Aligning Local Transverse Mercator (LTM) Grids with UTM Grids such as the Papua New Guinea Map Grid (PNGMG)

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Quickclose

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What is an LTM?

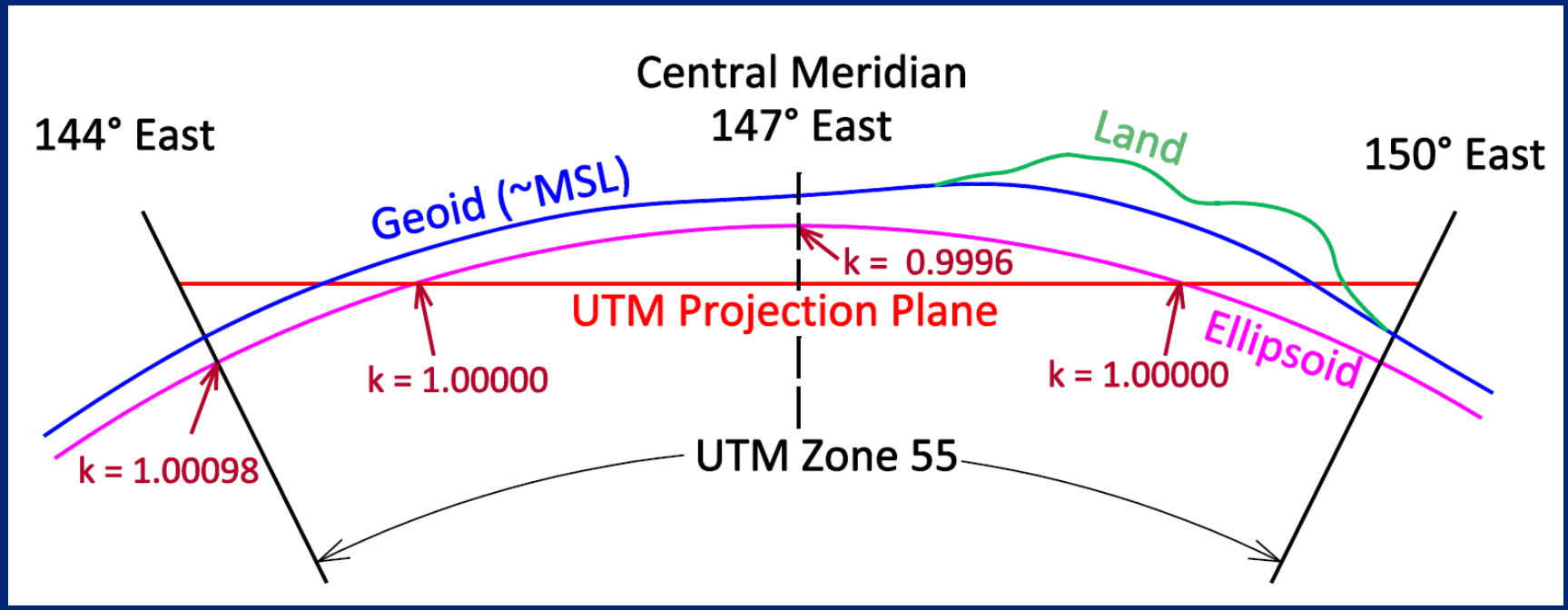
- An LTM (Local Transverse Mercator) is a working “Plane” Grid
- Used for cadastral surveys, engineering and construction
- Essential for surveys where better than 1:20,000 is required

An LTM or Plane grid aligned with UTM (PNGMG94 in PNG) is very useful

Why do we need an LTM??

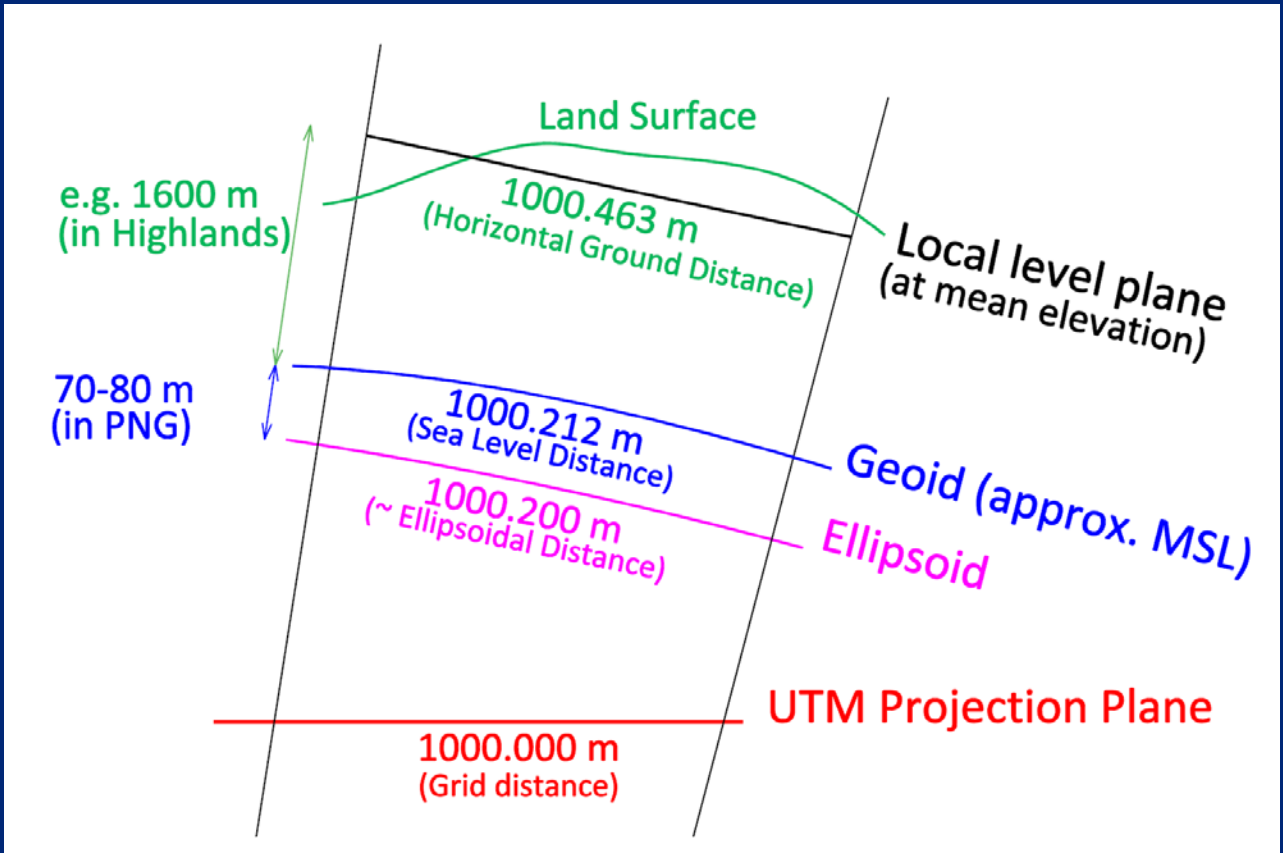
- If Ground distances are to be close to Grid distances
- If bearings are to be the same in local and global grids
- When using GNSS on cadastral and engineering surveys
- For setting up a local “Plane” grid system in a GIS
- Portability of a grid setup across different systems

Surfaces used in surveying



Different surfaces = different distances!

Distances between two points can vary …..

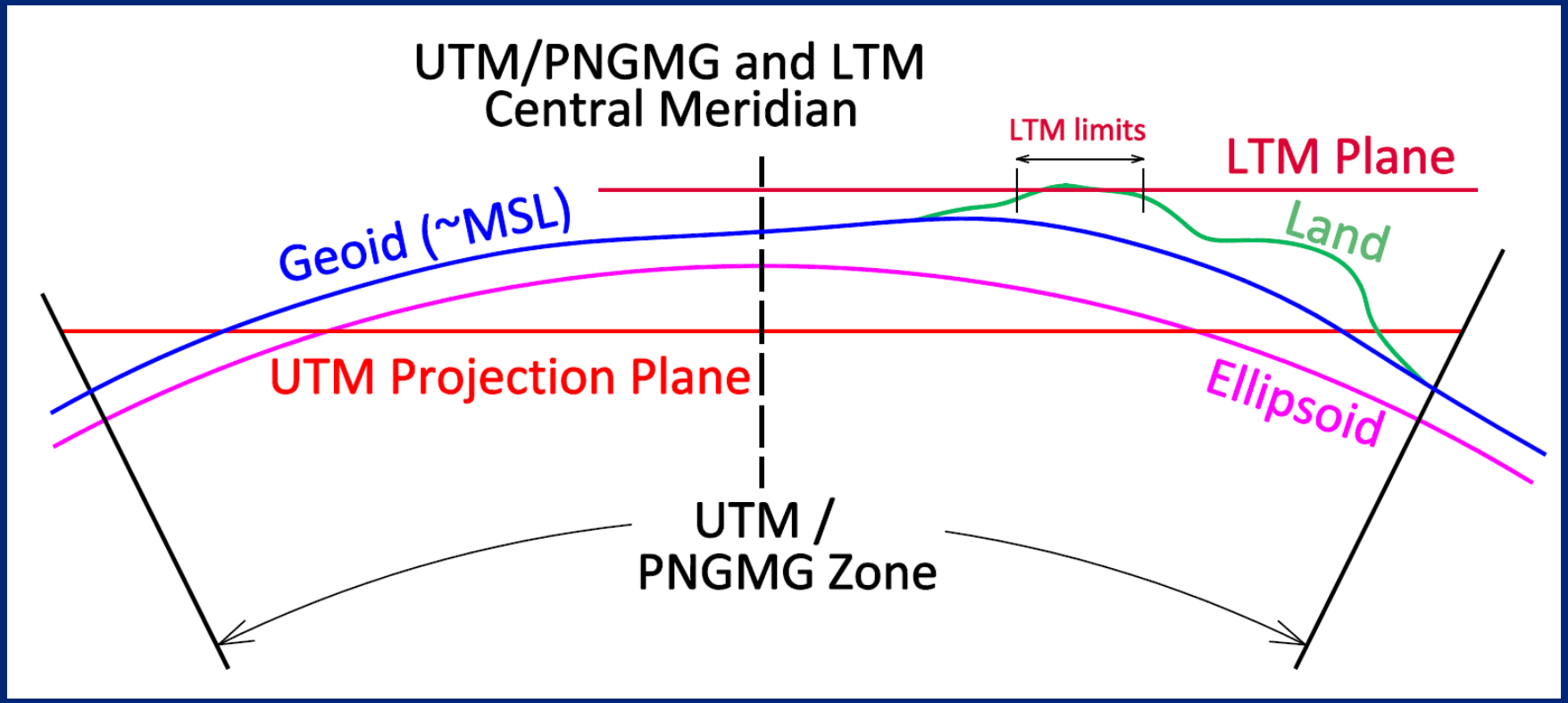


Ellipsoid distance / Grid distance = Grid Scale Factor (approx.)

Ground distance / Grid distance = Combined Scale Factor

Plane bearing = UTM bearing + rotation

Local Transverse Mercator (LTM) concept



Ground distance / LTM Grid (plane) distance = 1 (close to)

LTM Plane bearing = UTM Grid bearing

Comparing LTM approach with Site Calibrations

- LTM is a rigorous, control free method of defining a local plane grid
- Site Calibrations (also called site transformation or localisation) are commonly used with GNSS (RTK) when used with established local grids

Site Calibrations are easy, but there are snags!!

Site Calibration (localisation or site transformation)

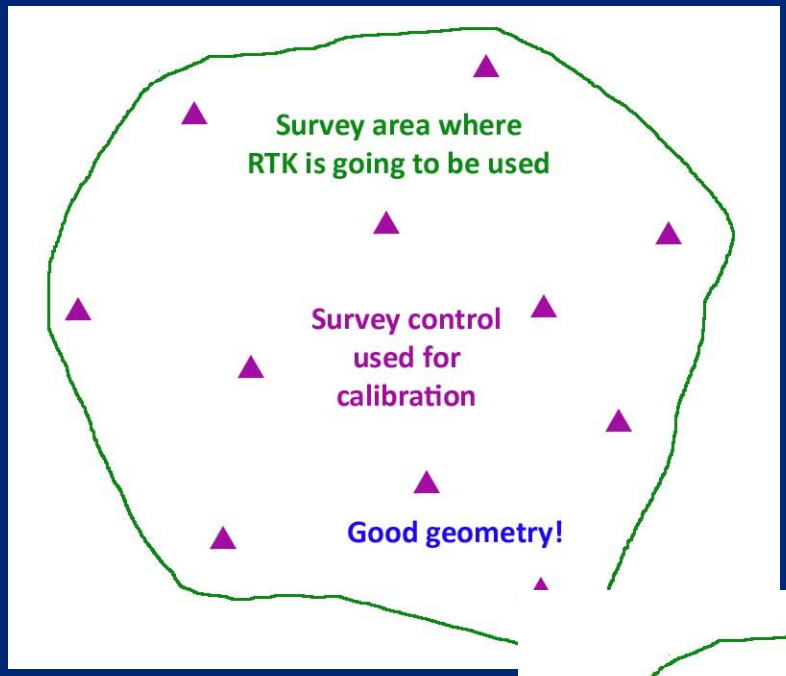
Benefits of using site calibration method

- Easy to setup in a GNSS system
- Accurate if geometry of calibration is good and existing control is of high quality

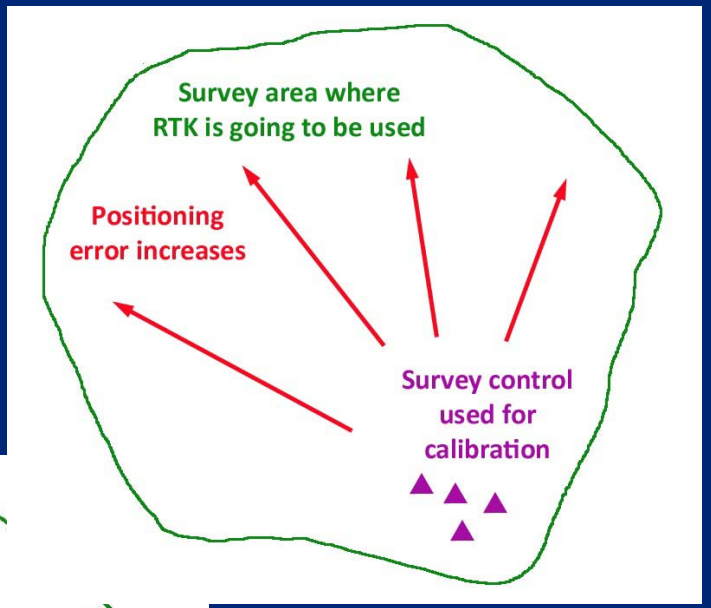
Disadvantages of the site calibration method

- Cannot be used on new sites where there is no existing control
- Propagates significant errors if the calibration geometry is poor
- Errors in coordinates or GPS fixing of the site control propagate into the transformation
- Site calibration not easily documented
- Site calibration not usually interchangeable with other GNSS manufacturers
- Site calibration not usable in conjunction with GIS software

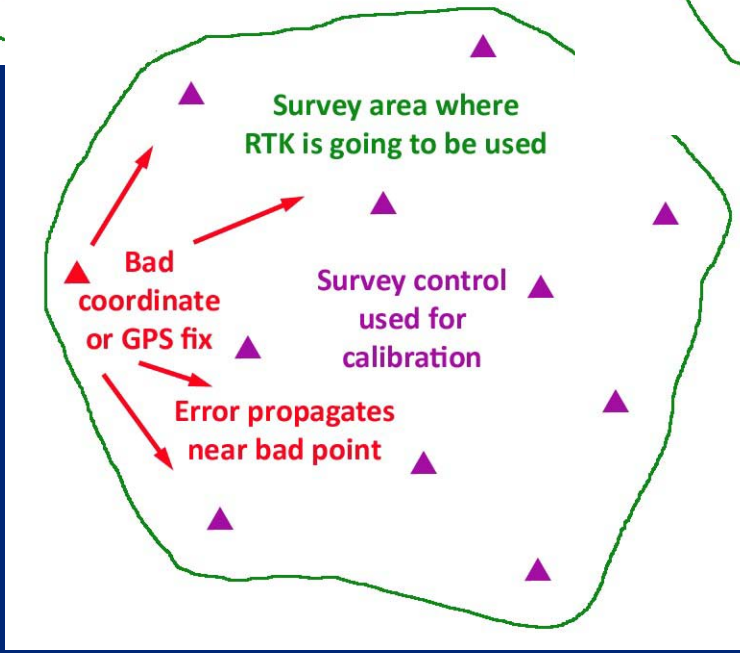
Site Calibration geometry



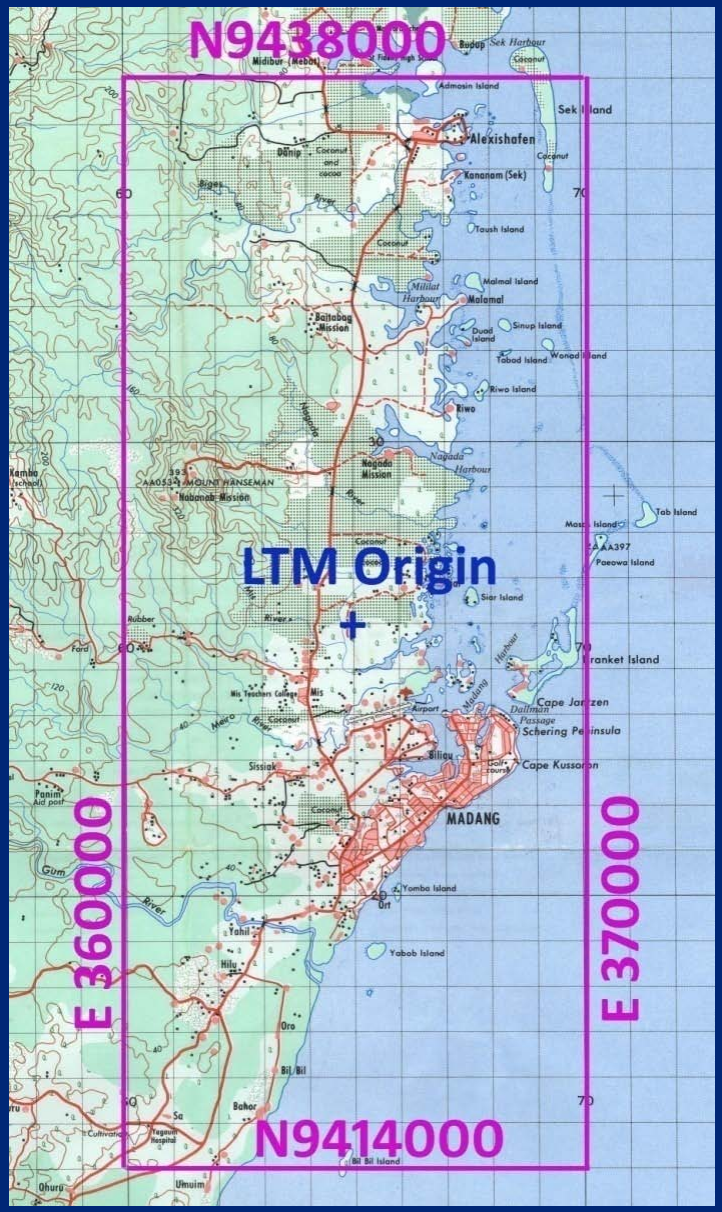
Good geometry



Bad geometry



Corrupt geometry



Building your own LTM (e.g. a Madang Grid)

1. Identify limits of LTM coverage

E-W limits 6000 m at UTM Zone boundary

60000m near central meridian for 1:20000

300 m elevation difference

2. Choose the LTM Origin

(Close to centre of project, can be a survey station but not essential)

Height should be mean of area

e.g. E 365000 N 9426000 Ellipsoid Ht 80 m

3. Choose LTM Origin Coordinates

(small magnitude)

(no negative coordinates)

(same number of significant figures)

(Easting range outside Northing range)

e.g. E 30000 N 80000

Local Transverse Mercator (LTM) terms

$$\lambda_{PO} = \lambda_M$$

$$\phi_{PO} = \phi_M = 0$$

$$E_{PO} = \left(E_{LO} + \frac{500000 - E_{MO}}{F_M} \right)$$

$$N_{PO} = \left(N_{LO} + \frac{10000000 - N_{MO}}{F_M} \right)$$

$$k_{PO} = \frac{0.9996}{F_M}$$

λ_{PO}	is the Longitude of the LTM central meridian
λ_M	is the Longitude of the UTM/PNGMG Zone central meridian
ϕ_{PO}	is the Latitude of the LTM latitude origin (usually 0°)
ϕ_M	is the Latitude of the UTM/PNGMG latitude origin (0°)
E_{PO}	is the LTM Easting of the UTM/PNGMG Central meridian
E_{LO}	is the LTM Easting of the local origin
E_{MO}	is the UTM/PNGMG Easting of the local origin
F_M	is the Combined Scale Factor (UTM/PNGMG and Sea level) at t
N_{PO}	is the LTM Northing of the UTM/PNGMG Latitude origin (0°)
N_{LO}	is the LTM Northing of the local origin
N_{MO}	is the UTM/PNGMG Northing of the local origin
k_{PO}	is the LTM scale factor at the UTM/PNGMG central meridian

λ_{PO}	= λ_M = 147° deg E (Zone 55)
ϕ_{PO}	= ϕ_M = (0°)
E_{LO}	= 30000
E_{MO}	= 365000
F_M	= 0.9998130 (from spreadsheet)
E_{PO}	= 165025.250 (formula)
N_{LO}	= 80000
N_{MO}	= 9426000
N_{PO}	= 654107.358 (formula)
k_{PO}	= 0.99978696 (formula)

Local Transverse Mercator (LTM) - Summary

- The scale factor (combined height and grid factor) is close to 1
- LTM bearings will be identical to those in the parent UTM projection grid (no swing)
- Coordinate magnitudes should be kept small to prevent confusion with UTM coordinates
- LTM parameters can be easily setup in GNSS RTK software (no calibration required)
- LTM parameters can be exchanged consistently between different manufacturers
- LTM parameters can also be setup easily in GIS software projection configurations

Local Transverse Mercator (LTM) - Limitations

- A UTM aligned LTM cannot be used beyond 6 kilometres close to the UTM Zone boundary
- An LTM is not particularly suited to regions that have large extents in an East/West orientation