Engineering Requirements & Industrial Opportunities

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CTA Observatory

- Sites
  - Infrastructure
  - Buildings
  - Telescopes
    - Mechanics
  - Optics
  - Cameras

- Off-site facilities
  - Headquarters
  - Datacenter
Some general numbers

- Two sites, one per hemisphere
- ~120 telescopes (+SCT)
  - 8 LST (23m), 40 MST (12m), 70 SST (4m)
- >8000 m² mirrors in >7k facets
- >200k electronic channels
- Long term operation (~30yr)
Sites Infrastructure

- Two sites, physics case dominated
  - CTA North: ~20 telescopes
  - CTA South: ~100 telescopes
- Variety of environment conditions:
  - ~2 km above sea level, sometimes remote locations
  - Extreme temperatures
  - Rain, floods, snow, hail, ice, lightning
  - Up to 200km/h wind gusts, earthquakes
- Construction and operation managed by central entity
- Existing study on generic infrastructures for sites
Industrial involvement - INFRA

- Civil engineering
- Geotechnical studies
- Landscaping (7 km²)
- Roads (12 km + 17 km)
- Ducts & Trenches (50 km)
- Foundations
- Water, sewers, rain, flood
Industrial involvement - INFRA

- Buildings (same for each site)
  - Operations (~850m²)
  - Technical (~2000m²)
  - Residential (~880m²)
- Power distribution (1.3MW sustained for all)
  - Aux. generators, transformers
- Optical fibers for data, timing, trigger
Telescopes - xST

- Alt-azimuth mounts
  - Not as demanding as conventional optical telescopes
- Quite demanding environmental conditions
  - No dome (except shelters for SSTs, maybe)
- Serial production & installation in 3-4 years period
- Reliable: 95-97% uptime
- 30 years life cycle structures, with modest maintenance

Different approaches:
- Few LST, design driven by performance
- Many MST / SST, design driven by cost effectiveness
- Existing detailed designs / prototypes
- In kind contributions from CTA institutions/countries
## Telescope Properties

<table>
<thead>
<tr>
<th></th>
<th>LST</th>
<th>MST</th>
<th>SCT</th>
<th>SST-1M</th>
<th>SST-2M ASTRI</th>
<th>SST-2M GATE</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Optical properties</strong></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Effective collecting area</td>
<td>370 m²</td>
<td>92 m²</td>
<td>47 m²</td>
<td>6.6m²</td>
<td>~6m²</td>
<td>~8m²</td>
</tr>
<tr>
<td>Focal length</td>
<td>28 m</td>
<td>16 m</td>
<td>5.6m</td>
<td>5.6m</td>
<td>2.2m</td>
<td>2.3m</td>
</tr>
<tr>
<td>Aperture</td>
<td>23 m</td>
<td>12 m</td>
<td>9.7m</td>
<td>4m</td>
<td>4.3 m</td>
<td>4m</td>
</tr>
<tr>
<td>f/#</td>
<td>1.2</td>
<td>1.3</td>
<td>0.6</td>
<td>1.4</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>FoV</td>
<td>4.5°</td>
<td>7°</td>
<td>0.6</td>
<td>1.4</td>
<td>0.5</td>
<td>0.6</td>
</tr>
<tr>
<td>PSF (@ 80% of the FoV diameter) (*)(for LST @ 1.2° from FoV center)</td>
<td>~0.11°(*)</td>
<td>&lt; 0.18°</td>
<td>&lt; 0.075°</td>
<td>0.21°</td>
<td>0.17°</td>
<td>0.12°</td>
</tr>
<tr>
<td>Pixel angular size</td>
<td>0.1°</td>
<td>0.18°</td>
<td>0.067°</td>
<td>0.24°</td>
<td>0.17°</td>
<td>0.16°</td>
</tr>
<tr>
<td><strong>Tracking and pointing properties</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Drive encoder precision</td>
<td>20”</td>
<td>10”</td>
<td>7-10”</td>
<td>5”</td>
<td>2”</td>
<td>2”</td>
</tr>
<tr>
<td>Tracking precision</td>
<td>&lt; 0.1”</td>
<td>&lt; 0.1”</td>
<td>0.03°</td>
<td>0.08°</td>
<td>&lt;0.1”</td>
<td>0.08°</td>
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<tr>
<td>Pointing precision after calibration</td>
<td>&lt;14”</td>
<td>El. 5”, Az. (5/sin(El.))”</td>
<td>&lt;10”</td>
<td>&lt; 7”</td>
<td>&lt; 7”</td>
<td>&lt; 7”</td>
</tr>
<tr>
<td><strong>Mechanical properties: dimensions</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height of telescope pointing horizontally</td>
<td>30 m</td>
<td>16 m</td>
<td>11 m</td>
<td>5 m</td>
<td>7 m</td>
<td>~5 m</td>
</tr>
<tr>
<td>Height of telescope pointing vertically</td>
<td>45 m</td>
<td>29 m</td>
<td>15 m</td>
<td>10 m</td>
<td>8 m</td>
<td>~7 m</td>
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<tr>
<td>Dish Diameter</td>
<td>25 m</td>
<td>14 m</td>
<td>10 m</td>
<td>4 m</td>
<td>4 m</td>
<td>4 m</td>
</tr>
<tr>
<td>Total Width of telescope</td>
<td>28 m</td>
<td>14 m</td>
<td>10 m</td>
<td>4 m</td>
<td>4 m</td>
<td>4 m</td>
</tr>
<tr>
<td>Outer maximum dimension of foundation</td>
<td>26 m</td>
<td>7 m</td>
<td>7 m</td>
<td>2 m</td>
<td>4 m</td>
<td>2.5 m</td>
</tr>
<tr>
<td>Radius of free area for Az. movement</td>
<td>30 m</td>
<td>21 m</td>
<td>10 m</td>
<td>8 m</td>
<td>6 m</td>
<td>5 m</td>
</tr>
<tr>
<td>Camera dimensions lateral × depth</td>
<td>~2.9 m × ~1.2 m</td>
<td>2.8 m × ~1.8 m</td>
<td>~1.2 m × ~1 m</td>
<td>~0.9 m × ~1 m</td>
<td>0.5 m × ~0.5 m</td>
<td>~0.5 m × ~0.5 m</td>
</tr>
<tr>
<td><strong>Mechanical properties: weights</strong></td>
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<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total weight</td>
<td>76.7 t</td>
<td>69 t</td>
<td>41 t</td>
<td>9 t</td>
<td>23 t</td>
<td>8 t</td>
</tr>
<tr>
<td>Dish Structure with counterweight</td>
<td>32 t</td>
<td>46 t</td>
<td>20 t</td>
<td>6 t</td>
<td>11 t</td>
<td>4.5 t</td>
</tr>
<tr>
<td>Camera Weight</td>
<td>~2 t</td>
<td>~2 t</td>
<td>&lt; 0.7 t</td>
<td>0.3 t</td>
<td>0.04 t</td>
<td>~ 0.04 t</td>
</tr>
</tbody>
</table>
Large Sized Telescope Mechanics

- Prototype is also the first telescope
- Space frame based structure
  - Steel, aluminum, CFRP struts
  - Glued, embedded end-pieces
- Arch / camera frame in CFRP
- Industrial partners for analysis
  - Load capability, performance
- Safety elements (stairs, catwalks)
- Condition monitoring (strain, vibration analysis)
Medium/Small sized telescopes

- Prototypes already existing / being completed
  - Davies-Cotton (single mirror)
    - Light concentrators in cameras
  - Schwarzschild-Couder (dual mirror)
    - Optical alignment more critical, stiffness
- More conventional materials/techniques
  - Mainly steel
<0.1° Tracking precision
- Mechanical corrections on drive
- 20-90 seconds repositioning
- Structure specific, similar elements
  - Rack & pinion, worm gears
  - Bearings, planetary gears, servos & controllers, encoders, limit switches
- Actuators for stow pins
- ~15k Mirror actuators total
Electrical engineering

- Cabling, chains, trays
- Electrical cabinets
  - Surge, shorts protections
  - Environment control
- Energy storage systems
  - Flywheels, batteries
  - Emergency stop
  - Peak power (~180kW in LST)
Integration and Control

- Many subsystems on each telescope
  - Drive, camera, mirrors, calibration devices...
  - Sub-arrays, targets of opportunity
- A few operators (1!) to control ~100 telescopes
  - High automation, safety
- OPC/UA for process control
- ACS as high level SW framework
Final words

- Wide range of industrial opportunities in CTA
  - Engineering (geotechnical, analysis)
  - Provider of standard parts
  - Manufacturing of mechanical parts
  - Contractors for site construction
  - Logistics - shipment
  - Integration
- Calls for tender should start soon
  - Work for site Q3 2014
  - Telescope installation Q3 2016
- Future workshops & CTA contact person