OUTLINES

• 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 2\textsuperscript{nd} 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

<table>
<thead>
<tr>
<th>MAGNITUDE LIMIT</th>
<th>11.5 mag (LEO); 16 mag (HEO、GEO)</th>
</tr>
</thead>
<tbody>
<tr>
<td>SIZE</td>
<td>10cm（1000km）； 20cm（2000km）</td>
</tr>
<tr>
<td>ACCURACY</td>
<td>3″</td>
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</table>
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.
<table>
<thead>
<tr>
<th>Index</th>
<th>Country</th>
<th>Address</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Bangladesh</td>
<td>Longitude: 90.5°E; Latitude: 23.5°; Altitude:</td>
</tr>
<tr>
<td>2</td>
<td>China</td>
<td>Longitude: 122°03’02”E; Latitude: 37°32’12”N; Altitude: 110m</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Longitude: 117°34’38.85”E; Latitude: 40°23’45.12”N; Altitude: 893m</td>
</tr>
<tr>
<td>3</td>
<td>Indonesia</td>
<td>Longitude:107°50’46.4”E; Latitude: 6°54’09.1”S; Altitude: 776m</td>
</tr>
<tr>
<td>4</td>
<td>Iran</td>
<td>Longitude: 46°19' 54&quot;N; Latitude: 37°52' 09&quot;E; Altitude: 2503 m</td>
</tr>
<tr>
<td>5</td>
<td>Mongolia</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Pakistan</td>
<td>Longitude: 67°01’E; Latitude: 24°25’N; Altitude: 210m</td>
</tr>
<tr>
<td>7</td>
<td>Peru</td>
<td>Longitude: 75.32°W; Latitude: -12.03°; Altitude: 3336m</td>
</tr>
<tr>
<td>8</td>
<td>Thailand</td>
<td>Longitude:98°55’29.9” E; Latitude: 18°47’19.5” N; Altitude: 789 m</td>
</tr>
<tr>
<td>9</td>
<td>Turkey</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Tajikistan</td>
<td></td>
</tr>
</tbody>
</table>
• **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.
• 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

Coverage at 1000 km
SIMULATION

Coverage at 36000 km
• 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
TRANSFORM FROM [TEME] to [ECEF]:

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

- TEME \rightarrow PEF

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

- PEF \rightarrow ECEF

\[ r_{[ECEF]} = [W]^T r_{[PEF]} \]
\[ \nu_{[ECEF]} = [W]^T \nu_{[PEF]} \]
SIMULATION

- CANNOT SEEs:
  - Below the horizon: \( \rho_z < 0 \)
  - Site in daytime:
    \[ r \cdot r_{\text{Site[ECEF]}} > 0 \]
  - Ground obstacle: \( el > 15^\circ \)

- CAN SEE:
  - CHECK: \( Dist = |r_{\text{[ECEF]}}| \cos(\zeta - 90^\circ) \)

\[ Dist > R_\oplus \]
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<thead>
<tr>
<th></th>
<th>DAY I (14905 objects)</th>
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<th>DAY II (14910 objects)</th>
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<tr>
<td></td>
<td>QTY</td>
<td>RATIO</td>
<td>QTY</td>
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<tr>
<td>XINGLONG</td>
<td>8302</td>
<td>55.70%</td>
<td>8377</td>
</tr>
<tr>
<td>WEIHAI</td>
<td>8770</td>
<td>58.84%</td>
<td>8772</td>
</tr>
<tr>
<td>CHANGCHUN</td>
<td>7726</td>
<td>51.83%</td>
<td>7724</td>
</tr>
<tr>
<td>URUMQI</td>
<td>7730</td>
<td>51.86%</td>
<td>7815</td>
</tr>
<tr>
<td>PERU</td>
<td>12422</td>
<td>83.34%</td>
<td>12393</td>
</tr>
<tr>
<td>PAKISTAN</td>
<td>10239</td>
<td>68.70%</td>
<td>10235</td>
</tr>
<tr>
<td>INDONESIA</td>
<td>12371</td>
<td>83.00%</td>
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</table>
XINGLONG

LON: 117.5774
LAT: 40.3958
ALT: 893 m

<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td></td>
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<td>RATIO</td>
<td>SIM</td>
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<td>LEO</td>
<td>5981</td>
<td>10740</td>
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<td>6061</td>
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<td>MEO</td>
<td>397</td>
<td>696</td>
<td>57.04%</td>
<td>398</td>
<td>696</td>
<td>57.18%</td>
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<tr>
<td>GEO</td>
<td>680</td>
<td>1626</td>
<td>41.82%</td>
<td>688</td>
<td>1624</td>
<td>42.36%</td>
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UNIQUE OBJECT:
• DAY I: 14
• DAY II: 23
WEIHAI

LON: 122.0505
LAT: 37.5366
ALT: 110 m

LEO

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<td>RATIO</td>
<td>SIM</td>
<td>TOTAL</td>
</tr>
<tr>
<td>LEO</td>
<td>6346</td>
<td>10740</td>
<td>59.09%</td>
<td>6369</td>
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<tr>
<td>MEO</td>
<td>421</td>
<td>696</td>
<td>60.49%</td>
<td>429</td>
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<tr>
<td>GEO</td>
<td>703</td>
<td>1626</td>
<td>43.23%</td>
<td>709</td>
</tr>
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</table>

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

LON: 125.3167
LAT: 43.7167
ALT: 90 m

UNIQUE OBJECT:
• DAY I: 5
• DAY II: 6

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<td>SIM</td>
<td>TOTAL</td>
<td>RATIO</td>
<td>SIM</td>
</tr>
<tr>
<td>LEO</td>
<td>5559</td>
<td>10740</td>
<td>51.76%</td>
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<tr>
<td>MEO</td>
<td>361</td>
<td>696</td>
<td>51.87%</td>
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<tr>
<td>GEO</td>
<td>619</td>
<td>1626</td>
<td>38.07%</td>
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URUMQI

LON: 87.6333
LAT: 43.7167
ALT: 800 m

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<td>SIM</td>
</tr>
<tr>
<td>LEO</td>
<td>5528</td>
<td>10740</td>
<td>51.47%</td>
<td>5617</td>
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<tr>
<td>MEO</td>
<td>392</td>
<td>696</td>
<td>56.32%</td>
<td>365</td>
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<td>GEO</td>
<td>680</td>
<td>1626</td>
<td>41.82%</td>
<td>676</td>
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UNIQUE OBJECT:
• DAY I: 3
• DAY II: 4
**PERU**

- **LON**: -75.32
- **LAT**: -12.03
- **ALT**: 3336 m

### Table:

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<tr>
<th></th>
<th>DAY I</th>
<th></th>
<th>RATIO</th>
<th>DAY II</th>
<th></th>
<th>RATIO</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>SIM</td>
<td>TOTAL</td>
<td></td>
<td>SIM</td>
<td>TOTAL</td>
<td></td>
</tr>
<tr>
<td>LEO</td>
<td>9315</td>
<td>10740</td>
<td>86.73 %</td>
<td>9286</td>
<td>10746</td>
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<tr>
<td>MEO</td>
<td>571</td>
<td>696</td>
<td>82.04 %</td>
<td>574</td>
<td>696</td>
<td>82.47 %</td>
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<tr>
<td>GEO</td>
<td>806</td>
<td>1626</td>
<td>49.57 %</td>
<td>811</td>
<td>1624</td>
<td>49.94 %</td>
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</table>

**UNIQUE OBJECT**:
- **DAY I**: 775
- **DAY II**: 739
LON: 66.9
LAT: 24.9
ALT: 30 m

<table>
<thead>
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<th>DAY I</th>
<th>DAY II</th>
</tr>
</thead>
<tbody>
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</tr>
<tr>
<td>LEO</td>
<td>7455</td>
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<tr>
<td>MEO</td>
<td>478</td>
<td>696</td>
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<tr>
<td>GEO</td>
<td>850</td>
<td>1626</td>
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</table>

UNIQUE OBJECT:
• DAY I: 171
• DAY II: 162
**UNIQUE OBJECT:**
- **DAY I:** 238
- **DAY II:** 240

**Location:**
- **LON:** 107.8462
- **LAT:** -6.9025
- **ALT:** 776 m

<table>
<thead>
<tr>
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<th>DAY I</th>
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<th>DAY II</th>
</tr>
</thead>
<tbody>
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<td>RATIO</td>
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<td>9192</td>
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<tr>
<td>GEO</td>
<td>914</td>
<td>1626</td>
<td>56.21%</td>
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SIMULATION

QUANTITY OF UNIQUE OBJECT

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<th>站点</th>
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<tr>
<td>Changchun</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Indonesia</td>
<td>200</td>
<td>200</td>
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<tr>
<td>Pakistan</td>
<td>100</td>
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<tr>
<td>Peru</td>
<td>800</td>
<td>800</td>
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<tr>
<td>Urumqi</td>
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<td>0</td>
</tr>
<tr>
<td>Weihai</td>
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<td>0</td>
</tr>
<tr>
<td>Xinglong</td>
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</tbody>
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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