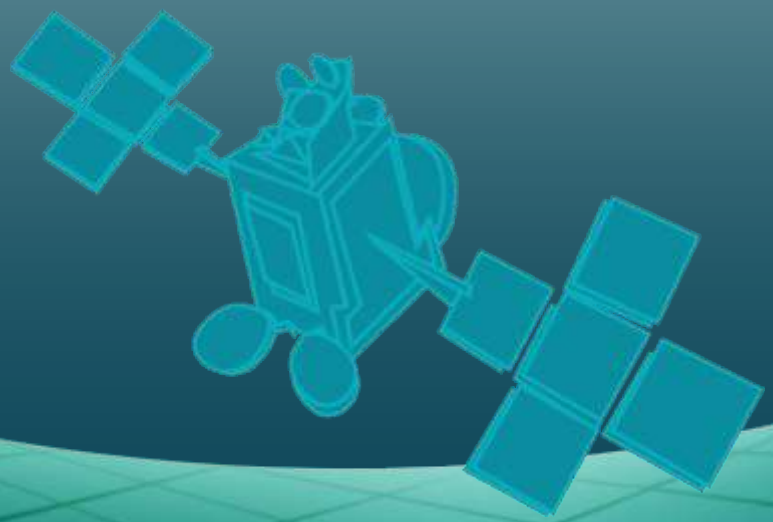
Satellite Operator

Satcom ABC series (3)



WU Boyang
APMT

Satellite Operators

Engineering Department

TT&C Station

Orbit and Satellite

ITU&RR / Orbit Resource / SatelliteOrder-IOT

Bus Operation

Intro / StationKeeping / AttitudeControl / Eclipse

Payload Operation

TransponderSetting / CarrierAllocating / VerificationTest / Line-upTest / CarrierMonitoring / InterferenceElimination

International organizations

CHINA APMT

- INTELSAT
  - International Telecommunications Satellite Organization
  - Global beam, hemi beam, regional beam, spot beam
- InterSputnik
  - Intersputnik International Organization of Space Communications
  - By former Soviet Union

- InMarSat
  - International Maritime Satellite Organization
  - Terrestrial and maritime coverage
  - Global beam, regional beam, spot beam
  - Traditional voice calls, low-level data tracking systems, high-speed Internet, distress and safety data services

International Corporations

CHINA APMT

- SES S. A.
  - Société Européenne des Satellites
  - SES Astra
  - SES World Skies
    - ⇨ formerly New Skies Satellites: privatized form partial IntelSat fleets
  - SES Americom
    - ⇨ formerly GE Americom
  - Satellite fleet
    - ⇨ SES series, Astra series, NSS series, and AMC series
    - ⇨ 40^{+} communication satellites at about 30 orbit slots

International Corporations (cont.)

- EuTelSat
  - European Telecommunications Satellite Organization
  - Satellite fleet
    - 30^{+} communication satellites at about 20^{+} orbit slots

- PanAmSat
  - Satellite fleet
    - PAS series, SBS series, and Galaxy series
    - about 20 communication satellites

Regional Corporations

CHINA APMT

- Asia-pacific
  - InSat of India
  - JCSAT of Japan
  - KoreaSat of Korea
  - Optus of Australia
- Southeast Asia
  - Palapa and ACeS of Indonesia
  - Shin (ThaiCom) of Thailand
  - MEASAT of Malaysia
  - SingTel of Singapore
  - Mabuhi of Philippines
- China
  - AsiaSat
  - APT Satellite
  - China Satcom

Satellite Operators

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Engineering Department of APT (later 1990's)

CHINA APMT

- Chief engineer
  - Communication engineer (5)
    - ⇨ payload management
    - ⇨ interference coordination
    - ⇨ technical support for marketing and customer
  - Satellite engineer (3)
    - ⇨ bus operation
  - Orbital analyzer (1)
  - Equipment engineer (1)
- Director of satellite control station
  - Controller (10^{+})
    - ⇨ system monitoring and order execution
    - ⇨ 3 shifts / 24 hours and 7 days per week

Engineering Department of AsiaSat (mid 2000's)

CHINA APMT

- Operating department (general manager)
  - Monitoring and control center (manager)
    - ⇨ satellite controller (10^{+})
  - Satellite engineering (manager)
    - ⇨ satellite engineer (5^{+})
  - Orbit and software (manager)
    - ⇨ orbital analyzer and software engineer (5^{-})
- Engineering department (general manager)
  - Communication engineering (manager)
    - ⇨ communication engineer (10)
  - Frequency coordination (manager)
    - ⇨ communication engineer (2)

Proposed Engineering Department for LaoSat

CHINA APMT

- Chief engineer
  - Communication engineer (4)
    - frequency and power assignment
    - specification test and line-up test
    - carrier spectrum monitoring
    - technical support and coordinating for customer and marketing
    - teleport management
    - interference coordination
  - Satellite engineer (2)
    - bus operation
  - Orbital analyzer (1)
  - Equipment engineer (1)
- Director of satellite control station
  - Controller (10)
    - system monitoring and command order execution

Satellite Operators

Engineering Department

TT&C Station

Orbit and Satellite

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Antennas in TT&C Station

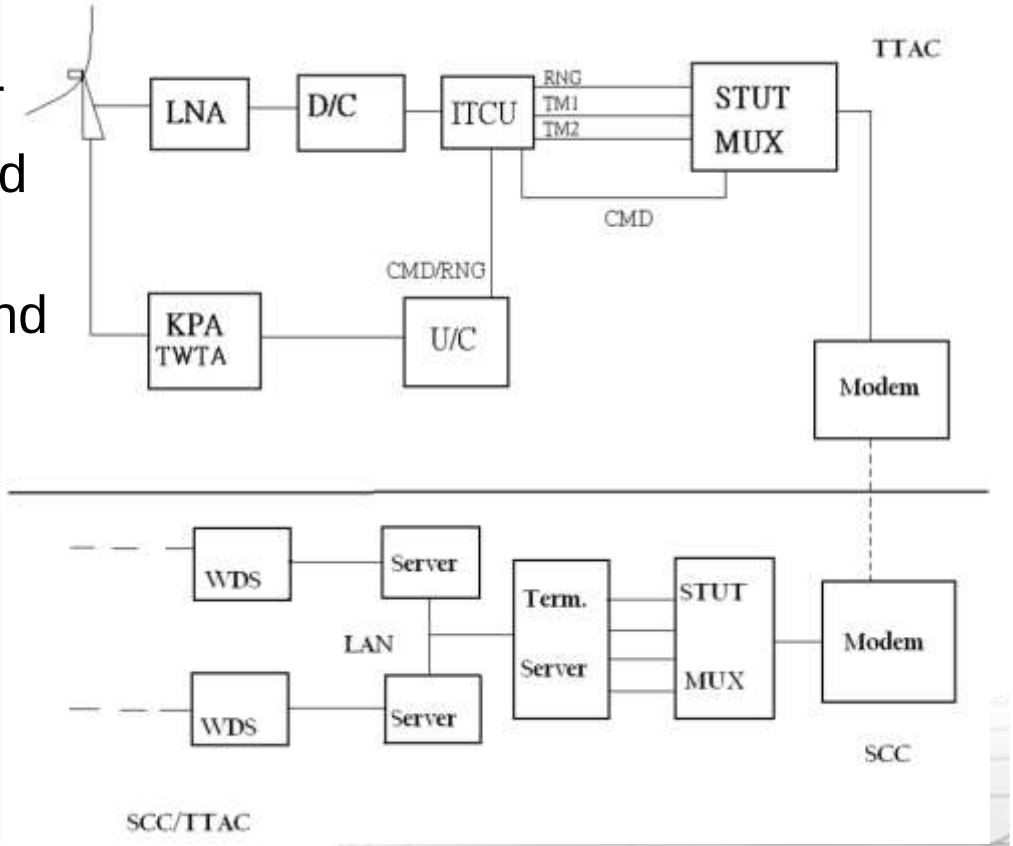
CHINA APMT

- C-band mono-pulse antenna
  - 11m or more, typhoon proof, (full motion for transfer orbit)
  - Telemetry, telecommand and ranging
- C-band step track antenna
  - 6m or more, limited motion
  - TT&C, carrier monitoring and teleport
- Ku-band step track antenna
  - 6m or more, limited motion
  - Carrier monitoring and teleport
- Receive only antenna
  - C- and Ku-band, 3.7m or less
  - Main building roof

Data Flows between TT&C and SCC

CHINA APMT

- TT&C Station
  - Tracking, Telemetry and Control
  - Antennas and RF/IF equipments
- SCC
  - Satellite Control Center
  - Computer hardware and software
  - Spacecraft operation and control



Data Flows between TT&C and SCC

CHINA APMT

- Data flow
  - Reception of telemetry and ranging signals
    - RF signals received by antenna, amplified by LNA, and frequency down converted by D/C
    - IF signals processed by ITCU (Integrated Telemetry and Command Unit)
    - digital signals modulated by stat-mux and modem, transmitted into SCC server
  - Transmission of command signals
    - digital signals from SCC server, modulated by stat-mux and modem, transmitted to TT&C, and modulated by ITCU
    - IF signals up converted by U/C
    - RF signals amplified by TWTA or KPA, and sent to satellite by antenna

Data Processing in SCC

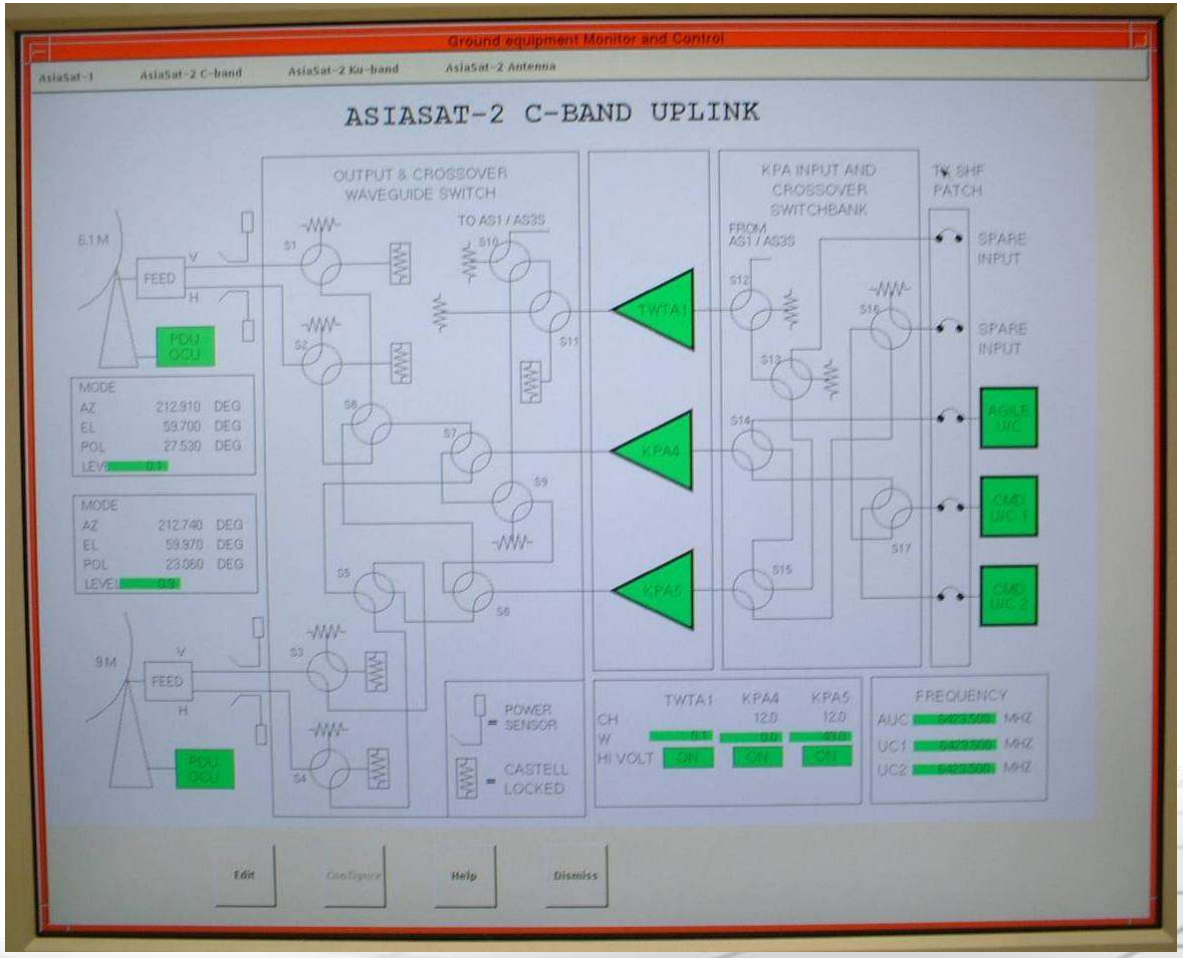
CHINA APMT

- Satellite control system
  - Consisted by several servers and workstations which connected by LAN as a network
  - Telemetry signals processed by server, decoded into engineering value
  - Engineering value managed and archived by workstation
  - Real time or historical data displayed at screen as text or graphic style
  - Telecommand and ranging signals automatically or manually generated by server, and transmitted to TT&C station and satellite
- Satellite controller
  - Sending orders by workstation
  - Orders including: orbit and attitude correcting, electrical power system maintaining, on-board computer system maintaining and updating, etc.

Data Flows between TT&C and SCC

CHINA APMT

- Graphical user interface (GUI)
  - Sending remote control orders to satellite as well as earth station equipments



Dynamic Simulator System

CHINA APMT

- Function
  - Supporting ground operations
    - normal and contingency operation training
    - spacecraft operating analysis
    - operation procedure developing
- Requirement
  - Functional simulating
    - attitude control, telemetry & command, data processing, propulsion, and power subsystem
  - External space environment simulating
    - for attitude control, telemetry & command link and power subsystem
  - Interface
    - with the ground station data processing system and base-band equipment
    - be identical to that of the actual spacecraft

TT&C Station Facilities

CHINA APMT

- Earth station
  - Good visibility to the southern horizon and good wind shelter
  - Intelligent building
  - Dual main power feed with dual UPS systems (300KVA x 2)
  - Diesel generators: main (1000^{+}KVA) and fire service (300^{+}KVA)
  - Fire protection and detection system (FM 200 and water sprinklers)
  - Full security system (CCTV, motion detectors, external wall infrared detectors and security card entry system)
  - Wind velocity and direction detection system and rain gauge
- Up-link equipment
  - Short term uplink: one stop service for customer requirement, not to compete with other uplink service providers
  - Terrestrial SDH (synchronous digital hierarchy) and submarine cables

Satellite Operators

Engineering Department

TT&C Station

Photos of AsiaSat SCC

Orbit and Satellite

ITU&RR / OrbitResource / SatelliteOrder-IOT

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Antennas in Stanley

CHINA APMT

11.3m and 7.3m Antennas in Taipo

CHINA APMT

Future Expansion on Roof

CHINA APMT

东翼扩展区 East Extension

主楼天台 Roof

Antenna Control Units

CHINA APMT

Antenna Backup Switches

CHINA APMT

RF Equipment Room

CHINA APMT

South View at SCC

CHINA APMT

Satellite Control Center

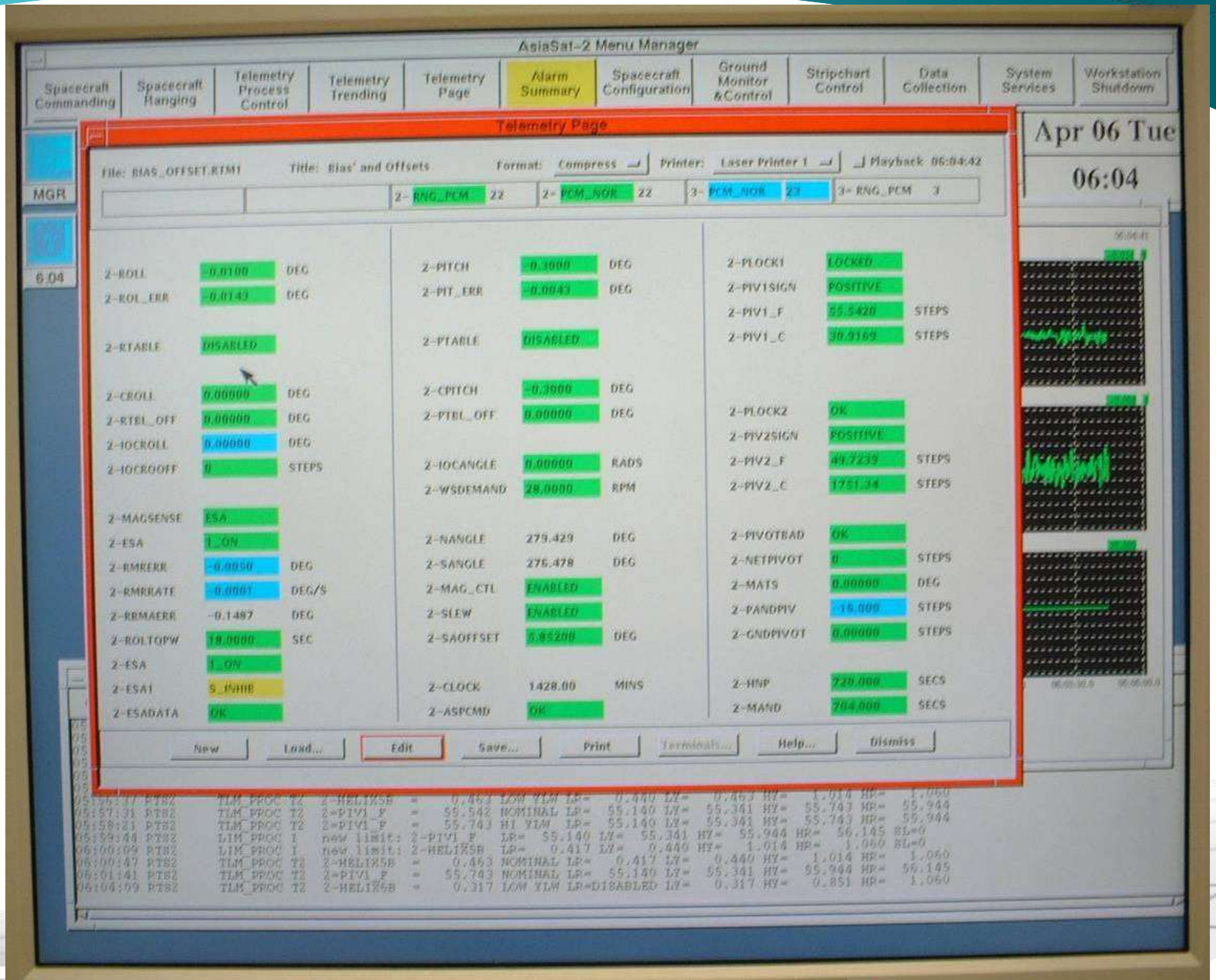
CHINA APMT

Control Room

CHINA APMT

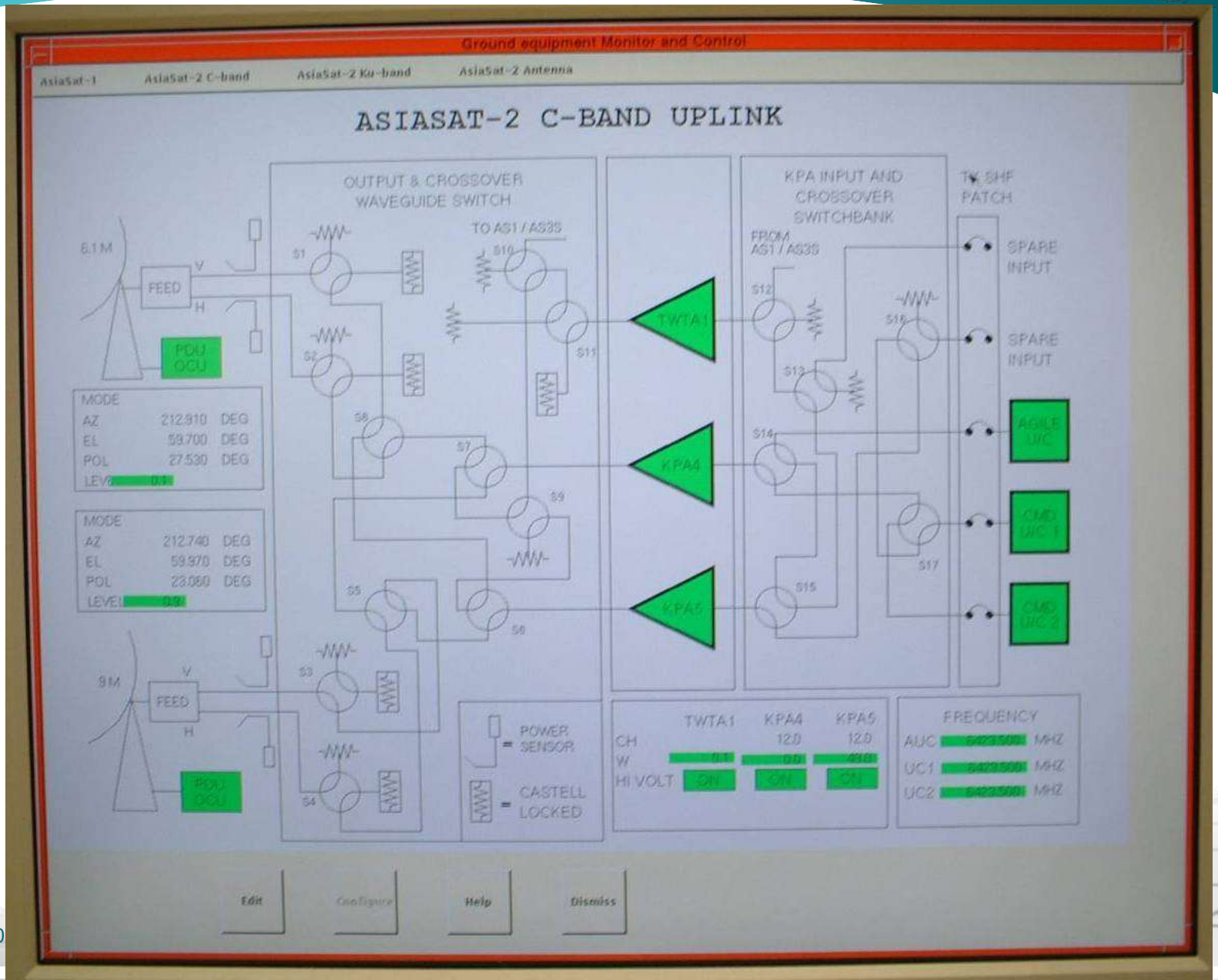
GUI for Satellite Control Software

CHINA APMT



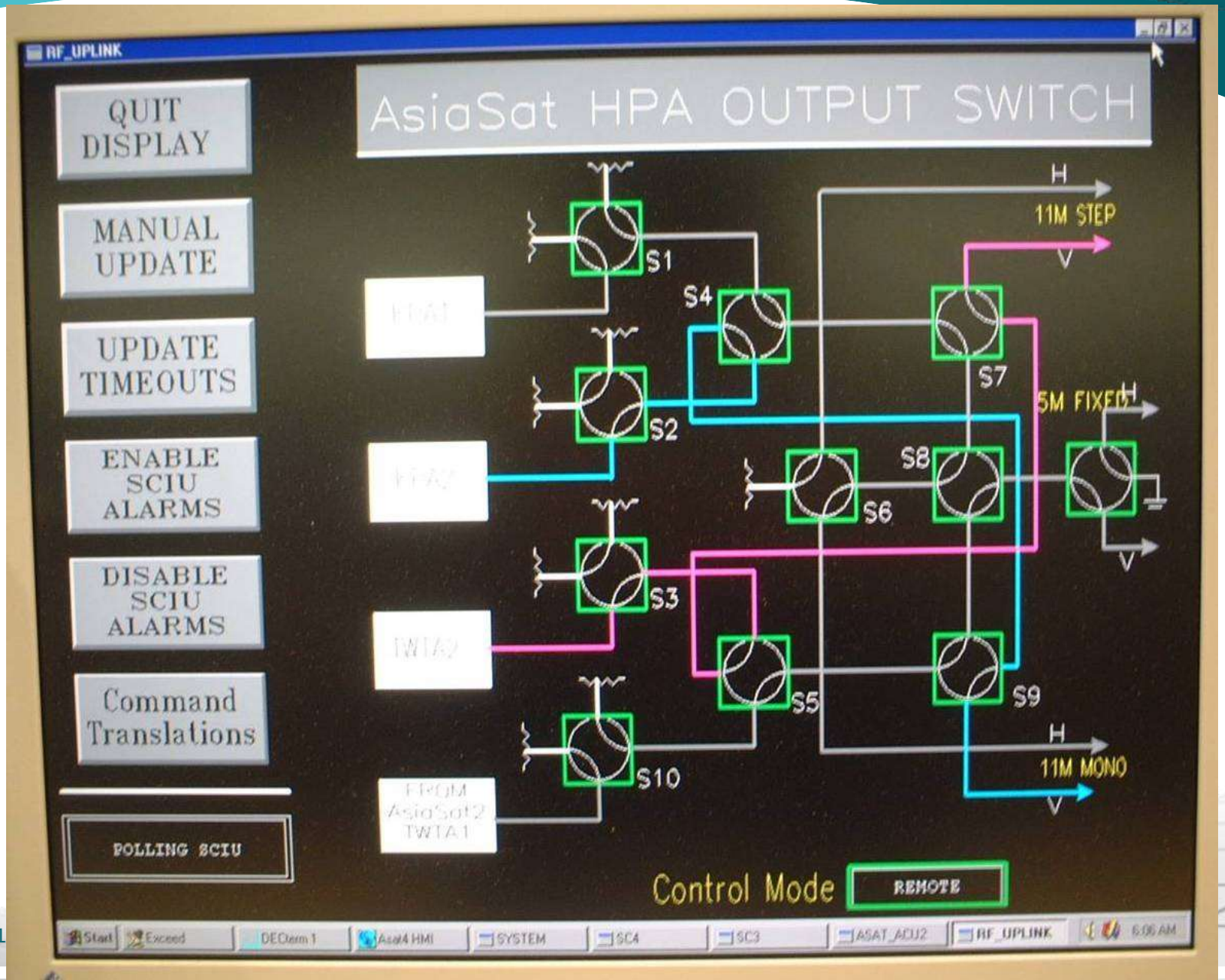
GUI for Uplink Switch

CHINA APMT



GUI for HPA Output Switch

CHINA APMT



Main Switch Room

CHINA APMT

1800KVA Diesel Generator

CHINA APMT

300KVA X 2 UPS System

CHINA APMT

电力配线柜
Distribution Cubicle

电池组 Batteries

Fire Protection Facilities

CHINA APMT

390千伏安消防柴油发电机
390KVA Fire Service Generator

FM200灭火气体　FM 200

Pre-Action Sprinkler System

CHINA APMT

CCTV System

CHINA APMT

闭路监控显示器 CCTV Monitors

红外探测器 Infrared Detector

可移动闭路摄像机
CCTV Movable Camera

Weather Station & Lightning Protection

CHINA APMT

避雷器 Lightning Rod

雨量计
Rain Gauge

风力测量器 Wind Detector

Satellite Operators

Engineering Department

TT&C Station

Orbit and Satellite

- ITU and Radio Regulation
- Orbit Resource
- Design, Manufacture, Launch and IOT

Bus Operation

- Intro / StationKeeping / AttitudeControl / Eclipse

Payload Operation

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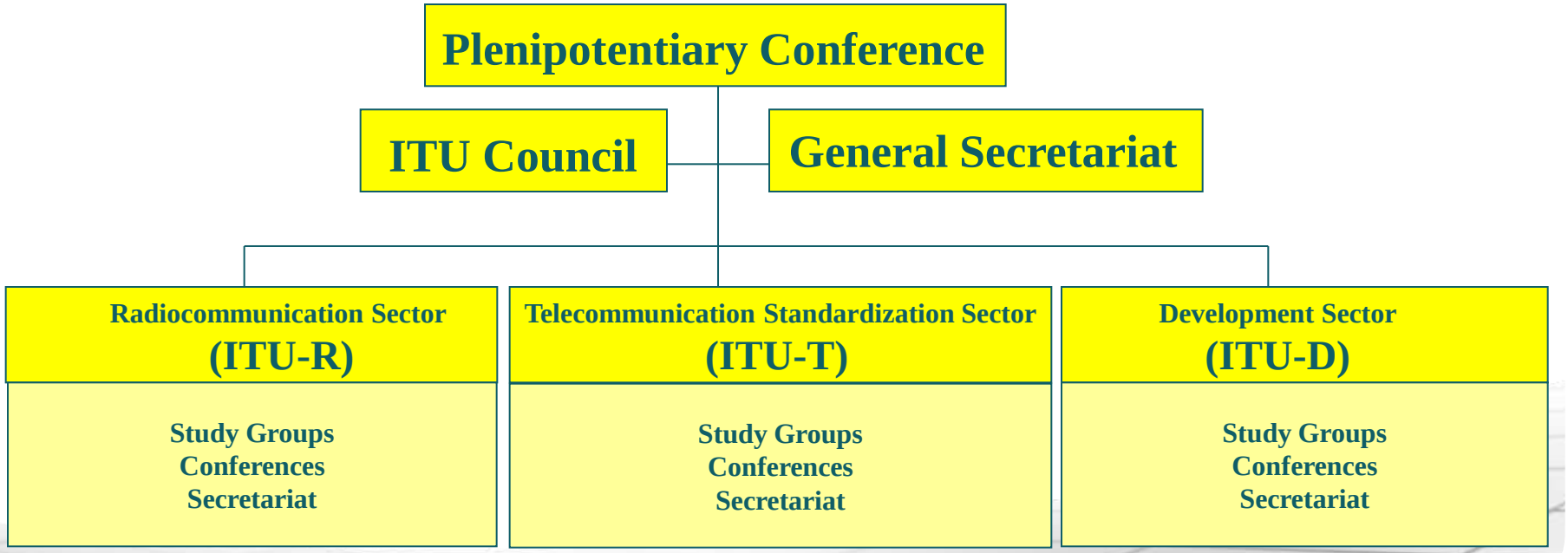
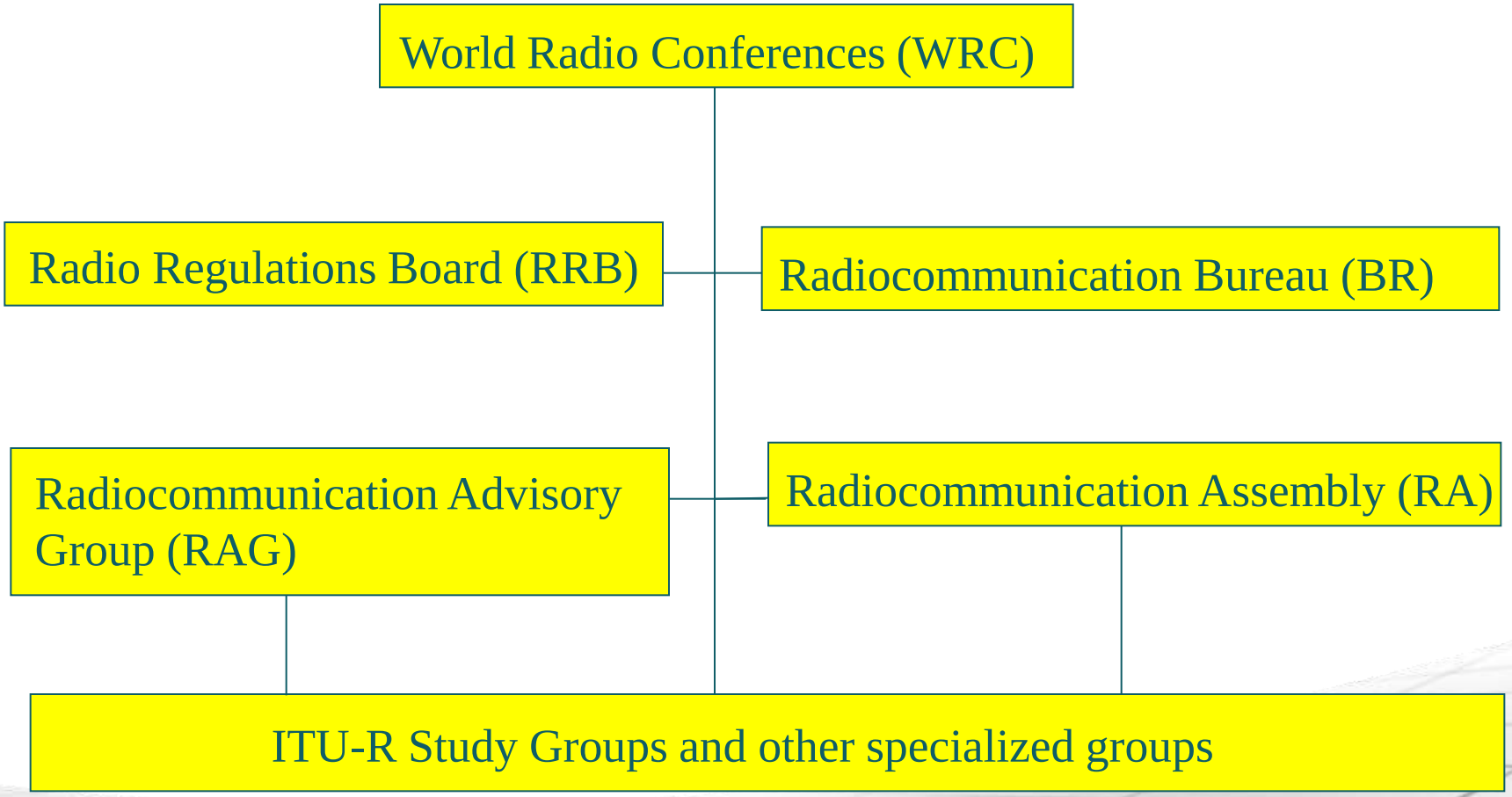
ITU

- International Telecommunications Union
  - Established in 1865, now a specialized agency of UN
  - Organization of sovereign member states
  - Each member state is sovereign to regulate its telecommunications according to its own preferences
  - Providing tools and procedures to assist nations to manage interference between users



ITU-R

- Radio communications sector



Role and Status

CHINA APMT

- Member state in ITU
  - Right to vote
  - To protect national interest
  - To lead operators to involve in ITU activities
- Recognized operating agency in ITU-R
  - No voting right
  - Participate independently in working groups

Radio Regulations

- Fundamental principals
  - Applied for usage of radio frequency spectrum
  - Allocation of spectrum for different applications
  - Procedures
    - ⇨ ensure no harmful interference into other users of the spectrum
    - ⇨ protection for harmful interference from other users' spectrum
- Frequency coordination
  - Identifies potentially interfered countries
  - Specifies relative priority between networks
  - Requires an agreement from all potentially affected countries
  - Frequency coordination is a bilateral process between nations, operators often play an active role in this process

Satellite Operators

Engineering Department

TT&C Station

Orbit and Satellite

- ITU and Radio Regulation **Orbit Resource**
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Getting Access to Spectrum Resource

- A country submits a filing with the intended characteristics to the ITU
- During the frequency coordination process, limitations may occur
- Frequency coordination is between filings, not between satellites
- Each filing grants access to a specified amount of spectrum capacity
- Satellites may draw capacity from a number of filings

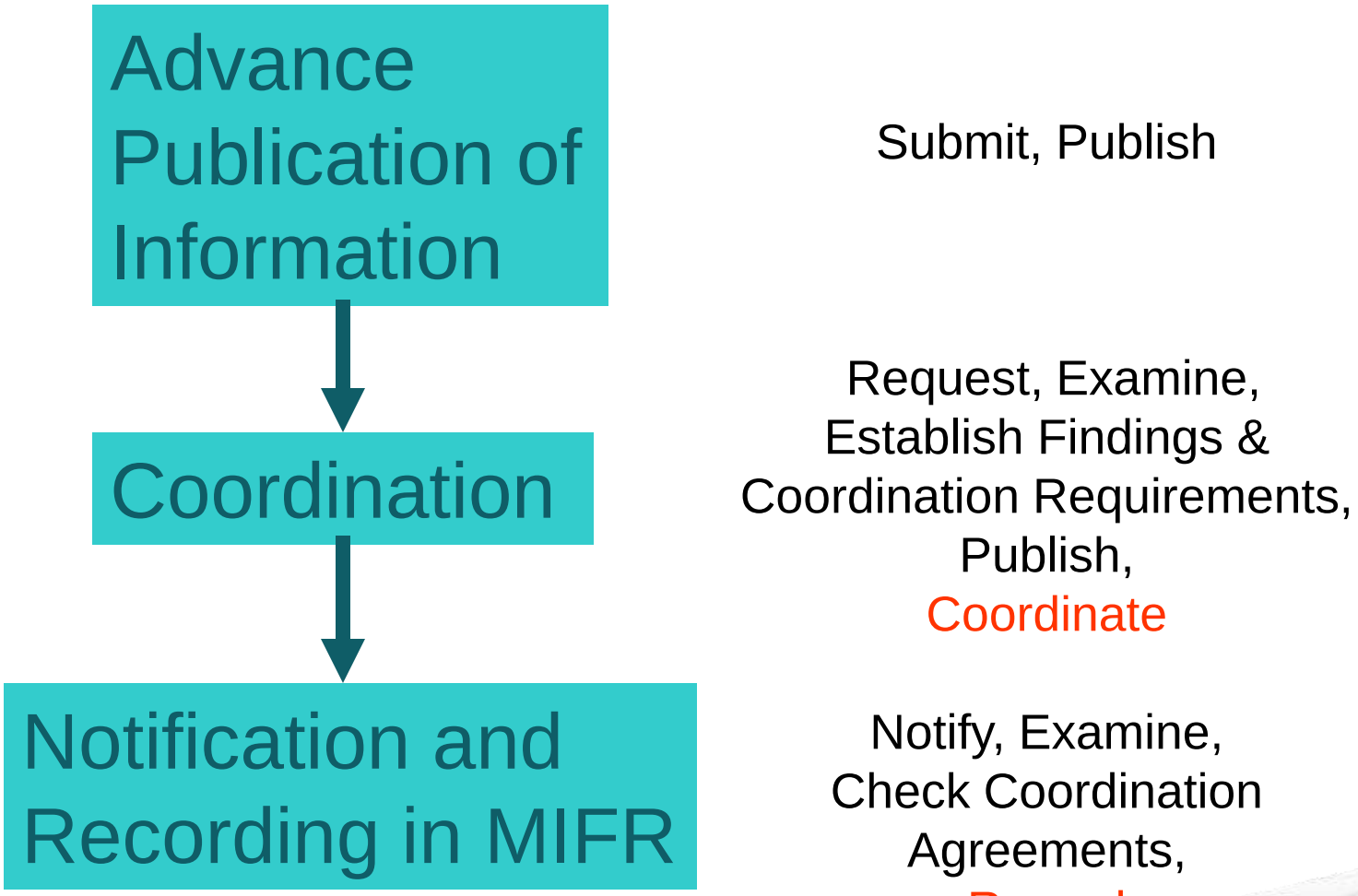
Limitations of ITU

CHINA APMT

- ITU has no any super national authority and cannot overrule a decision by a sovereign state
- ITU has no any authority to enforce the Radio Regulations or other ITU instruments
- Radio Regulations does not provide detailed guidelines for how countries are to perform the bilateral frequency coordination
- ITU Recommendations are not a part of the Radio Regulations

Filing Procedure

CHINA APMT



Coordination Process

CHINA APMT

- Coordination of an operator
  - Determine the need and formulate the technical parameters (orbital location, emission type, power density, antenna size, etc.) to develop operating envelop
  - Prepare and submit appropriate publications to ITU-R by the administration
  - Perform all technical assessment on interference scenario for protection of LaoSat's emissions
  - Active in administration and operator level meetings
- Interference management
  - Study the interfering case that ITU identified, and determine if harmful interference may occur
  - Assess the required service quality and prepare the expected interference scenario
  - Determine the acceptable level from the interference that requests coordination

Summary of Frequency Coordination

CHINA APMT

- To provide a managed, predictable interference scenario
- To provide protection against future harmful interference
- To ensure licenses for satellites
- To enable licenses for earth stations and networks
- To provide access to spectrum resources for future satellites

Satellite Operators

Engineering Department

TT&C Station

Orbit and Satellite

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Design Stage

CHINA APMT

- Orbit position
  - Assigned
  - Coordinated
- Market survey
  - Market demand
  - Market supply
  - Potential customer
- License
  - Space segment
  - Earth segment

Design Stage (cont.)

CHINA APMT

- RFP
  - Request for Proposal
  - Orbit slot
  - Launch date
  - Payload requirement
    - ⇨ frequency and polarization plan
    - ⇨ beam coverage of EIRP and G/T requirements
    - ⇨ SFD and gain step
    - ⇨ redundancy and reliability
  - Bus requirement
    - ⇨ life time and reliability
    - ⇨ station keeping tolerance
    - ⇨ antenna pointing accuracy
    - ⇨ requirements for each subsystem

Satellite Operators

Engineering Department

TT&C Station

Orbit and Satellite

ITU and Radio Regulation Orbit Resource

Design, **Manufacture,** Launch and IOT

Bus Operation

Intro / StationKeeping / AttitudeControl / Eclipse

Payload Operation

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Manufacture Stages

CHINA APMT

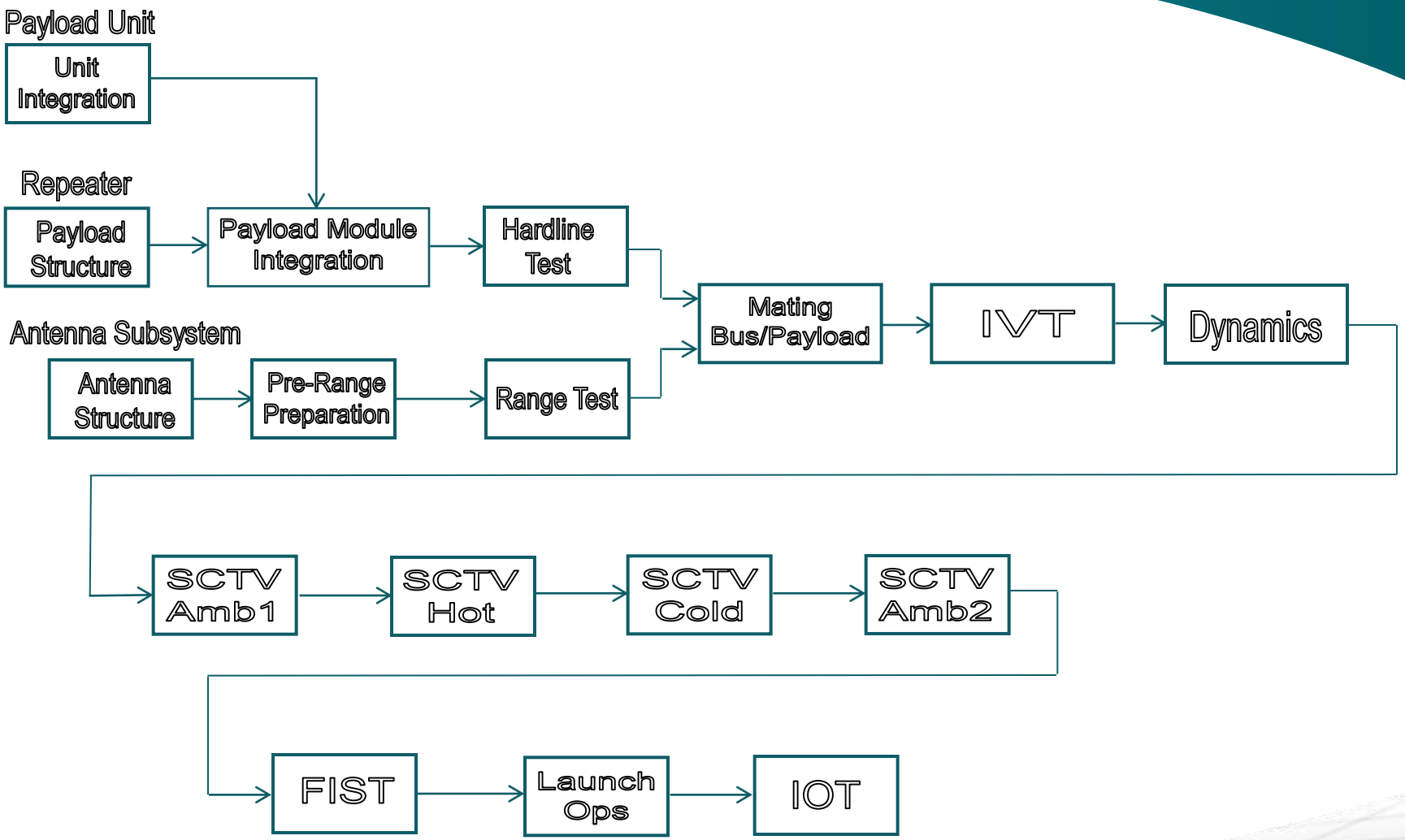
- Stages
  - Manufacture
  - Integration
  - Test
  - Delivery to launch site
- Operator
  - Monthly and quarterly review
  - PDR
    - ⇨ preliminary design review
  - CDR
    - ⇨ critical design review
  - Witness
    - ⇨ integration
    - ⇨ test
    - ⇨ data review

Manufacture Stages (cont.)

CHINA APMT

- System performance test
  - Manufacturer site test
    - ⇨ verifying whether payload system satisfies design requirements
    - ⇨ test results as key parameters for performance
    - ⇨ thermal vacuum test simulating space environment
  - In orbit test
    - ⇨ test results restricted by the influence of transmitting environment
    - ⇨ functional comparison with ground test results, measured data not acceptant for performance
    - ⇨ verifying satellite health after launch, orbit raising missions and the initial in-station environments

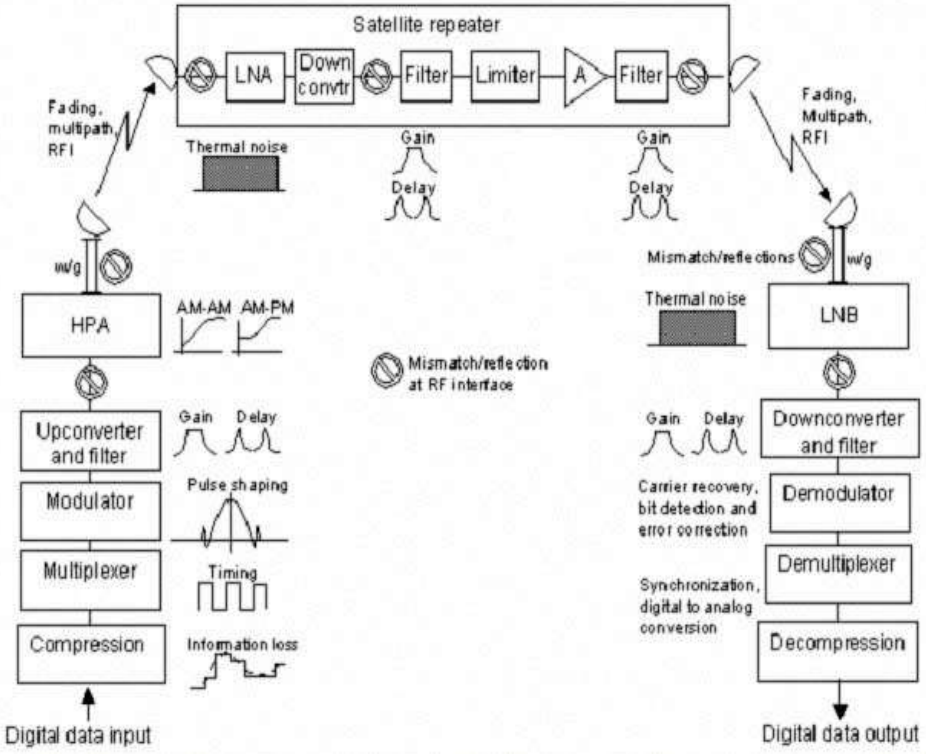
Payload System Integration and Test Flow



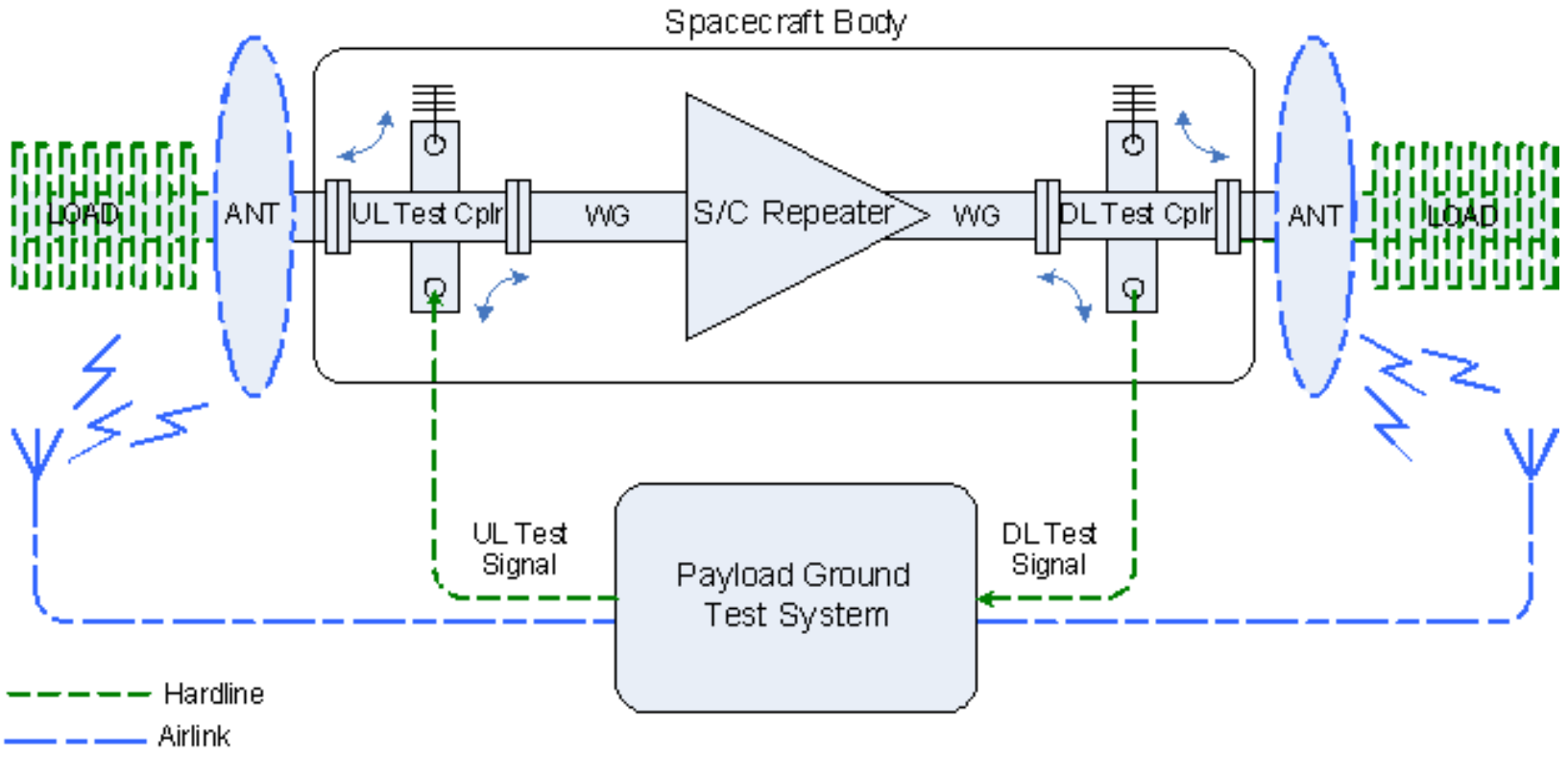
Payload Integration Test Description

CHINA APMT

- Measurements for bent-pipe payload
  - EIRP, SFD and gain transfer
  - G/T (noise figure)
  - Frequency response
  - Antenna mapping
  - Others
    - ⇨ spurious
    - ⇨ group delay
    - ⇨ gain step
    - ⇨ x-pol isolation
    - ⇨ frequency conversion and stability
    - ⇨ C/3IM: carrier to 3rd order inter-modulation



Block Diagram of Payload Ground Test



Ground Test Configuration

Satellite Operators

Engineering Department

TT&C Station

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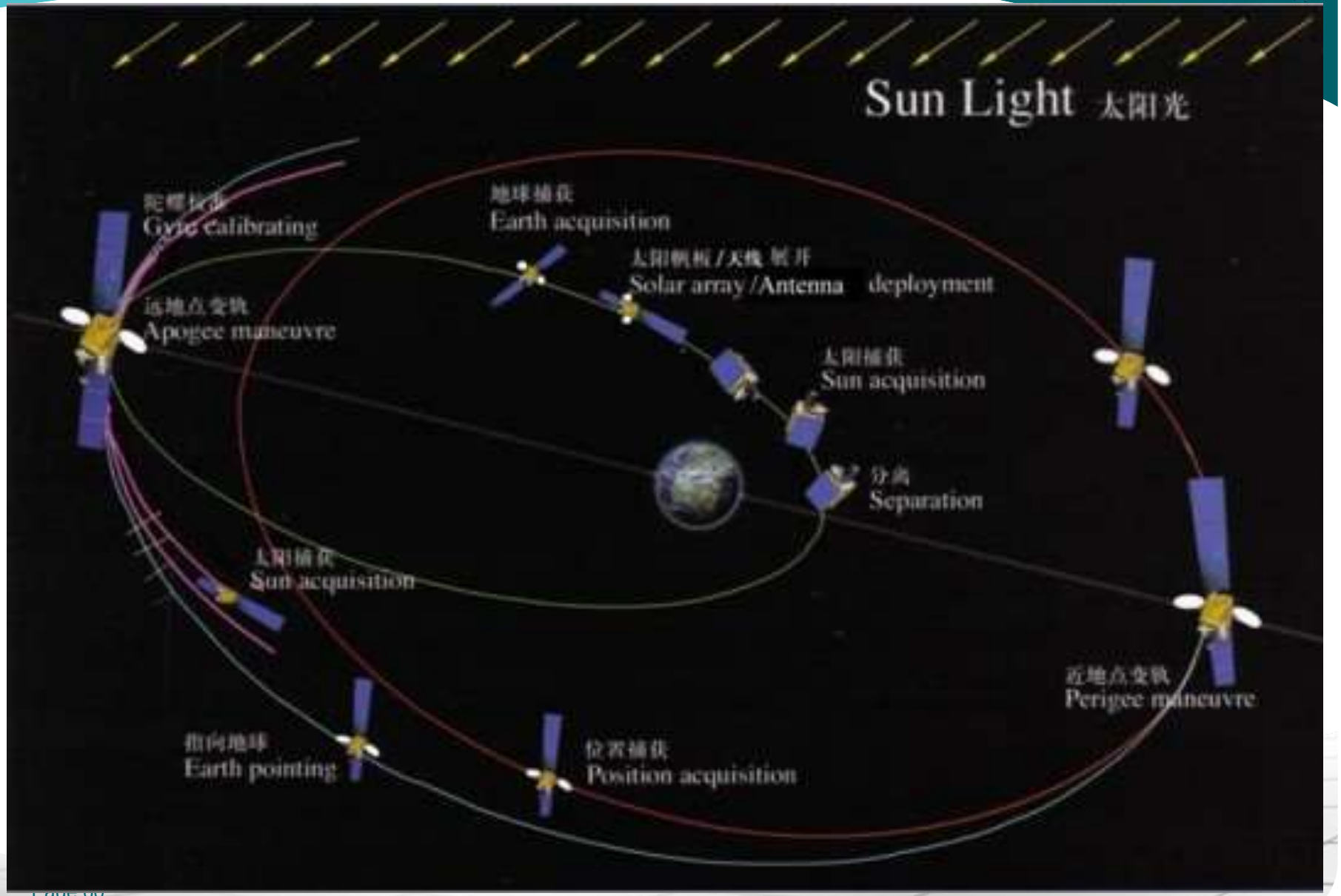
Launch Stage

CHINA APMT



Launch Stage (cont.)

CHINA APMT

- Event sequence
  - Launch phase
    - ⇨ Lift off, SC/LV separation
  - Transfer orbit phase
    - ⇨ sun acquisition, solar array and antenna deployment, earth acquisition, gyro calibrating, first apogee maneuver
  - First intermediate orbit phase
    - ⇨ earth acquisition, gyro calibrating, second apogee maneuver
  - Second intermediate orbit phase
    - ⇨ gyro calibrating, perigee maneuver
  - Third intermediate orbit phase
    - ⇨ gyro calibrating, third apogee maneuver
  - Drift orbit phase
    - ⇨ wheel spin-up to establish the normal attitude, station acquisition

- Satellite Operators
- Engineering Department
- TT&C Station
- **Orbit and Satellite**
  - ITU and Radio Regulation Orbit Resource
  - Design, Manufacture, Launch and **IOT**
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In Orbit Test

CHINA APMT

- Purpose
  - Verify satellite function and performance to ensure them not to degrade due to launch and the initial in-station environments
- Test facility
  - Antenna calibration
  - Test equipments calibration
- Bus IOT
  - Performed during transfer orbit phase and in-station phase
  - TC&R Subsystem
    - EIRP test: measuring TM EIRP by omni and comm antenna
    - frequency stability
    - channel check and receiving sensitivity: TC&R receiver sensitivity at different U/L power
    - health and function check for telemetry and command

In Orbit Test (cont.)

- Bus IOT (cont.)
  - Attitude Control Subsystem
    - ⇨ control mode function: after S/C and L/V separation, checking control modes and their effects
    - ⇨ earth sensor protect function: checking ES auto-protect capability and validating ES protect function
    - ⇨ attitude precision: attitude angle data and pitch orientation ability
    - ⇨ orbit control precision: orbit measure data after E/W and S/N station keeping, observing S/C drift state
  - Thermal Control Subsystem
    - ⇨ thermal function: verifying temperature data to check thermal function
    - ⇨ heater function: checking heaters' status

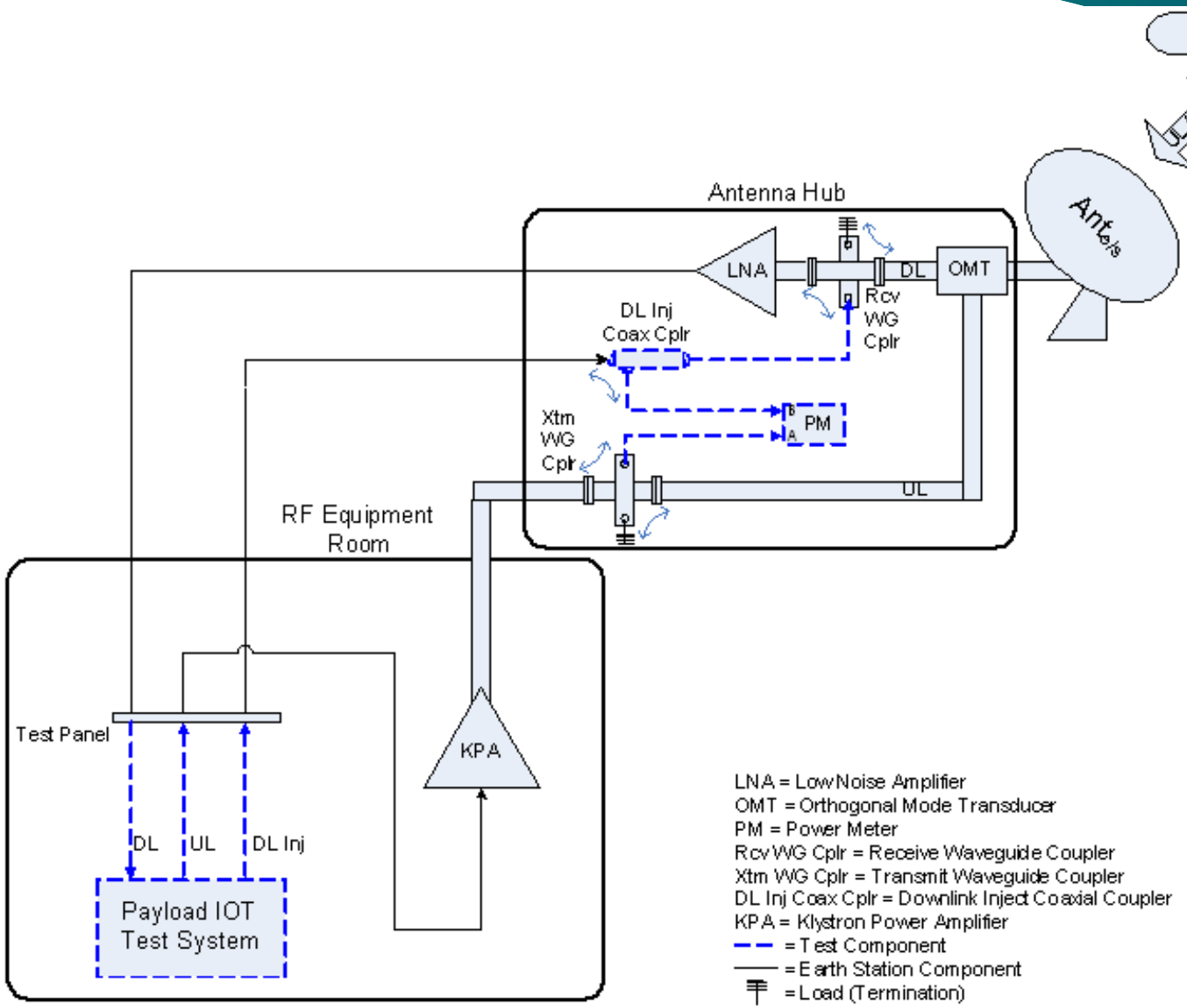
In Orbit Test (cont.)

CHINA APMT

- Payload IOT
  - Performed at the exact orbit or a temporary IOT orbit
  - Antenna cut: verifying receive and transmit antenna patterns
  - Gain transfer curve, EIRP and SFD
    - ⇨ all HPAs and all channels
    - ⇨ recording helix current, anode voltage and input/output power
  - G/T
    - ⇨ primary and redundant receivers across the frequency band
    - ⇨ all channels for primary receiver
  - Others
    - ⇨ in-band and out-of-band frequency response
    - ⇨ frequency conversion stability

Block Diagram of Payload IOT Test

CHINA APMT



Satellite Operators

Engineering Department

TT&C Station

Orbit and Satellite

ITU&RR / Orbit Resource / SatelliteOrder-IOT

Bus Operation

Introduction

Attitude Control

Station Keeping

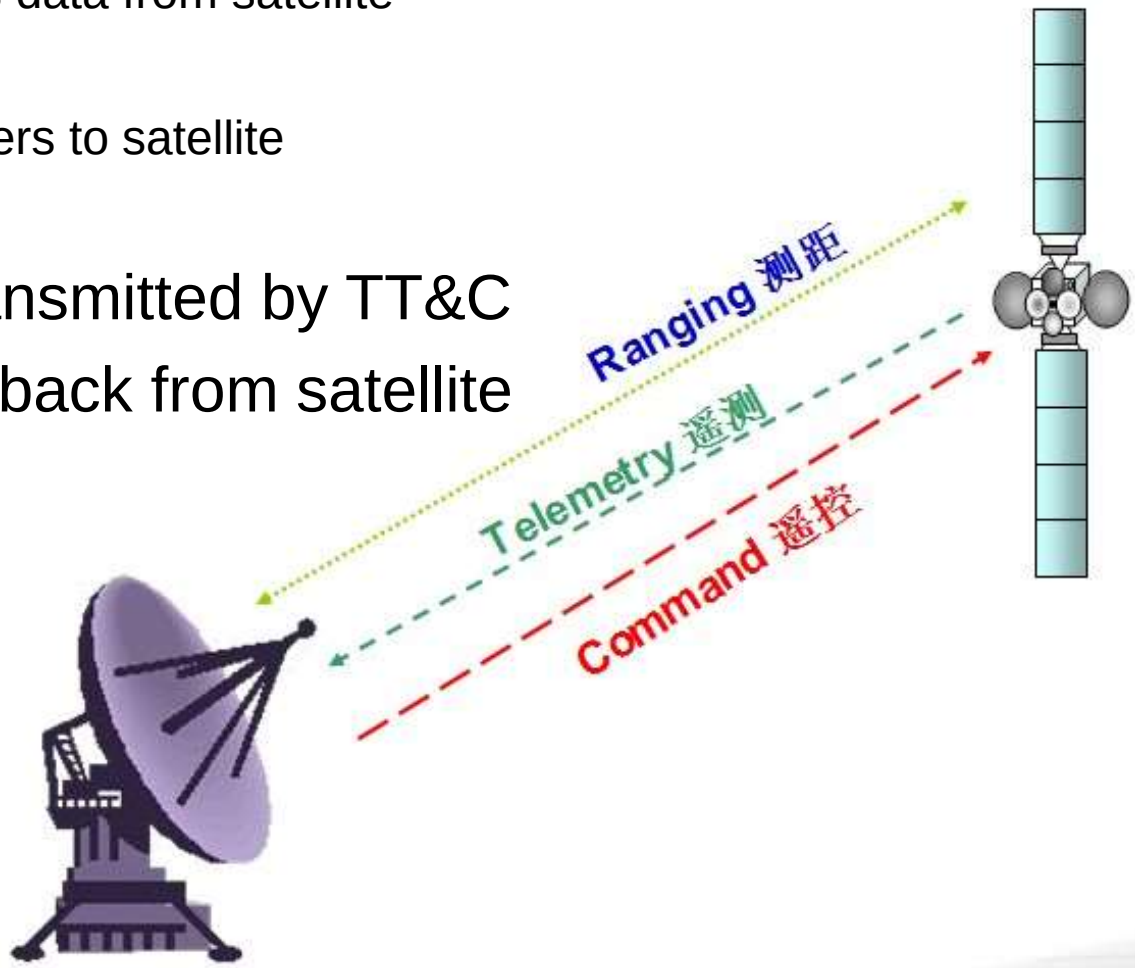
Eclipse Operation

Payload Operation

TransponderSetting / CarrierAllocating / VerificationTest / Line-upTest / CarrierMonitoring / InterferenceElimination

Satellite Operation

- TC&R
  - Telemetry
    - ⇨working status data from satellite
  - Command
    - ⇨command orders to satellite
  - Ranging
- Ranging tone transmitted by TT&C station and loop back from satellite



Duties for Satellite Operation

CHINA APMT

- Satellite control
  - Telemetry and tracking
    - ⇨ operating status data gathering
    - ⇨ satellite angle and distance data gathering
  - Command and operation
    - ⇨ subsystem parameter adjustment
    - ⇨ station keeping operation
    - ⇨ attitude control operation
- Orbit analysis
  - Orbital parameters calculation on the basis of tracking data
  - Periodic adjustment operation to keep right position and attitude for the satellite
  - Sun outage forecast

Duties for Satellite Operation (cont.)

CHINA APMT

- Satellite engineering
  - Working status
    - ⇨ telemetry data analysis (temperature, pressure, voltage, current)
    - ⇨ satellite operation status evaluating
    - ⇨ anomaly processing and working condition recovery
  - Eclipse process
    - ⇨ adjustment for electricity power subsystem and thermal control subsystem

- Satellite Operators
- Engineering Department
- TT&C Station
- Orbit and Satellite
  - ITU&RR / Orbit Resource / SatelliteOrder-IOT
- **Bus Operation**
  - Introduction
  - Attitude Control
  - **Station Keeping**
  - Eclipse Operation
- Payload Operation
  - TransponderSetting / CarrierAllocating / VerificationTest / Line-upTest / CarrierMonitoring / InterferenceElimination

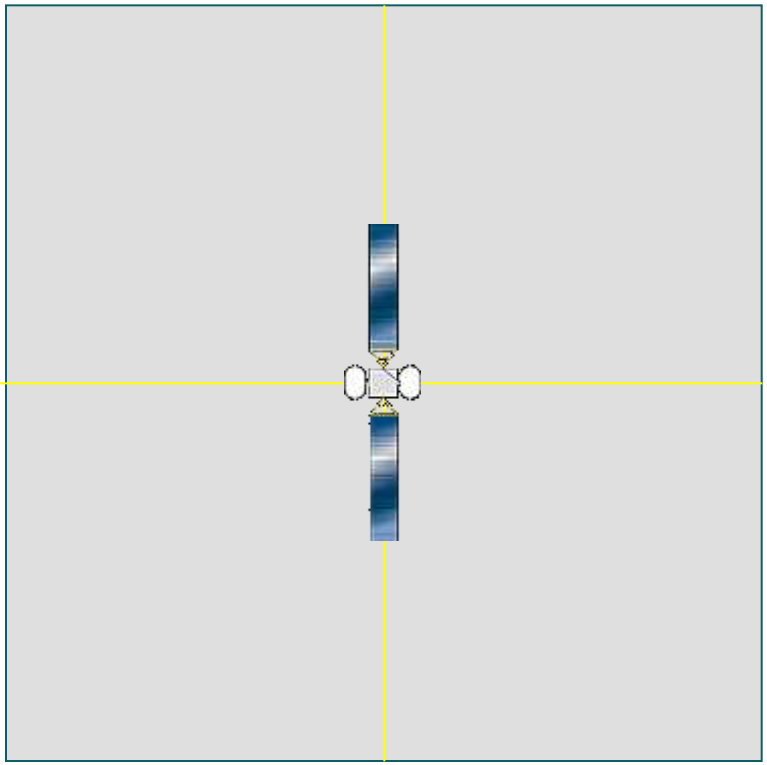
Why Station Keeping

CHINA APMT

- Perturbation and orbital drift
  - Source
    - ⇨ lunar gravitation and solar gravitation
    - ⇨ gravitational force of the earth's homogeneous sphere
    - ⇨ solar radiation pressure
  - Effort
    - ⇨ changing S/C's orbital period (east/west)
    - ⇨ changing S/C's inclination (north/south)
- Drift
  - Daily drift
    - ⇨ north/south
    - ⇨ east/west
    - ⇨ composed figure '8' style
  - Long term drift

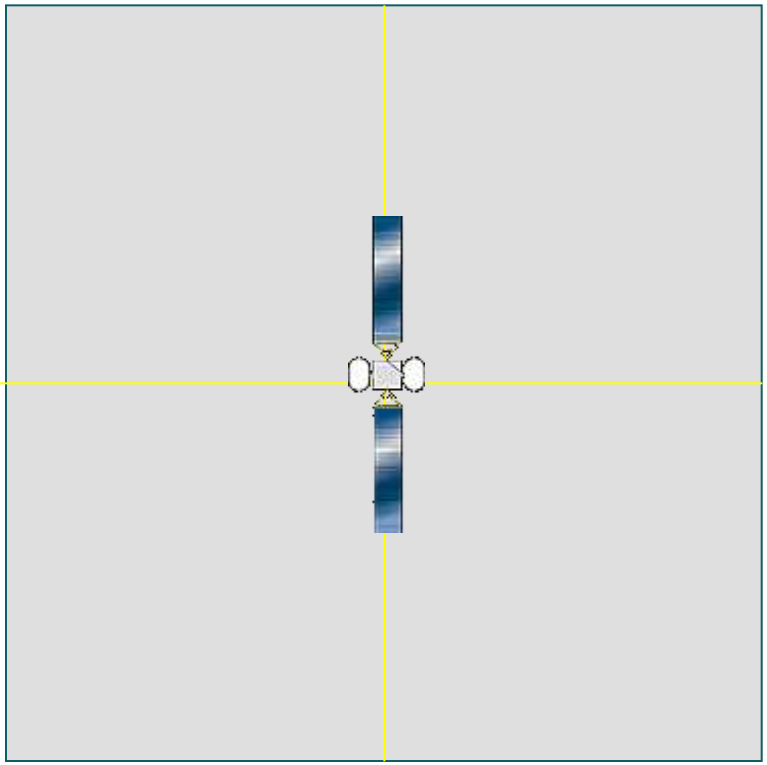
Daily drift at East/West

CHINA APMT



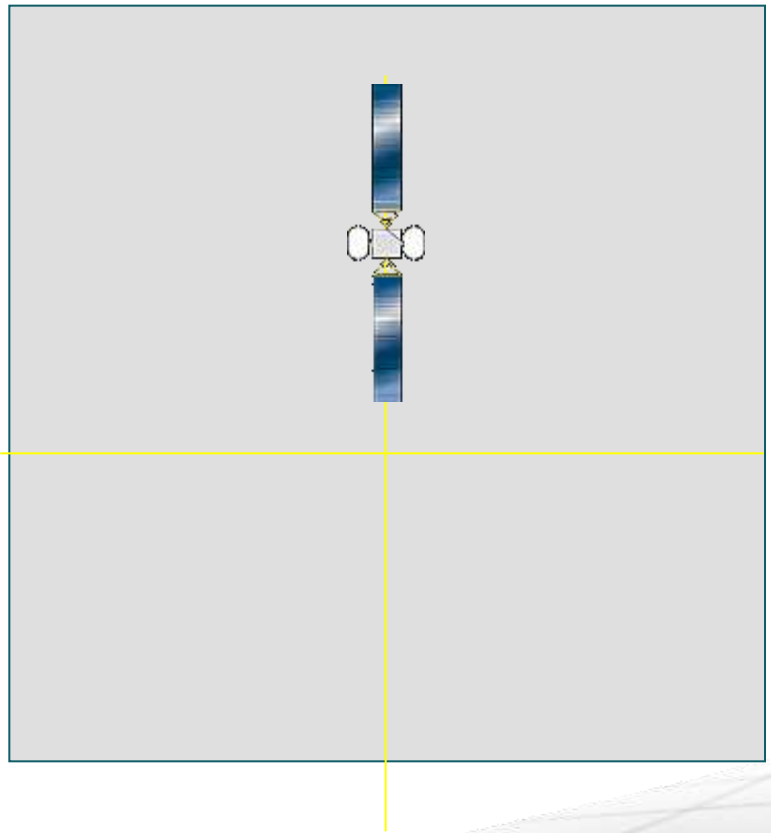
Daily drift at North/South

CHINA APMT



Daily Drift: Composed Figure ‘8’

CHINA APMT



How Station Keeping

- Station keeping
  - To counteract the movement of a satellite witch be affected by the gravitational field of the sun, the moon, and the earth
  - The amount of movement can be predicted using some complicated mathematical equations
- North-south maneuver
  - To counteract the inclination variance which caused by lunar gravity, solar gravity, and earth flattening
    - ⇨ about once every two weeks
    - ⇨ 95% of the total station-keeping propellant budget

How Station Keeping (cont.)

- East-west maneuver
  - To counteract longitudinal drift caused by asymmetry of the earth
  - To compensate the eccentricity variation by solar radiation pressure
    - ⇨ about once a week
    - ⇨ to keep orbital period synchronous with earth rotation
    - ⇨ to keep minimum eccentricity sufficiently

- Satellite Operators
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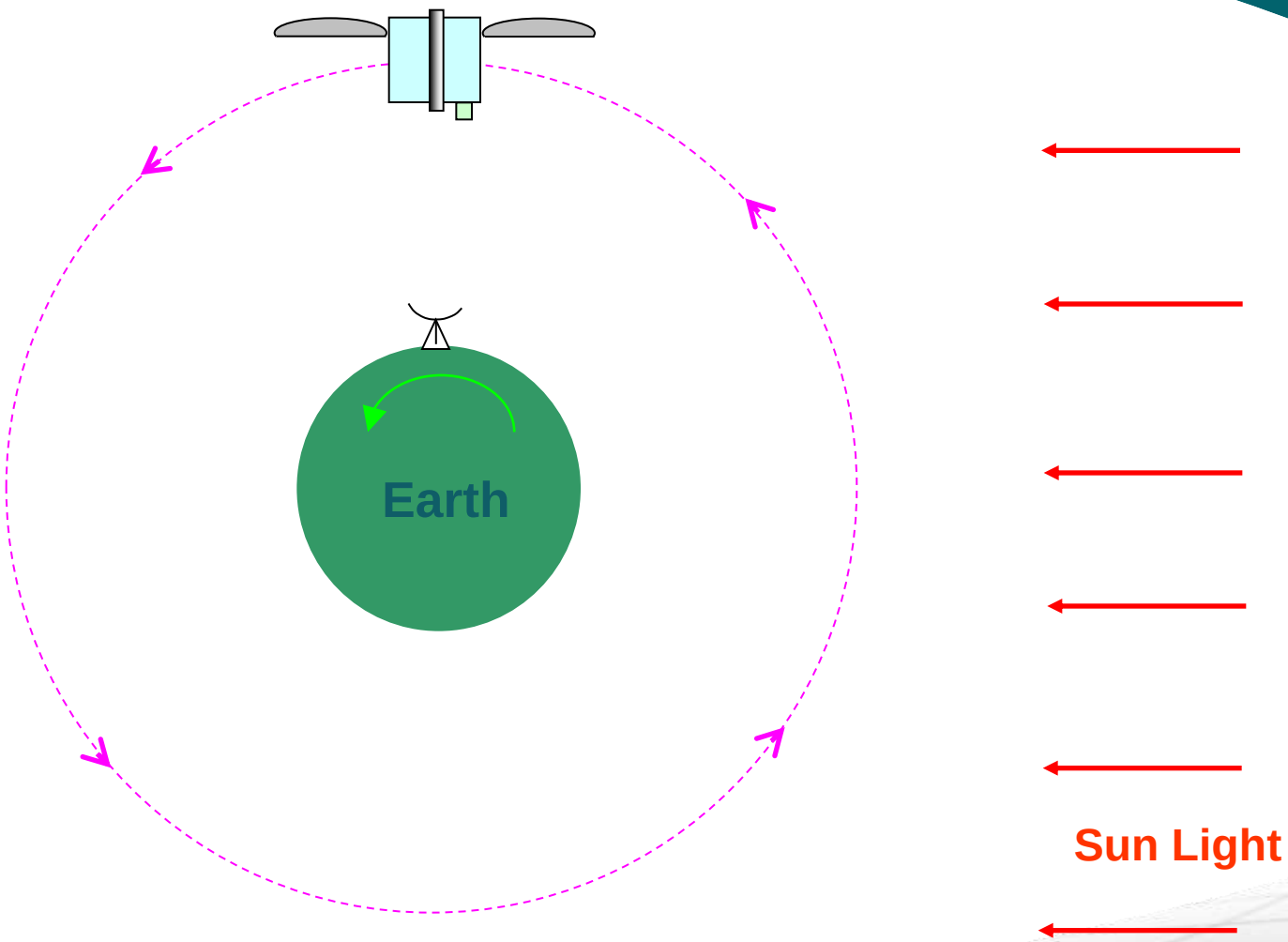
  - Introduction
  - **Attitude Control**
  - Station Keeping
  - Eclipse Operation
- Payload Operation
  - TransponderSetting / CarrierAllocating / VerificationTest / Line-upTest / CarrierMonitoring / InterferenceElimination

Satellite Attitude with ACS

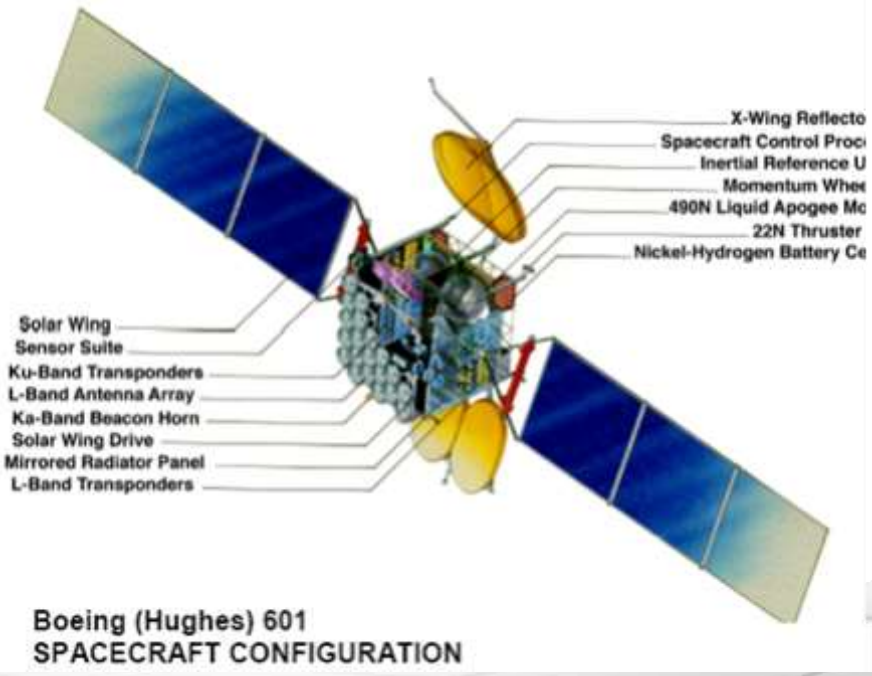
CHINA APMT



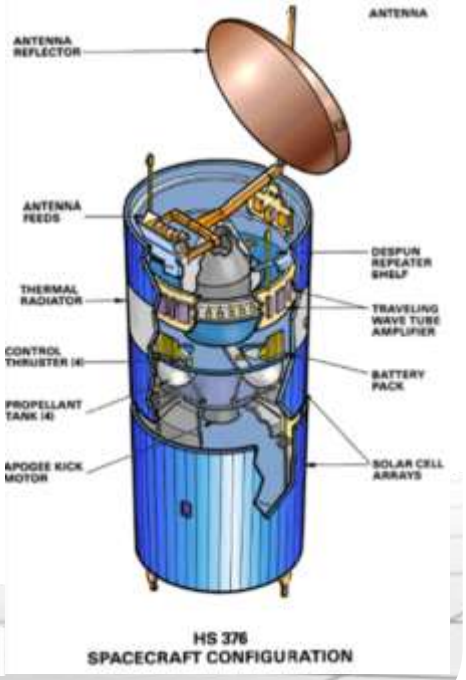
Why Attitude Control

CHINA APMT

- Stabilization Type
  - Spin stabilization
  - 3-axis stabilization
- GNC
  - Guidance, Navigation and Control
  - Combination of sensors, actuators and algorithms



Boeing (Hughes) 601
SPACECRAFT CONFIGURATION



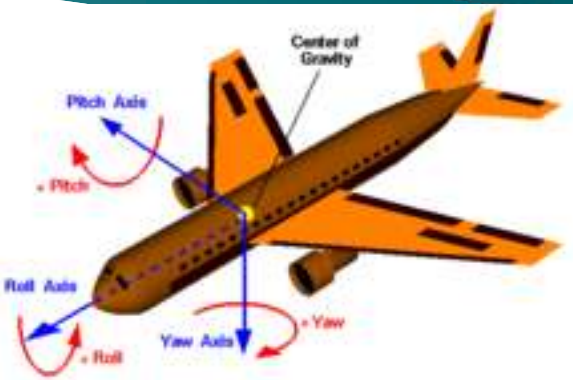
HS 376
SPACECRAFT CONFIGURATION

How Attitude Control

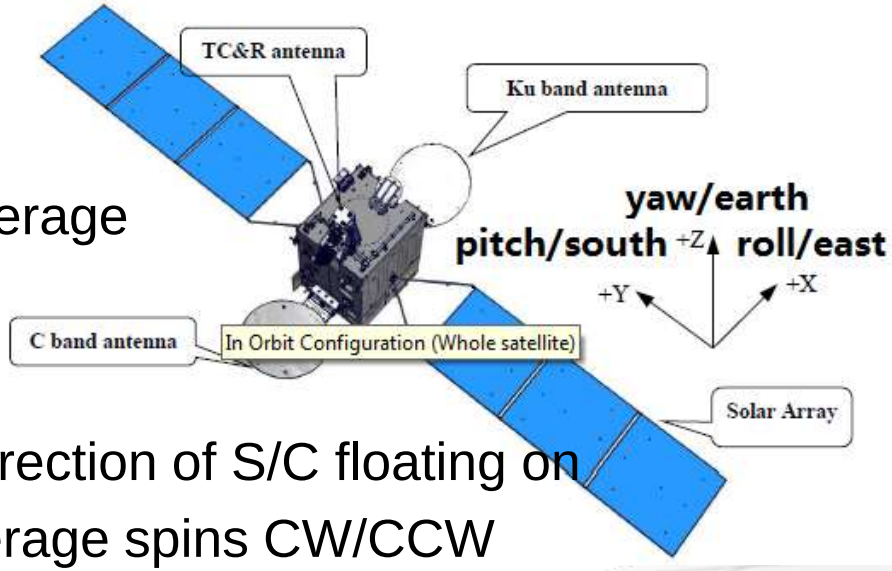
CHINA APMT

- Attitude control
  - Fixed attitude maintaining
    - ⇨ automatically or manually
    - ⇨ relative to spacecraft's orbital track
  - Antenna pointing
  - Solar wing orientation
- Attitude control system
  - Accurate data collection and subsequent data interpretation
  - Short propulsive maneuvers executed in the right direction
  - To accomplish precise pointing

On-station Coordinates



- Three-dimensional coordinates
  - Carry forward the axes to control the attitude of a plane
- Roll
  - Pointing to east, the direction of S/C flying to
  - Roll rotation: antenna coverage shifts to N/S
- *Pitch*
  - Pointing to south
  - Pitch rotation: antenna coverage shifts to E/W
- *Yaw*
  - Pointing to the earth, the direction of S/C floating on
  - Yaw rotation: antenna coverage spins CW/CCW



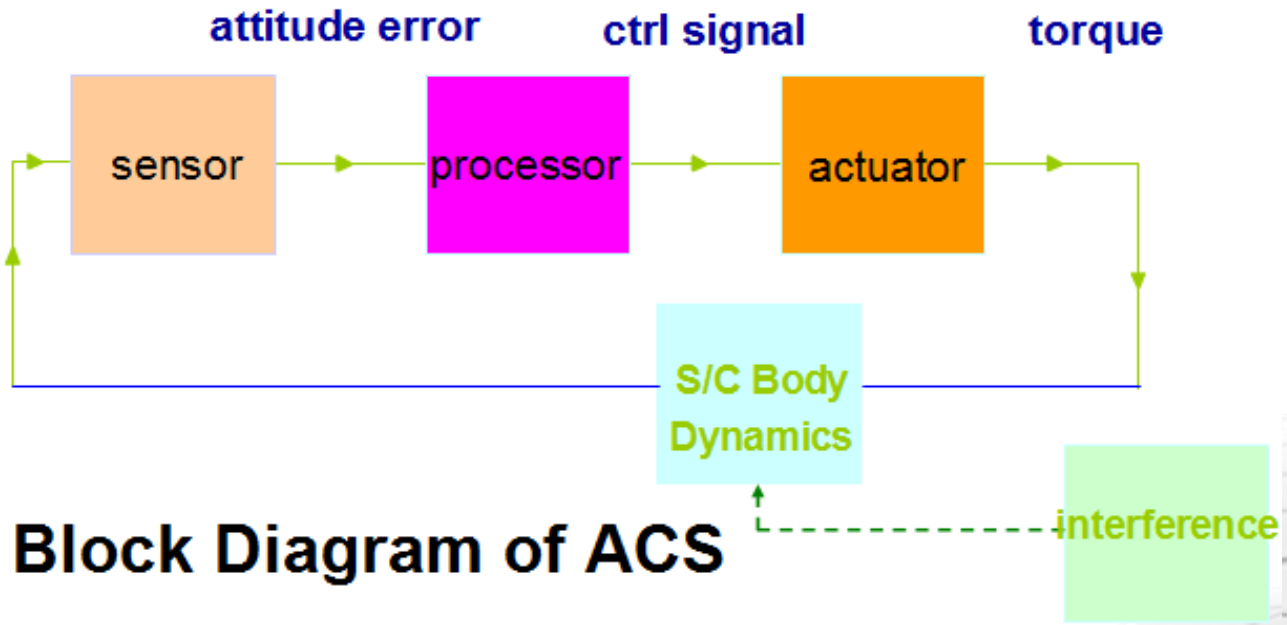
Sensor and Actuator

- Sensors
  - To measure vehicle orientation
  - Gyroscopes
    - mechanical
    - fiber optic: roll/yaw angles
  - Sensors
    - sun sensor: transfer orbit, roll/yaw angles in station keeping mode
    - earth sensor: roll/pitch angles
    - star tracker: roll/pitch/yaw angles
- Actuators
  - To apply the torques to re-orient the vehicle to a desired attitude
  - Propellant thrusters
  - Reaction wheels
    - unloaded by thrusters
  - Solar array drive mechanism

Processor

CHINA APMT

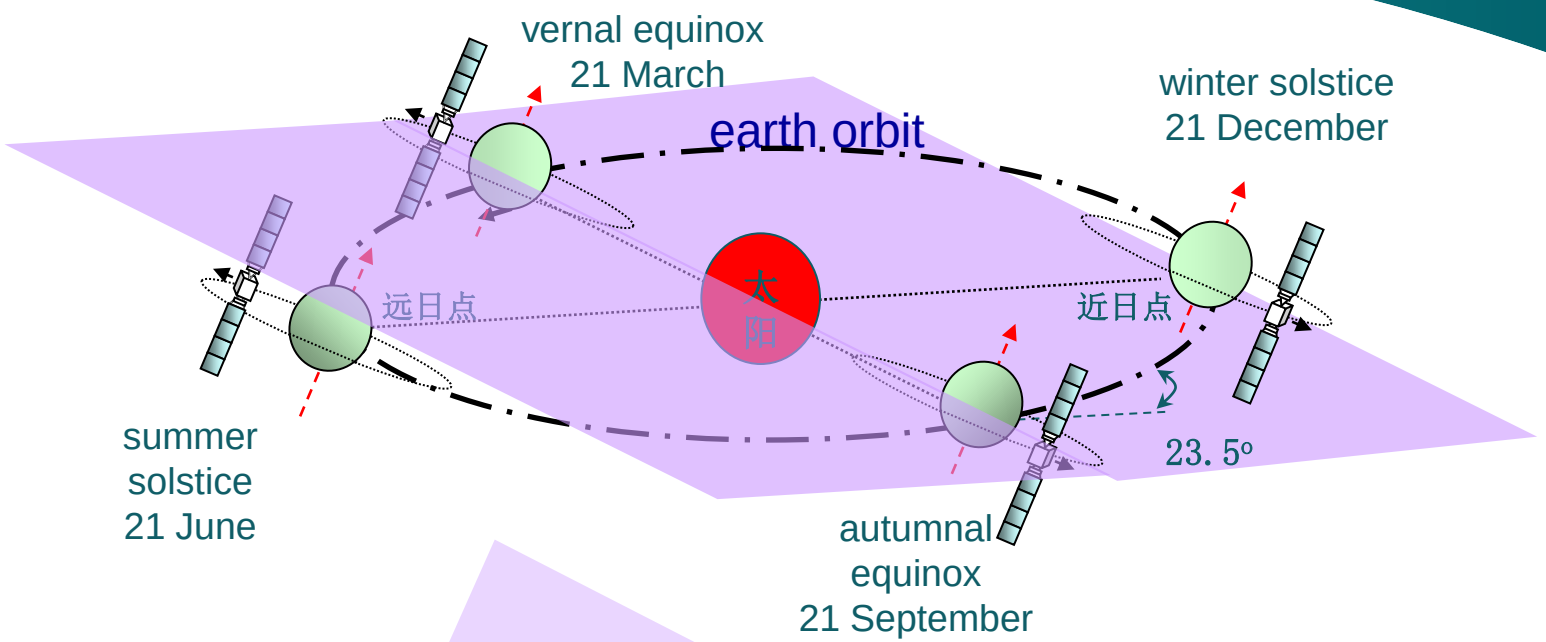
- Onboard processor
  - Processing the information offered by sensors
    - ⇨ accurate data collection
    - ⇨ subsequent data interpretation
  - Selecting proper actuator
  - Short propulsive maneuvers executed in the right direction
  - Attitude corrected to accomplish precise pointing

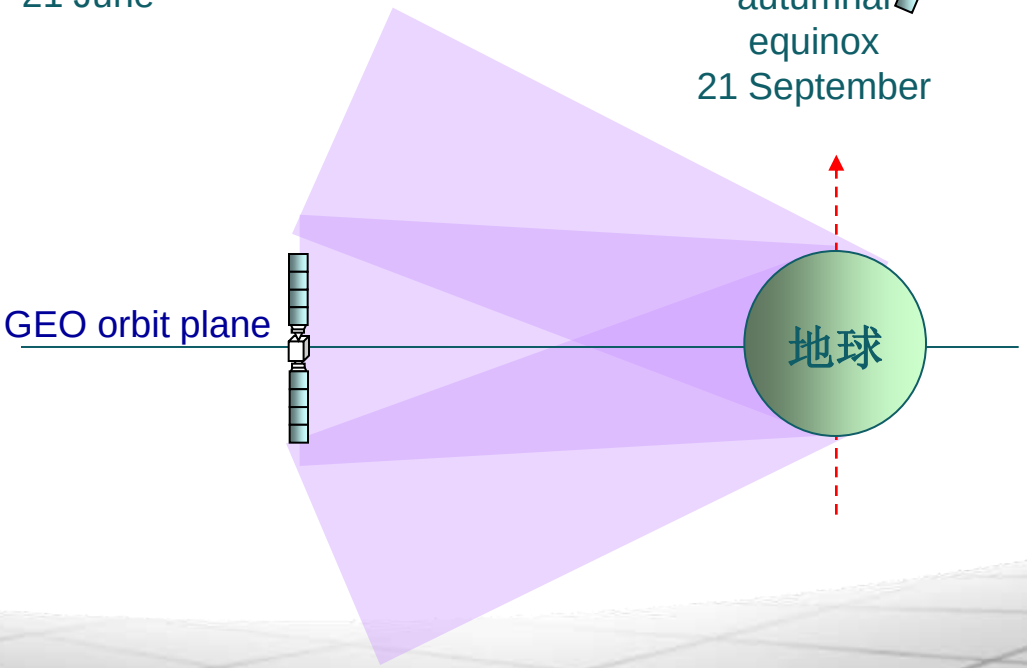


Block Diagram of ACS

- Satellite Operators
- Engineering Department
- TT&C Station
- Orbit and Satellite
  - ITU&RR / OrbitResource / SatelliteOrder-IOT
- **Bus Operation**
  - Introduction
  - Attitude Control
  - Station Keeping
  - **Eclipse Operation**
- Payload Operation
  - TransponderSetting / CarrierAllocating / VerificationTest / Line-upTest / CarrierMonitoring / InterferenceElimination

Why Eclipse

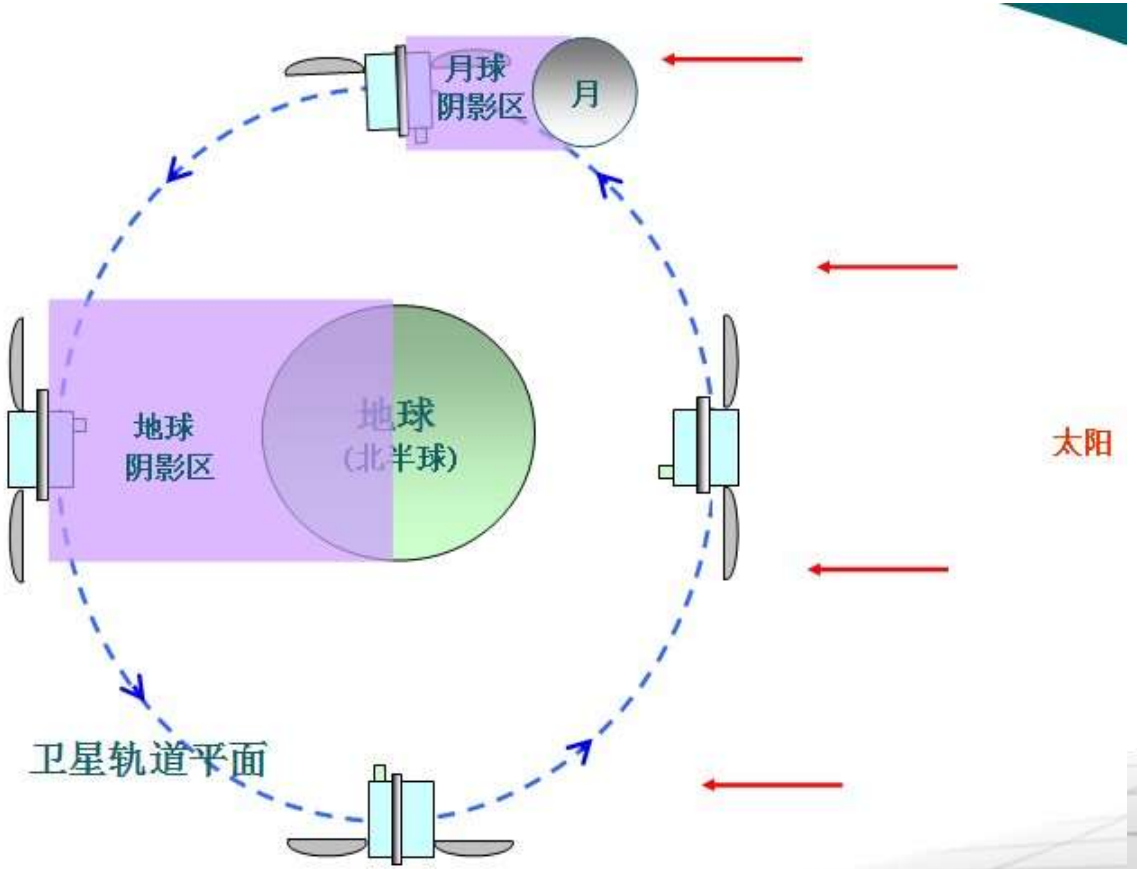

vernal equinox
21 March
earth orbit
winter solstice
21 December
远日点
太
阳
近日点
23. 5°
summer
solstice
21 June
autumnal
equinox
21 September


GEO orbit plane
地球
阳
summer solstice
阳
vernal equinox
autumnal equinox
阳
winter solstice

Why Eclipse (cont.)

CHINA APMT

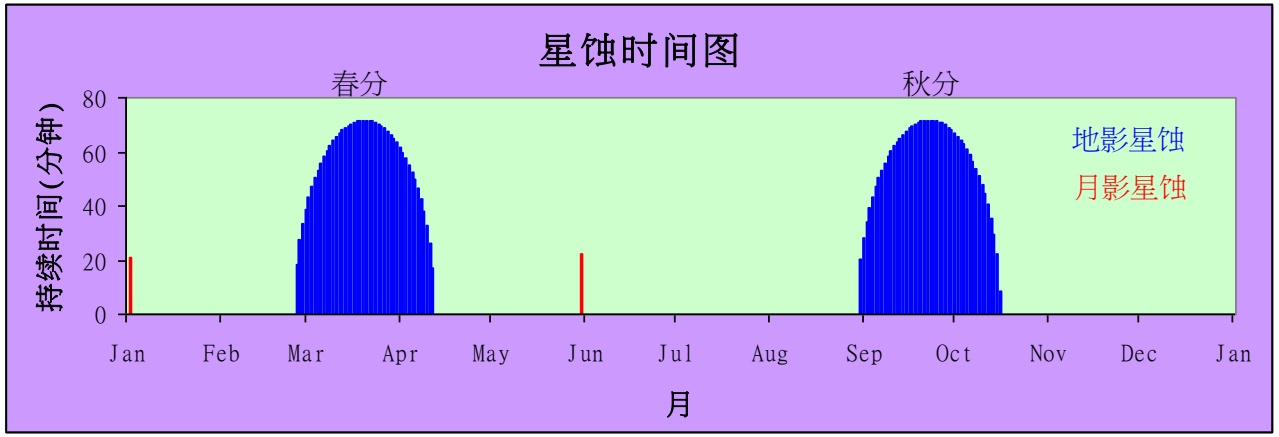
- Eclipse
  - Satellite passing into earth's or moon's shadow
  - Satellite powered by on-board storage batteries



Eclipse Period

CHINA APMT

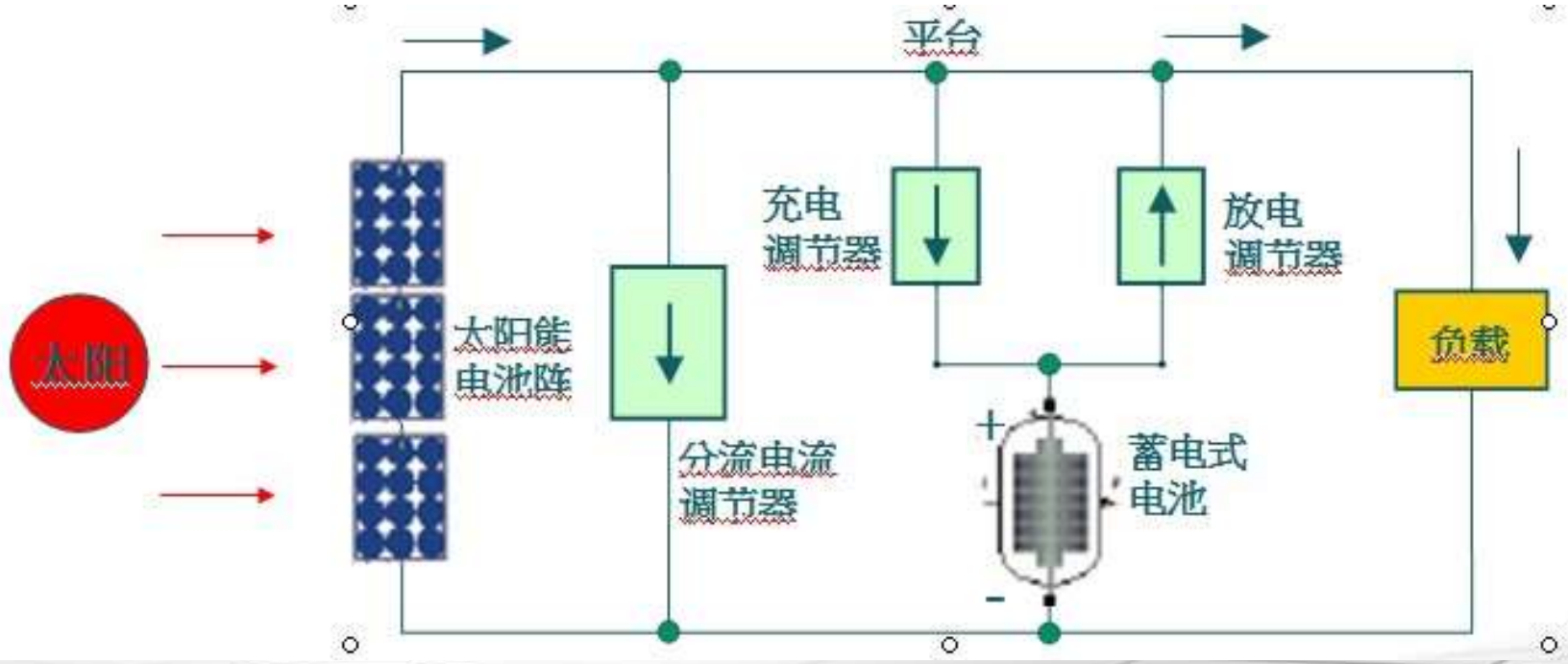
- Eclipse period
  - Around vernal equinox and autumnal equinox
  - The sun, the earth and the satellite are on the same line, at mid night
  - The satellite goes into the shadow of the earth
  - Each period is about 42 days
  - The longest duration is 72 minutes



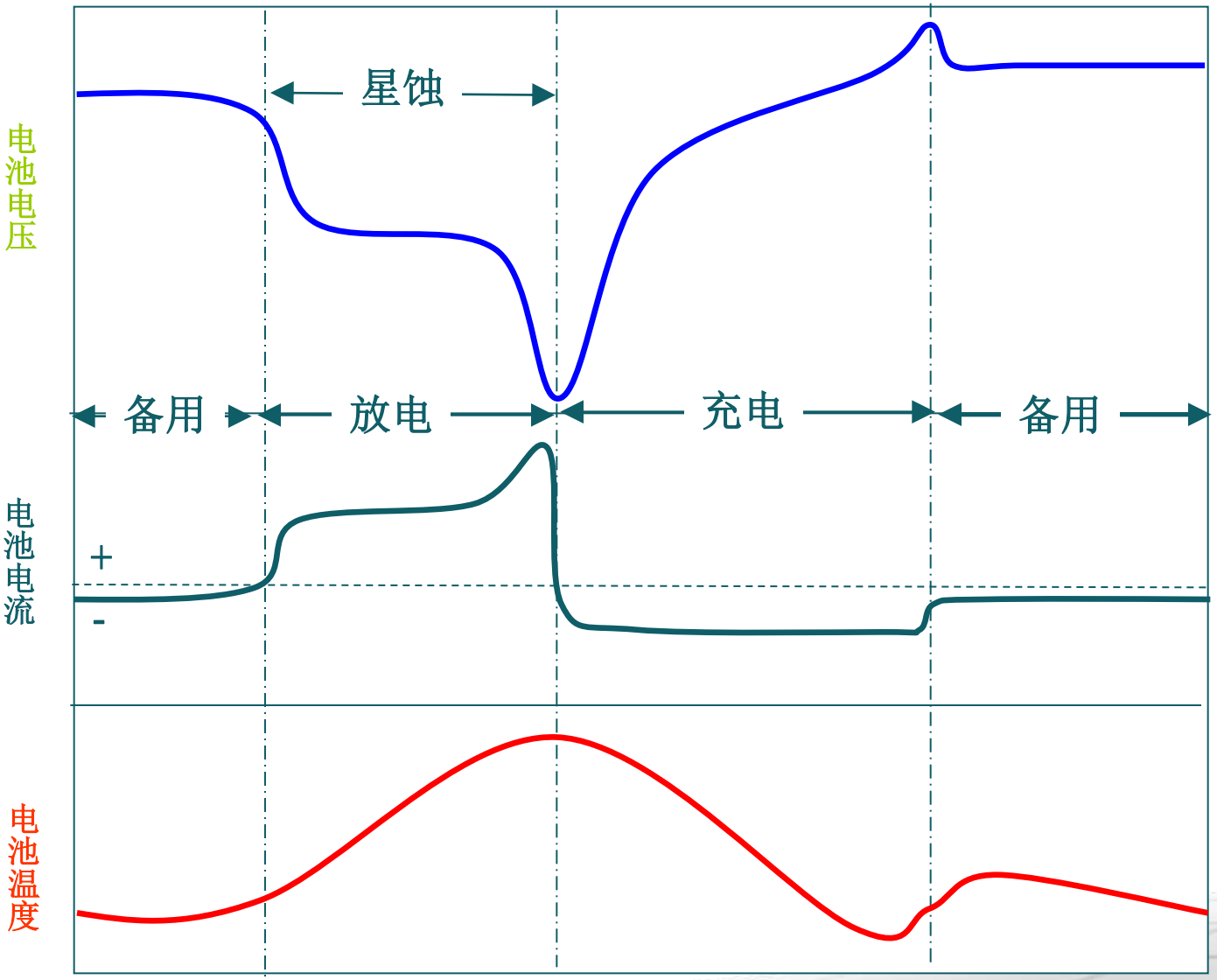
- Eclipse by the moon
  - Shorter duration and lower influence
  - Happened date and time being unspecified

Battery Charge and Discharge

- Charge and discharge
  - Pressure, voltage, current and temperature data monitoring
  - Charge capacity and discharge depth calculating
  - Proper control to avoid damage of battery



Characteristics of Nickel-hydrogen Battery



Satellite Operators

Engineering Department

TT&C Station

Orbit and Satellite

- ITU&RR / Orbit Resource / SatelliteOrder-IOT

Bus Operation

- Intro / StationKeeping / AttitudeControl / Eclipse

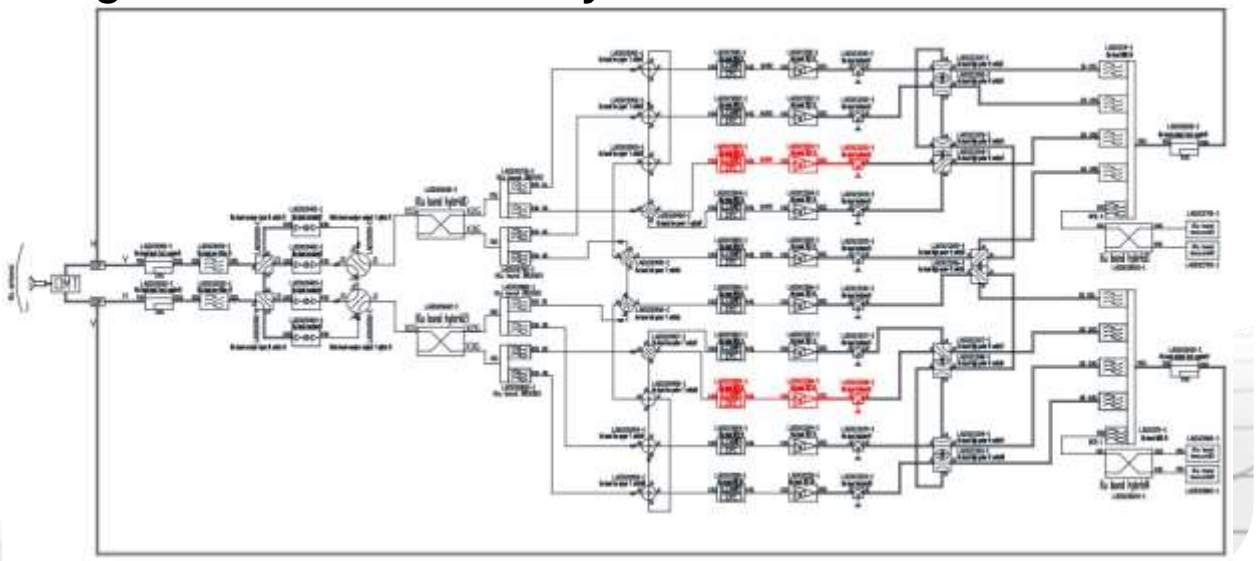
Payload Operation

- **Transponder Setting**
- Carrier Assignment
- Verification Test
- Line-up Test
- Carrier Monitoring
- Interference Elimination

Redundancy Switching

CHINA APMT

- Redundant ring for receivers
  - Both C- and Ku-band, 4 for 2 redundancy
- Redundant ring for TWTAs
  - Both C- and Ku-band, N+2 for N redundancy
- Redundancy switching
  - To minimize service outage if any two receivers or two TWTAs failed
  - According to the guidance set down by manufacturer



LCTWTA Setting

CHINA APMT

- LCTWTA
  - LCAMP
    - ⇨ Linearized Channel Amplifier, pre-amplifier of TWTA
    - ⇨ linearizer: to compensate TWTA non linearity
    - ⇨ FGM mode: pre-amplifier at a fixed (but adjustable) gain
    - ⇨ ALC mode: pre-amplifier by AGC for fixed output power level
  - TWTA
    - ⇨ Travelling Wave Tube Amplifier, power amplifier of transponder
  - Maximum gain of LCTWTA: about 90dB
- LCAMP setting
  - FGM/ALC mode selecting
  - FGM mode
    - ⇨ channel gain step setting
  - ALC mode
    - ⇨ output power level setting

FGM and ALC

CHINA APMT

- FGM
  - Fixed Gain Mode
  - LCAMP working at fixed (but adjustable) gain mode
  - Keeping channel gain at a TM changeable step
  - Channel SFD synchronously changed by gain step setting
- ALC
  - Automatic Level Control
  - LCTWTA working at fixed (but adjustable) output mode
  - Keeping output power at a TM changeable level
  - Variable channel gain automatically controlled relative to uplink power level
  - Normally used for single station uplinking

SFD Setting

CHINA APMT

- SFD
  - Saturated Flux Density
  - The uplink power density at satellite antenna feed required to saturate the transponder TWTA
    - ⇨ normal range: -70 to -100 dBW/m^2
    - ⇨ normally selected value: -85 to -93 dBW/m^2
- SFD setting
  - More sensitive SFD, less uplink power required
    - ⇨ less C/N at uplink
    - ⇨ less C/I by uplink adjacent satellite interference
  - Most insensitive SFD, used for idle channel setting
  - Insensitive SFD, often used for broadcasting to increase uplink C/N
  - Sensitive SFD, often used for VSAT to decrease required uplink power

Satellite Operators

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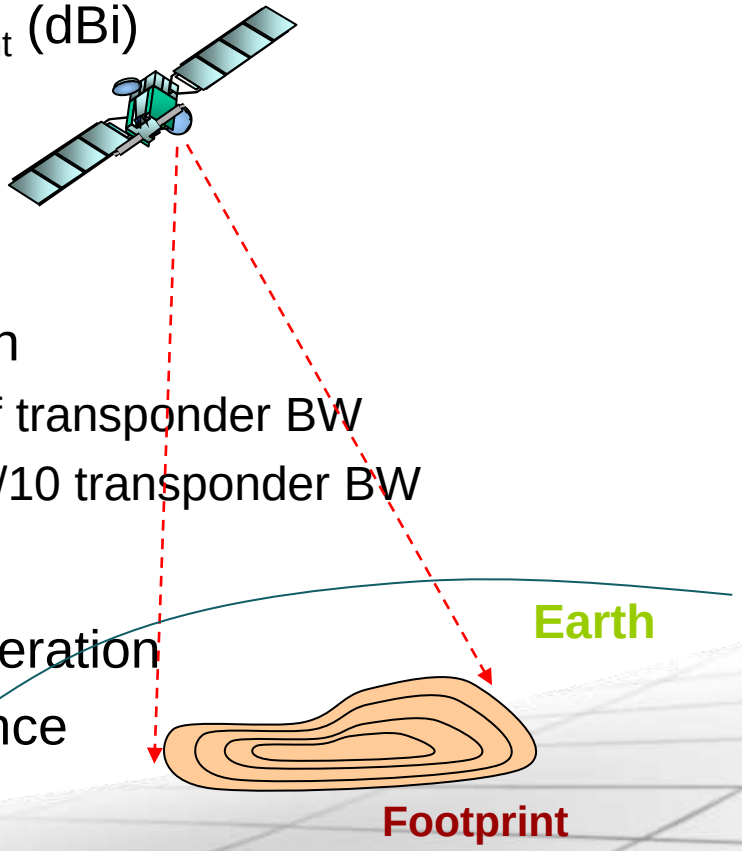
Payload Operation

Transponder Setting	**Carrier Assignment**
Verification Test	Line-up Test
Carrier Monitoring	Interference Elimination

ERIP

- EIRP
  - Effective Isotropic Radiated Power
  - The power radiated by a directional antenna with an antenna gain relative to an isotropic antenna

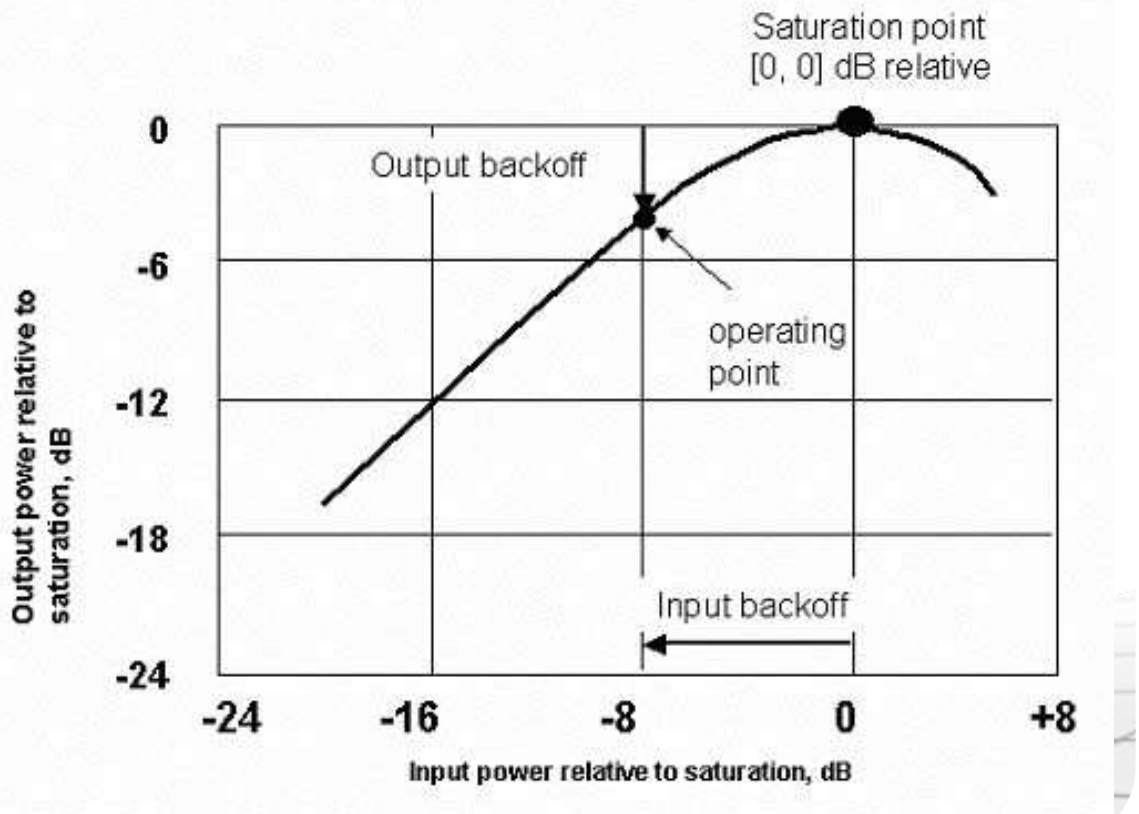
    EIRP (dBW) = P_{feed} (dBW) + G_{ant} (dBi)
- Allocated EIRP
  - Transponder resources
    - ⇨ power and bandwidth
  - EIRP equally shared by bandwidth
    - ⇨ half EIRP (-3dB) allocated for half transponder BW
    - ⇨ 1/10 EIRP (-10dB) allocated for 1/10 transponder BW
- Linear EIRP
  - Proper back-off for multicarrier operation to avoid intermodulation interference



Output/Input Power Relationship

CHINA APMT

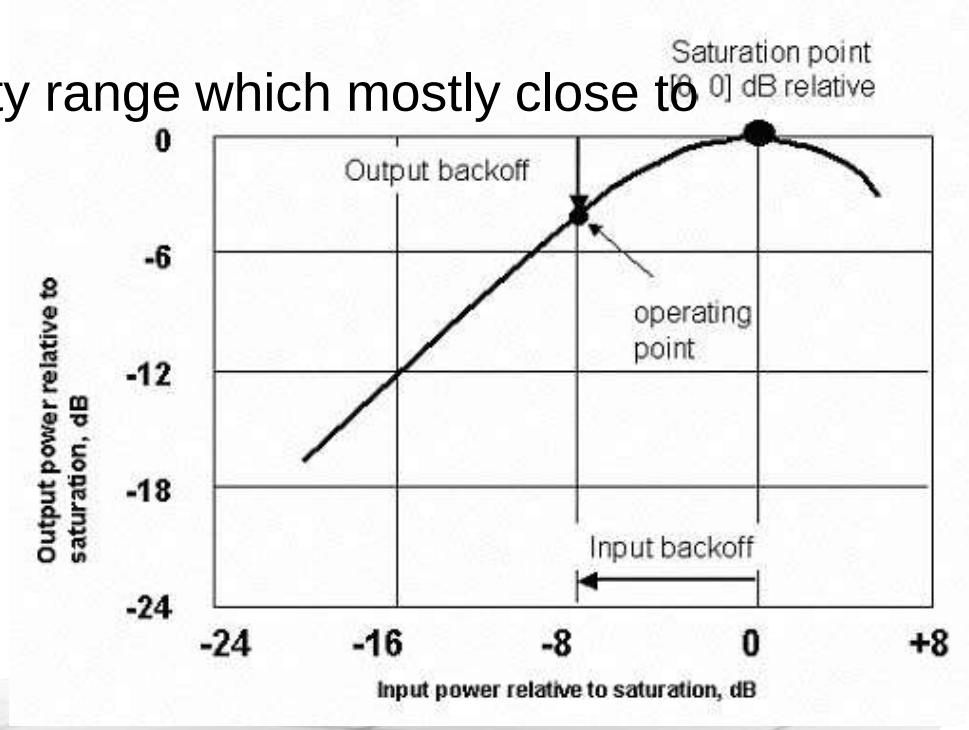
- Gain transfer curve
  - TWTA
    - ⇨ non-linear amplifier
  - Gain transfer
    - ⇨ relationship between output and input power level



Back-off

CHINA APMT

- Back-off
  - Power level difference between operation point and saturation point
    - ⇨ input back-off
    - ⇨ output back-off
    - ⇨ larger back-off, lower power level
- Linear back-off
  - Operation point at linearity range which mostly close to saturation point
    - ⇨ to avoid intermodulation
  - For non-linear TWTA
    - ⇨ 4.5dB output back-off
    - ⇨ 9dB input back-off
  - For LCTWTA
    - ⇨ 3dB output back-off
    - ⇨ 6dB input back-off



Allocated Bandwidth and Power

CHINA APMT

- Carrier bandwidth allocation
  - Calculated by signal information rate, modulation type and coding rate
  - Proper guard band reserved to avoid interference between neighboring carriers
  - Rental for the user carrier based on carrier BW + guard band
- Transponder operation point
  - Reserving sufficient output back-off
  - Keeping transponder power limited in linear range

Allocated Bandwidth and Power (cont.)

CHINA APMT

- Carrier power allocation
  - When power balanced with bandwidth

    $EIRP_C = EIRP_{Xpd} - OPBO_C$

    where, $EIRP_C$ and $EIRP_{Xpd}$ means EIRP for carrier and transponder, and $OPBO_C$ means carrier output back-off
  - Downlink carrier power allocated as

    $OPBO_C = OPBO_{Xpd} + 10\ lg(BW_{Xpd}/BW_C)$

    where, $OPBO_C$ and $OPBO_{Xpd}$ means output back-off of carrier and transponder respectively, and BW_{Xpd} and BW_C means bandwidth of transponder and carrier
  - Higher carrier power level than transponder average, more bandwidth payment than average

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Payload Operation

Transponder Setting Carrier Assignment

Verification Test Line-up Test

Carrier Monitoring Interference Elimination

Why, When and Which

CHINA APMT

- Why verification test
  - To ensure antennas and earth station equipments satisfied for operation
  - To avoid neighboring carriers and adjacent satellite to be interfered
- When verification test
  - New network in progress
  - Expansion scheduled for existing network
  - Renewal or augment equipments planned
- Which should be tested
  - Antennas
  - Uplink equipments
  - Only approved ones could be allowed to enter space segment

Verification Test

CHINA APMT

- Verification test for transmit antennas
  - Satisfying far lobe formula as follows

    $G(\theta) = 29 - 25 \log(\theta)$ (dBi)
  - Guarantee of 30dB crosspol isolation in -1dB beam width
  - Large antennas should be tested one by one
  - VSAT antennas (4.5m or less) could be arranged a batch test
    - ⇨ the antenna types approved by other satellite operators may be accepted
- Verification test for uplink equipments
  - Equipments: modulators, up converters, and power amplifiers
  - Testing items: spurious, intermodulation, modulation, power and frequency stabilities
  - Earth stations should be tested individually
  - VSAT equipments could be assigned a batch test
    - ⇨ the equipments approved by other satellite operators may be accepted

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Transponder Setting　Carrier Assignment

Verification Test　**Line-up Test**

Carrier Monitoring　Interference Elimination

When, Why and How

- When line-up test
  - Before carrier launch up and into service
- Why line-up test
  - Crosspol isolation calibration
  - Power and frequency band calibration
  - To avoid potential interference
  - As a record to help analyzing possible anomaly later
- Line-up test
  - Transmit crosspol calibration
    - ⇨ crosspol isolation of pure carrier at peak: > 30 even 35 dB
  - Carrier power calibration
    - ⇨ by checking pure carrier's output back-off calculated by link budget
    - ⇨ or by comparing modulated carrier with neighboring carriers
  - Frequency band calibration

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Transponder Setting Carrier Assignment

Verification Test Line-up Test

Carrier Monitoring Interference Elimination

Carrier Monitoring

CHINA APMT

- Manual monitor
  - Daily tour
    - channel by channel, carrier by carrier
    - compared by previously plotted spectrums
    - pay attention to interference and exceeding carrier power
- Automatic monitor
  - By carrier monitoring system
    - with carriers information pre-setting
  - Anomalies would be detected and alarmed automatically
    - power exceeding, carrier loss, and interfered status
    - Unnecessary alarm often happened
- Process
  - Power exceeding: reduce the uplink power
  - Carrier loss: notice the customer to check uplink equipments
  - Interfered status: seek the source and proper handle it

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Payload Operation

- Transponder Setting
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- Verification Test
- Line-up Test
- Carrier Monitoring
- **Interference Elimination**

Introduction

- Satellite interference caused by
  - Overloaded orbital and frequency resources
  - Overlapping coverage by adjacent satellites
  - Equipment anomaly
  - Improper operation
  - Unauthorized and intentional uplink
  - Terrestrial interference
  - Satellite anomaly
  - Space environment
- Reference
  - http://www.satcomengr.com/Satcom/anomaly.htm

Interference and Relative Process

CHINA APMT

- Adjacent satellite
  - Co-frequency band and overlapping coverage with 2 degrees or less orbital separation
  - Antenna size versus beam width
  - Uplink interference reduced by SFD adjusting
- Improper operation
  - Cross-polarization
    - ⇨ by uplink station: polarization angle or antenna pointing mismatch
    - ⇨ by downlink station: pol-angle or antenna pointing mismatch
  - Intermodulation
    - ⇨ by uplink carrier: driving TWTA operation point into nonlinear range
    - ⇨ by uplink equipment: multi-carrier uplink station only

Interference and Relative Process (cont.)

CHINA APMT

- Equipment anomaly
  - Up-link equipment
    - IF transition: loop composed from D/L to U/L
    - frequency hopping or sweeping: unlocked oscillator in U/C
  - Cable coupling
    - FM coupling: FM radio radiating into IF band
    - inter-cable coupling: Tx and Rx cables between ODU and IDU
- Terrestrial interference
  - Micro-wave
    - C-band: antenna at low elevation angle
  - Radar
    - microwave coupling into cable or RF equipments

Interference and Relative Process (cont.)

- Unauthorized and intentional uplink
  - Stealing
    - ⇨ short term or testing usage
  - Purposive interference
    - ⇨ against to satellite operator
    - ⇨ against to carrier launcher
- Satellite and space anomaly
  - Transponder gain setting
    - ⇨ lost FGM setting
  - Noise floor raising
    - ⇨ Influenced by adjacent transponder
  - Orbit and attitude destabilization

Reference:

AsiaSat: Customer Training Materials, April 2004
Wikipedia

Thanks!

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