Map Projection (SUR314)

Lecture No: 9

MAP PROJECTIONS IN EGYPT

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Overview of Previous Lecture

Mathematical Conical Projection

Global Properties of Mathematical Conical Projections

Types of Mathematical Conical Projection

Bonne's Projection

Summary

OVERVIEW OF TODAY'S LECTURE

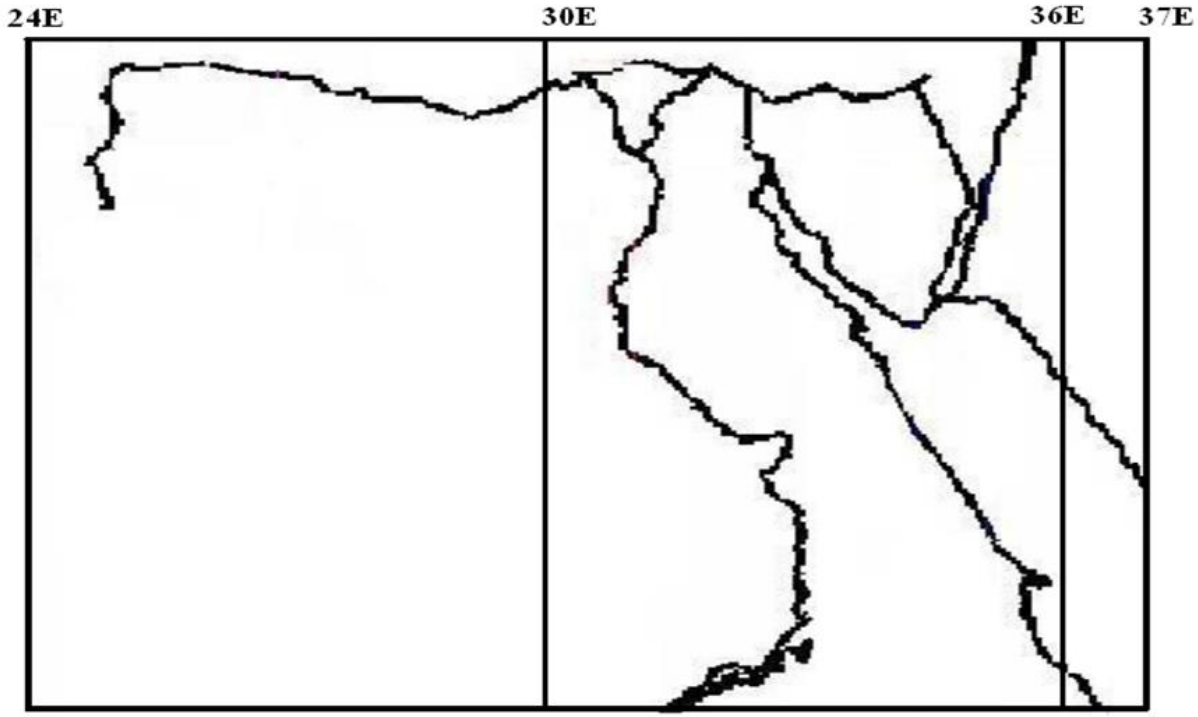
- EXPECTED LEARNING OUTCOMES
- BORDERS OF EGYPTIAN TERRITORY
- UNIVERSAL MAPPING SYSTEMS USED IN EGYPT
- NATIONAL MAPPING SYSTEMS USED IN EGYPT
- APPLICABILITY OF MAPPING SYSTEMS USED IN EGYPT
- LIMITATIONS AND CHALLENGES OF MAPPING SYSTEMS USED IN EGYPT
- REAL-WORLD APPLICATIONS
- SUMMARY

Expected Learning Outcomes

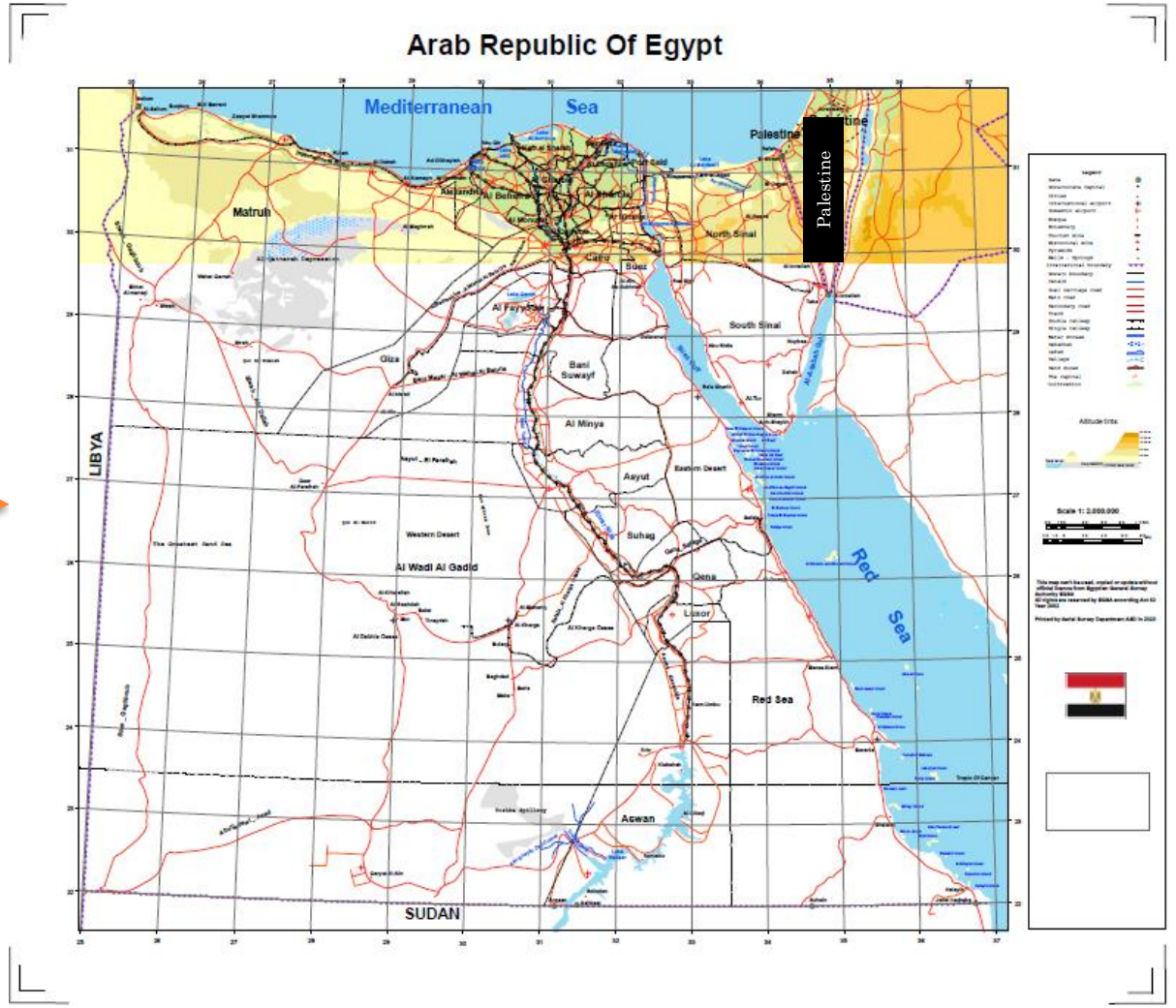
1. Understanding the geographical boundaries that define the territory of Egypt.
2. Become familiar with international mapping systems that are commonly used in Egypt.
3. Understand the characteristics, coordinate reference frames, and projection systems of national mapping systems, such as the Egyptian Transverse Mercator (ETM) system.
4. Explore the practical applications of mapping systems used in Egypt.
5. Gain insight into the limitations and challenges associated with mapping systems used in Egypt.
6. Explore real-world applications of mapping systems in Egypt.

Arab Republic of Egypt

- Egypt is a *transcontinental* country spanning the northeast corner of Africa and the Sinai Peninsula in the southwest corner of Asia.
- It is bordered by the Mediterranean Sea to the north, Palestine to the northeast, the Red Sea to the east, Sudan to the south, and Libya to the west.
- It occupies an area of 1 million km²; compared, it is almost twice the size of France or more than twice the size of the U.S. State of California.
- Egypt has a population of some 102 million (in 2021)
- **Egypt extends from: -**
- East-west: 25° E to 37° E, and
- North-south: 22° N to 32° N.



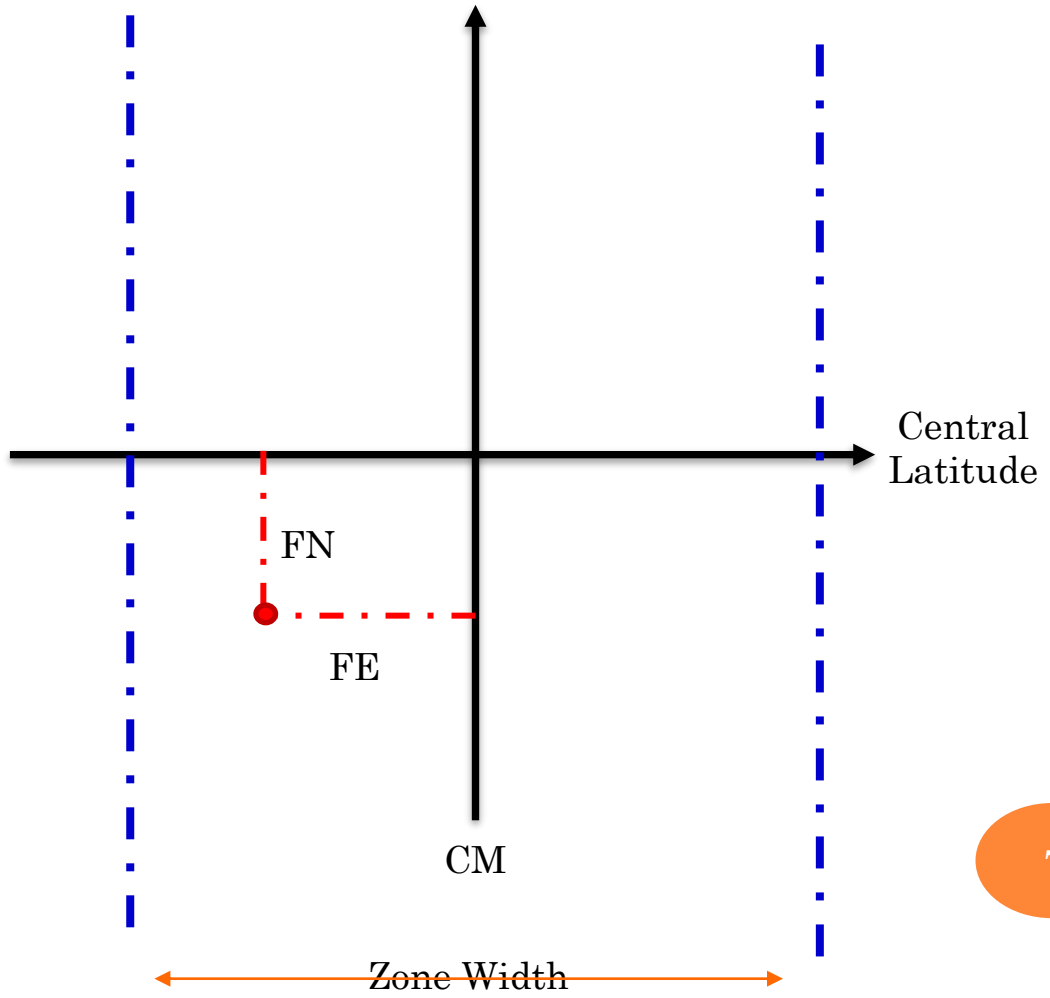
Arab Republic of Egypt



Egyptian Surveying Authority 2023

Elements of a Map Projection

- Type (Lambert, Mercator, normal, transverse, etc.,)
- Datum (WGS84, Helmert 1906, Hyford 1910, etc.,)
- Number of zones
- Zone width
- Latitude of origin (Central latitude)
- Longitude of origin (Central meridian CM)
- False Easting FE
- False Northing FN
- Scale factor SF at central meridian CM.



Practical Consideration – Zone Width

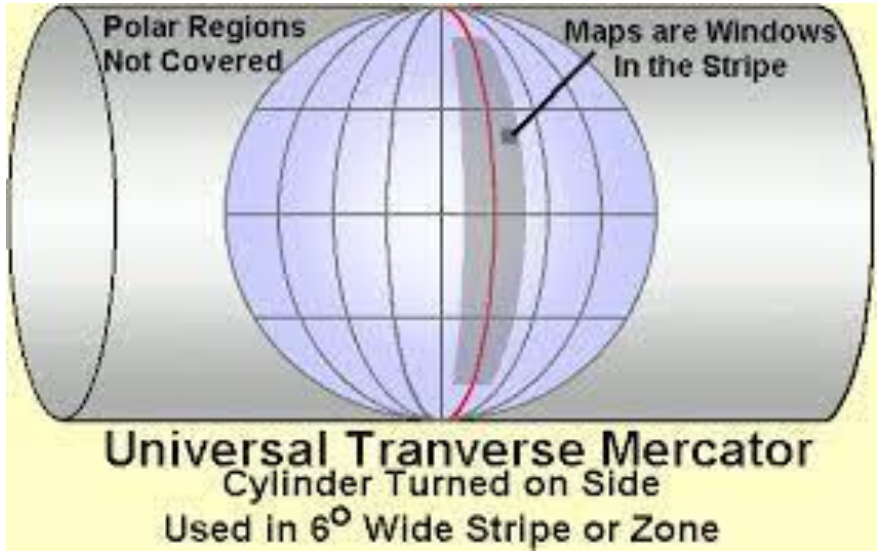
Latitude (°)	Length of a degree of latitude (km)	Length of a degree of longitude (km)
0	110.574	111.320
15	110.649	107.551
30	110.852	96.486
45	111.132	78.847
60	111.412	55.800
75	111.618	28.902

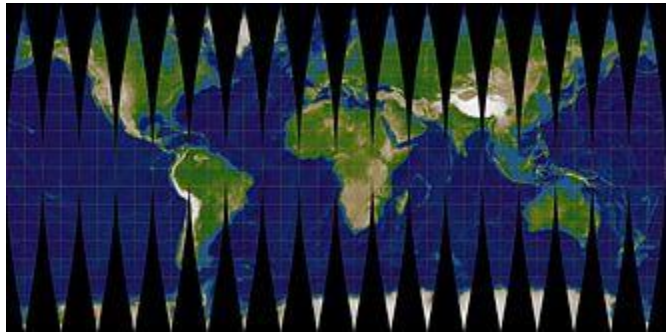
Map Projections In Egypt

(1) Universal Transverse Mercator (UTM)

(1) Universal Transverse Mercator (UTM)

- Type: Transverse Mercator (*What does this mean?*)
- Datum: WGS1984
- Divide the world into 60 vertical strips (zones) extending west to east.
- Zone Width: 6° degrees of longitude.
- Central latitude: equator.
- Central Meridian: mid-longitude of each zone.
- SF at CM: 0.9996.
- True Origin Location: intersection of equator and CM.
- FE: 500,000.
- FN: zero at northern hemi-sphere and 10,000,000 at southern hemi-sphere.





(1) Universal Transverse Mercator (UTM)

- Mercator projection **formulas** are as follows: -

$$N = \frac{a}{\sqrt{1-\varepsilon^2 \sin^2\phi}}$$

$$\frac{X}{N} = \lambda' \cos\phi + \frac{\lambda'^3 \cos^3\phi}{6}(1 - t^2 + \eta^2) + \frac{\lambda'^5 \cos^5\phi}{120}\left(5 - 18t^2 + t^4 + 14\eta^2 - 58t^2\eta^2 + 13\eta^4\right) + \cdots$$

$$\frac{Y}{N} = \frac{S_\phi}{N} + \frac{\lambda'^2}{2}\sin\phi\cos\phi + \frac{\lambda'^4}{24}\sin\phi\cos^3\phi\,(5 - t^2 + 9\eta^2 + 4\eta^4) + \frac{\lambda'^6}{720}\sin\phi\cos^5\phi\left(61 - 58t^2 + t^4 + 720\eta^2 - 330t^2\eta^2 + 445\eta^4\right) + \cdots$$

Where;

- ✓ $t = \tan\phi$
- ✓ $\eta^2 = \varepsilon'^2 \cos^2\phi = \frac{\varepsilon^2 \cos^2\phi}{1-\varepsilon^2} = \frac{(a^2-b^2)\cos^2\phi}{b}$
- ✓ ε is the eccentricity, and $\varepsilon^2 = \frac{(a^2-b^2)}{a^2}$
- ✓ a is the semi-major axis of the earth ellipsoid.
- ✓ b is the semi-minor axis of the earth ellipsoid.

(1) Universal Transverse Mercator (UTM)

- Mercator projection **formulas** are as follows: -

  - ✓ $\lambda' = \lambda - \lambda_0$= longitude difference from central meridian λ_0, in radians.
  - ✓ S_ϕ is the length of the meridian arc from the equator to latitude ϕand is given by.

$$S_\phi = \int_0^\phi \frac{a(1-e^2)}{(1-e^2\sin^2\phi)^{3/2}}d\phi \qquad \text{or} \qquad S_\phi = a(A_0\phi - A_1\sin 2\phi + A_2\sin 4\phi - A_3\sin 6\phi + \cdots)$$

Where;

- $A_0 = 1 - \frac{1}{4}\varepsilon^2 - \frac{3}{64}\varepsilon^4 - \frac{5}{256}\varepsilon^6 - \cdots$
- $A_1 = \frac{3}{8}\varepsilon^2 + \frac{3}{32}\varepsilon^4 + \frac{45}{1024}\varepsilon^6 + \cdots$
- $A_2 = \frac{15}{256}\varepsilon^4 + \frac{45}{1024}\varepsilon^6 + \cdots$
- $A_3 = \frac{35}{3072}\varepsilon^6 + \cdots$

(1) Universal Transverse Mercator (UTM)

- The scale factor (S.F) can be calculated from either (ϕ, λ) or from (E, N) coordinates: -

$$S.F = 1 + \frac{(\lambda'')^2 \cos^2\phi}{2}(1+\eta^2) + \frac{(\lambda'')^4 \cos^4\phi}{24}\left(5 - 4t^2 + 14\eta^2 + 13\eta^4 - 28t^2\eta^2 + 4\eta^6 - 48t^2\eta^4 - 24t^2\eta^6\right) + \frac{(\lambda'')^6 \cos^6\phi}{720}(61 - 148t^2 + 16t^4)$$

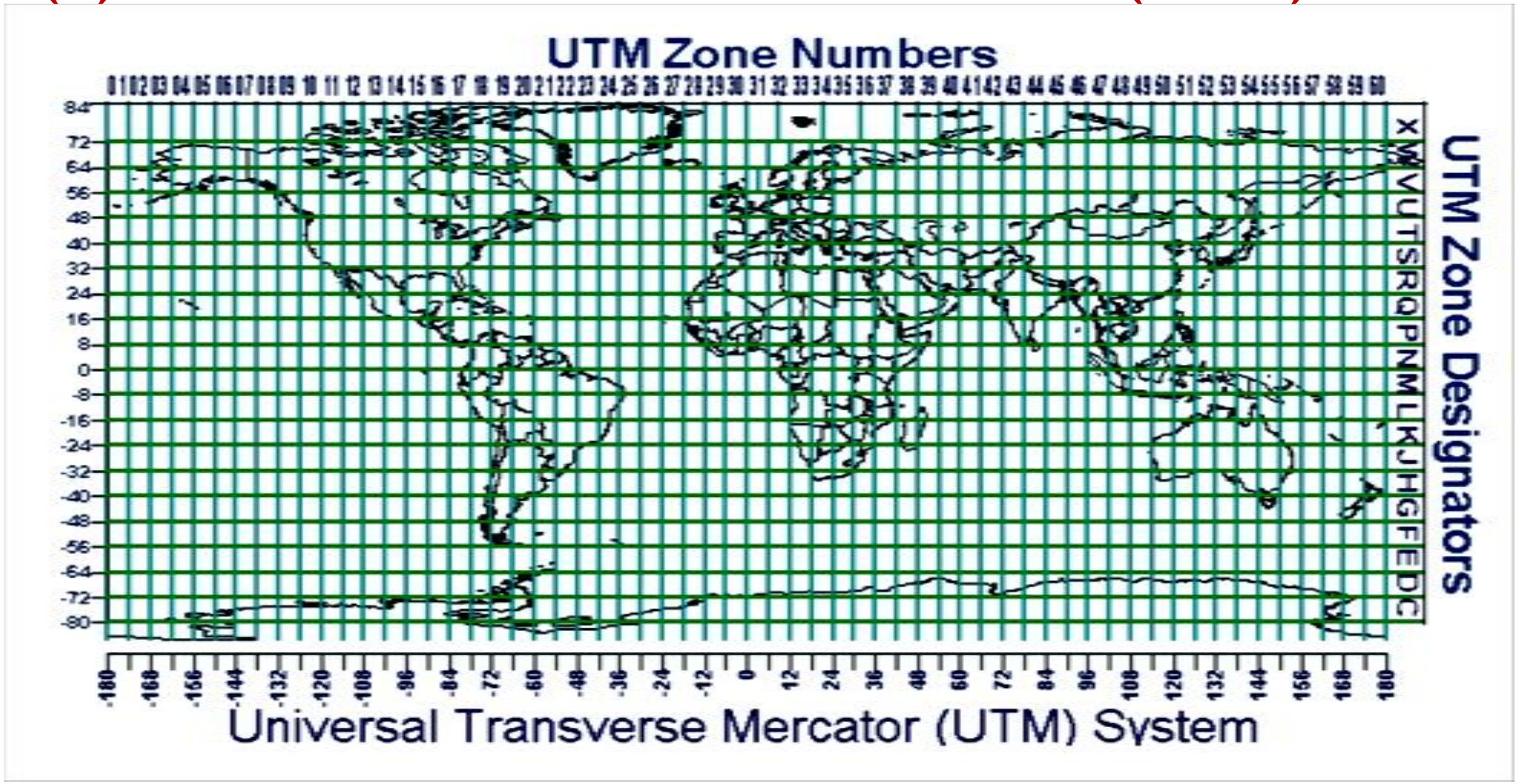
$$S.F = (S.F)_0 + \frac{1}{2}\left(\frac{\Delta E}{N}\right)^2(1+\eta^2) + \frac{1}{24}\left(\frac{\Delta E}{N}\right)^4(1+6\eta^2)$$

Where;

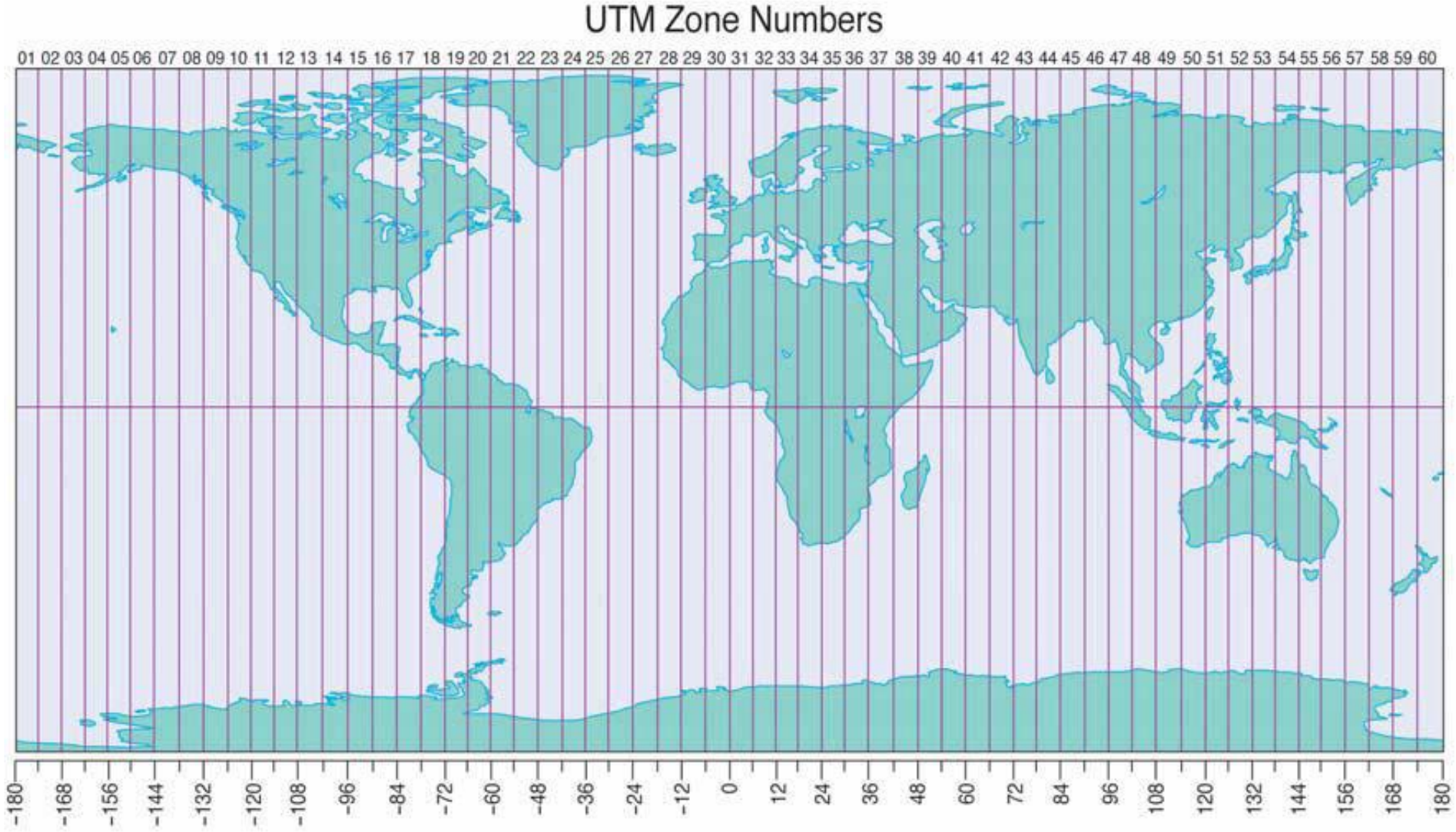
- ✓ $(S.F)_0$ is the scale factor value at the central meridian of the zone
- ✓ $\Delta E = E_i - E_0 \Rightarrow$ For (E_0) value
- ✓ E_0 and E_i are the East of coordinates at the central meridian and Point (i) respectively.

* Nowadays, several software's have capability to convert the coordinates of points from (ϕ, λ) system to (E, N) projected coordinates and vise verse. Then the S.F can be calculated for any location using the East value of projected coordinates (E).

(1) Universal Transverse Mercator (UTM)

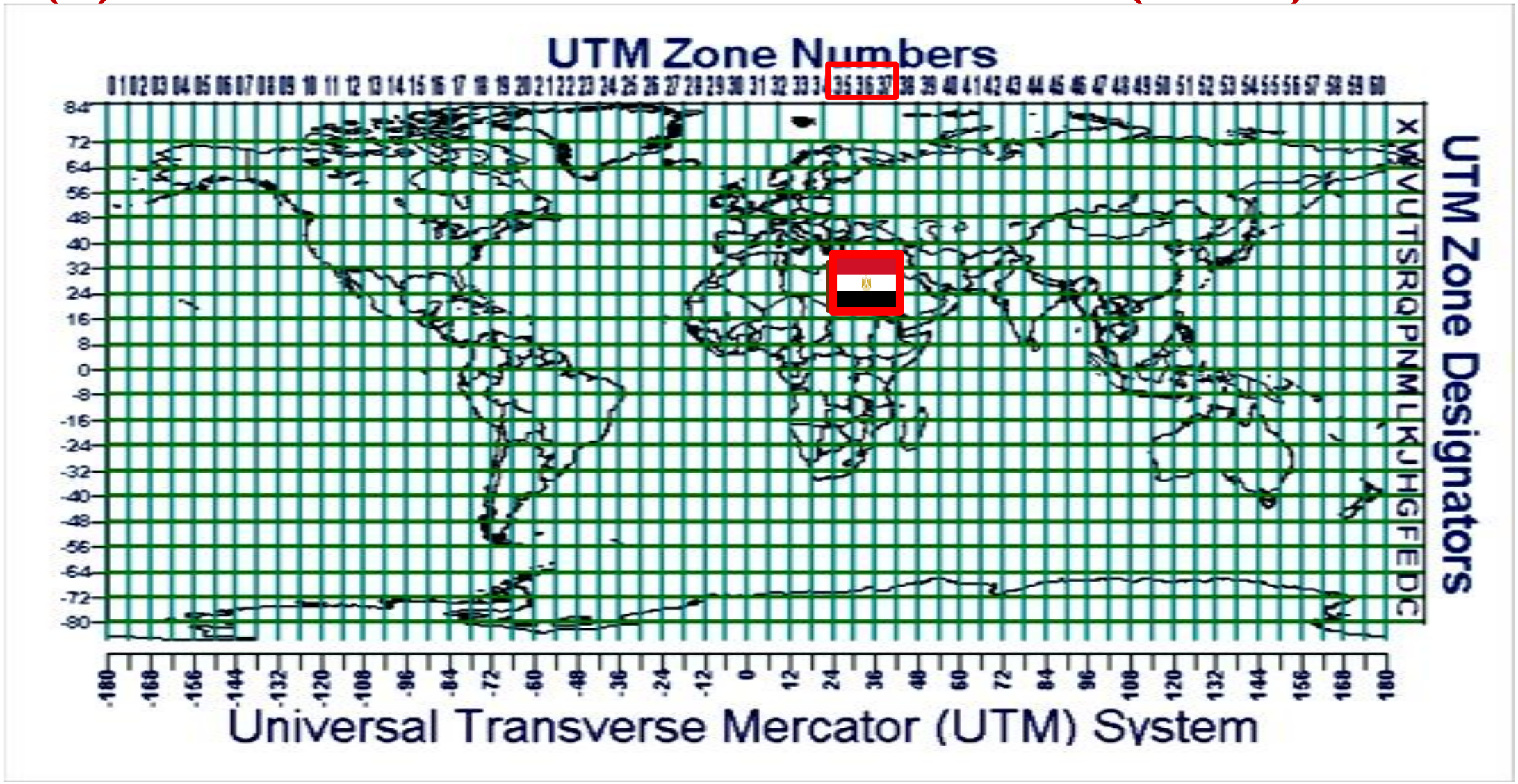


(1) Universal Transverse Mercator (UTM)

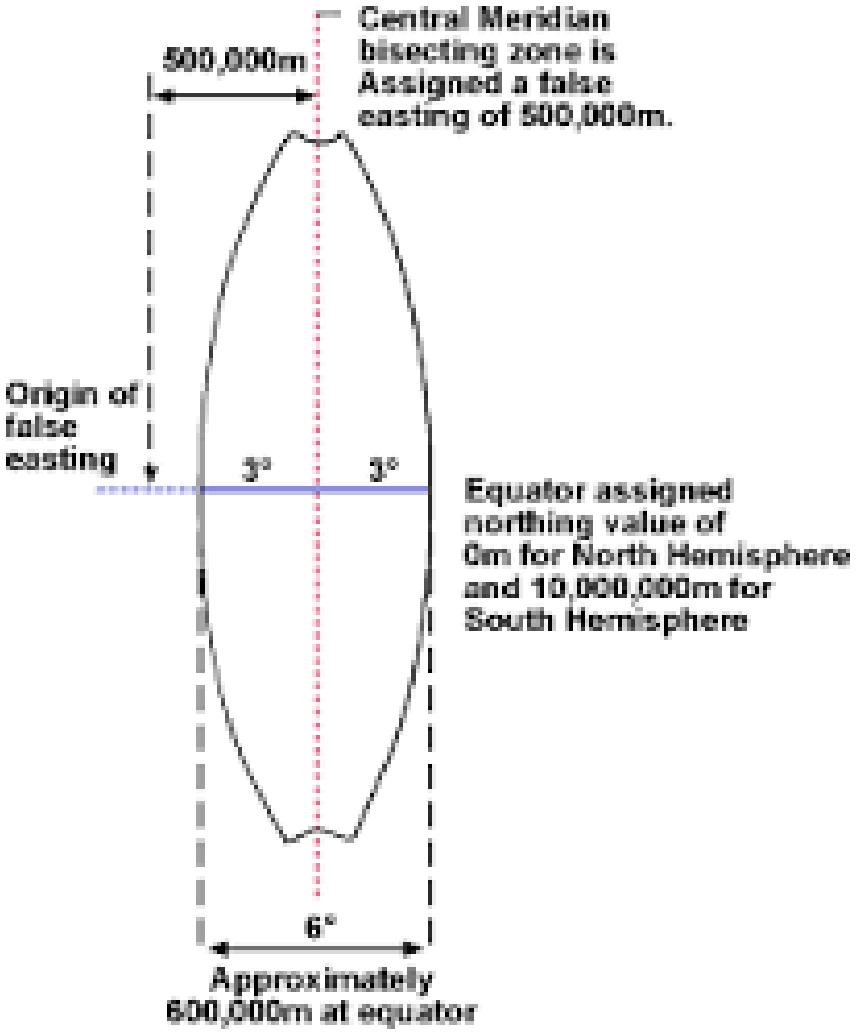


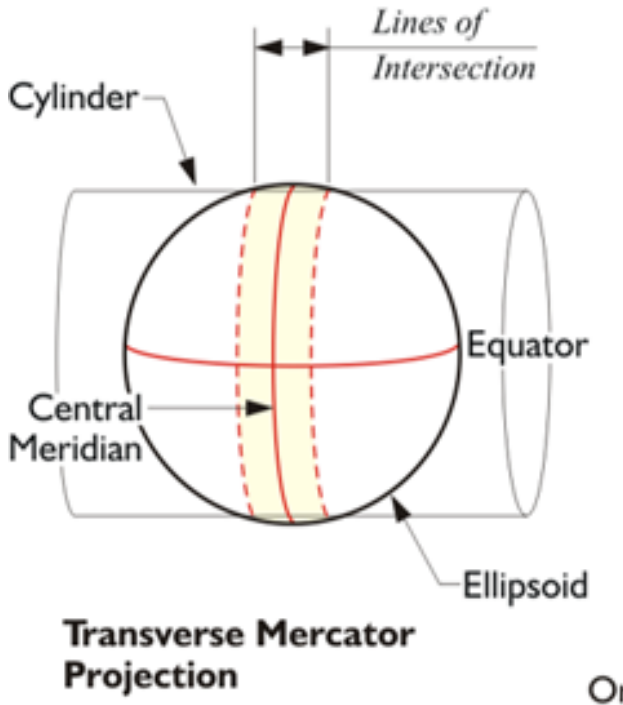
Universal Transverse Mercator (UTM) System

(1) Universal Transverse Mercator (UTM) - Egypt

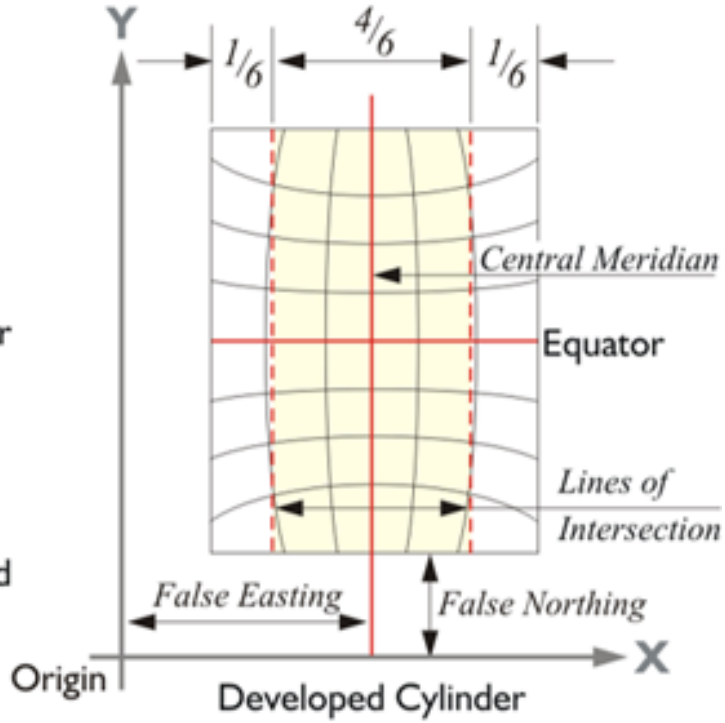


(1) Universal Transverse Mercator (UTM) – Zone





Transverse Mercator Projection



(2) Egyptian Transverse Mercator (ETM)

(2) Egyptian Transverse Mercator (ETM)

- Type: Transverse Mercator
- Datum: Helmert 1906 (*How does this affect practical applications?*)
- Divide the area of Egypt into 3 vertical strips (zones) extending west to east.
- Three Zones are named: Purple belt (Western Desert), Red Belt (Nile Valley), and Blue belt (Eastern desert).
- Zone Width: 4° degrees of longitude, two degrees at each side of the central meridian.
- Central latitude: 30° N.
- Central Meridian: mid-longitude of each zone.
- True Origin Location: intersection of latitude 30° N and CM.
- SF at CM: 1.

(2) Egyptian Transverse Mercator – Purple Belt

- Width: : 4° degrees of longitude, two degrees at each side of the central meridian.
- Extension: 25° E to 29° E.
- Central Latitude: 30° N.
- Central Meridian CM: 27° E.
- FE: 700 km.
- FN: 200 km.

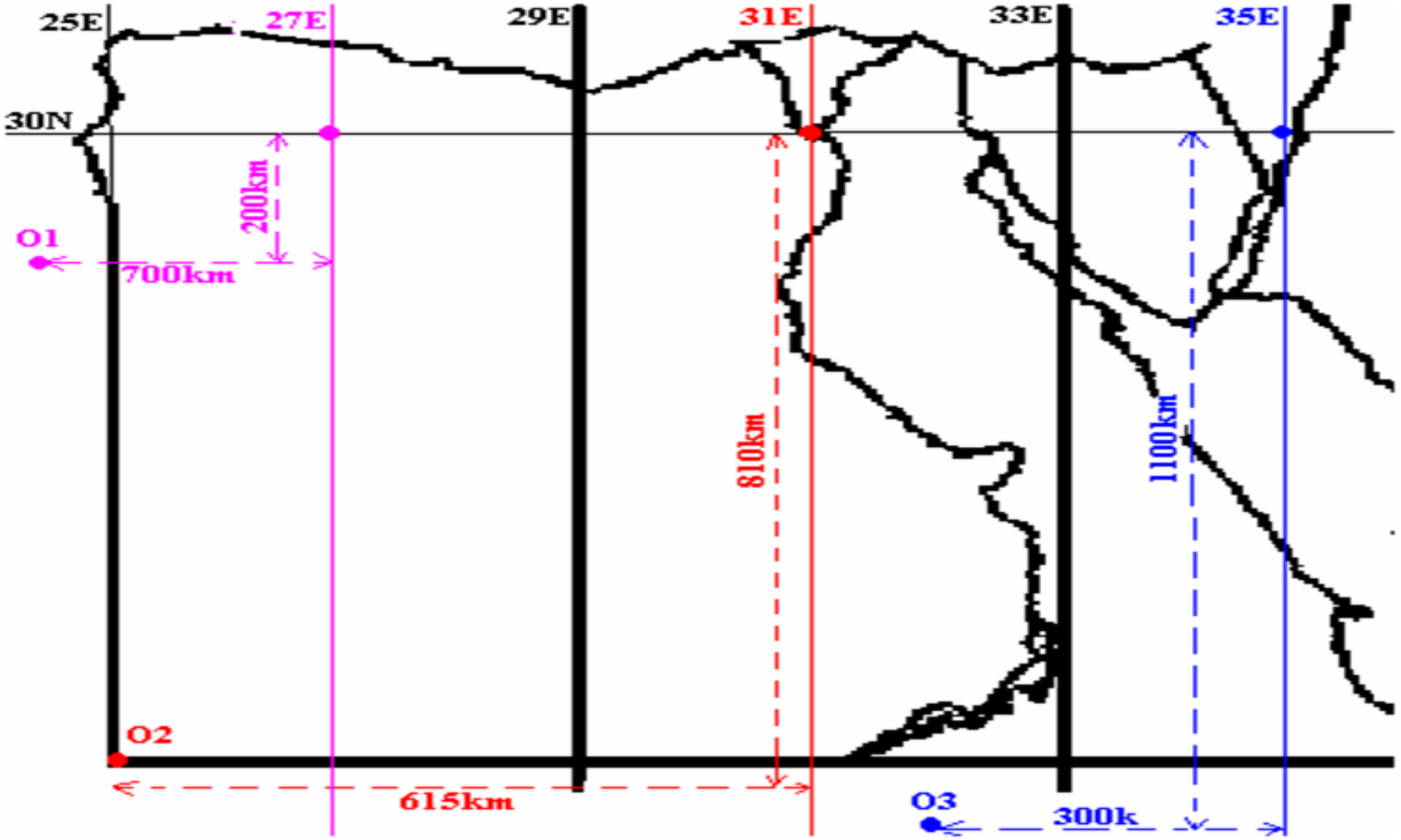
(2) Egyptian Transverse Mercator – Red Belt

- Width: : 4° degrees of longitude, two degrees at each side of the central meridian.
- Extension: 29° E to 33° E.
- Central Latitude: 30° N.
- Central Meridian CM: 31° E.
- FE: 615 km.
- FN: 810 km.

(2) Egyptian Transverse Mercator – Blue Belt

- Width: : 4° degrees of longitude, two degrees at each side of the central meridian.
- Extension: 33° E to 37° E.
- Central Latitude: 30° N.
- Central Meridian CM: 35° E.
- FE: 300 km.
- FN: 1,100 km.

(2) Egyptian Transverse Mercator (ETM)



How could you interpret this figure?

(3) Modified Transverse Mercator (MTM)

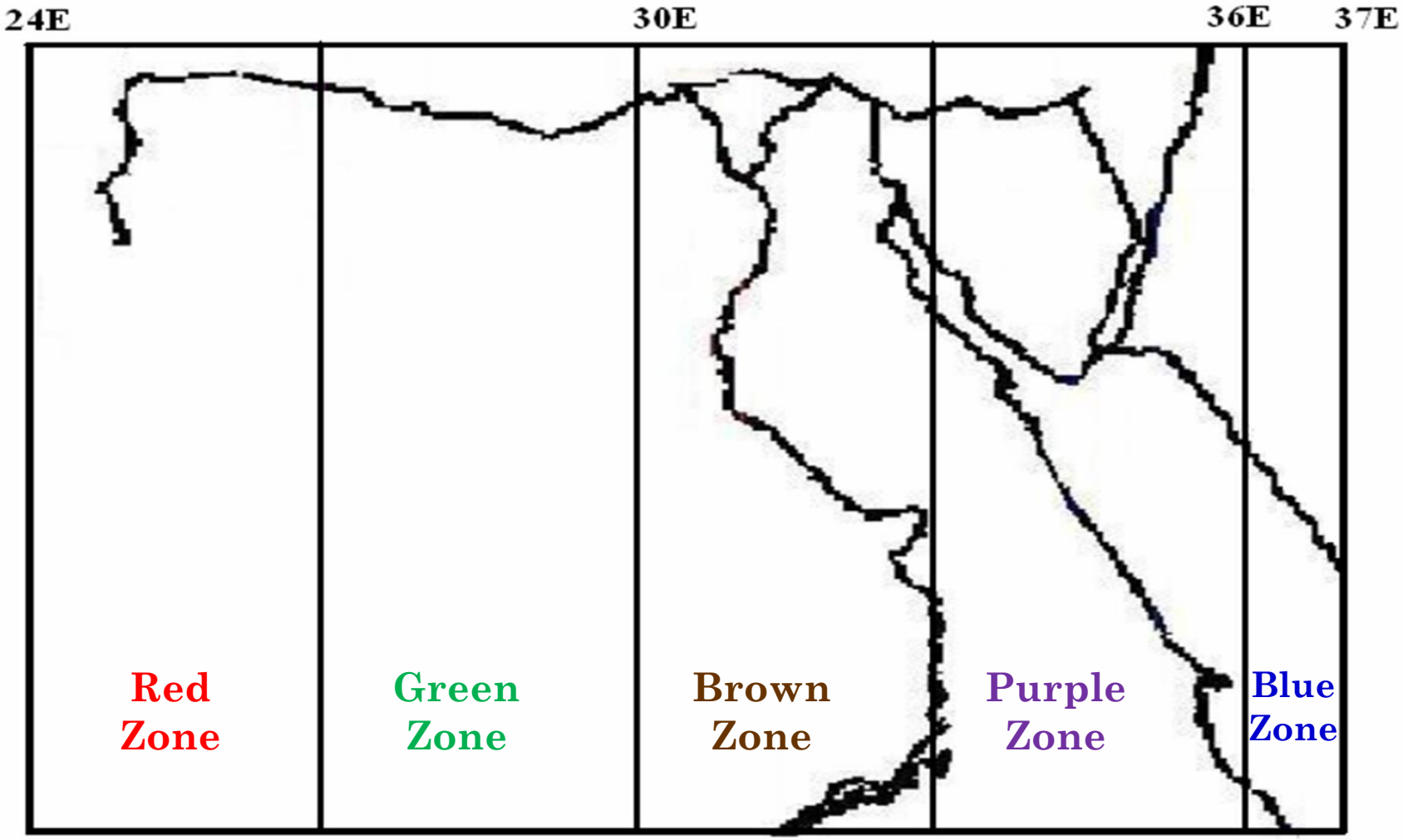
(3) Modified Transverse Mercator (MTM)

- Type: Transverse Mercator
- Datum: WGS 1984 (*How could this benefit?*)
- Divide the area of Egypt into 5 vertical strips (zones) extending west to east.
- Three Zones are named (West to east): Red zone, Green zone, Brown zone, Purple zone, and Blue zone.
- Zone Width: 3° degrees of longitude, 1.5 degrees at each side of the central meridian.
- Central latitude: Equator.
- Central Meridian: mid-longitude of each zone.
- True Origin Location: intersection of Equator and CM.
- FE: 300 km
- FN: zero
- SF at CM: 0.9999

(3) Modified Transverse Mercator (MTM) - Zones

No	Zone	Extension	CM	True Origin Location	FE, FN
1	Red Zone	24° - 27° E	25° 30`	Intersection of Equator and CM	300 km, 0
2	Green Zone	27° - 30° E	28° 30`		
3	Brown Zone	30° - 33° E	31° 30`		
4	Purple Zone	33° - 36° E	34° 30`		
5	Blue Zone	36° - 39° E	37° 00`		

(3) Modified Transverse Mercator (MTM) - Zones



LIMITATIONS AND CHALLENGES

- **The challenges of map projection systems in Egypt include: -**

1. Zone width
2. Project extension
3. Scale variations away from CM.
4. Different FE and FN in case of ETM zones.
5. ….
6. ….
7. ….

Real-World Applications – National Projects

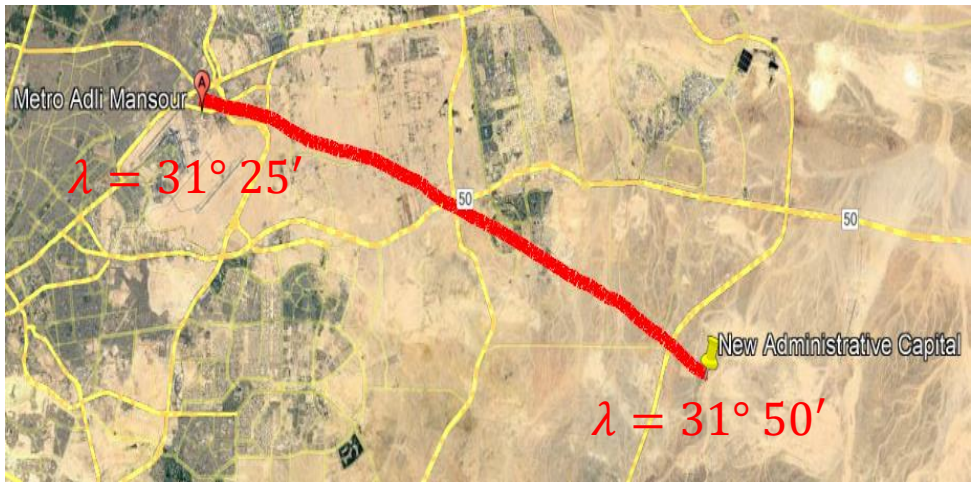
REAL-WORLD APPLICATIONS - HSR

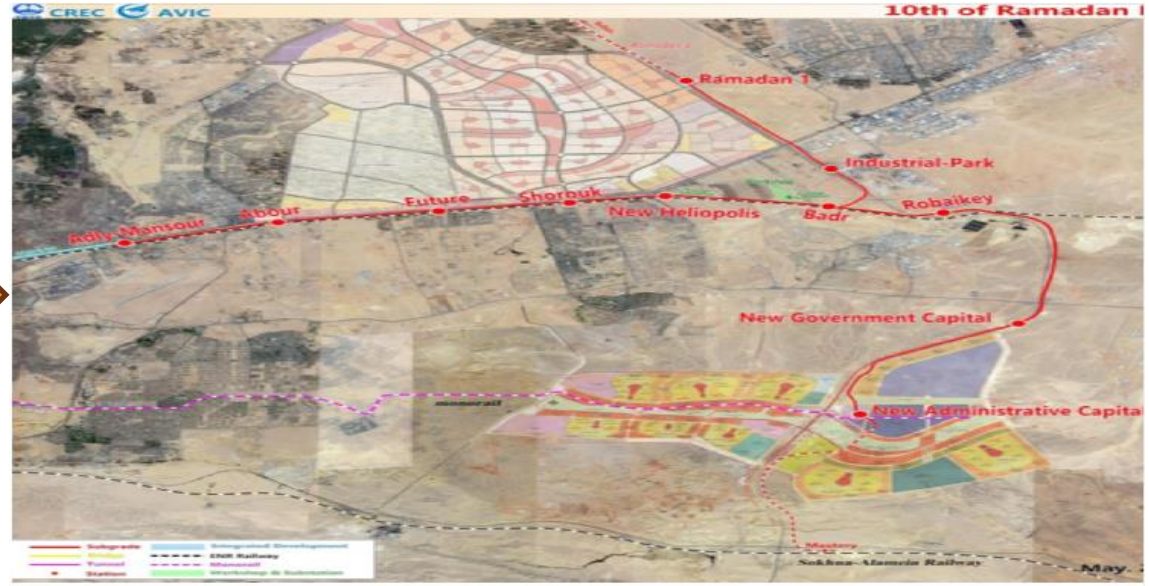
- Egypt HSR spring 2022

- The project was launched in 2018 to construct three such lines with a total length of about 2,000 kilometres (1,200 mi).
- The ***first line*** links the cities of Ain Sukhna and Marsa Matrouh,
- The ***second*** connects the cities of Sixth of October and Abu Simbel, and
- The ***third*** connects the city of Qena with the cities of Hurghada and Safaga.
- The project is being established by a coalition of German Siemens companies, the Arab Contractors and Orascom Construction.

REAL-WORLD APPLICATIONS - LRT

- Cairo LRT is an electrified regional rail system linking the city of Cairo to Egypt's New Administrative Capital and the 10th of Ramadan City. An initial 70 km route consisting of 12 stations was inaugurated on 3 July 2022.
- The full system is projected to extend over 100 km with 19 stations.





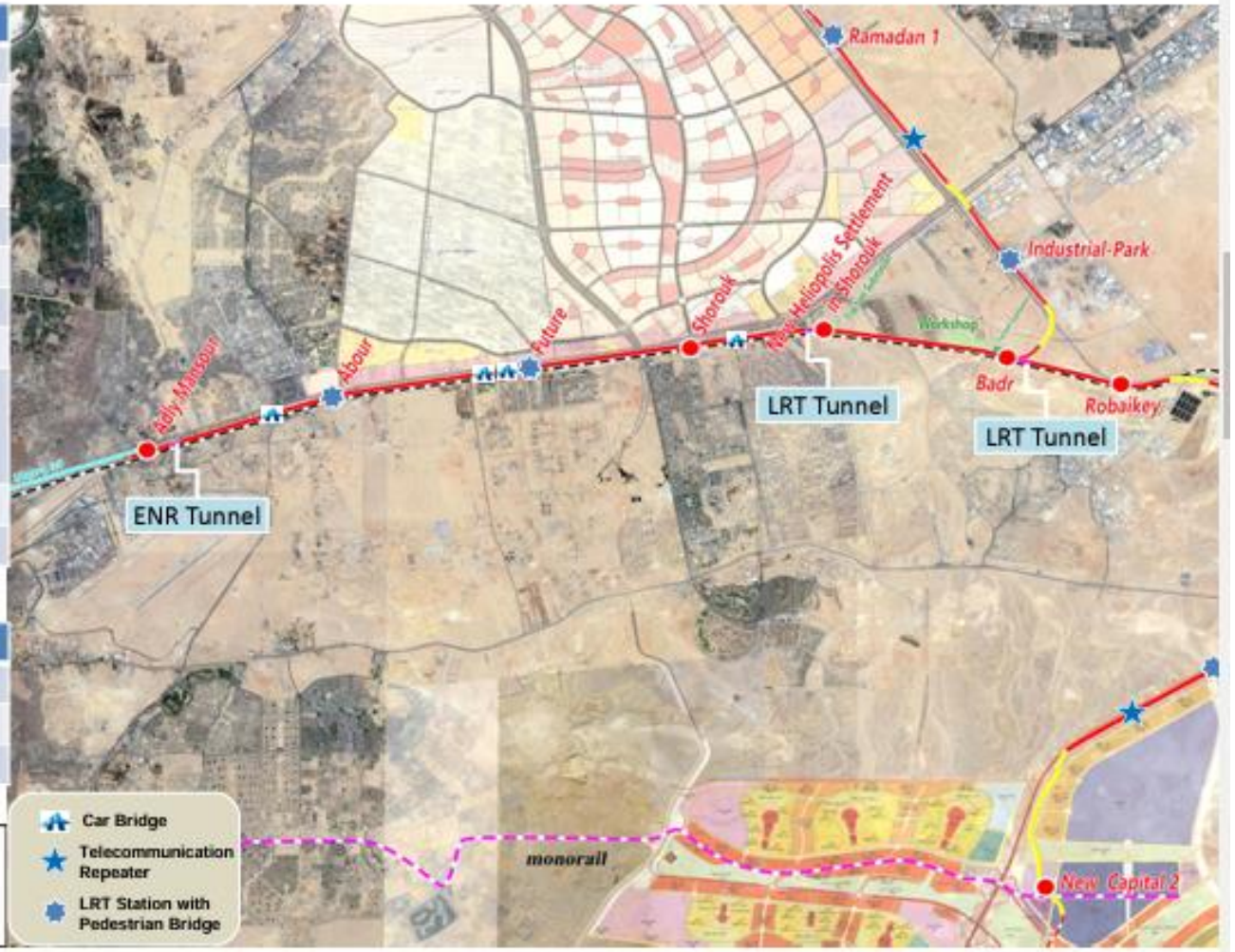
REAL-WORLD APPLICATIONS - LRT

1.1 Latest Alignment Overview

Total Length		74.49km
Subgrade		64.78km
6 LRT Bridge		9.15km
3 Tunnel		0.56km
Station	At-grade	10
	Elevated	1
Depot		1 (Including OCC)
Traction Substation		2
Pedestrian Bridge		5 No.
Telecommunications Repeater		3 No.
ENR shifting		7.3km
4 Car Bridge		9.29km

The alignment details Based on :

Transmittal No.	Date
76M-T-PEO-NAT-PM-01-404	2019.04.04
76M-T-PEO-NAT-PM-01-423	2019.04.22
76M-T-PEO-NAT-PM-01-424	2019.04.22



THANK YOU

End of Presentation