE VILLAGE

• THE PLOTS FOR MEASUREMENT WILL BE SELECTED BY THE QUALITY ASSURANCE TEAM

• THE PLOT DIMENSIONS MEASURED USING DGPS AND ETS WILL BE VERIFIED OVER THE IMAGE BY THE QC TEAM

• IF THE DIMENSION OF ANY MEASUREMENT BETWEEN TWO VERTICES VARIES BEYOND 20 CM THE VENDOR HAS TO REDRAW THE PARCELS AGAIN
FIELD VALIDATION OF IMAGE DERIVED PARCEL VECTOR (QC-2)
FIELD VALIDATION OF IMAGE DERIVED PARCEL VECTOR (QC-2)

FIELD OBSERVATION STATISTICS OF GUNDICHAPUR VILLAGE

<table>
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<tr>
<th>PLOT NO</th>
<th>FIELD MEASURE LENGTH</th>
<th>VECTORIZATION LENGTH</th>
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OBSCURED AREA SURVEY

- Plot boundary under grooves
- Village boundary obscured
- Construction sites
- Areas on urban fringe with plotting
- Settlement/habitation areas
- Corner vertices obscured
OBSCURED AREA SURVEY

SURVEY THROUGH DGPS & ETS

- VEGETATED AREA
- URBAN AND RURAL HABITATION AREA
- OBSTRUCTION AREAS
- LOCATING CORNER VERTICES
SURVEY THROUGH DGPS & ETS

GHARBARI AREAS ARE TO BE SURVEYED FIRST USING DGPS & ETS WITH THE HELP OF LOCAL REVENUE OFFICIALS AND PREPARATION OF RoR FOR THE GHARBARI AREAS

SEPARATE MAP FOR THE GHARBARI AREA **WILL BE PREPARED** FIRST AND HAS TO BE AUTHENTICATED BY CONCERNED TAHASILDAR FOR EACH VILLAGE, THE SAME VECTOR WILL BE INTEGRATED TO THE BLANK VILLAGE BOUNDARY BEFORE EXTRACTION OF OTHER PARCEL BOUNDARIES FROM THE ORTHOIMAGE
INTEGRATION OF FIELD SURVEY TO IMAGE DERIVED VECTOR

INTEGRATION OF GHARBARI AREA

INTEGRATION OF OBSCURED VERTICS

CORRECTION OF UNIDENTIFIED FEATURES AFTER FIELD VERIFIED DATA

PARCELS UNDER TREE CLAD AREA
DGPS/ETS SURVEYED AREA INTEGRATION

WORLDVIEW-0.5 M SATELLITE DATA, 2009 WITH PLOT VECTOR
DGPS/ETS SURVEYED AREA INTEGRATION
GENERATION & LINKING OF ROR

INPUTTING PLOT NUMBERS TO ORTHOIMAGE DERIVED MAPS FROM GEOREFERENCED DIGITISED CADAstral MAP

LINK THROUGH PLOT NUMBER WITH BHULEKH RECORD & QUALITY CHECK

GIS DATABASE CREATION OF ROR USING ORTHOIMAGE DERIVED PLOT VECTORS

DERIVATION OF AREA & CHAHUADI DETAILS FROM ORTHOIMAGE VECTORS AND INPUT TO ROR

PRINTING OF LAND PARCEL MAP (LPM) WITH ROR FOR TENANT INTERACTION
LINKING OF ROR

VECTOR ATTRIBUTE TABLE
LINKING OF ROR

VECTOR ATTRIBUTE TABLE WITH ROR DATABASE
VECTORISATION AND INTEGRATION OF MUTATION DATA UP TO THE DATE OF SURVEY NOTIFICATION

DATA ACQUISITION IS BEING DONE AT A DIFFERENT TIME
THE MUTATION TAKES PLACE IN VILLAGES TILL THE DATE OF SURVEY NOTIFICATION

AFTER LINKING WITH ROR PLOTS, REMAINING UNIDENTIFIED FROM THE IMAGE HAVE TO BE RESOLVED

PLOTS ARE TO BE DRAWN AS PER TIPPONS OR DIMENSIONS PROVIDED BY THE CONCERNED TAHASIL DAR

PLOTS ARE TO BE IDENTIFIED BY LOCAL RI/AMIN AND THE VERTICES ARE TO BE MEASURED BY DGPS/ETS AND VECTORS HAVE TO BE INCORPORATED INTO THE MAP
TITLE CONFIRMATION THROUGH INTERACTION WITH TENANTS

A4 SIZE MAP GENERATION FOR TENANT INTERACTION

LAND PARCEL MAP (LPM)
FINALISATION OF DRAFT CADASTRAL MAP /GIS DATABASE

INCORPORATION ALL NECESSARY SUGGESTIONS AND RECOMMENDATIONS MADE BY THE TAHASILDAR DURING KHANAPURI OPERATION TO THE MAP, PREPARE THE FINAL VILLAGE MAP IN THE PROVISIONAL FORMAT AND SUBMIT IN REQUIRED DELIVERABLE FORMAT

- MAP SCALE : 1: 2000 (16 INCH= 1 Mile)
  (INSET 1:1000)
- MAP SIZE A1 SIZE
- CODING-AS PER NRLMP GUIDELINE
- EXISTING NUMBERING SYSTEM TO BE FOLLOWED AND NEW PLOT NOS ARE TO BE ASSIGNED
- SYMBOL-AS PER EXISTING FORMAT(ALAMAT)
- FONT:-ORIYA AND ENGLISH
- DELIVERABLE:-BOTH HARD AND SOFT COPY
FINALISATION OF DRAFT CADAstral MAP /GIS DATABASE