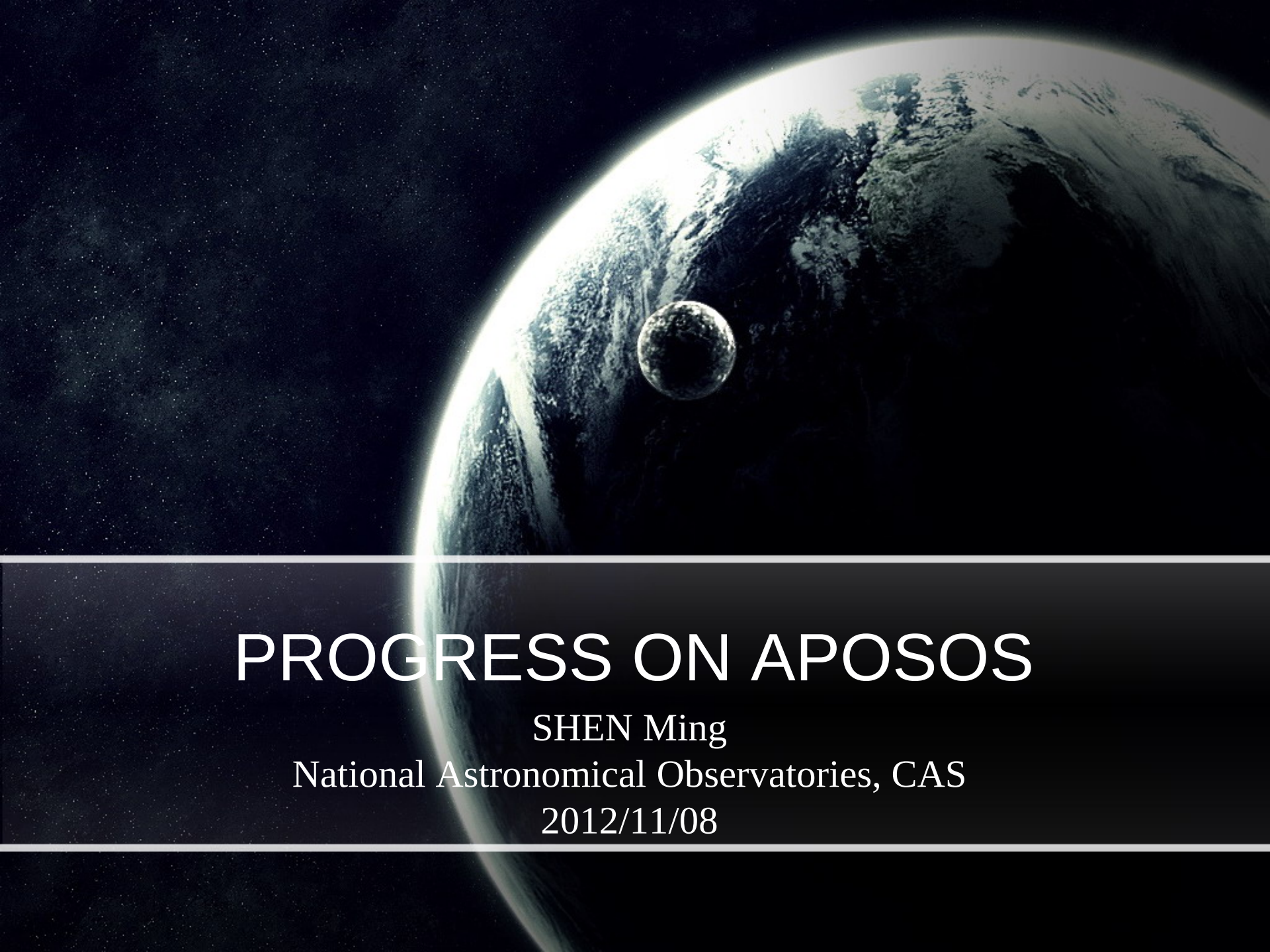


PROGRESS ON APOSOS

SHEN Ming
National Astronomical Observatories, CAS
2012/11/08

OUTLINES

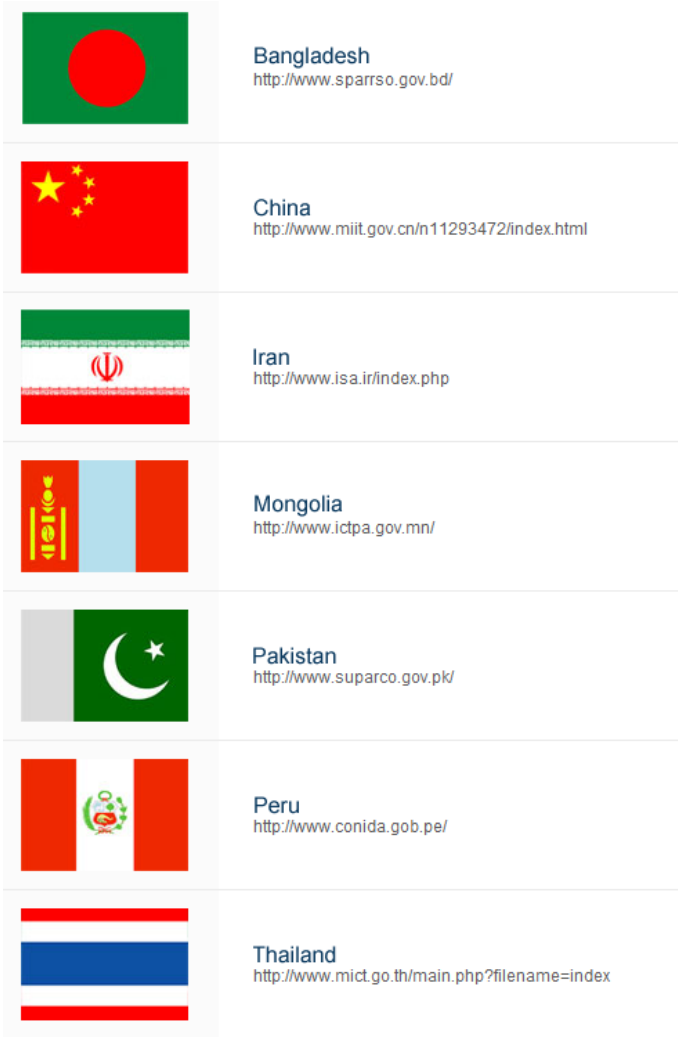
APSCO
ASIA-PACIFIC MULTILATERAL COOPERATION IN SPACE TECHNOLOGY AND APPLICATIONS

- INTRODUCTION
- PILOT OBSERVATION
- SIMULATION
- CONCLUSION

Note: Artist's impression; size of debris exaggerated as compared to the Earth

INTRODUCTION

- APSCO
  - Founded in 2008
  - Granted permanent observer in Committee on Peaceful Uses of Outer Space (UN/COPUOS)
  - Turkey congress approved to join APSCO recently
  - Indonesia…
- APOSOS
  - Asia-Pacific Optical Satellite Observation System
  - Unite member states to establish a global optical network



INTRODUCTION

- Project APOSOS was proposed by Peru, Turkey and China in the first APSCO council meeting in 2008
- Approved by 2nd council meeting in 2009
  - The council also decided China & Turkey to be the leading states.

PROGRESS IN PAST YEARS

- In April and May 2010, two symposium held in Beijing and Ankara.
- China MIIT delegated NAOC to study the feasibility in the beginning of 2010.
- In Jan. 2011, APSCO council approved APOSOS.
  - BASIC GOAL: establish a network on the basis of existing facilities.
  - OPTIONAL GOAL: new facilities

MAGNITUDE LIMIT	11.5 mag (LEO); 16 mag (HEO、GEO)
SIZE	10cm（1000km）；20cm（2000km）
ACCURACY	3″

PROGRESS IN PAST YEARS

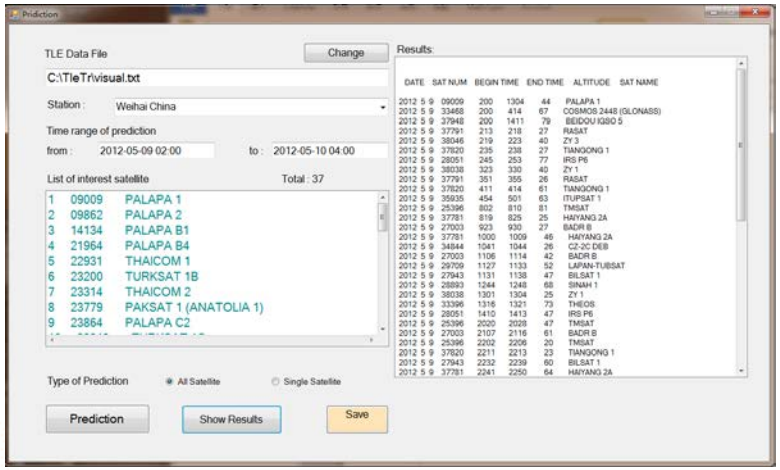
- 1st stage of APOSOS：
  - Construction of Observation Center (also data center)：
    - Reconstruction of APSCO headquarter.
    - Infrastructure for database and network.
  - Training:
    - Basic knowledge/skill for observation
    - Dec. 2011，theoretical in Beijing, practical in Weihai.
  - Pilot observation :
    - Based on existing facilities, held in Apr 2012.
    - PURPOSE:
      - Evaluate facility capability: observe the specified objects.
      - Establish network and coordinate mechanism: form basic ability of demand/distribution/data transfer/sharing and application.

PILOT OBSERVATION

Index	Country	Address
1	Bangladesh	Longitude: 90.5°E; Latitude: 23.5°; Altitude:
2	China	Longitude: 122°03'02"E; Latitude: 37°32'12"N; Altitude:110m Longitude: 117° 34' 38.85"E; Latitude: 40°23'45.12"N; Altitude: 893m
3	Indonesia	Longitude:107°50'46.4"E; Latitude: 6°54' 09.1"S; Altitude: 776m
4	Iran	Longitude: 46°19' 54"N; Latitude: 37°52' 09"E; Altitude: 2503 m
5	Mongolia	
6	Pakistan	Longitude: 67°01'E; Latitude: 24°25'N; Altitude: 210m
7	Peru	Longitude: 75.32°W; Latitude: -12.03°; Altitude: 3336m
8	Thailand	Longitude:98°55'29.9" E; Latitude: 18°47'19.5" N; Altitude: 789 m
9	Turkey	
10	Tajikistan	

PILOT OBSERVATION

- NO observation capability except China:
  - Indonesia/Iran, improving
  - Cooperation between SURPARCO and China
  - Mongolia & ISON
  - Thailand, Turkey, Peru…
  - Bangladesh，rejected
- Solution: Technical support if member state provide financial support.



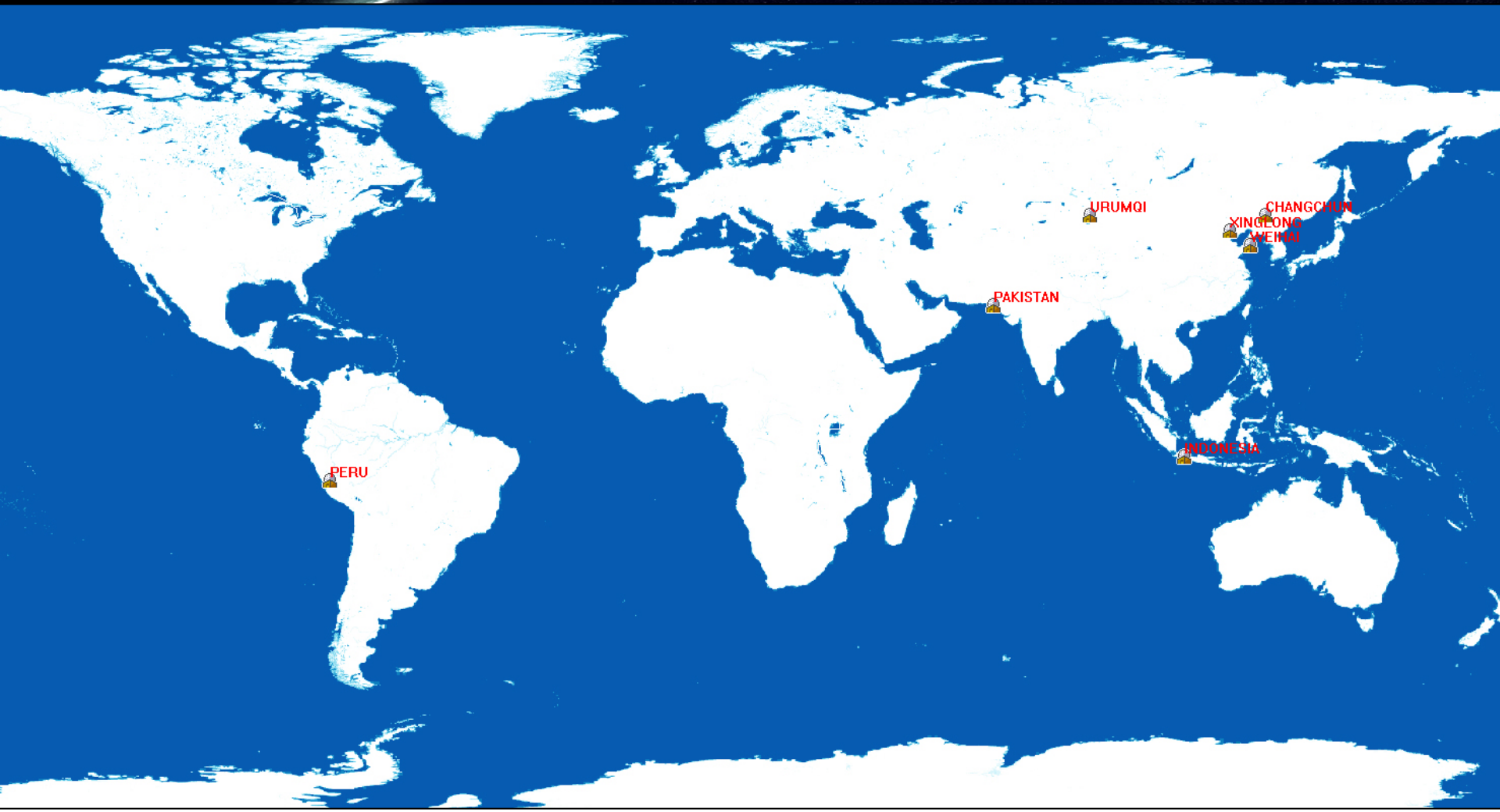
33468

37948

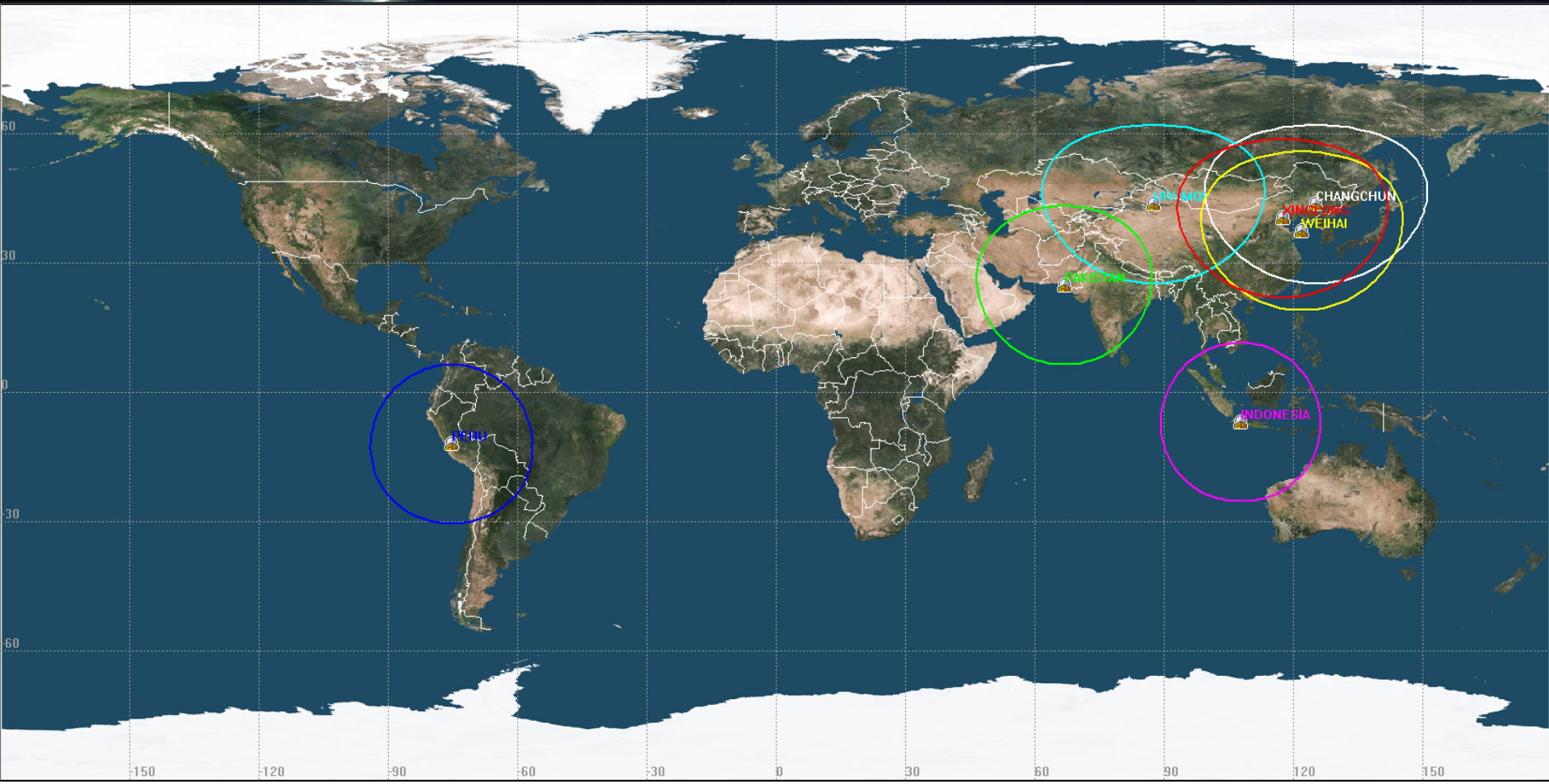
SIMULATION

- WHY?
  - Evaluate the site value to make priorities.
    - Count the quantity of objects can be observed.
- HOW?
  - DATA SOURCE：TLE
  - PROPOGATOR：SGP4/SDP4
  - COORDINATE TRANSFORM：FK5 Based
    →TEME to ECEF
  - OPTICAL VISIBILITY
    - Solar position
    - Ground obstacle
    - Telescope capability and weather condition NOT considered yet.

SIMULATION

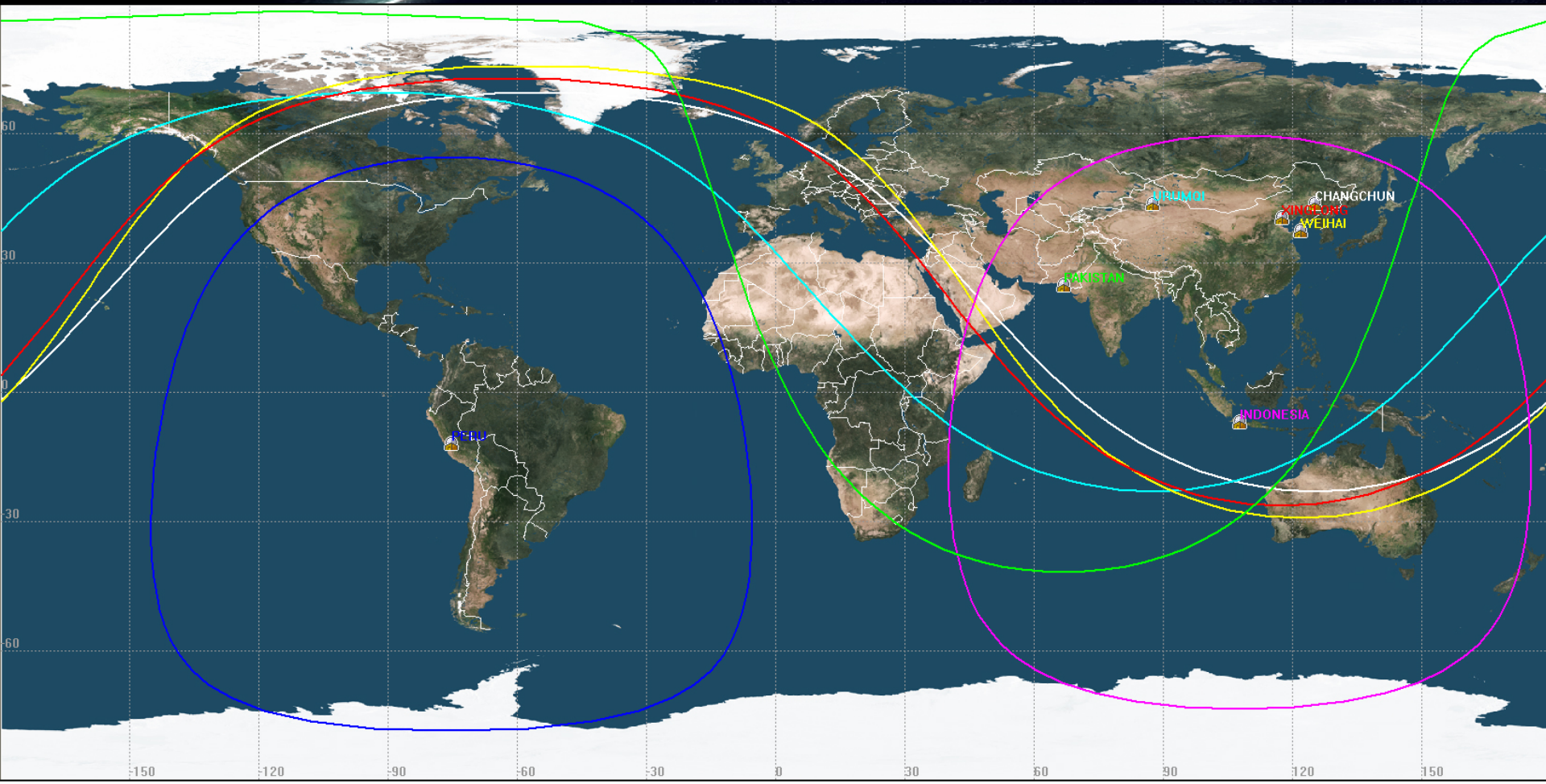

URUMQI
CHANGCHUN
XINGLONG
WEIHAI
PAKISTAN
INDONESIA
PERU

SIMULATION



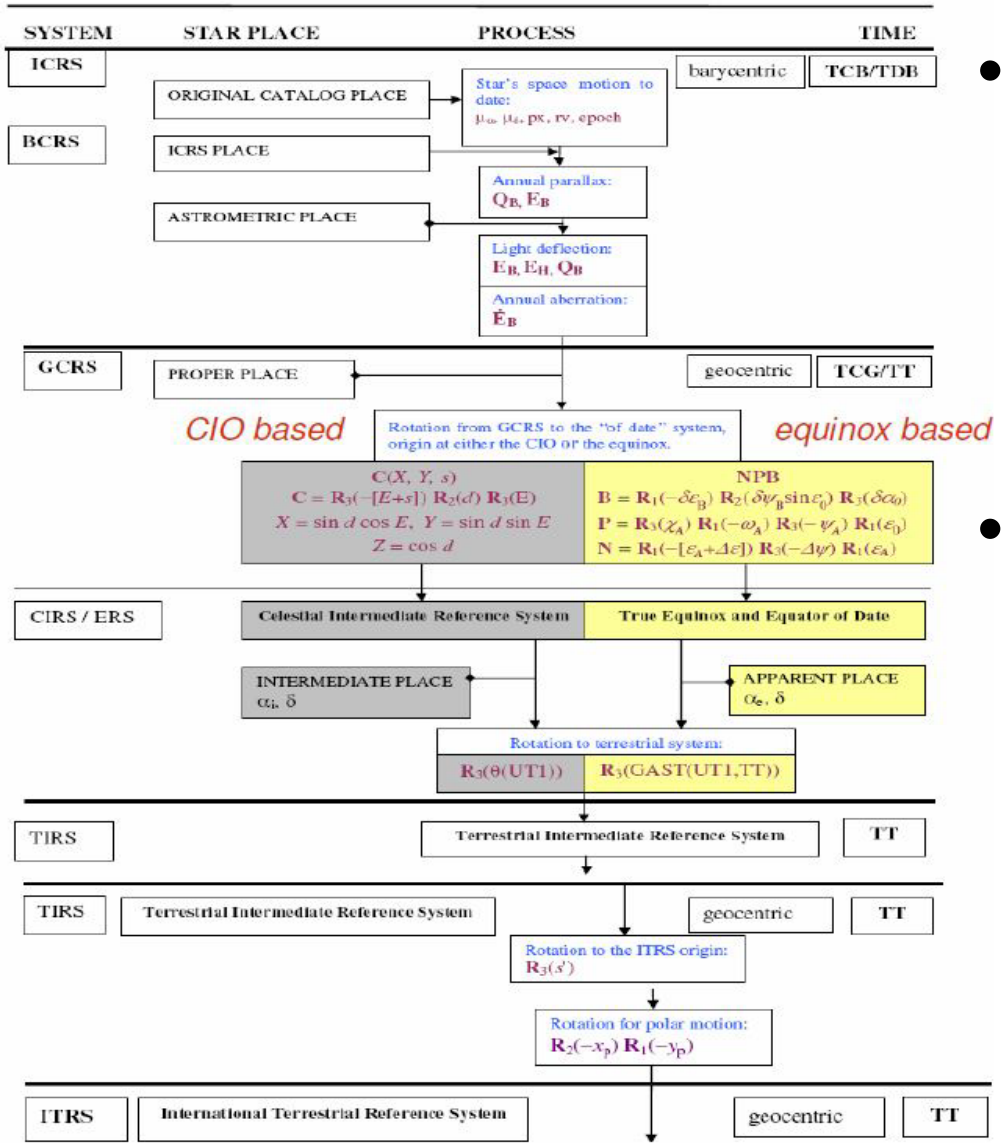
Coverage at 1000 km

SIMULATION



Coverage at 36000 km

SIMULATION



- Celestial Reference Frame, CRF
  - Newtonian inertial
  - Easy to describe the satellite movement.
- Terrestrial reference frames, TRF
  - Ground-based observation
  - Most popular: International Terrestrial Reference Frames, ITRF

SIMULATION

- TRANSFORM FROM [TEME] to [ECEF]:

$$[\text{TEME}] \xrightarrow{\theta_{\text{GMST1982}}} [\text{PEF}] \xrightarrow{[W]=[x_p, y_p]} [\text{ECEF}]$$

  - TEME→PEF

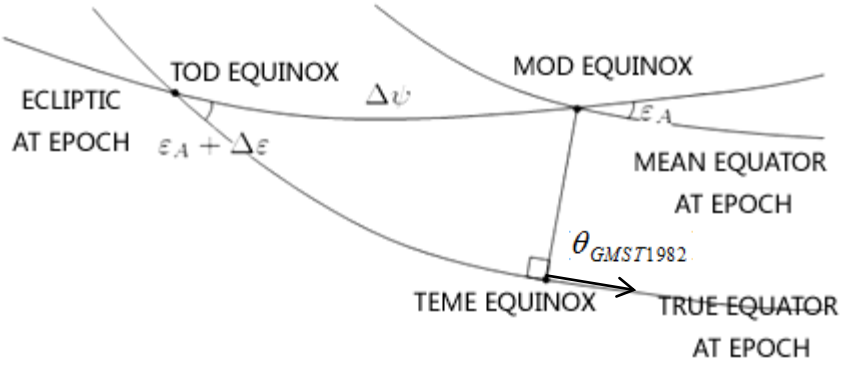
$$r_{[\text{PEF}]} = R_Z(\theta_{\text{GMST1982}}) r_{[\text{TEME}]}$$

$$v_{[\text{PEF}]} = R_Z(\theta_{\text{GMST1982}})(v_{[\text{TEME}]} - \omega_{\oplus} \times r_{[\text{PEF}]})$$

  - PEF→ECEF

$$r_{[\text{ECEF}]} = [W]^T r_{[\text{PEF}]}$$

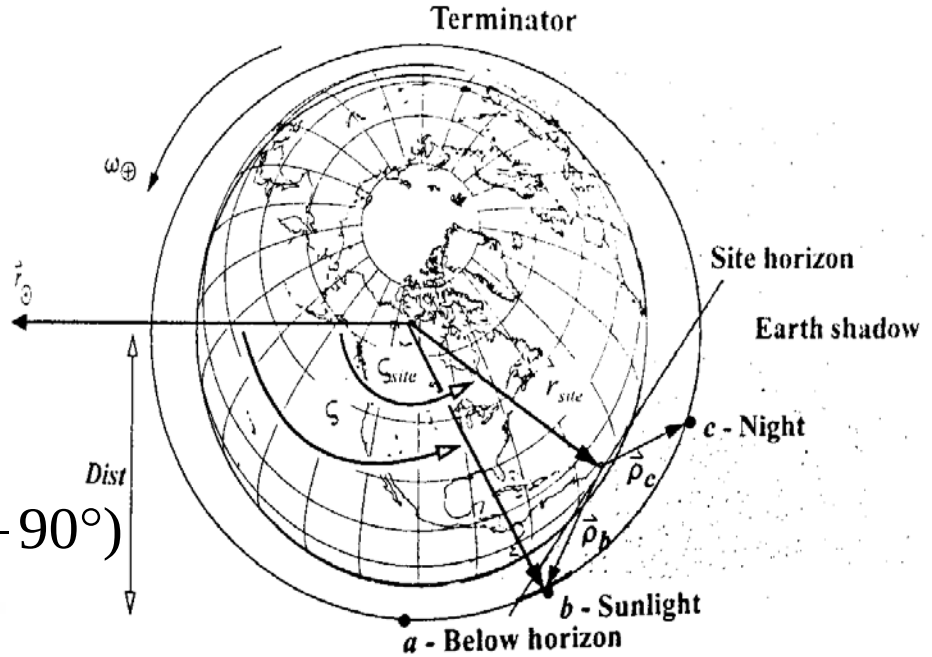
$$v_{[\text{ECEF}]} = [W]^T v_{[\text{PEF}]}$$

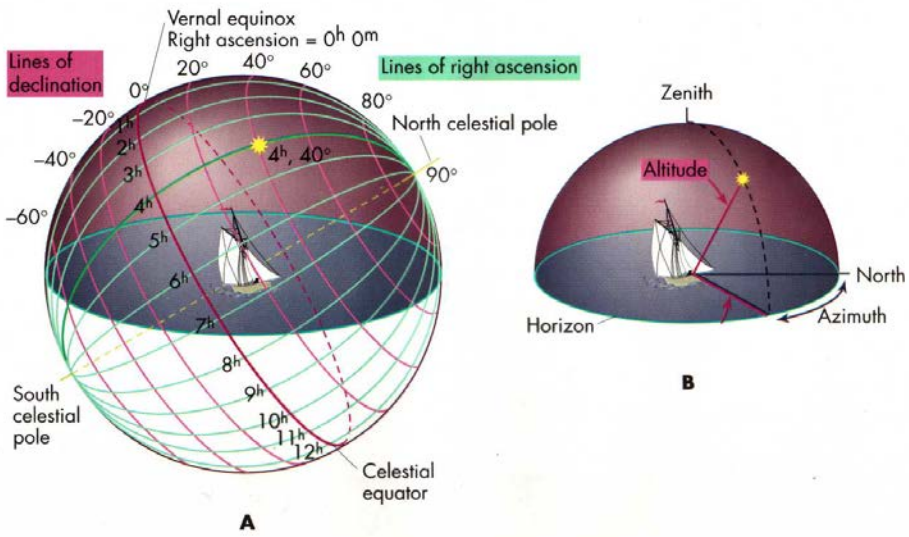


SIMULATION

- CANNOT SEEs:
  - Below the horizon: $\rho_z < 0$
  - Site in daytime:

    $r_{\odot} \cdot r_{\text{Site[ECEF]}} > 0$
  - Ground obstacle: $el > 15°$
- CAN SEE:
  - CHECK: $Dist = | r_{[\text{ECEF}]} | \cos(\zeta - 90°)$





$$Dist > R_{\oplus}$$

SIMULATION

	DAY I （14905 objects）		DAY II （14910 objects）	
	QTY	RATIO	QTY	RATIO
XINGLONG	8302	55.70%	8377	56.18%
WEIHAI	8770	58.84%	8772	58.83%
CHANGCHUN	7726	51.83%	7724	51.80%
URUMQI	7730	51.86%	7815	52.41%
PERU	12422	83.34%	12393	83.12%
PAKISTAN	10239	68.70%	10235	68.65%
INDONESIA	12371	83.00%	12371	82.97%

XINGLONG

	DAY I			DAY II		
	SIM	TOTAL	RATIO	SIM	TOTAL	RATIO
LEO	5981	10740	55.69%	6061	10746	56.40%
MEO	397	696	57.04%	398	696	57.18%
GEO	680	1626	41.82%	688	1624	42.36%

LON：117.5774
LAT：40.3958
ALT：893 m

UNIQUE OBJECT：
- DAY I： 14
- DAY II： 23

WEIHAI

	DAY I			DAY II		
	SIM	TOTAL	RATIO	SIM	TOTAL	RATIO
LEO	6346	10740	59.09%	6369	10746	59.27%
MEO	421	696	60.49%	429	696	61.64%
GEO	703	1626	43.23%	709	1624	43.66%

LON：122.0505
LAT：37.5366
ALT：110 m

UNIQUE OBJECT：
- DAY I： 16
- DAY II： 21

CHANGCHUN

LON：125.3167
LAT：43.7167
ALT：90 m

	DAY I			DAY II		
	SIM	TOTAL	RATIO	SIM	TOTAL	RATIO
LEO	5559	10740	51.76%	5550	10746	51.65%
MEO	361	696	51.87%	373	696	53.59%
GEO	619	1626	38.07%	634	1624	39.04%

UNIQUE OBJECT：
- DAY I： 5
- DAY II： 6

URUMQI

LON：87.6333
LAT：43.7167
ALT：800 m

	DAY I			DAY II		
	SIM	TOTAL	RATIO	SIM	TOTAL	RATIO
LEO	5528	10740	51.47%	5617	10746	52.27%
MEO	392	696	56.32%	365	696	52.44%
GEO	680	1626	41.82%	676	1624	41.63%

UNIQUE OBJECT：
- DAY I： 3
- DAY II： 4

PERU

	DAY I			DAY II		
	SIM	TOTAL	RATIO	SIM	TOTAL	RATIO
LEO	9315	10740	86.73%	9286	10746	86.41%
MEO	571	696	82.04%	574	696	82.47%
GEO	806	1626	49.57%	811	1624	49.94%

LON：-75.32
LAT：-12.03
ALT：3336 m

UNIQUE OBJECT：
- DAY I： 775
- DAY II： 739

巴基斯坦

	DAY I			DAY II		
	SIM	TOTAL	RATIO	SIM	TOTAL	RATIO
LEO	7455	10740	69.41%	7455	10746	69.37%
MEO	478	696	68.68%	503	696	72.27%
GEO	850	1626	52.28%	828	1624	50.99%

LON：66.9
LAT：24.9
ALT：30 m

UNIQUE OBJECT：
- DAY I： 171
- DAY II： 162

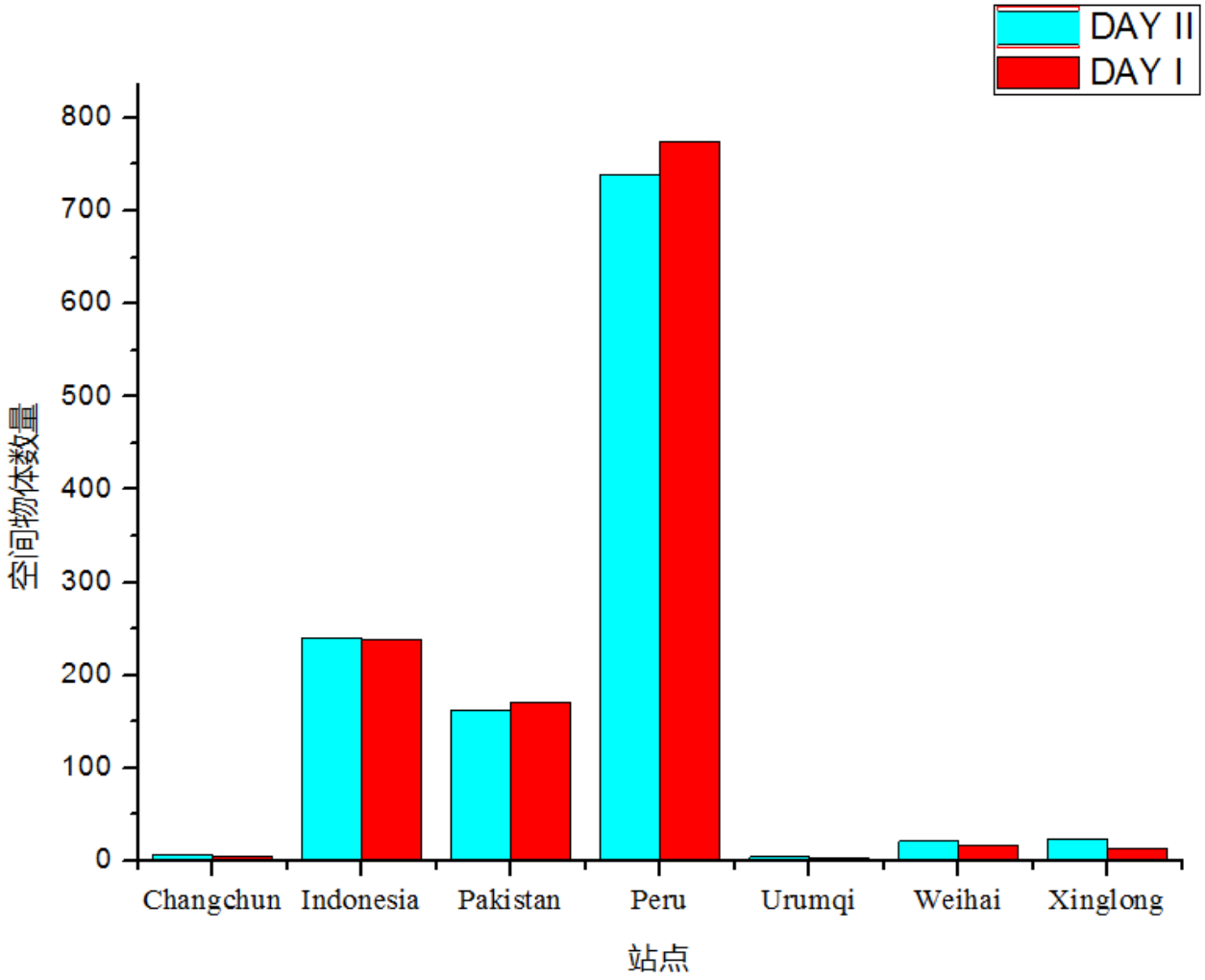
印度尼西亚

LON：107.8462
LAT：-6.9025
ALT：776 m

	DAY I			DAY II		
	SIM	TOTAL	RATIO	SIM	TOTAL	RATIO
LEO	9192	10740	85.59%	9201	10746	85.62%
MEO	583	696	83.76%	570	696	81.90%
GEO	914	1626	56.21%	912	1624	56.16%

UNIQUE OBJECT：
- DAY I： 238
- DAY II： 240

SIMULATION



QUANTITY OF UNIQUE OBJECT

CONCLUSION

- Have the basic capability of:
  - Communicating
  - Task collecting
  - plan making/publishing
- ONLY China have certain observation capability.
  - Some member states upgrade/improved existing facilities, looking forward in the future.
  - Most member states need to build new facilities to meet the requirements.
- 2nd pilot observation will be taken in December.
- SUPPORTS NEEDED: financial especially.


THANKS FOR ATTENTION