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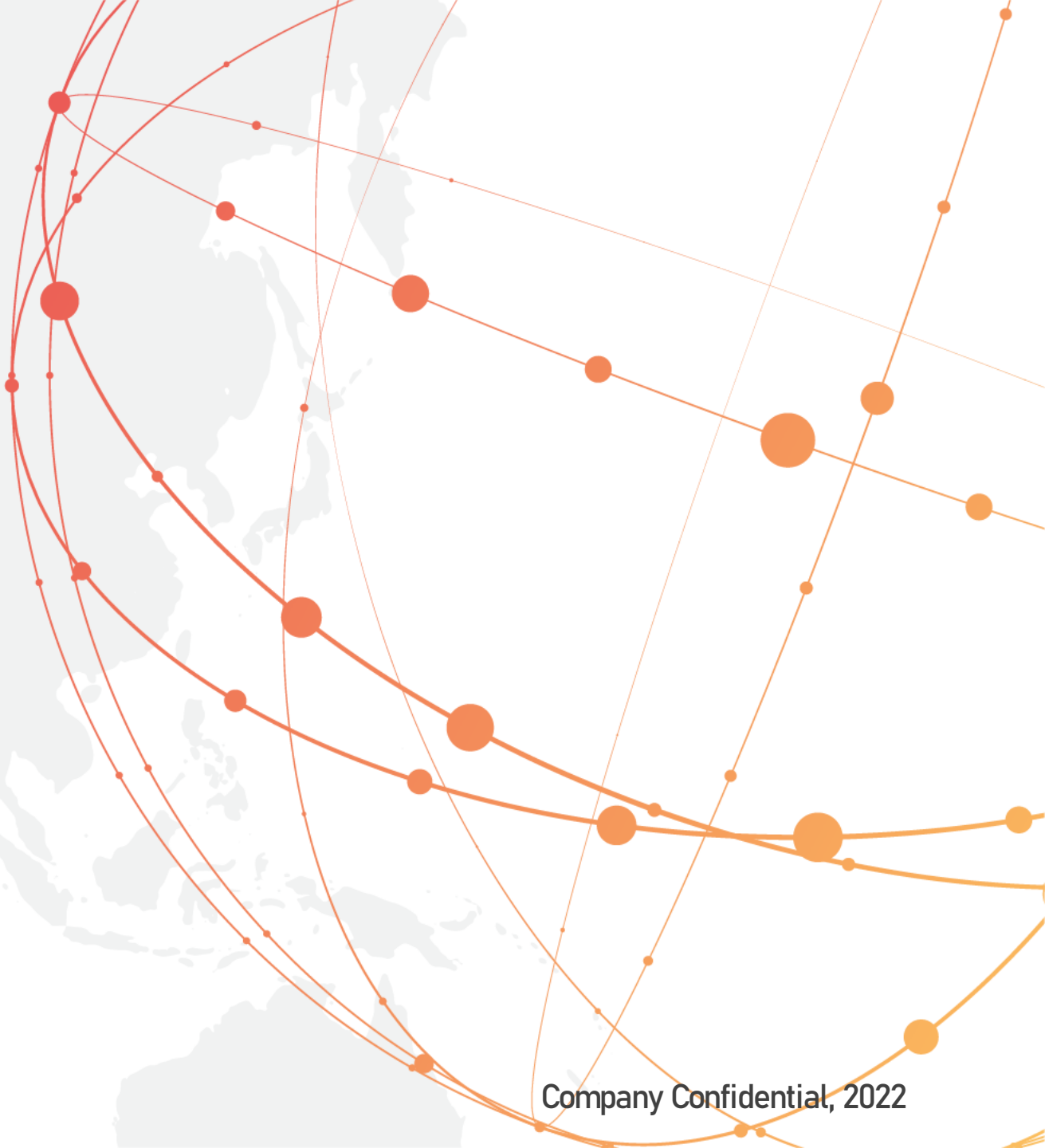
低軌衛星用戶設備開發測試關鍵解密

Merry Hsu



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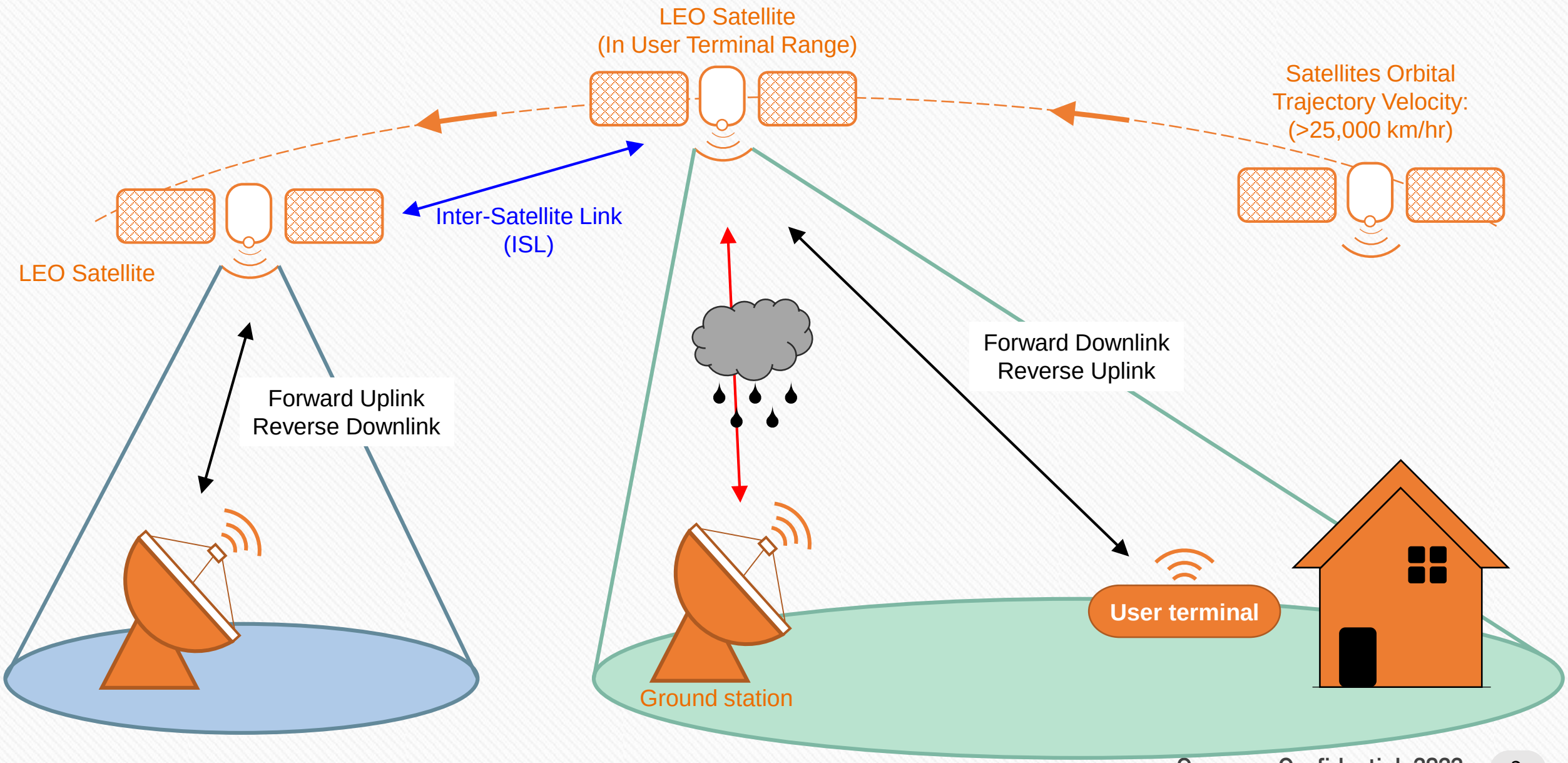
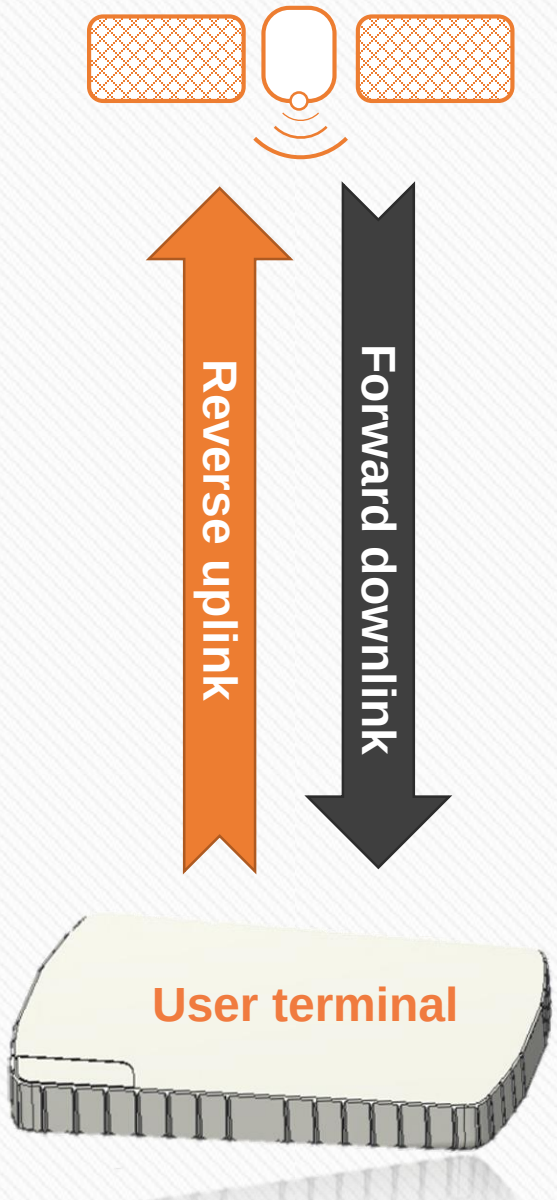
Agenda

1. 低軌道衛星簡介
2. 低軌道衛星-UT驗冊簡介
3. 結論

低軌道衛星簡介

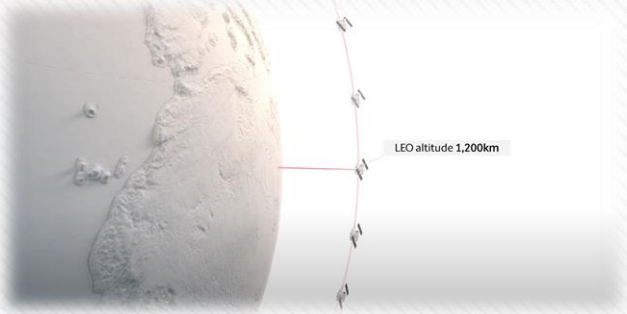

LEO Satellite
(In User Terminal Range)
Satellites Orbital
Trajectory Velocity:
(>25,000 km/hr)
Inter-Satellite Link
(ISL)
LEO Satellite
Forward Uplink
Reverse Downlink
Forward Downlink
Reverse Uplink
User terminal
Ground station

低軌道衛星簡介



UT

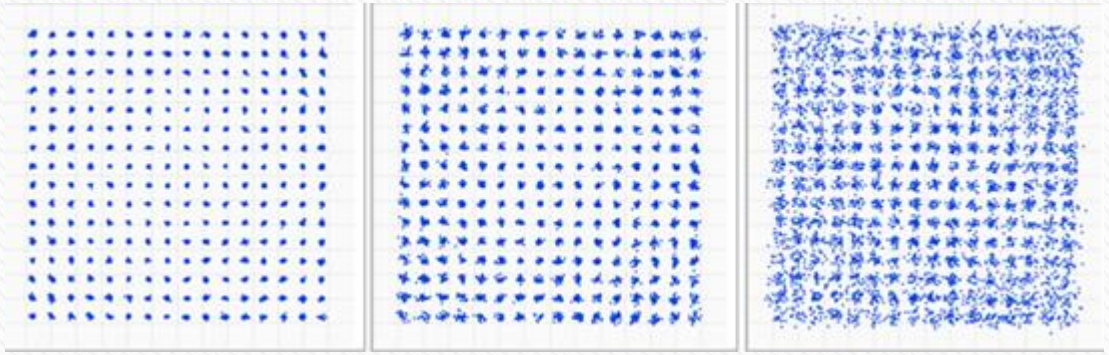
- Reverse uplink
  - EIRP
- Forward downlink
  - G/T
- Communication
  - EVM
  - Beam switching time
  - Scan loss
  - Side-lobe level



www.youtube.com/watch?v=8_kytEDxC0A&t=74s

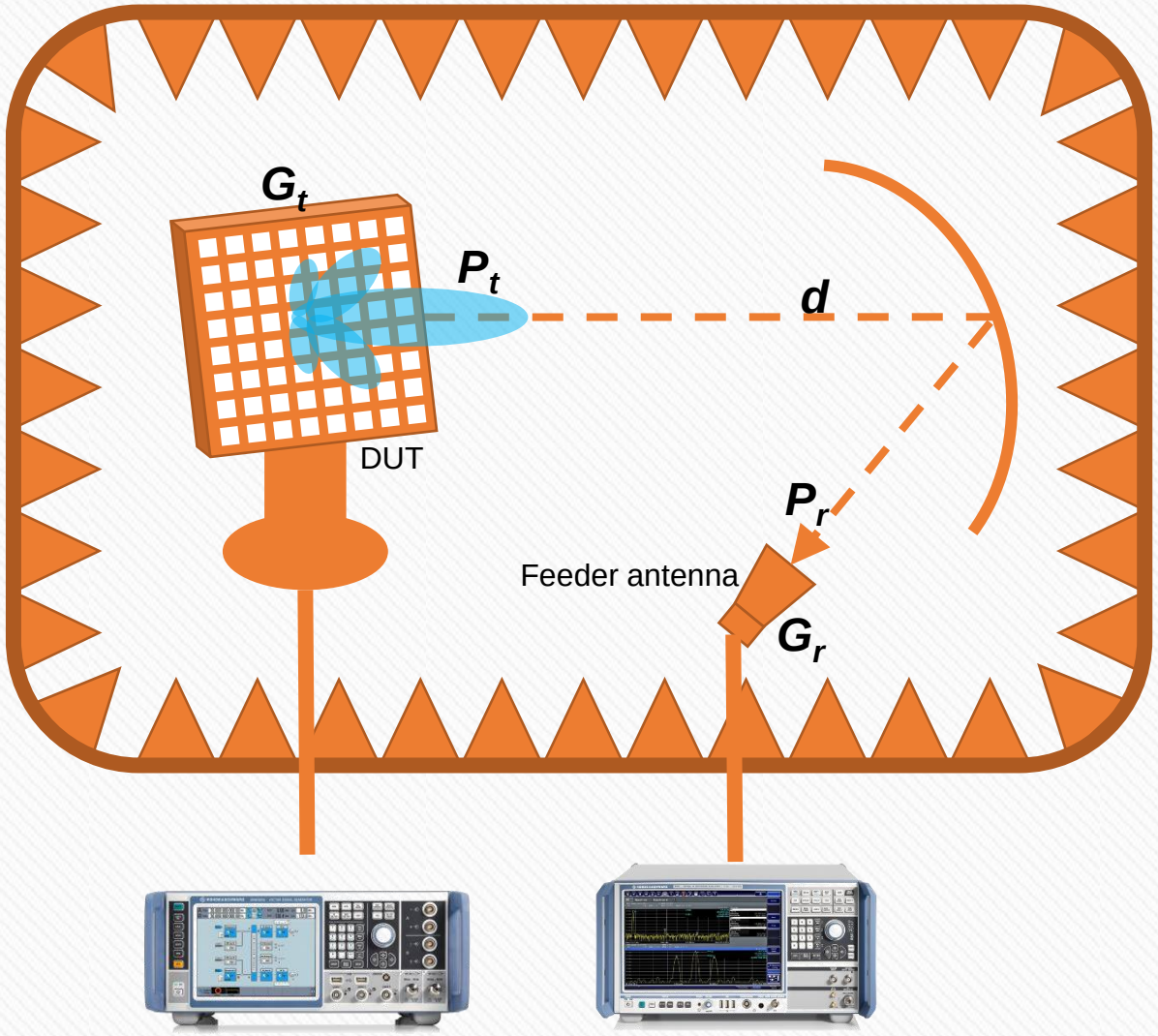
EVM

EVM, Error Vector Magnitude 誤差向量幅度



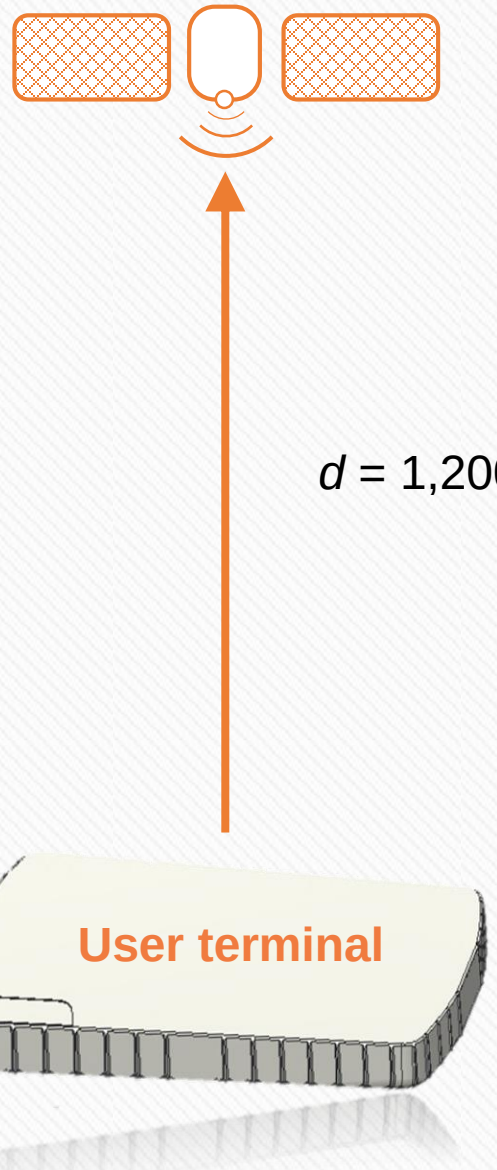
影響EVM的可能原因

- PCB版上的損耗
- Supply Voltage Ripple
- Phase Noise
- Intermodulation



https://www.witimes.com/evm-snr-80211ac/
https://en.wikipedia.org/wiki/Intermodulation

EIRP



EIRP, equivalent isotropically radiated power 等效全向輻射功率

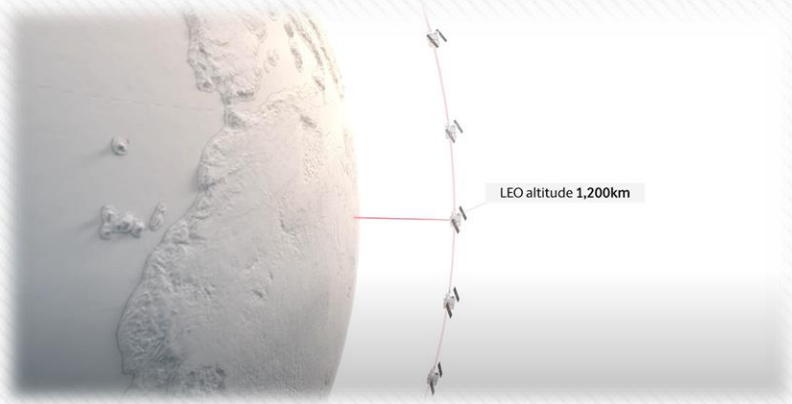
$EIRP = P_t \times G_t$

P_t: the output power of the transmitting antenna
G_t: the gain of the transmitting antenna

d = 1,200 km

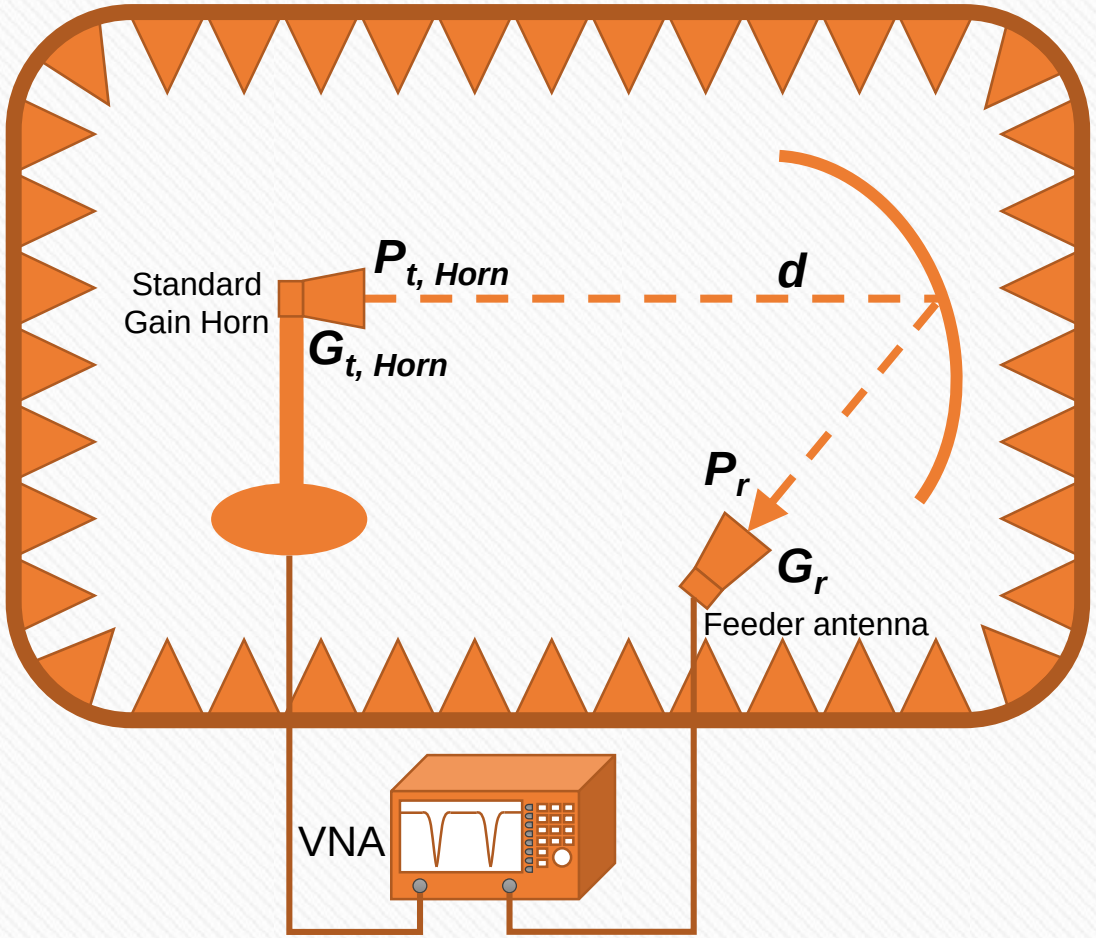
$$20\log_{10}\left(\frac{4\pi d}{\lambda}\right) = 20\log_{10}\left(\frac{4\pi \times 1{,}200{,}000}{3\times 10^8 / 14\times 10^9}\right) \approx 177\text{dB}$$

The path loss at 14 GHz is **177** dB.

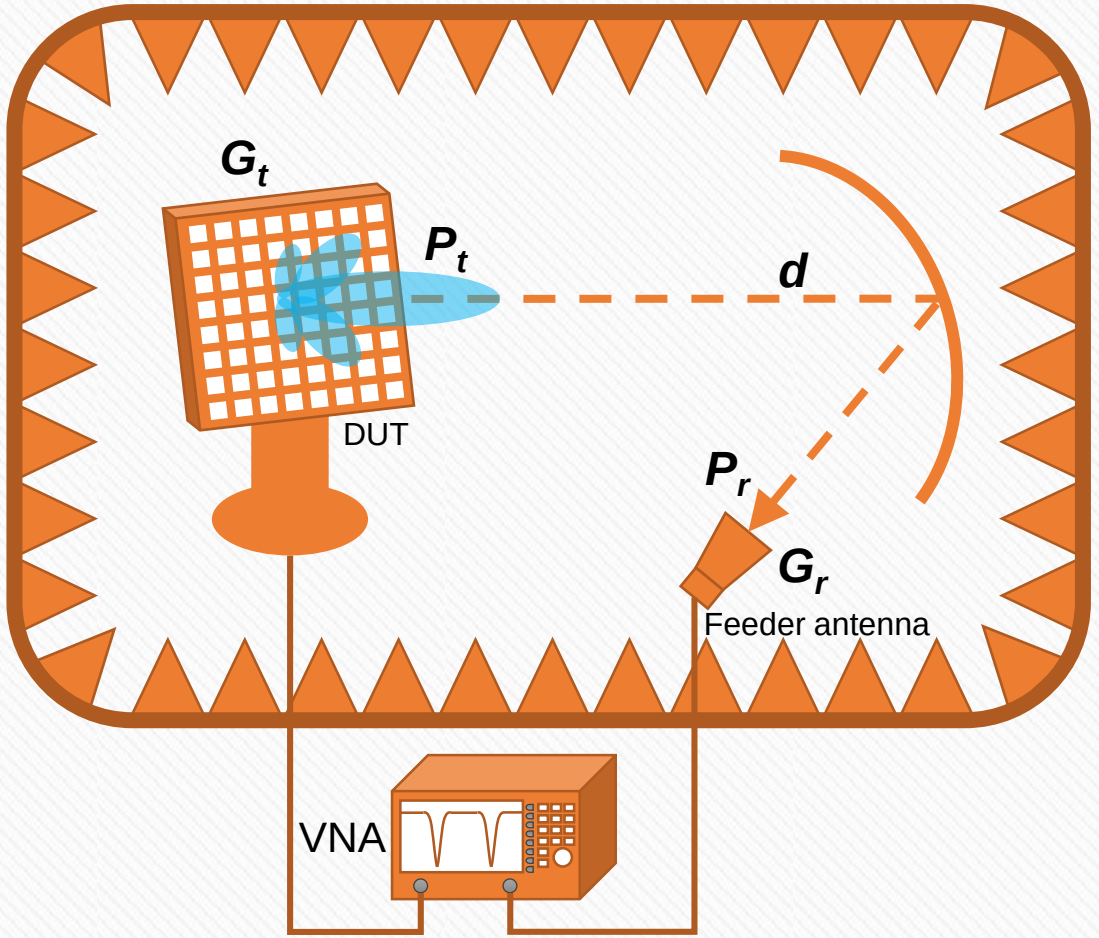


EIRP

$$P_r = \boxed{P_{t,Horn} G_{t,Horn}} G_r \left(\frac{\lambda}{4\pi d}\right)^2$$



$$P_r = \boxed{P_t G_t} G_r \left(\frac{\lambda}{4\pi d}\right)^2$$



G/T

G/T, Antenna gain-to-noise-temperature

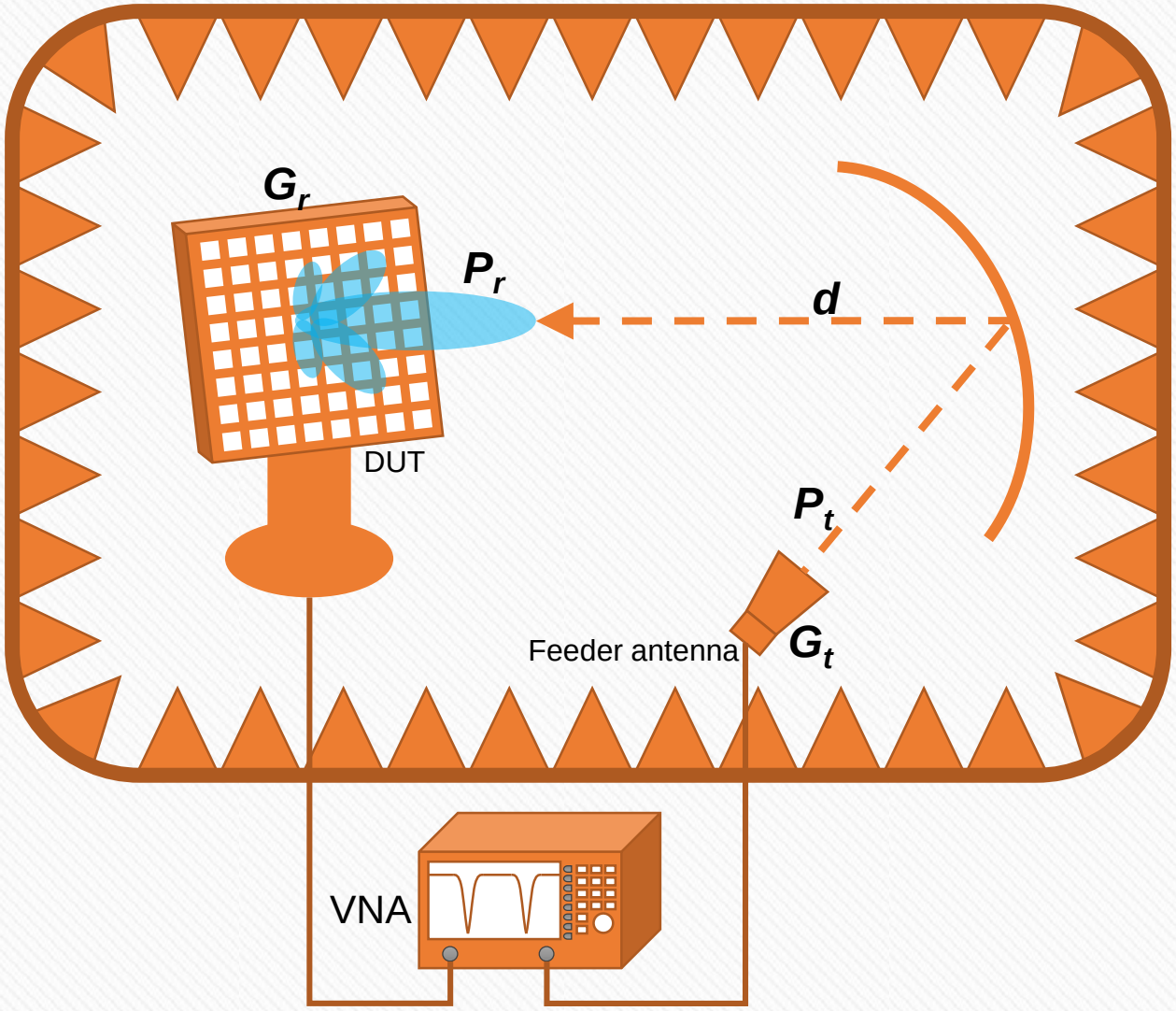
G/T (dB) = G_{ant}(dB)-10$log(T_{sys})$

G_{ant} is the Receive antenna gain.
T_{sys} is the system noise temperature.

Carrier to noise ratio

$$\frac{C}{N} = (P_t G_t)\left(\frac{\lambda}{4\pi d}\right)^2 \left(\frac{G_r}{T_R}\right)\left(\frac{1}{k}\right)$$

k is the Boltzmann constant



Beam Switching Time

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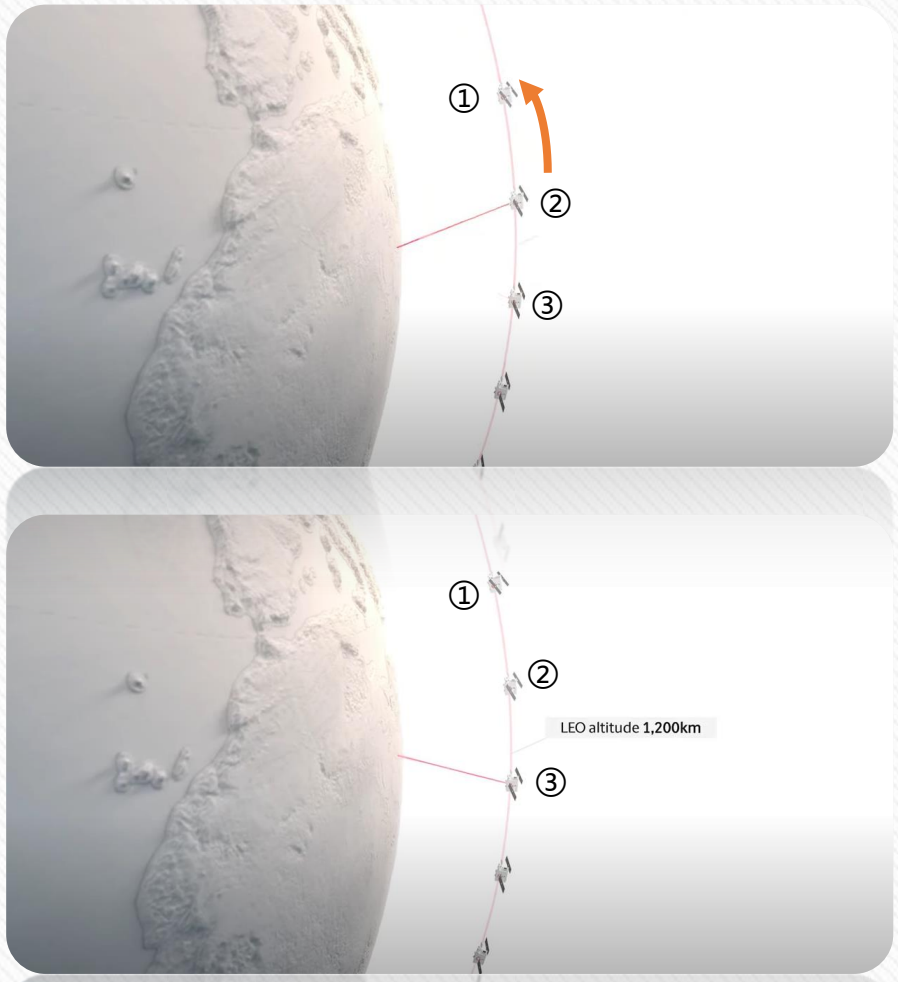
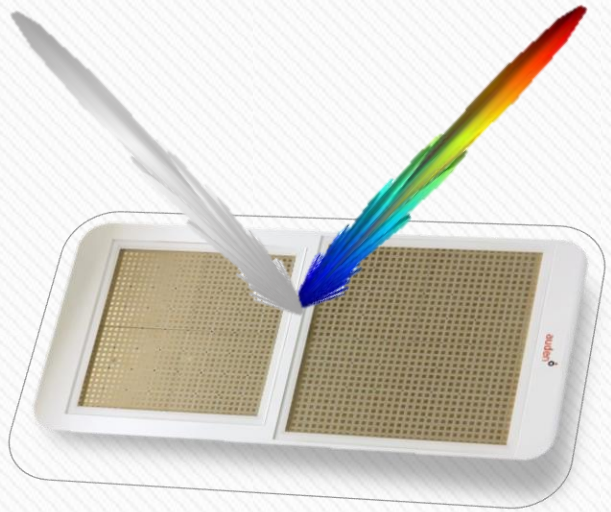


www.youtube.com/watch?v=8_kytEDxC0A&t=74s

Inter-Satellite Handover



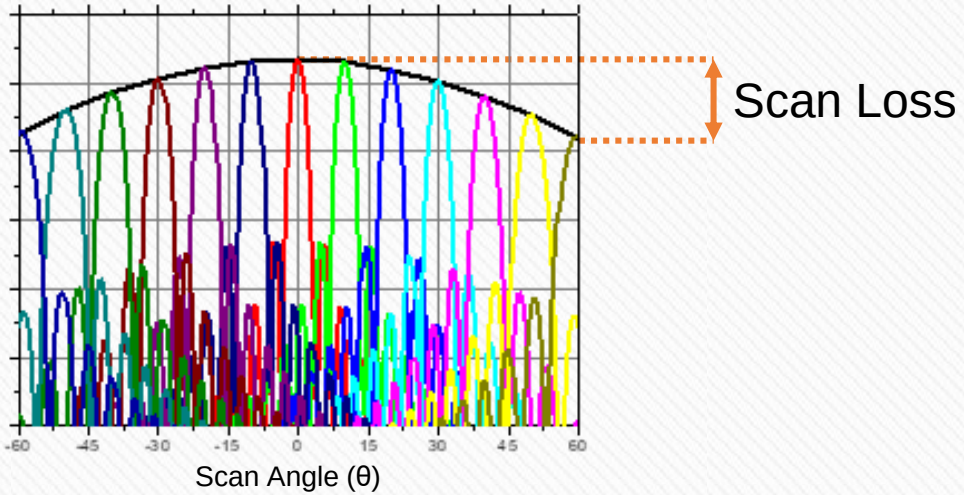
Beam Switching Time < 400 μs

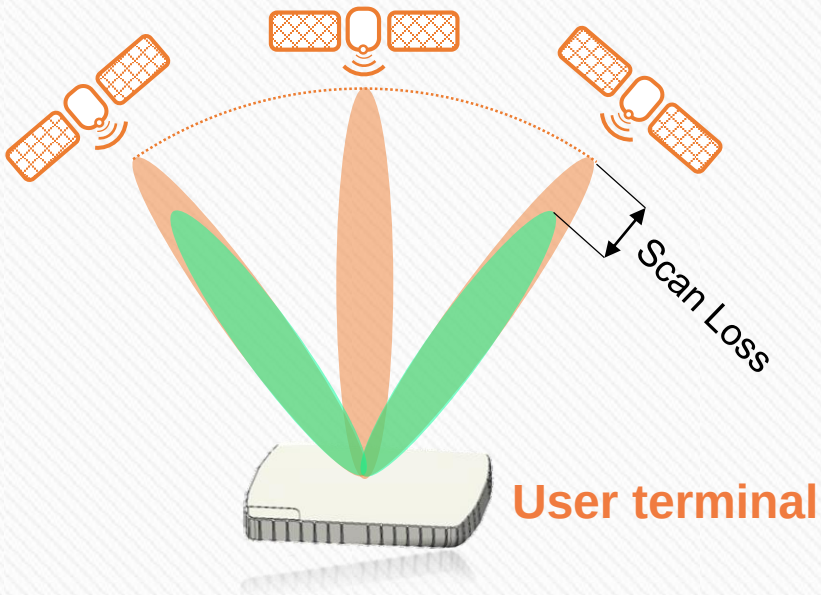
Scan Loss

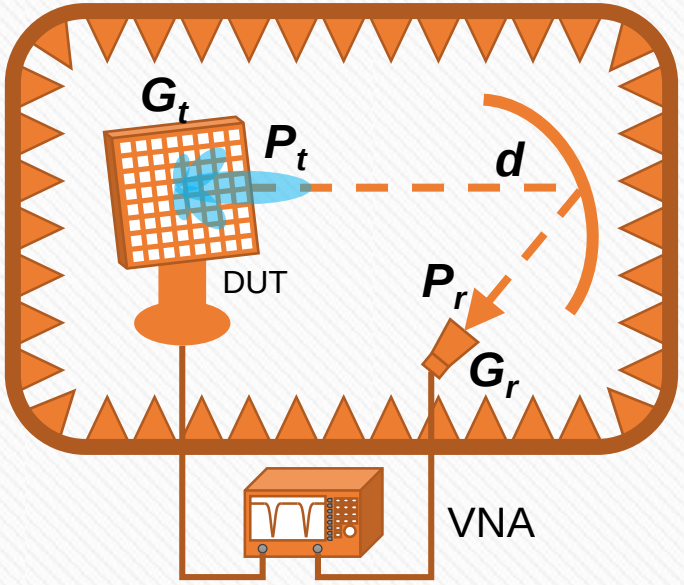
aka Roll of factor

$$Scan\ Loss = 10\log(\cos^N \theta)$$

θ is the scan angle of boresight
N is the roll of factor, typically in the 1.3 range







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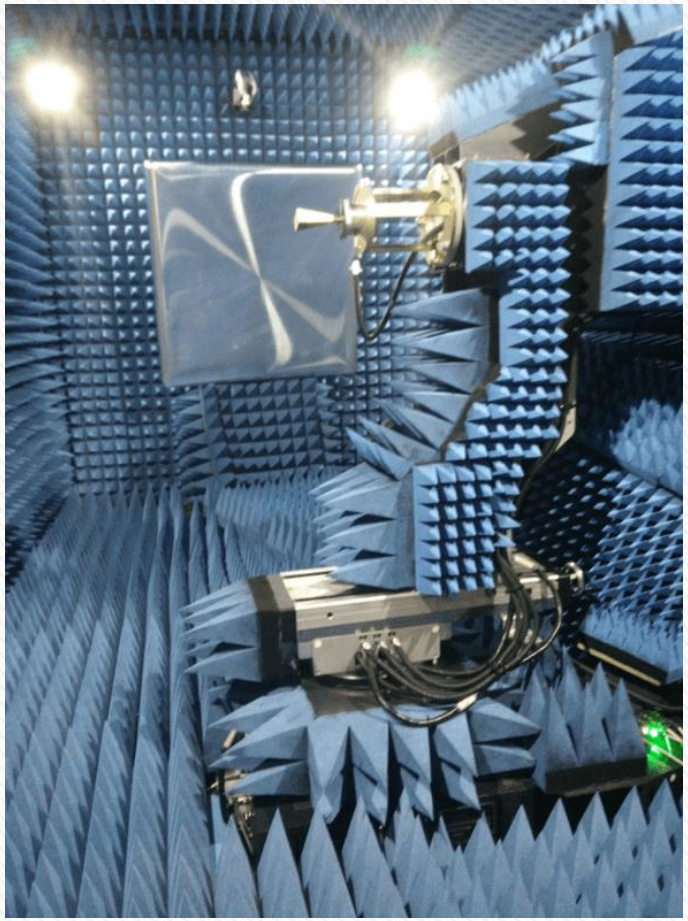
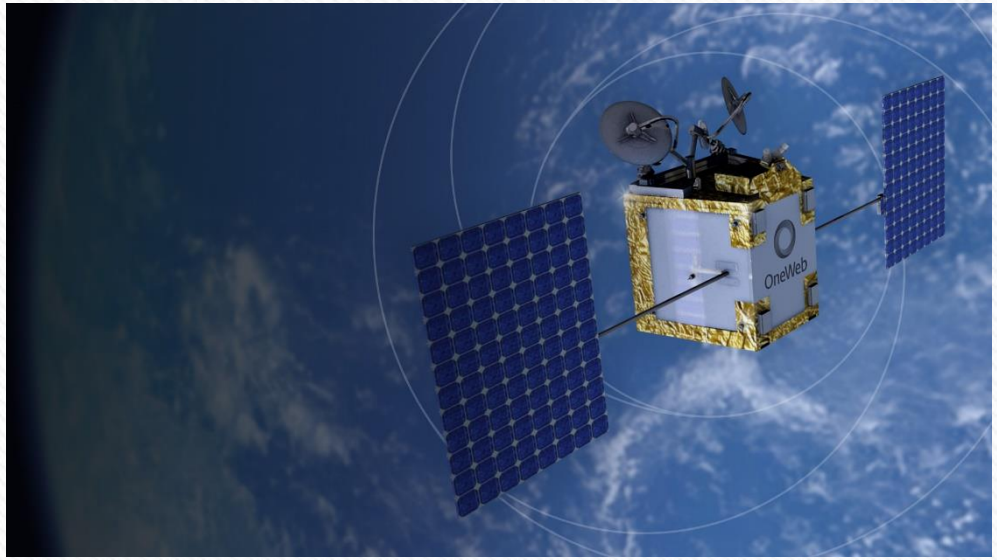
毫米波縮距場天線量測實驗室
為滿足低軌道衛星通訊、第五代行動通訊毫米波頻段以及車用雷達天線量測需求，耀登科技建構以縮距場形式天線量測實驗室，可用於主被動天線量測使用。其相關規格如下所示：

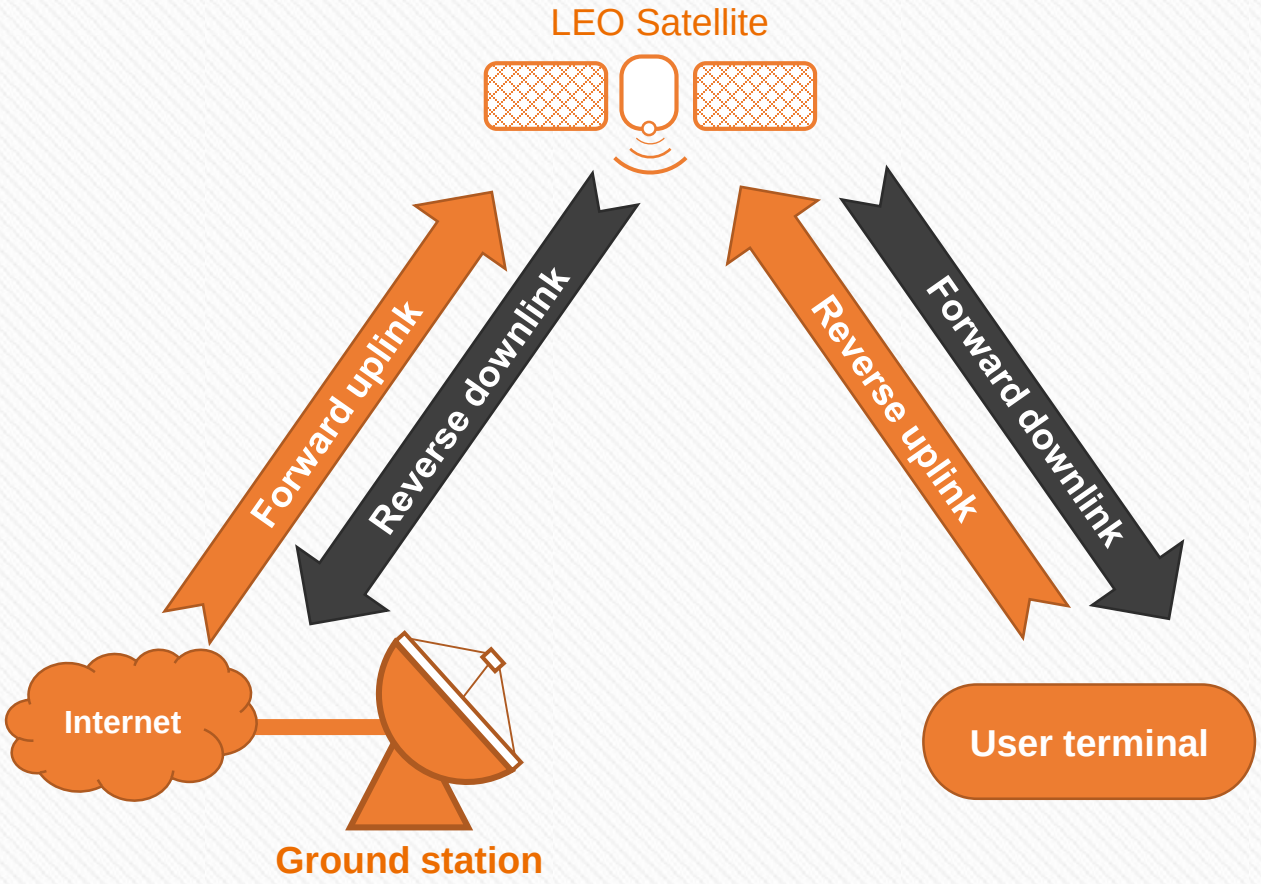
量測頻率範圍：4 ~ 94 GHz
待測物大小：50 x 50 x 50 cm^3
量測項目： Antenna gain, 2D pattern, 3D pattern, EIRP, G/T



Field Test

- 建立國內低軌衛星通訊實證場域
- 2025發射第一顆實驗衛星
- 2026發射第二顆實驗衛星





https://oneweb.net/resources/oneweb-resume-satellite-launches-through-agreement-spacex

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THANK YOU