The background of the slide features a large, dark planet with a prominent, bright white ring around its middle. In the lower-left foreground, a smaller, dark sphere, resembling a moon or a celestial body, is visible. The overall composition has a futuristic, space-themed feel.

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



Bangladesh
<http://www.sparso.gov.bd/>



China
<http://www.miit.gov.cn/n11293472/index.html>



Iran
<http://www.isa.ir/index.php>



Mongolia
<http://www.ictpa.gov.mn/>



Pakistan
<http://www.suparco.gov.pk/>



Peru
<http://www.conida.gob.pe/>



Thailand
<http://www.mict.go.th/main.php?filename=index>



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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

Prediction

TLE Data File Results:

C:\Tle\Trivisual.txt

Station: Weihai China

Time range of prediction
from: 2012-05-09 02:00 to: 2012-05-10 04:00

List of interest satellite Total: 37

| | | | | | | | | |
|------------------|------------------|-------------------|-------------------|-------------------|--------------------|-------------------|------------------------------|-------------------|
| 1 09009 PALAPA 1 | 2 09862 PALAPA 2 | 3 14134 PALAPA B1 | 4 21964 PALAPA B4 | 5 22931 THAICOM 1 | 6 23200 TURKSAT 1B | 7 23314 THAICOM 2 | 8 23779 PAKSAT 1(ANATOLIA 1) | 9 23864 PALAPA C2 |
|------------------|------------------|-------------------|-------------------|-------------------|--------------------|-------------------|------------------------------|-------------------|

Type of Prediction All Satellite Single Satellite

| DATE | SAT NUM | BEGIN TIME | END TIME | ALTITUDE | SAT NAME |
|----------|---------|------------|----------|----------|-----------------------|
| 2012 5 9 | 09009 | 200 | 1304 | 44 | PALAPA 1 |
| 2012 5 9 | 33468 | 200 | 414 | 67 | COSMOS 2448 (GLONASS) |
| 2012 5 9 | 37948 | 200 | 1411 | 78 | BEIDOU IGSO 5 |
| 2012 5 9 | 37949 | 200 | 1317 | 78 | PAKSAT |
| 2012 5 9 | 38046 | 219 | 223 | 40 | ZY 3 |
| 2012 5 9 | 37820 | 235 | 238 | 27 | TIANGONG 1 |
| 2012 5 9 | 37821 | 235 | 239 | 29 | TMSP 76 |
| 2012 5 9 | 38038 | 323 | 330 | 40 | ZY 1 |
| 2012 5 9 | 37791 | 381 | 395 | 26 | RASAT |
| 2012 5 9 | 37822 | 412 | 414 | 14 | TIANGONG 1 |
| 2012 5 9 | 35835 | 454 | 501 | 63 | ITUPSAT 1 |
| 2012 5 9 | 25396 | 802 | 819 | 81 | TMSP 1 |
| 2012 5 9 | 27003 | 928 | 929 | 100 | HAYANG 2A |
| 2012 5 9 | 27003 | 923 | 930 | 27 | BADR 8 |
| 2012 5 9 | 37781 | 1000 | 1059 | 48 | HAYANG 2A |
| 2012 5 9 | 37781 | 1041 | 1059 | 48 | HAYANG 2B |
| 2012 5 9 | 27003 | 1106 | 1114 | 42 | BADR 8 |
| 2012 5 9 | 29709 | 1127 | 1133 | 52 | LAPAN-TUBSAT |
| 2012 5 9 | 27843 | 1181 | 1187 | 48 | BILSAT 1 |
| 2012 5 9 | 27843 | 1244 | 1248 | 48 | BILSAT 1 |
| 2012 5 9 | 38038 | 1301 | 1304 | 25 | ZY 1 |
| 2012 5 9 | 33398 | 1316 | 1321 | 73 | THS 06 |
| 2012 5 9 | 37948 | 1423 | 1423 | 47 | TMSP 76 |
| 2012 5 9 | 25396 | 2020 | 2028 | 47 | TMSP 1 |
| 2012 5 9 | 27003 | 2107 | 2116 | 61 | BADR 8 |
| 2012 5 9 | 37820 | 2203 | 2211 | 20 | PAKSAT |
| 2012 5 9 | 37820 | 2211 | 2213 | 23 | TIANGONG 1 |
| 2012 5 9 | 27943 | 2232 | 2239 | 60 | BILSAT 1 |
| 2012 5 9 | 37781 | 2241 | 2250 | 64 | HAYANG 2A |



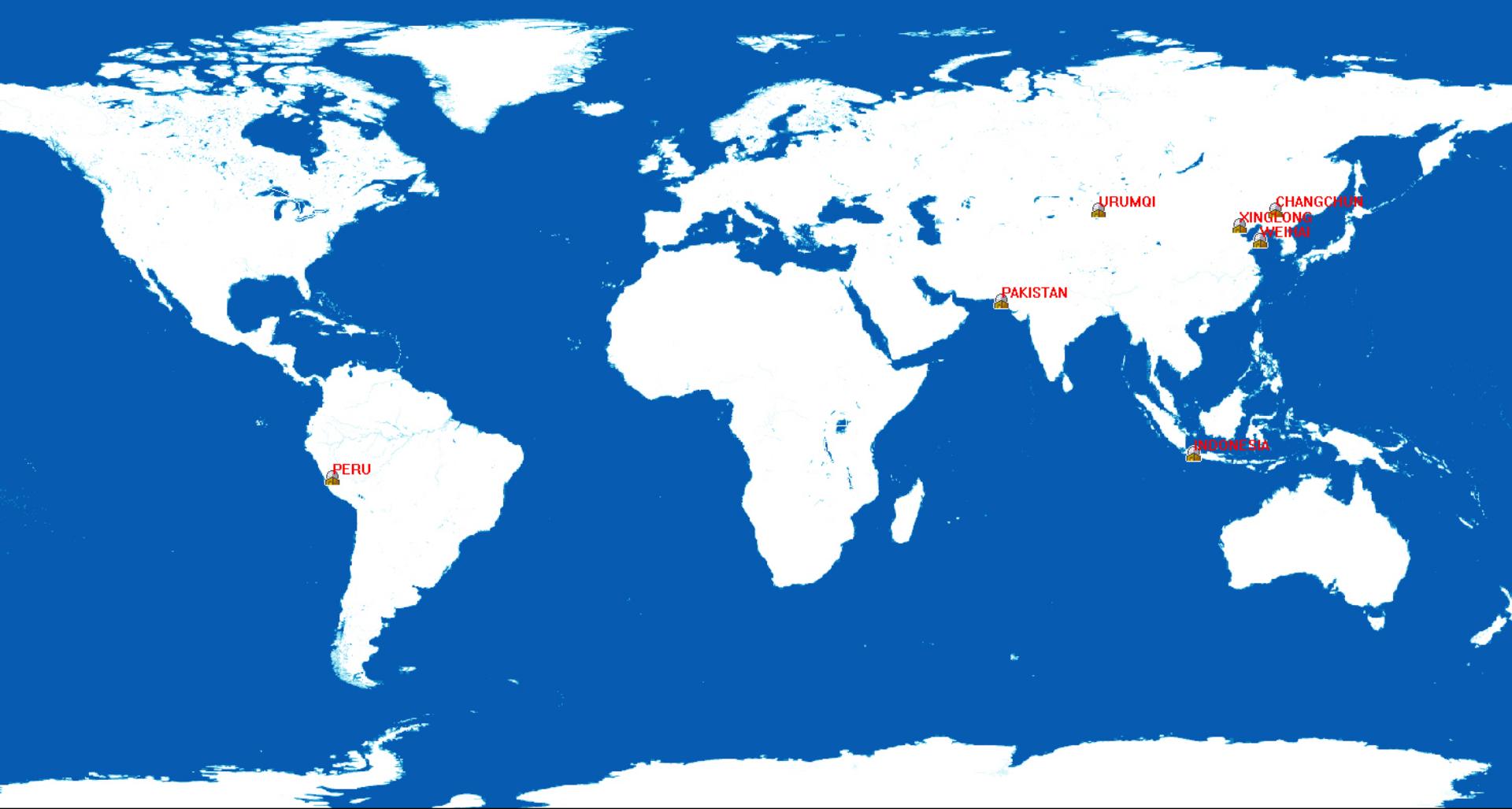
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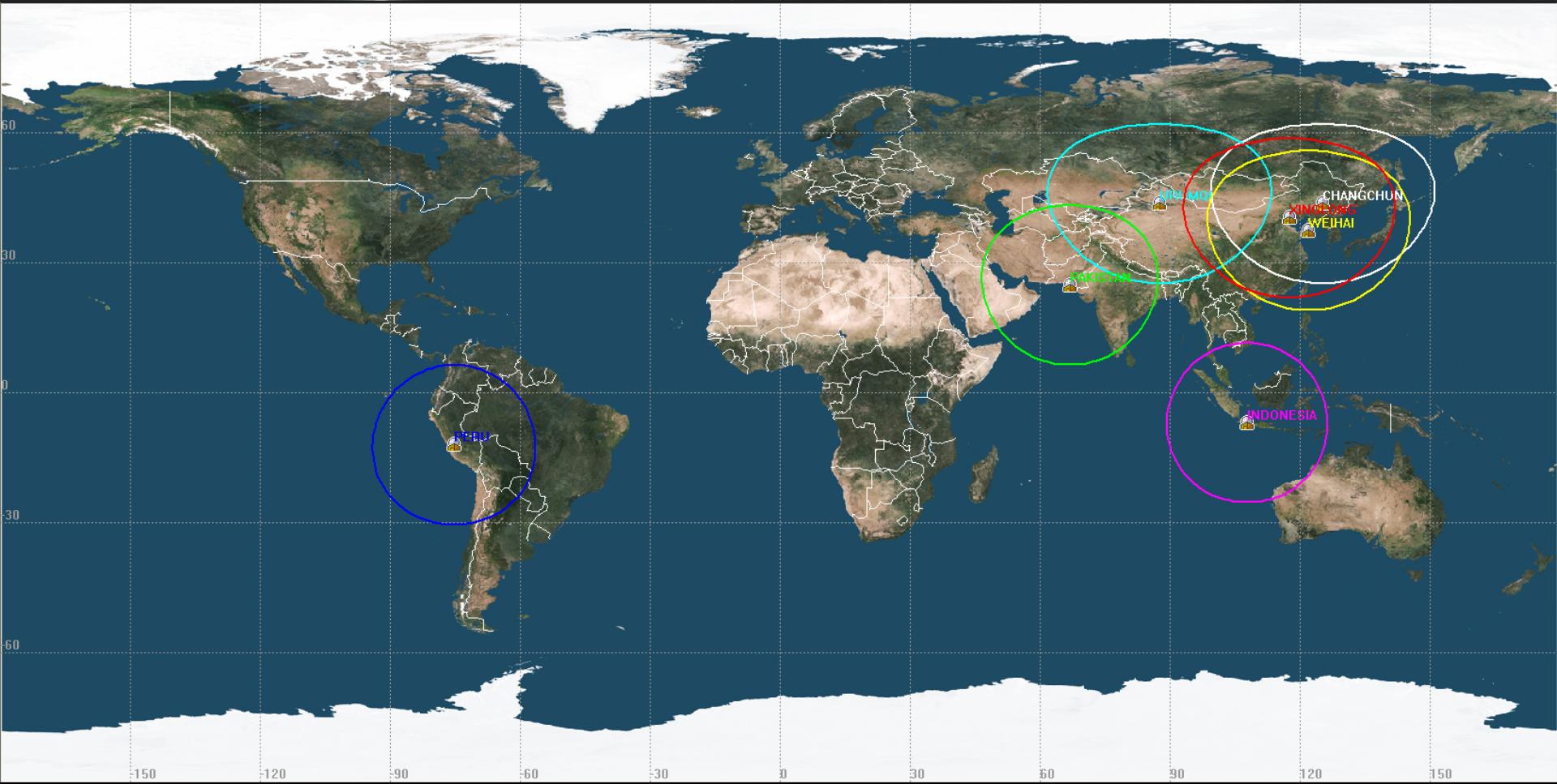
SIMULATION

- 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

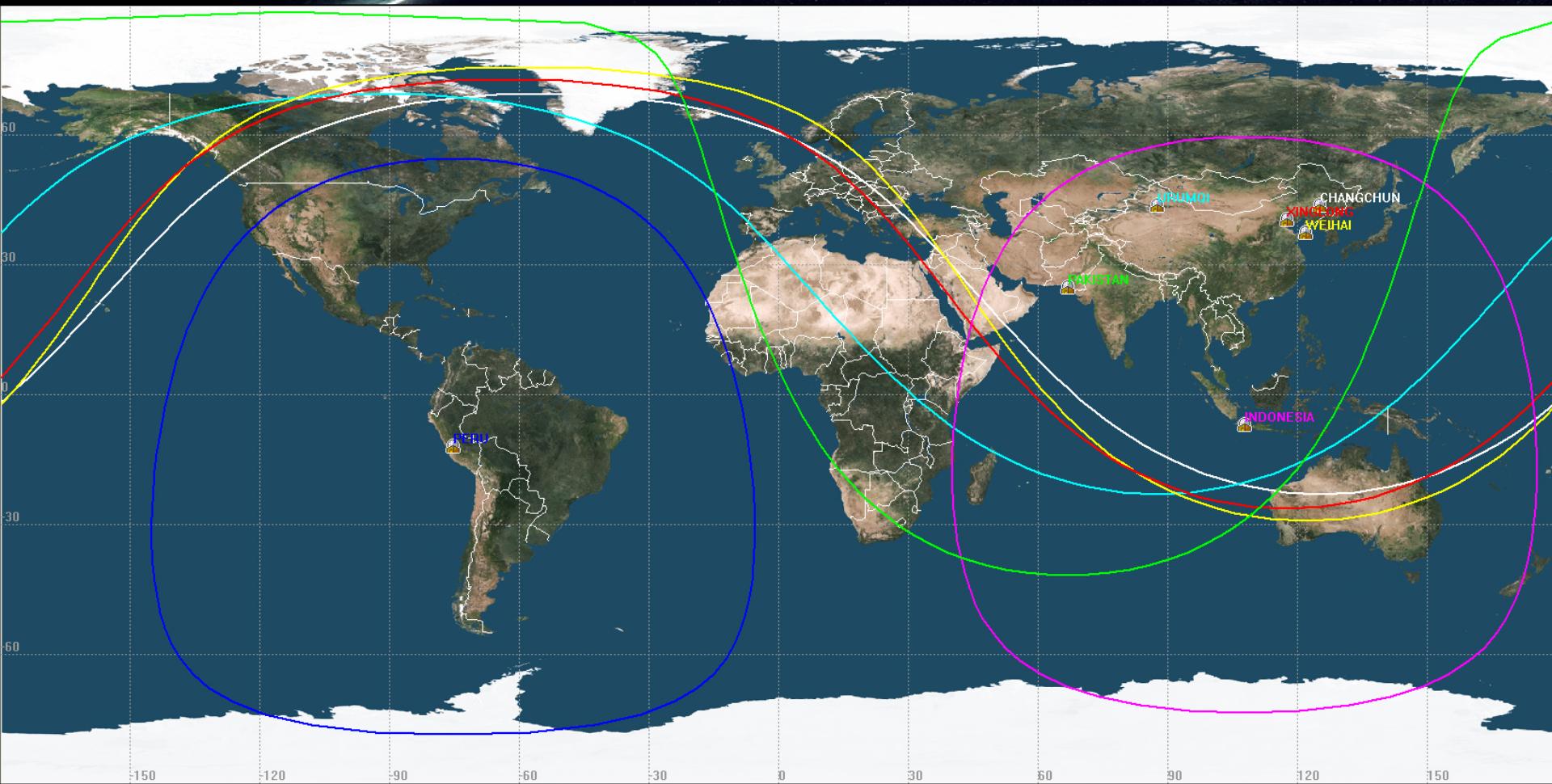


SIMULATION

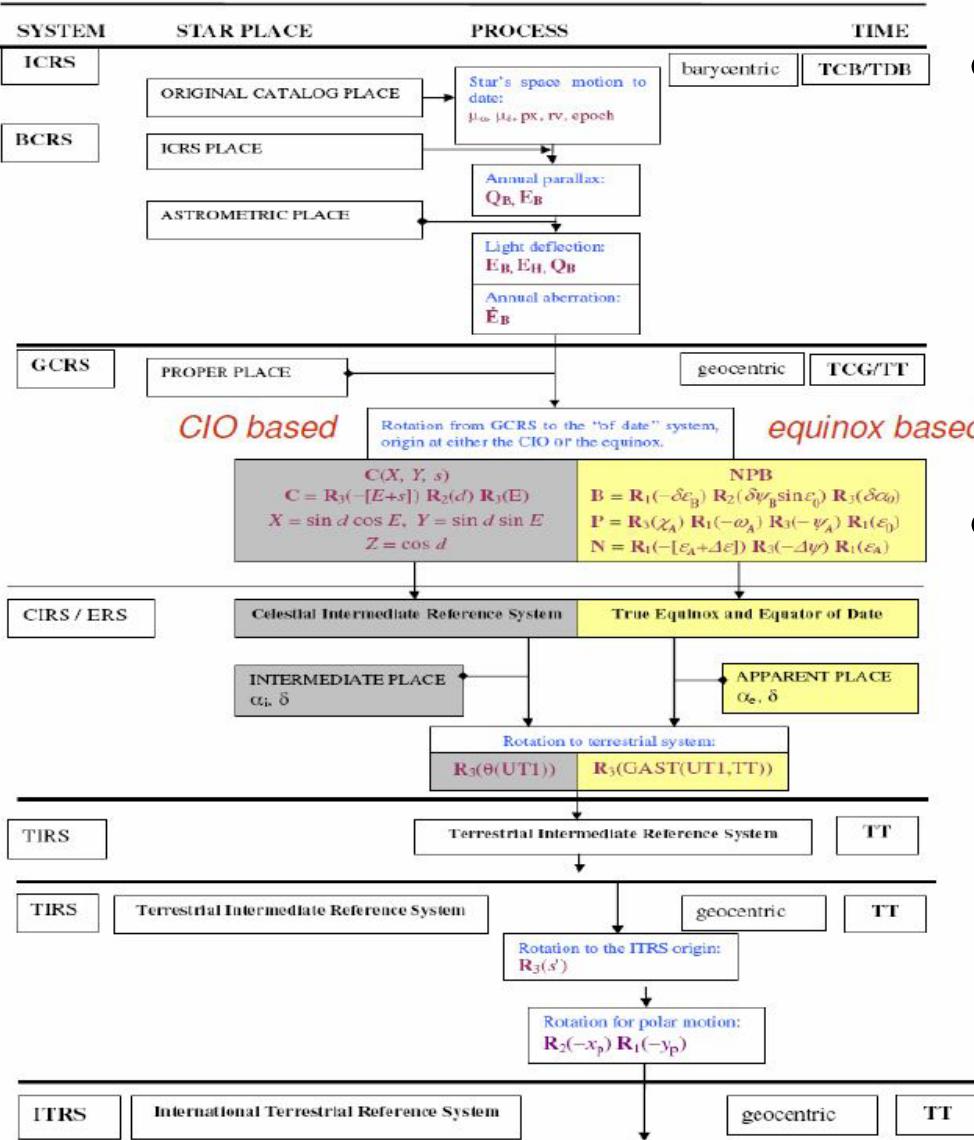


Coverage at 1000 km

SIMULATION



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

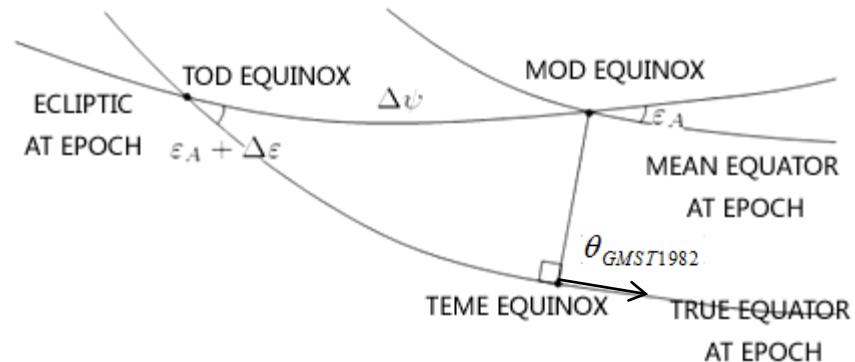
$$\mathbf{r}_{[\text{PEF}]} = R_z(\theta_{\text{GMST1982}}) \mathbf{r}_{[\text{TEME}]}$$

$$\mathbf{v}_{[\text{PEF}]} = R_z(\theta_{\text{GMST1982}})(\mathbf{v}_{[\text{TEME}]} - \boldsymbol{\omega}_\oplus \times \mathbf{r}_{[\text{PEF}]})$$

- PEF → ECEF

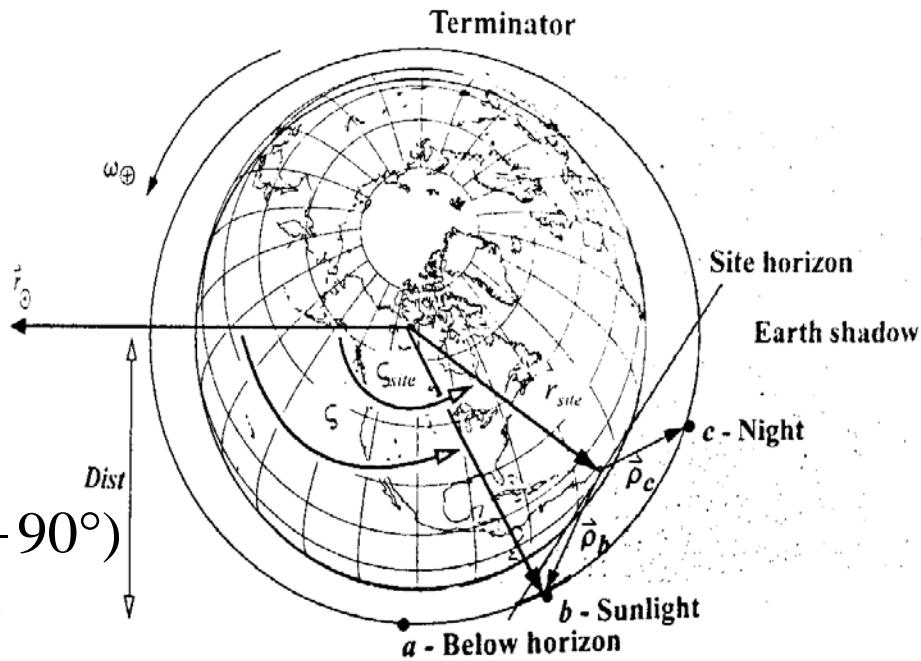
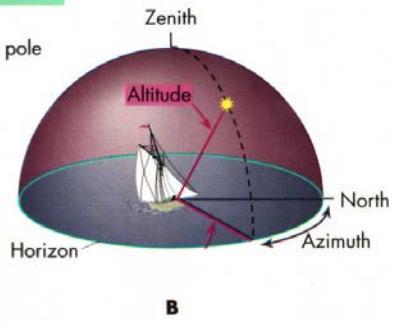
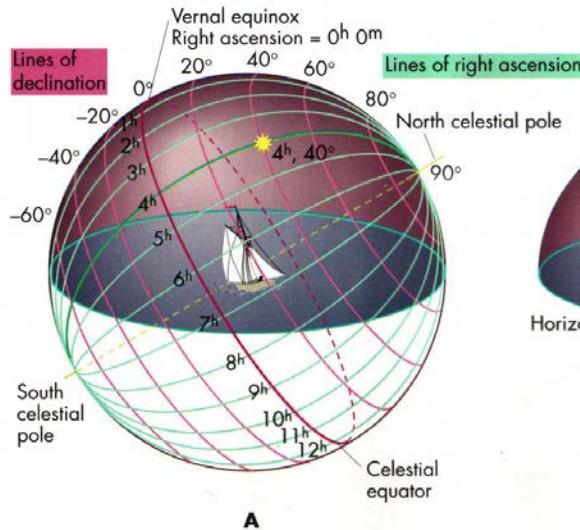
$$\mathbf{r}_{[\text{ECEF}]} = [W]^T \mathbf{r}_{[\text{PEF}]}$$

$$\mathbf{v}_{[\text{ECEF}]} = [W]^T \mathbf{v}_{[\text{PEF}]}$$



SIMULATION

- CANNOT SEEs:
 - Below the horizon: $\rho_z < 0$
 - Site in daytime: $r_{\square} \cdot r_{\text{Site[ECEF]}} > 0$
 - Ground obstacle: $el > 15^\circ$
- CAN SEE:
 - CHECK: $Dist = |r_{[\text{ECEF}]}| \cos(\zeta - 90^\circ)$



$$Dist > R_{\oplus}$$

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



LON: 117.5774
LAT: 40.3958
ALT: 893 m



| | 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% |

UNIQUE OBJECT:

- DAY I: 14
- DAY II: 23



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WEIHAI



LON: 122.0505
LAT: 37.5366
ALT: 110 m

| | 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% |

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



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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



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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



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PERU



LON: -75.32

LAT: -12.03

ALT: 3336 m

| | 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% |

UNIQUE OBJECT :

- DAY I: 775
- DAY II: 739



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巴基斯坦



LON: 66.9

LAT: 24.9

ALT: 30 m

| | 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% |

UNIQUE OBJECT :

- DAY I: 171
- DAY II: 162



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印度尼西亚

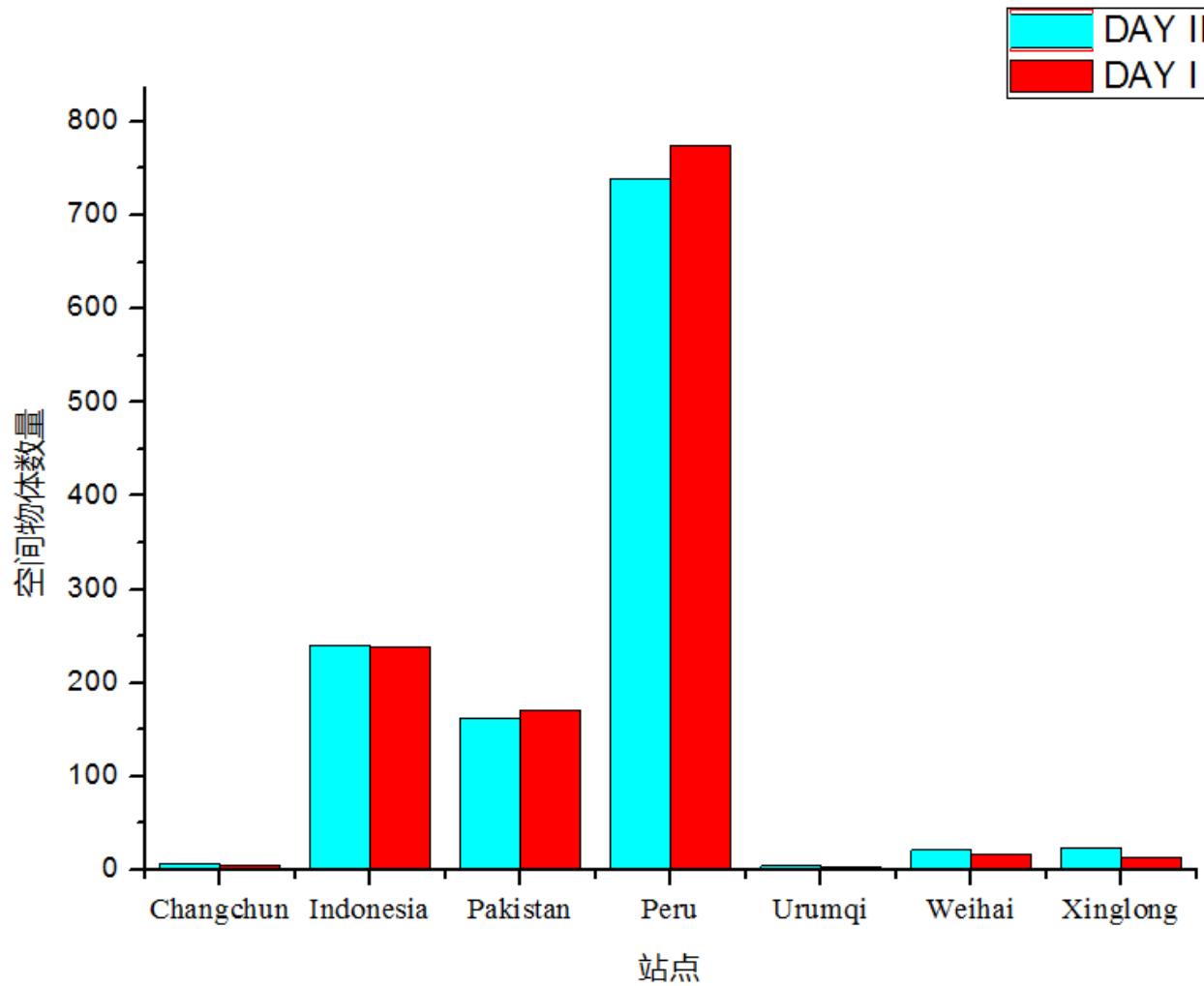


LON: 107.8462
LAT: -6.9025
ALT: 776 m

| | 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