Demystifying EMC Korea 2025

INTRODUCTION TO SATELLITE RF TESTING: EMC, SLT & PAYLOAD COMMUNICATION

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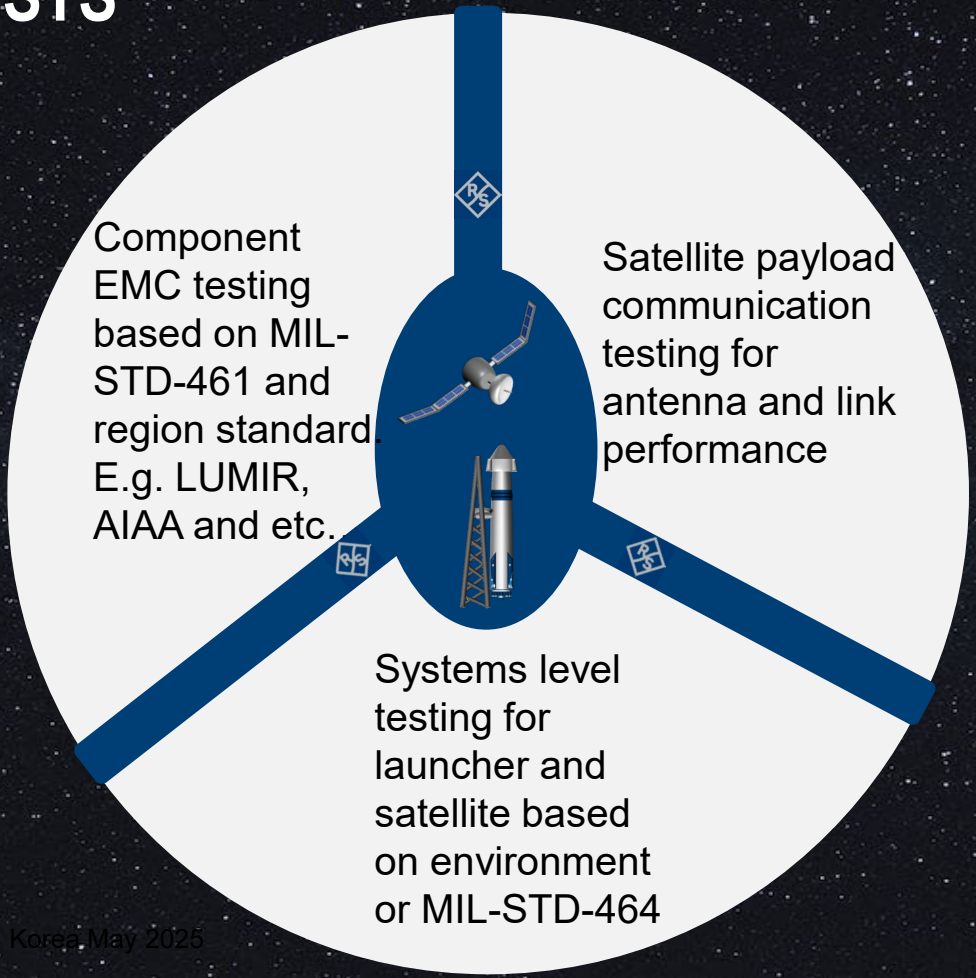
ROHDE&SCHWARZ
Make ideas real

AGENDA

- Introduction & Standards
- EMC Testing
- System Level Testing
- Satellite Payload Communication Testing

RELATED TESTS



EMC STANDARDS BASED ON EUT

► Different Electronic Equipment require compliance to different Standards

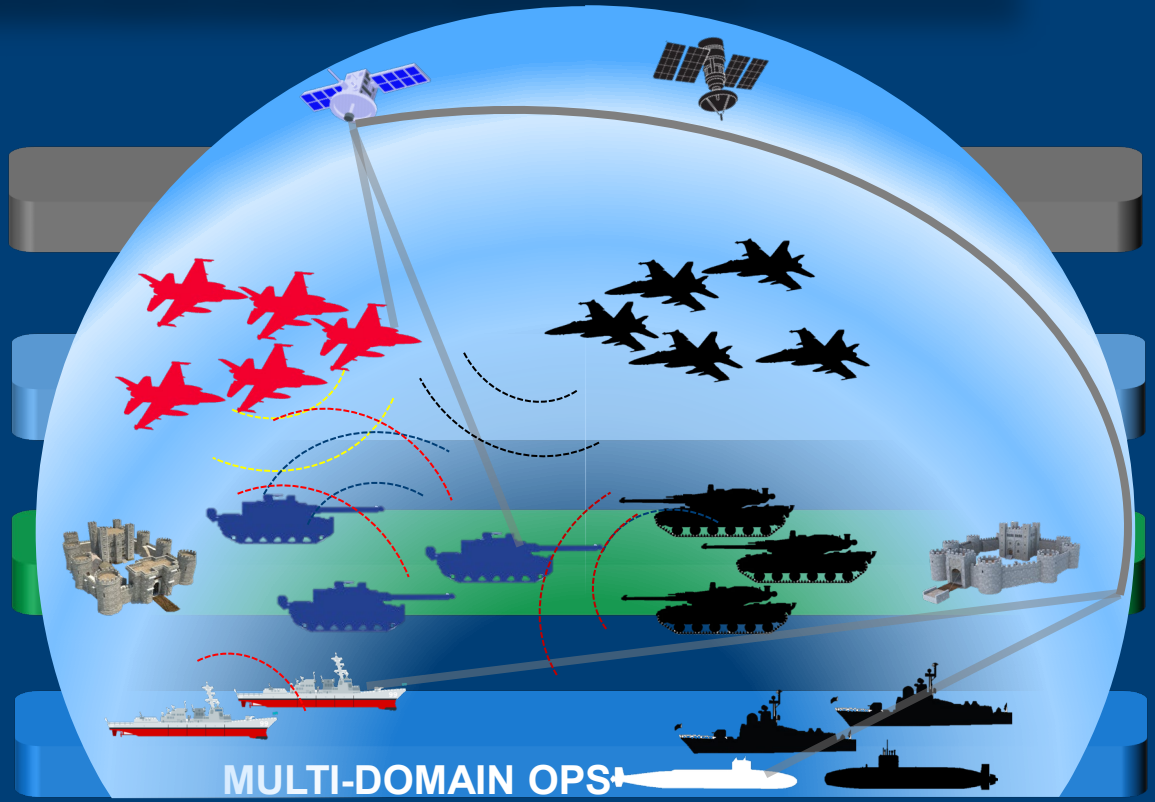
Military Equipment:

- Aircraft Equipment
- Ship & Submarine Equipment
- Land Based Equipment

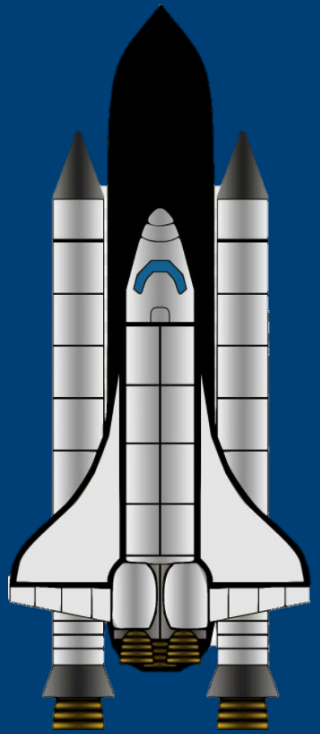
Applicable Standards:

- Mil-Std 461
- Mil-Std 464
- RTCA DO-160
- GJB151A/152A-97

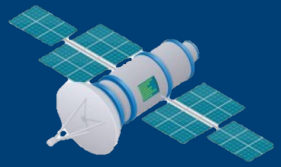
GJB
中华人民共和国国家军用标准



MIL-STD461G APPLICABLE TO SPACE SYSTEMS



Equipment and subsystems Installed In, On or Launched from the following platforms or Installations	Applicability of Requirement Based n 461G																	
	CE101	CE102	CE106	CS101	CS103	CS104	CS105	CS109	CS114	CS115	CS116	CS117	CS118	RE101	RE102	RE103	RS101	RS103	RS105
Space systems, Including Launch Vehicles		A	L	A	S	S	S		A	A	A	L			A	L		A	



Space Systems including Launch Vehicles
EMI: 10kHz - 18GHz,
EMS: 30Hz - 40GHz (20 V/m refer to table XI).

SATELLITE EMC STANDARDS (COMPONENT)

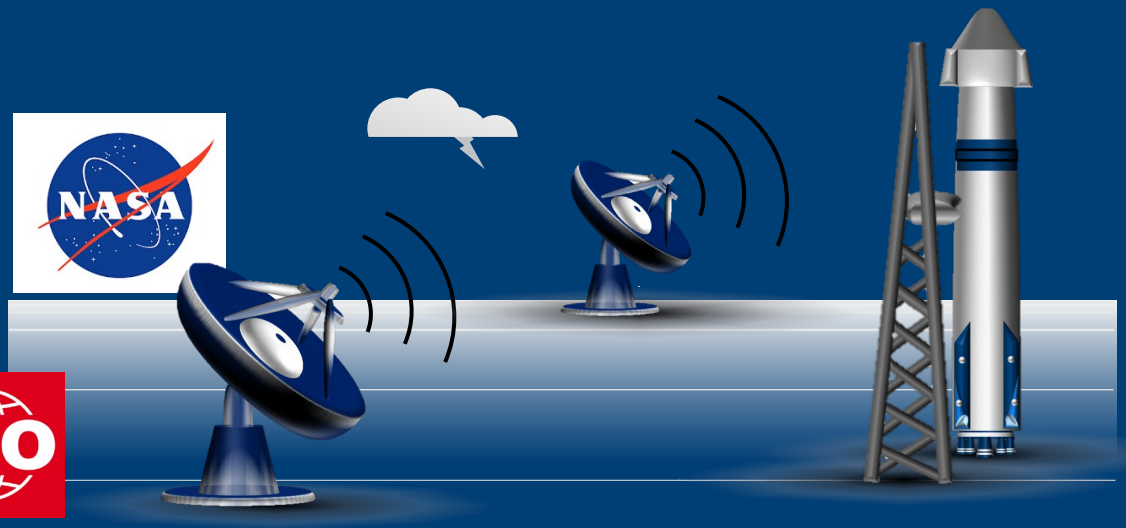
- Different Electronic Equipment require compliance to different Standards

Space Equipment:

- Space Vehicle Equipment
- Launch Vehicle Equipment
- Ground Based Equipment

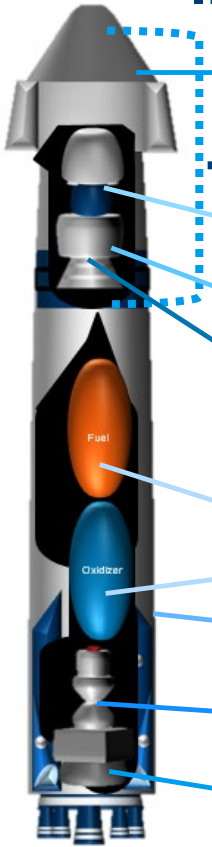
Applicable Standards:

- AIAA
- GSFC
- ECSS
- MIL-Std-461G
- ISO
- IEC
- CAS500-3



SATELLITE – EMC TEST GUIDE

WHAT IS INSIDE THE SATELLITE ROCKET



Launch Abort System (LAS)
If launch system threatens crew, it fires a solid-fuel rocket that carries the payload away from the system.

Payload Fairing:
Protective cone to protect payload from extreme pressure and heat.

Crew / Cargo Module:
Section containing items that needed to be delivered to space. (space station / satellite / crew / passengers)

Service Module:
Payload propulsion and power systems to provide thrust and allow maneuver of payload.

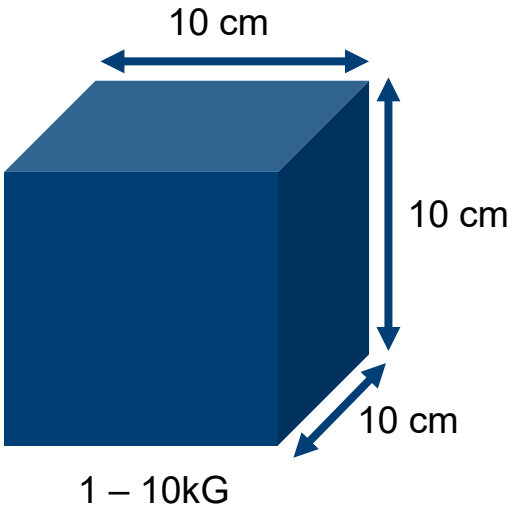
Guidance System:
Sensors, computers, radars and communication equipment coordinated with exhaust nozzles for rocket stability during launch, ascent and maneuvers

Liquid Fuel:
Main Engines to mix fuel (e.g. liquid hydrogen) and an oxidizer (e.g. liquid oxygen) in combustion chamber.

Structural System:
Frame of launch system.

Rocket Engine:
Engine burn fuel chamber. Gas expands at supersonic speed

Nozzle:
Accelerates flow of gas from combustion chamber to produce thrust



1 – 10kG

PURPOSE

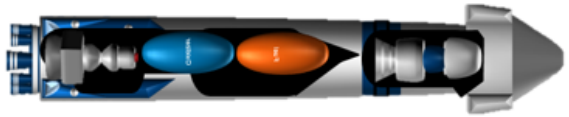
- Ensuring space systems system level electromagnetic compatibility (EMC),for all Intersystem and Intra-system including all electromagnetic environmental effects.

- Guidelines for environmental verification programs for payloads, subsystems and components. Through baseline test and/or analysis and that minimum workmanship standards have been met.

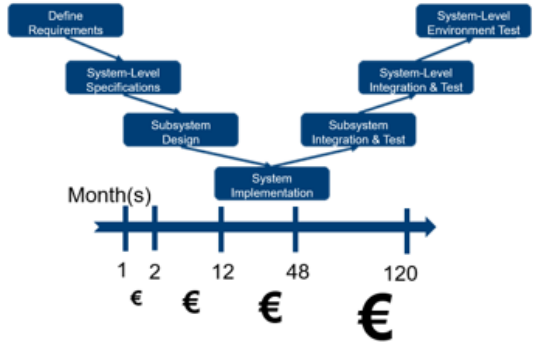
- Gives guideline test levels, provides guidance in the choice of test options, and describes acceptable test and analytical methods for implementing the requirements.

PURPOSE

- Space system or equipment has the ability to function satisfactorily in its electromagnetic environment without introducing intolerable electromagnetic disturbances and are compatible with its external natural, induced, or man-made electromagnetic environment.

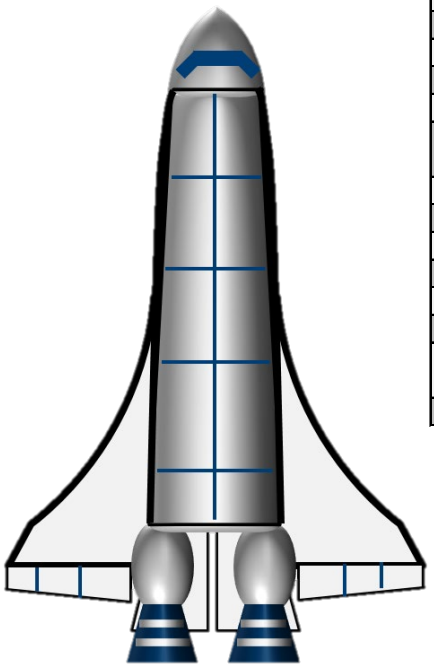


- An Electromagnetic Interference Safety Margin (EMISM) must be defined by comparison of noise level and susceptibility to ensure all electrical, electronic, electromagnetic, and electromechanical equipment within the space vehicle shall not exhibit any malfunction, degradation of performance or deviation beyond the tolerance indicated.



- Design and realization at system level are the basis for definition of activities of the EMC program to ensure space-system-level compatibility with minimum impact to program, cost, schedule, and operational capabilities.

ECSS APPLICABLE TO SPACE SYSTEMS (EMC)



ECSS (Table 5-4 Correspondence between Test procedures and limits)				
S/N	Requirement	Description	Frequency	
1	A.2	CE on power leads, differential mode (Part 1)	30Hz - 100kHz	Limit and Test method provided
2	A.2	CE on power leads, differential mode (Part 2)	100kHz - 100 MHz	Limit provided, Test method Ref. to A.4
3	A.3	CE on power leads, in-rush currents	Transients	Limit and Test method provided
4	A.4	CE on power and signal leads, common mode	100kHz - 100 MHz	Limit and Test method provided
5	A.6	DC Magnetic field emission	Transients	NEW
6	A.7	RE, low frequency Magnetic field	Specific	Analysis needed
7	A.8	RE, low frequency Electric field	Specific	Analysis needed
8	A.9	RE, Electric Field	30MHz - 18GHz	Limit provided. Setup: RE102
9	A.10	CS, power leads, differential mode	30Hz - 100kHz	Limit and Test method provided
10	A.11	CS, power and signal leads, common mode	50kHz - 100MHz	Limit and Test method provided
11	A.12	CS, power leads, short spike transients	Transients	Limit and Test method provided
12	A.13	RS, Magnetic field	30Hz - 100kHz	Immunity level provided. Setup: RS101
13	A.14	RS, Electric Fields	30MHz - 18GHz	Immunity level provided. Setup: RS103
14	A.15	Susceptibility to Electrostatic Discharge (Legacy method)	Transients	Legacy and Alternate method specified.

SATELLITE – SYSTEM LEVEL TESTING

ECSS SYSTEM LEVEL TESTING – 3.2.5 / 5.3

Completion of component level testing

System level testing

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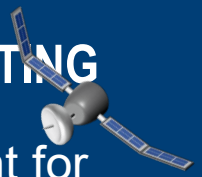
SATELLITE EMC STANDARDS SYSTEMS LEVEL TESTING

- **MIL-STD 461G**
  Requirements For The Control of Electromagnetic Interference Emission and Susceptibility
- **MIL-STD 464D**
  Electronmagnetic environmental effects, requirements for systems.

- **RTCA/DO160G**
  Electronmagnetic environmental effects, requirements for systems.

ELECTROMAGNETIC ENVIRONMENT EFFECTS
IN THE SATELLITE AND LAUNCHER DOMAIN EMC TESTS REQUIRES E3 TESTING



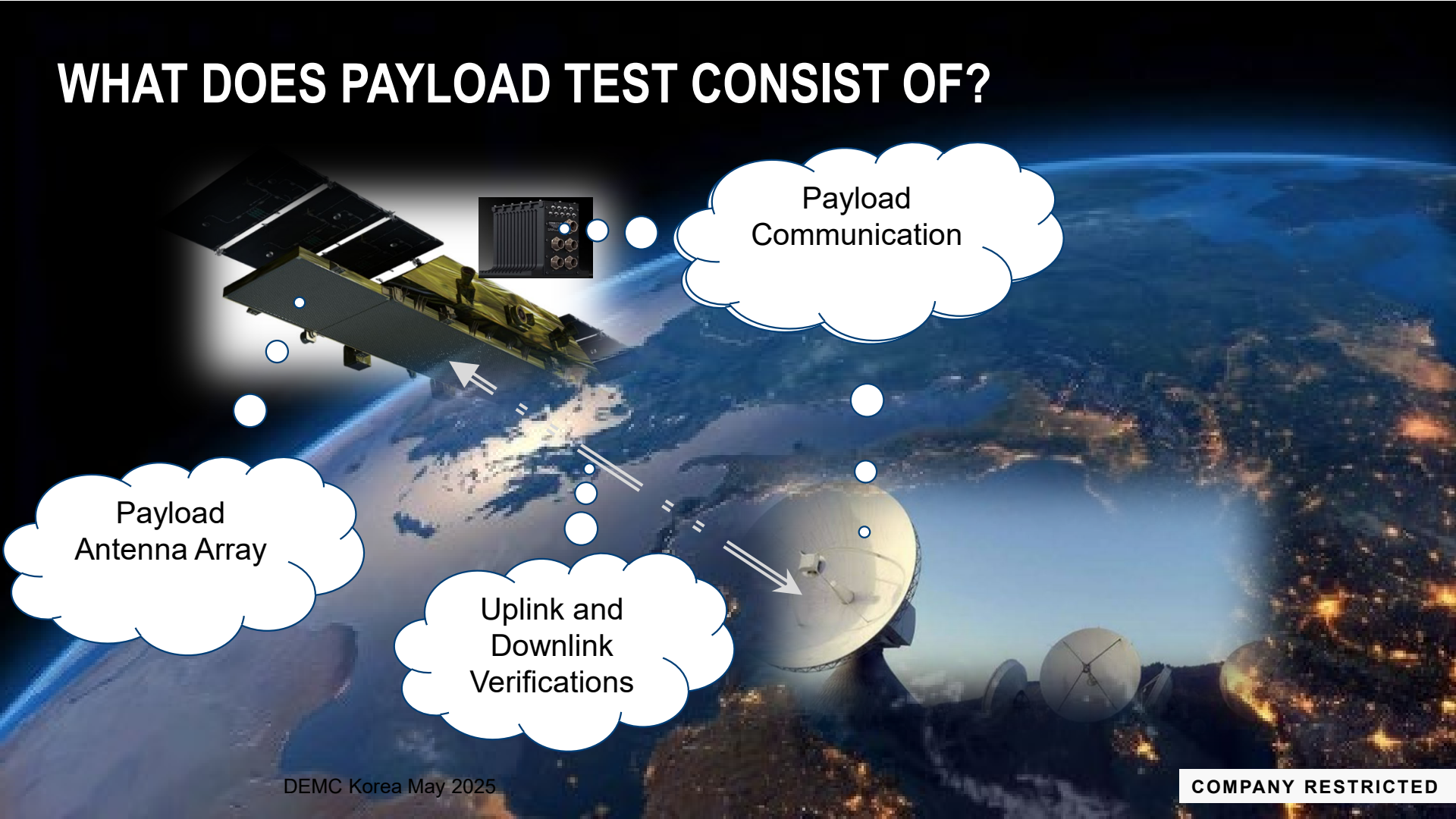
- Beside Standard EMC testing, there are RF Spectrum Measurement for Transmitters which installed on System.

- Some existing EMC customers had planned and enquired to extend their existing EMC test system (base on Mil-std-461) specifications and capabilities to meet E3 test requirements.

- Such as System Level NEMP, ESD, HIRF, HERO, HERP, PIM, Transmitter and Receiver Performance, Antenna Radiation Patterns. etc… measurements

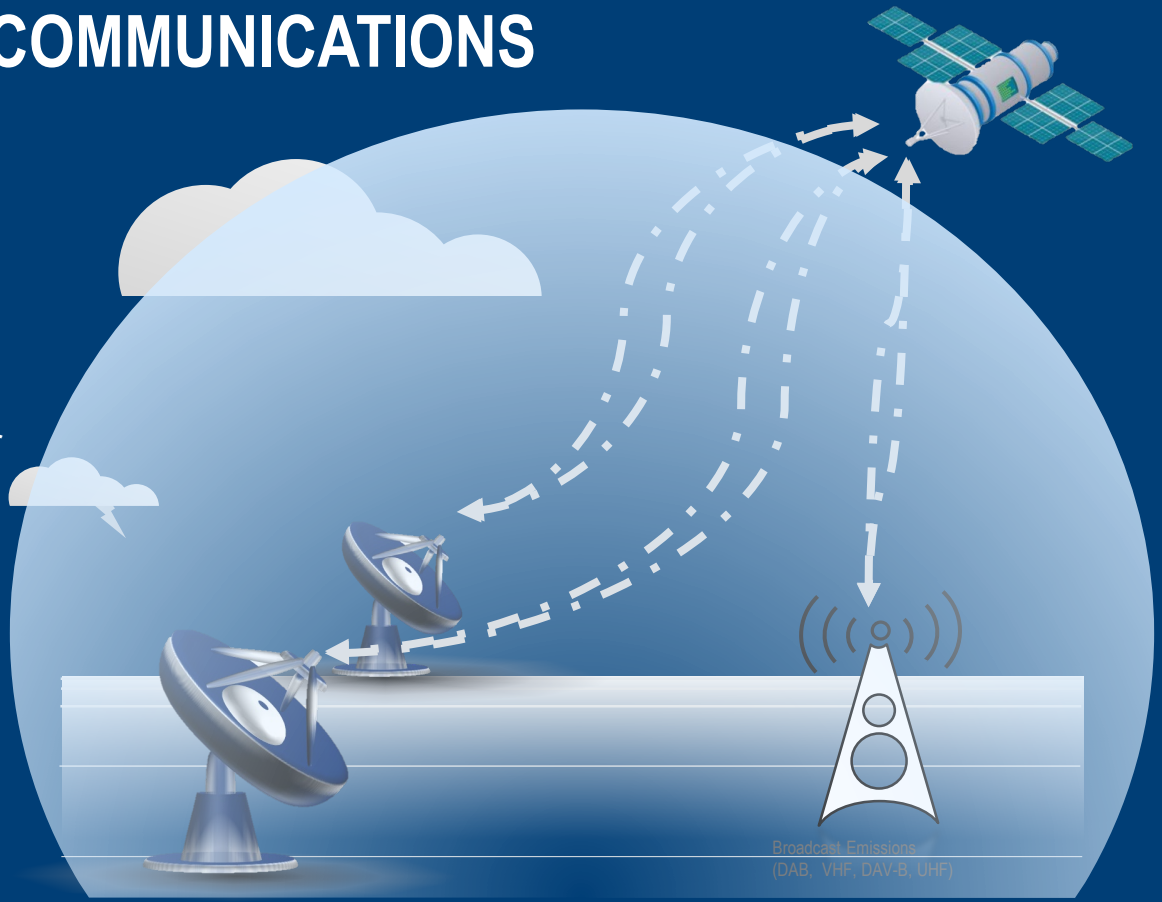
SATELLITE - PAYLOAD COMMUNICATION TESTING

WHAT DOES PAYLOAD TEST CONSIST OF?



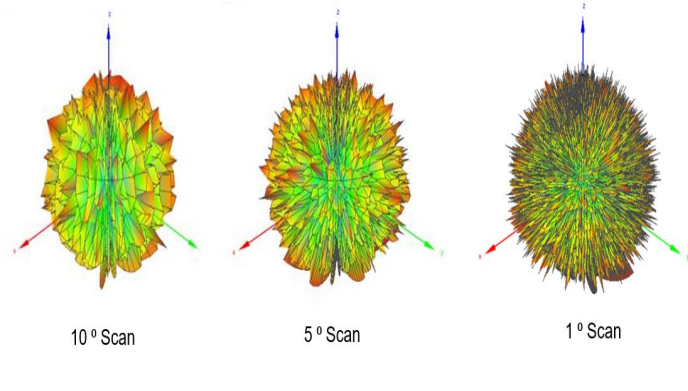
SATELLITE PAYLOAD COMMUNICATIONS

- RF power measurement
- Gain Vs Freq.
- Group delay Vs Freq
- Gain slope, Gain ripple Vs Freq
- Gain Vs Time
- Gain Vs Power
- Saturation for input and output power
- AM/PM conversion coefficient
- Noise Figure
- Frequency Accuracy
- Phase noise
- Spurious Signal / Harmonics / Out of band response.



PAYLOAD LINK VERIFICATIONS

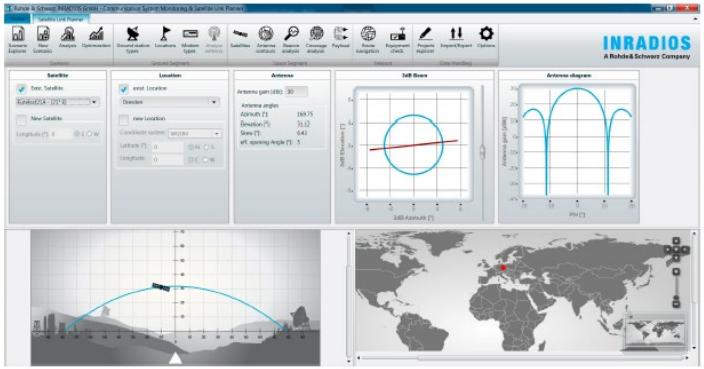
- EIRP, TRP, TIS
- Directivity, gain, realized gain
- Efficiency
- Beam width
- 2D and 3D pattern
- Near field to far field transformation



PAYLOAD LINK VERIFICATIONS

- Managing Multi-beam scenarios
- Link Budget calculation
- Atmospheric conditions
- Frequency and location effects on transmit power density.
- Interference Analysis
- Gain flatness and Group delay.

Figure 4: Antenna diagram modeling and interference analysis



- Simulation of Field of view, overflight duration, satellite ground path.
- Simulation of Altitude and LOS (Line of Sight)
- Adjacent satellite interference.

Fig. 11: Adjacent satellite interference

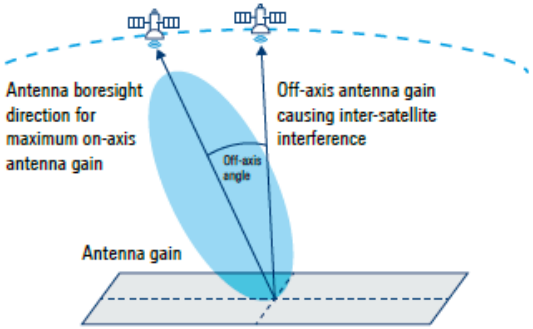
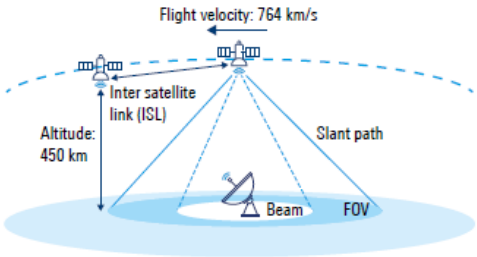


Fig. 4: Example of LEO satellite system at 450 km altitude



Satellite orbital inclination

Defines the angle between the earth's equatorial plane and the orbital plane.

THANK YOU FOR THE ATTENTION