Arecibo Lidar Survey

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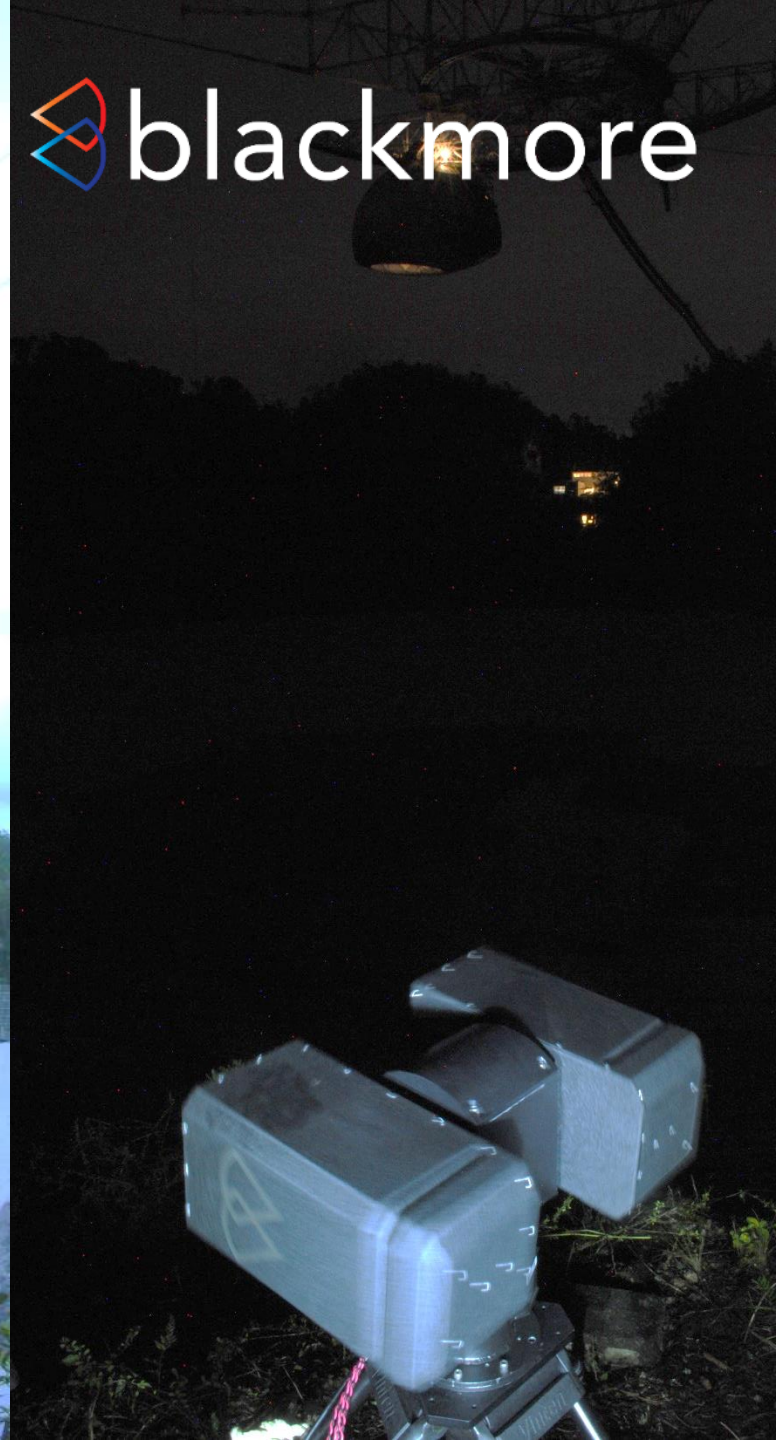
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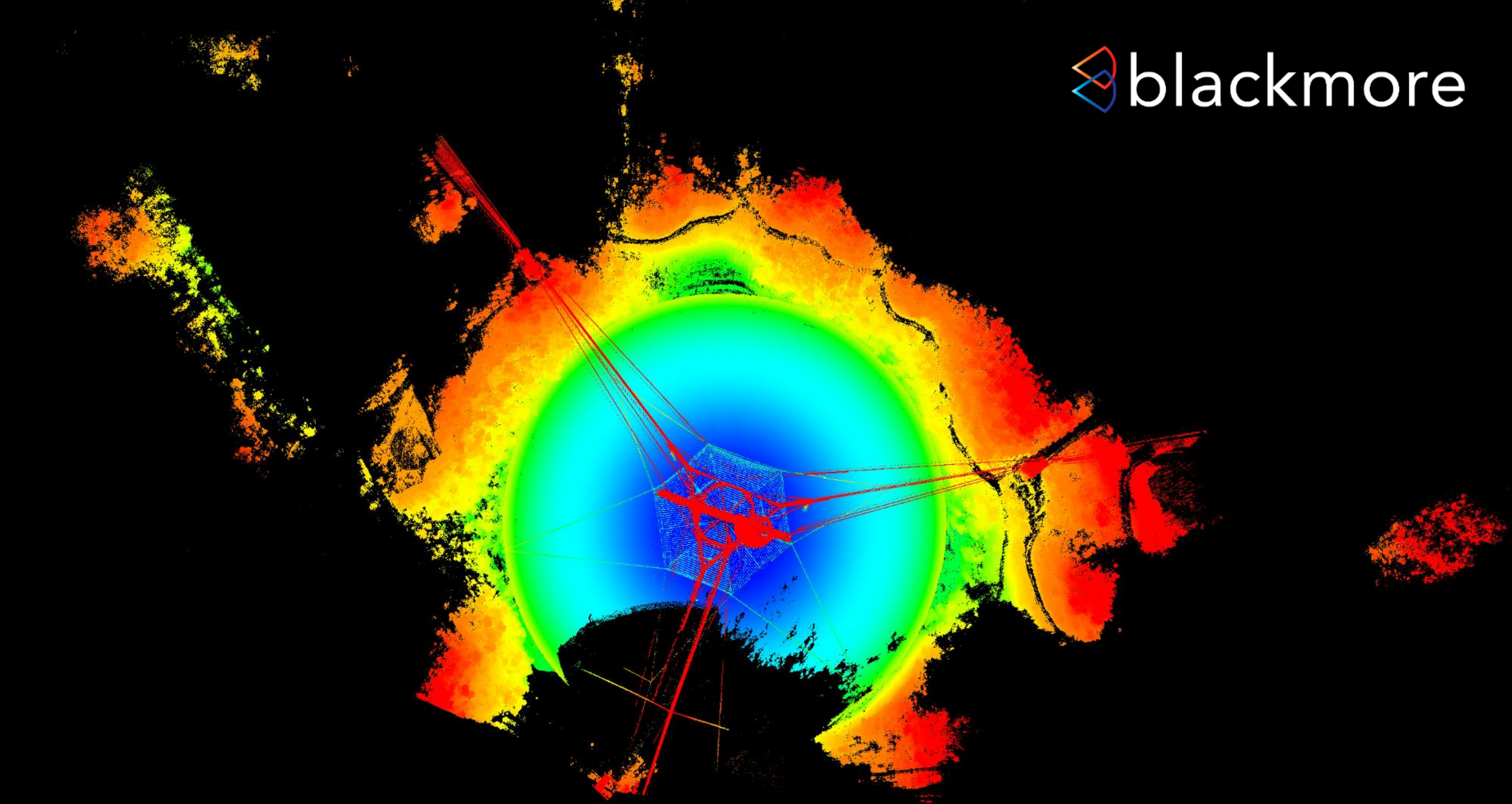
Lidar Imagery



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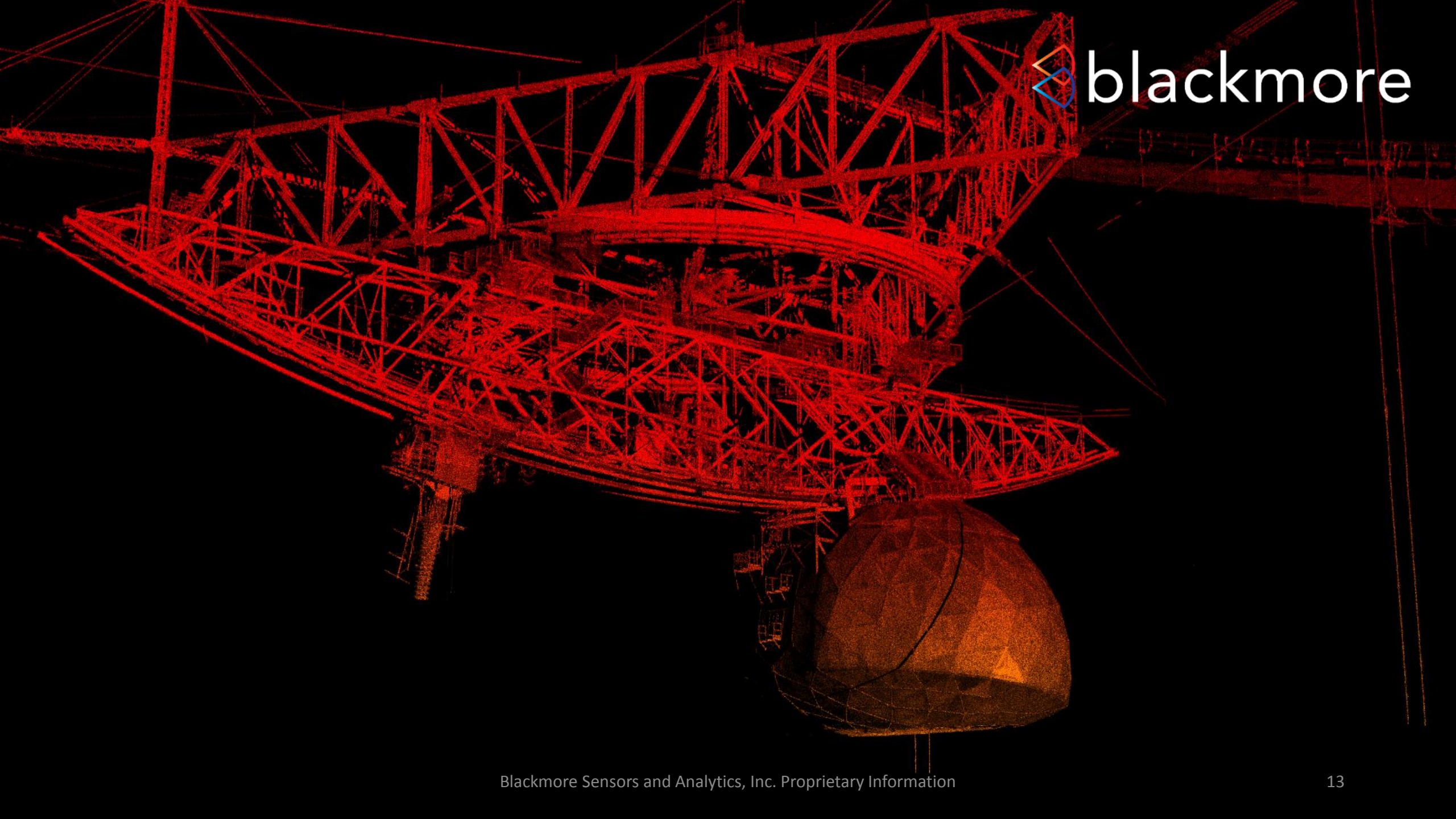
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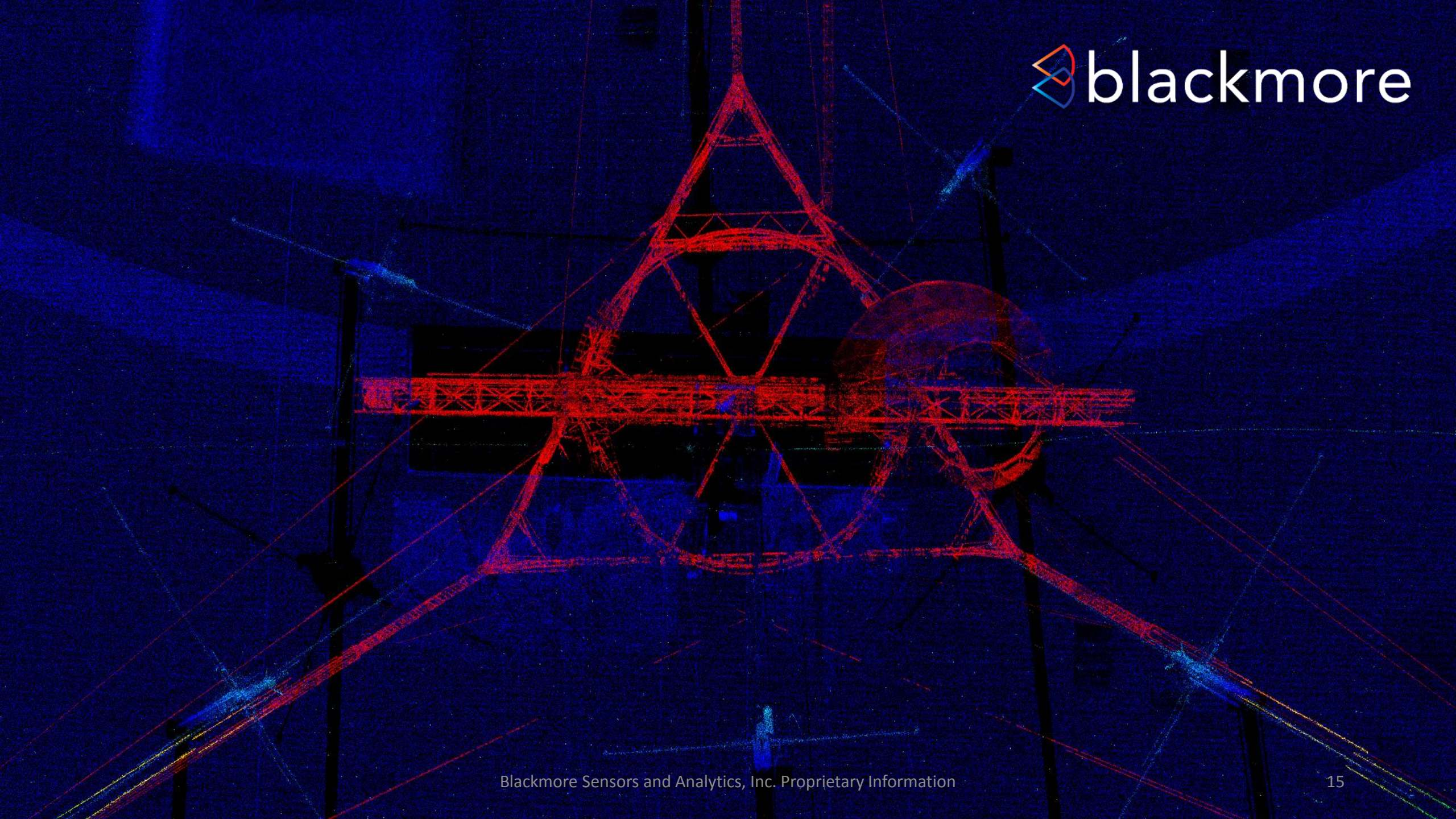

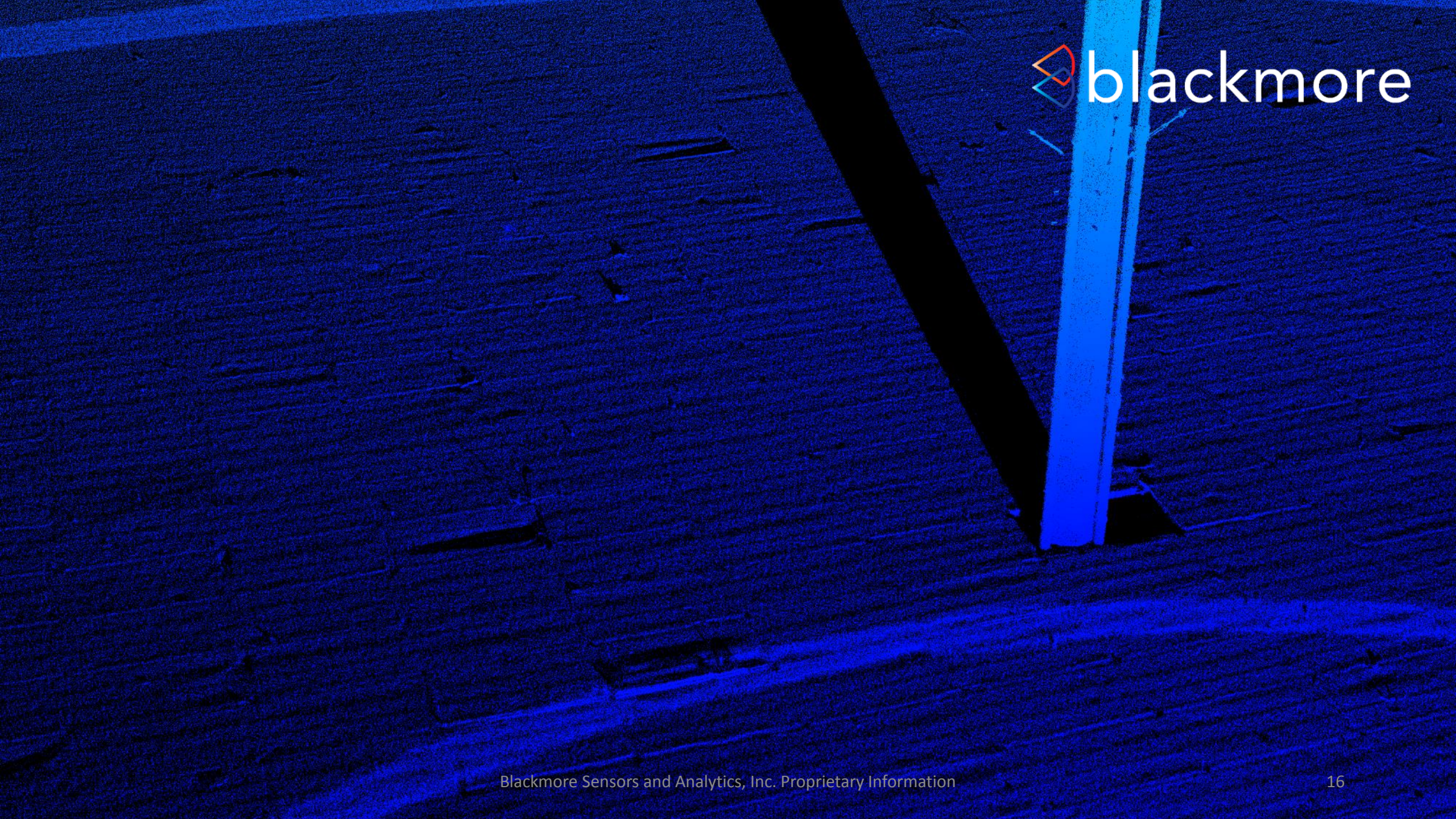
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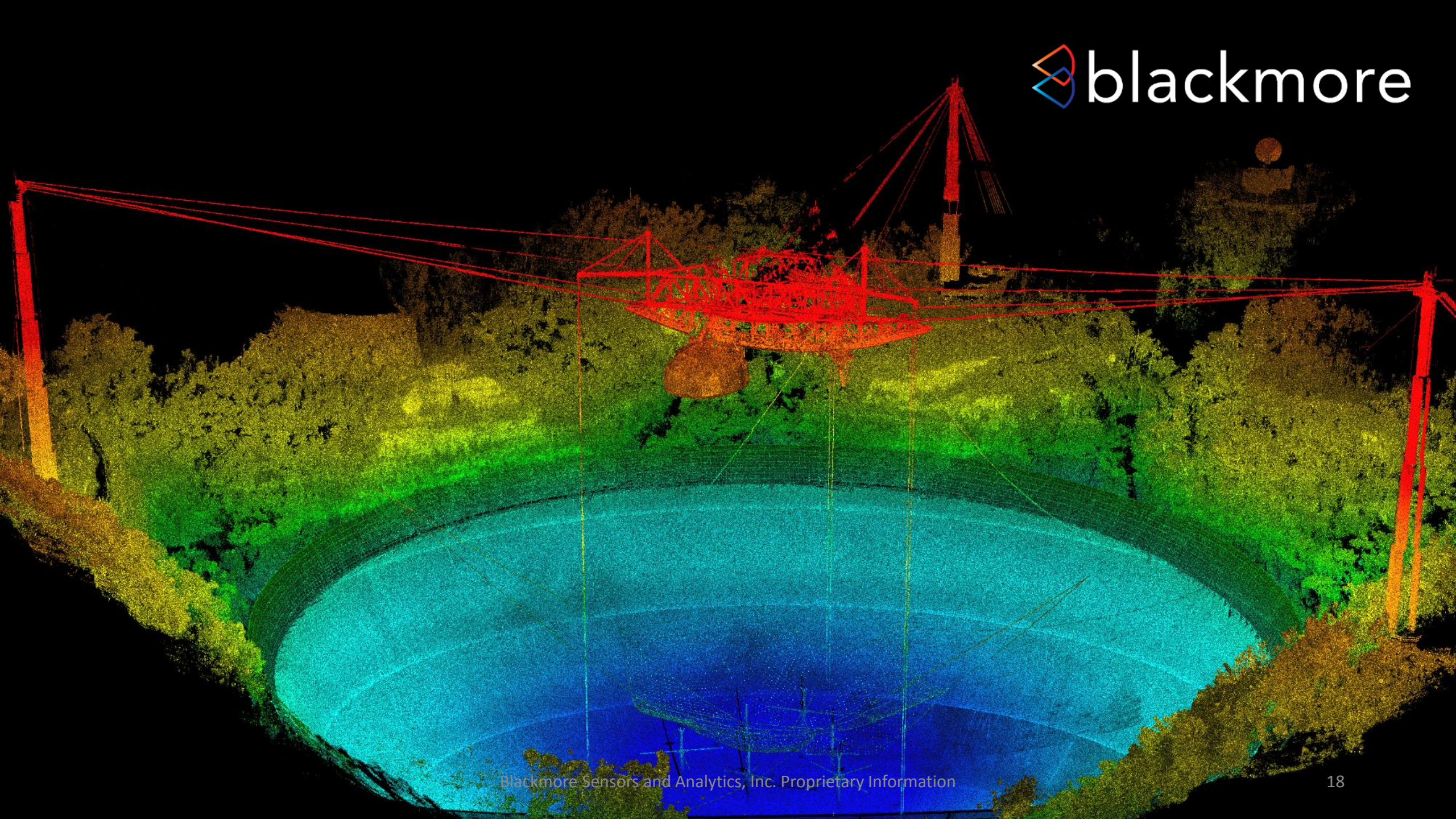
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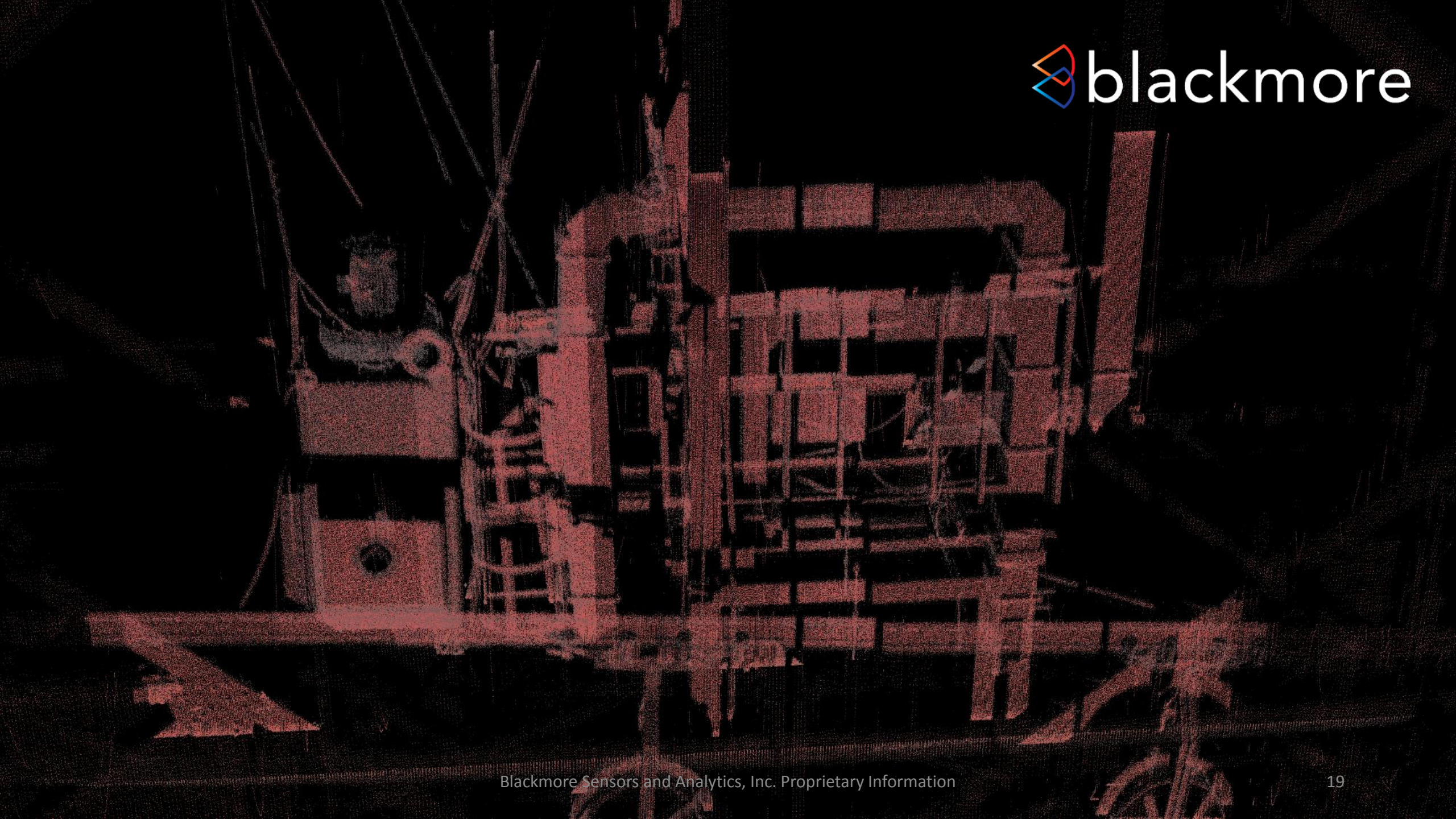

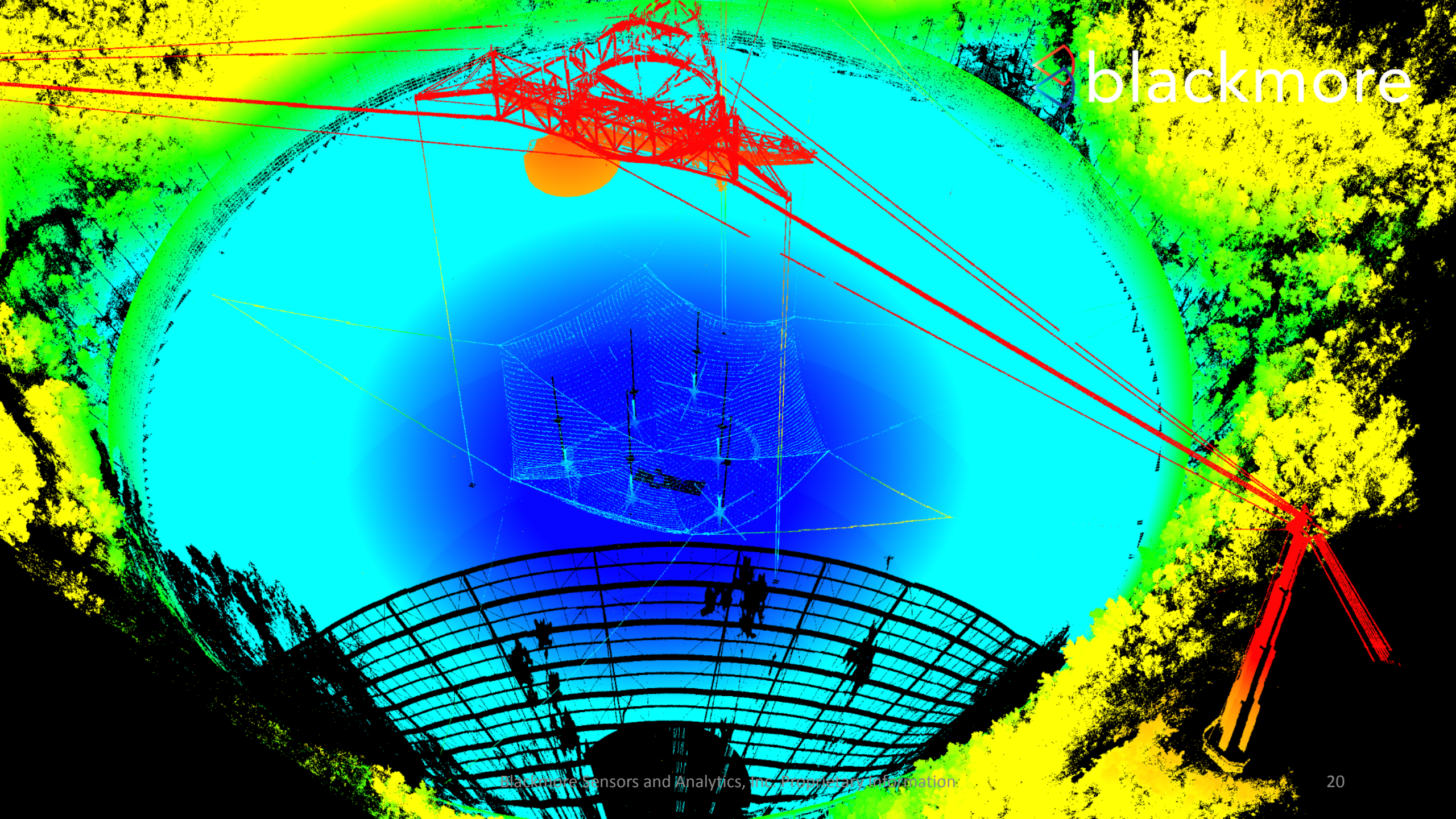
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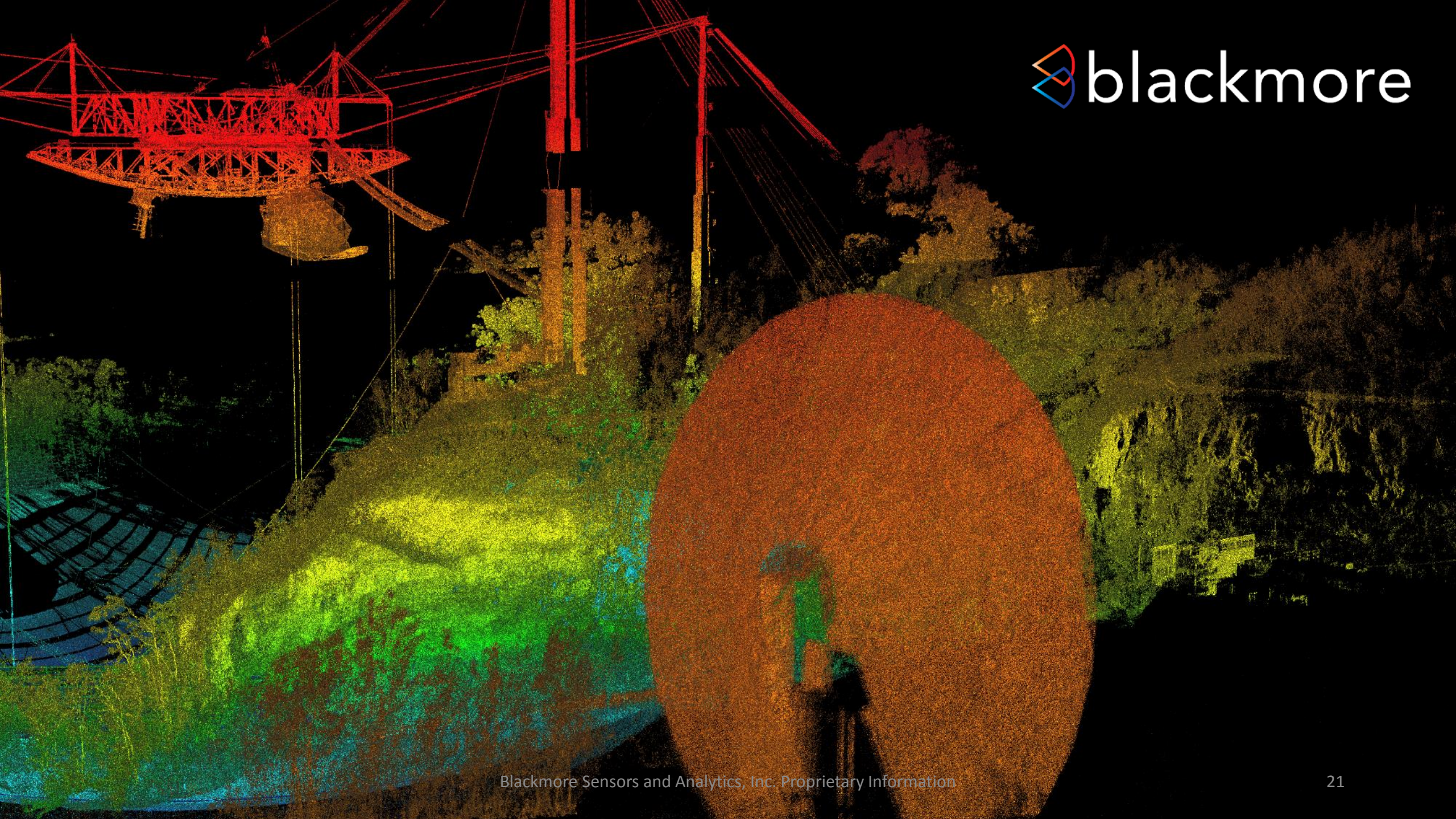
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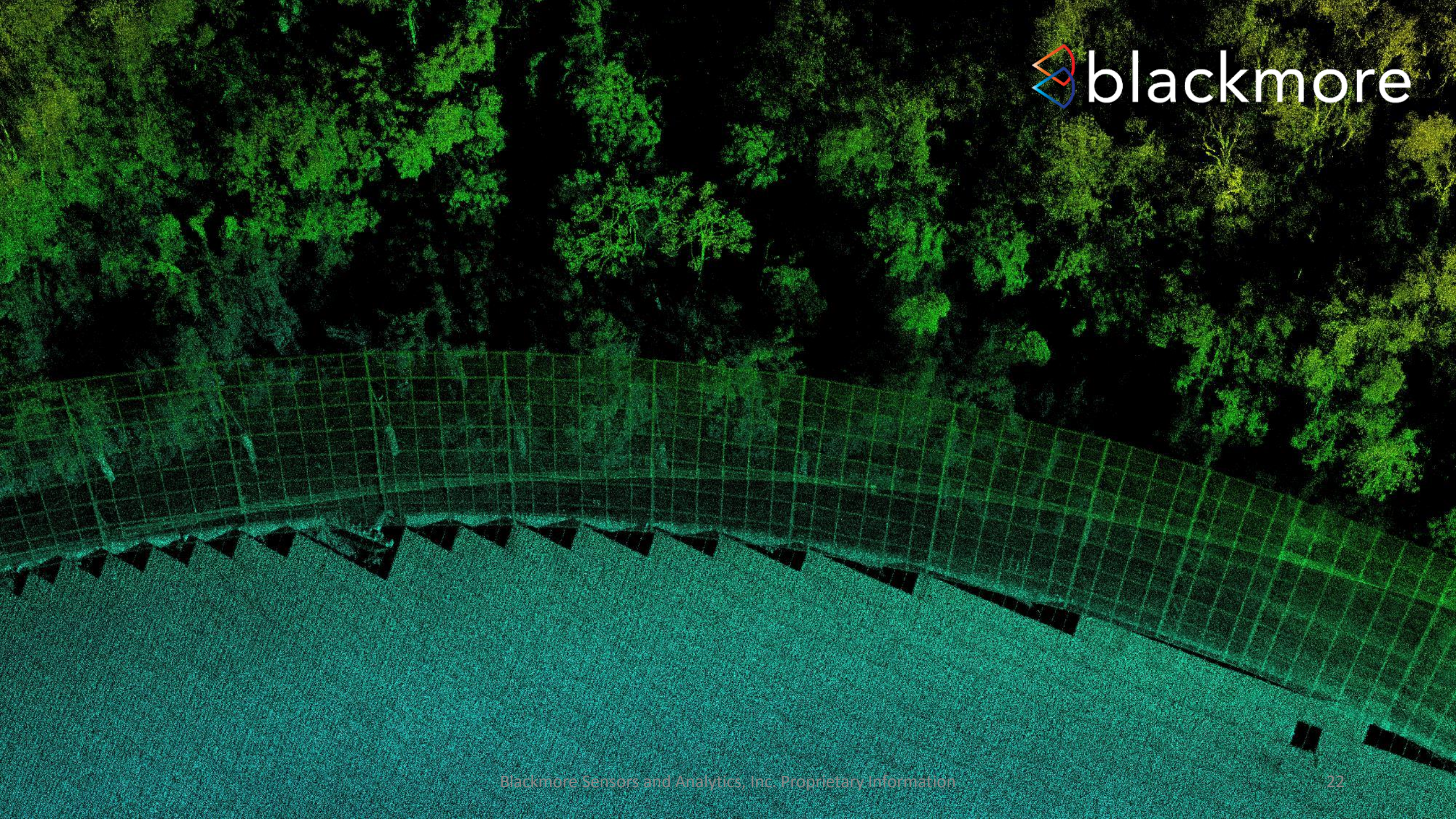
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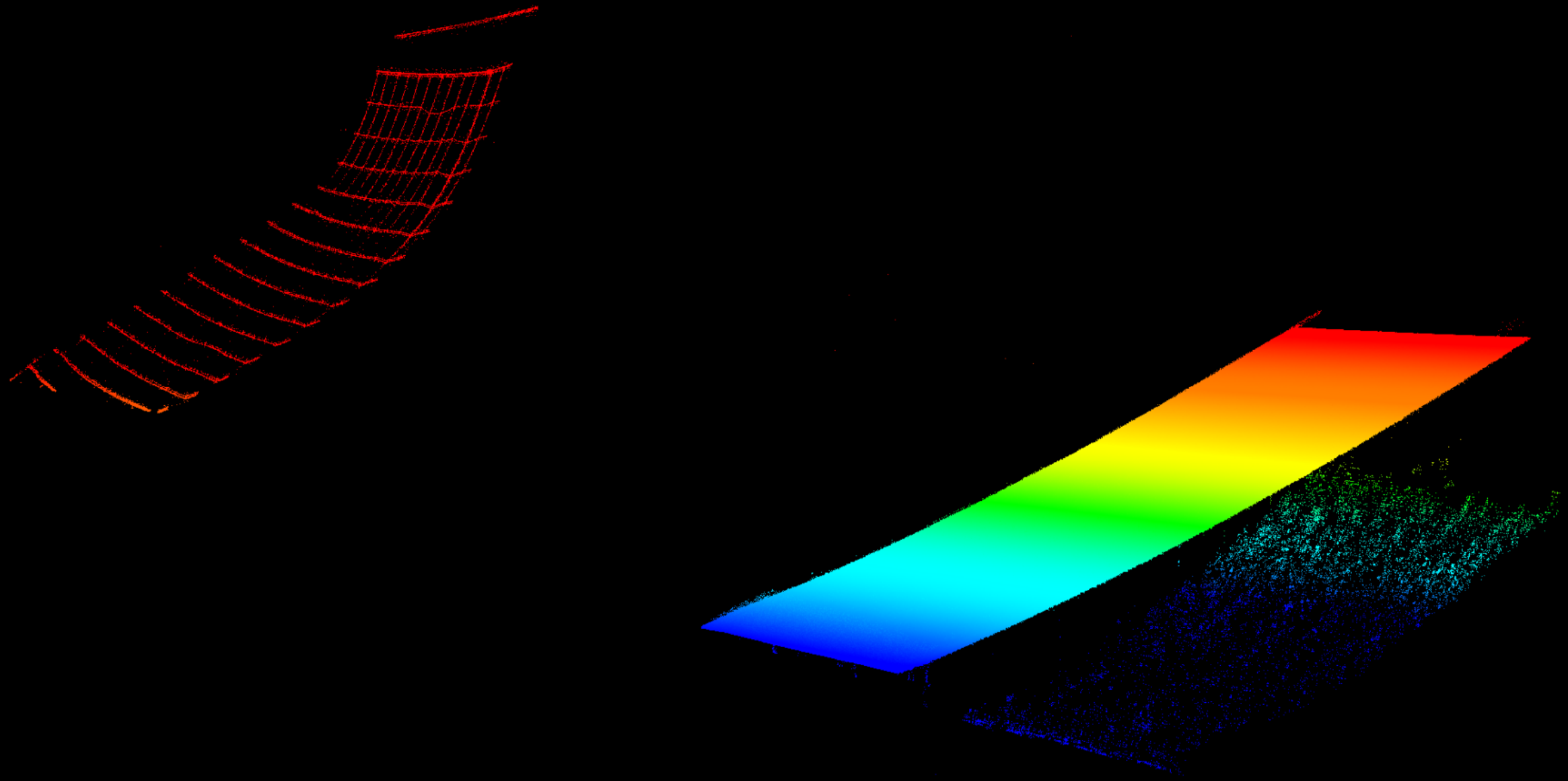

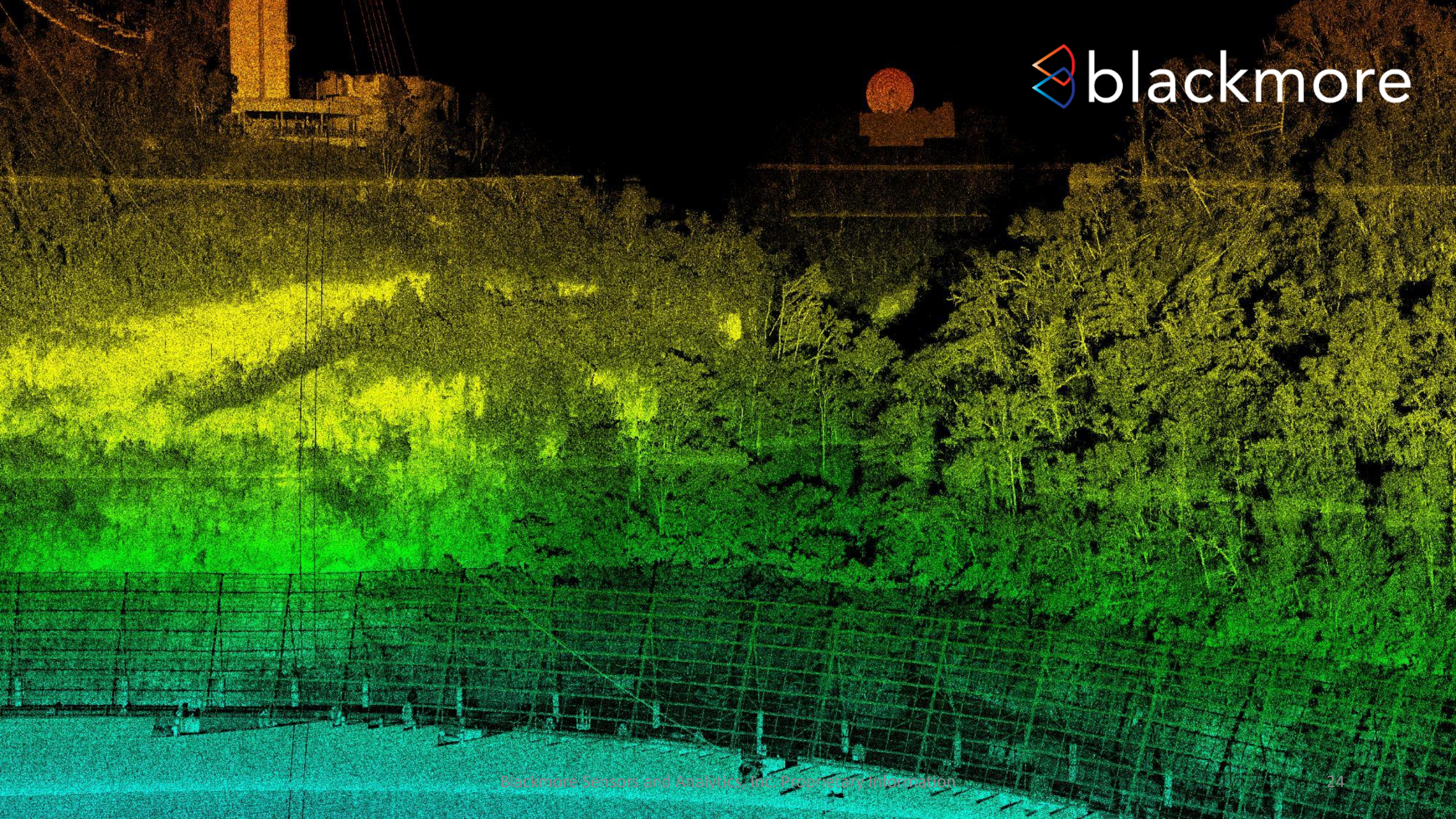

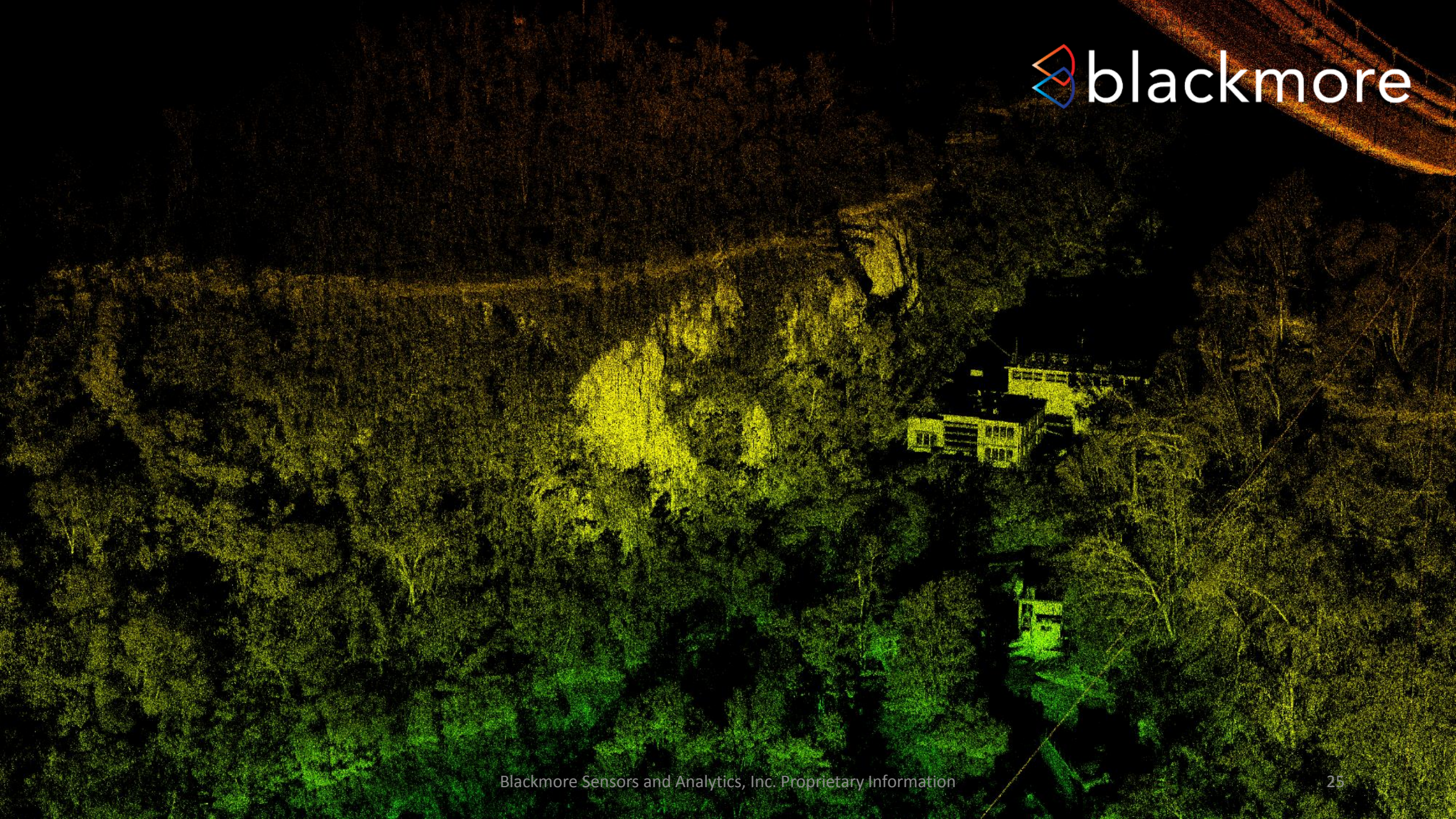
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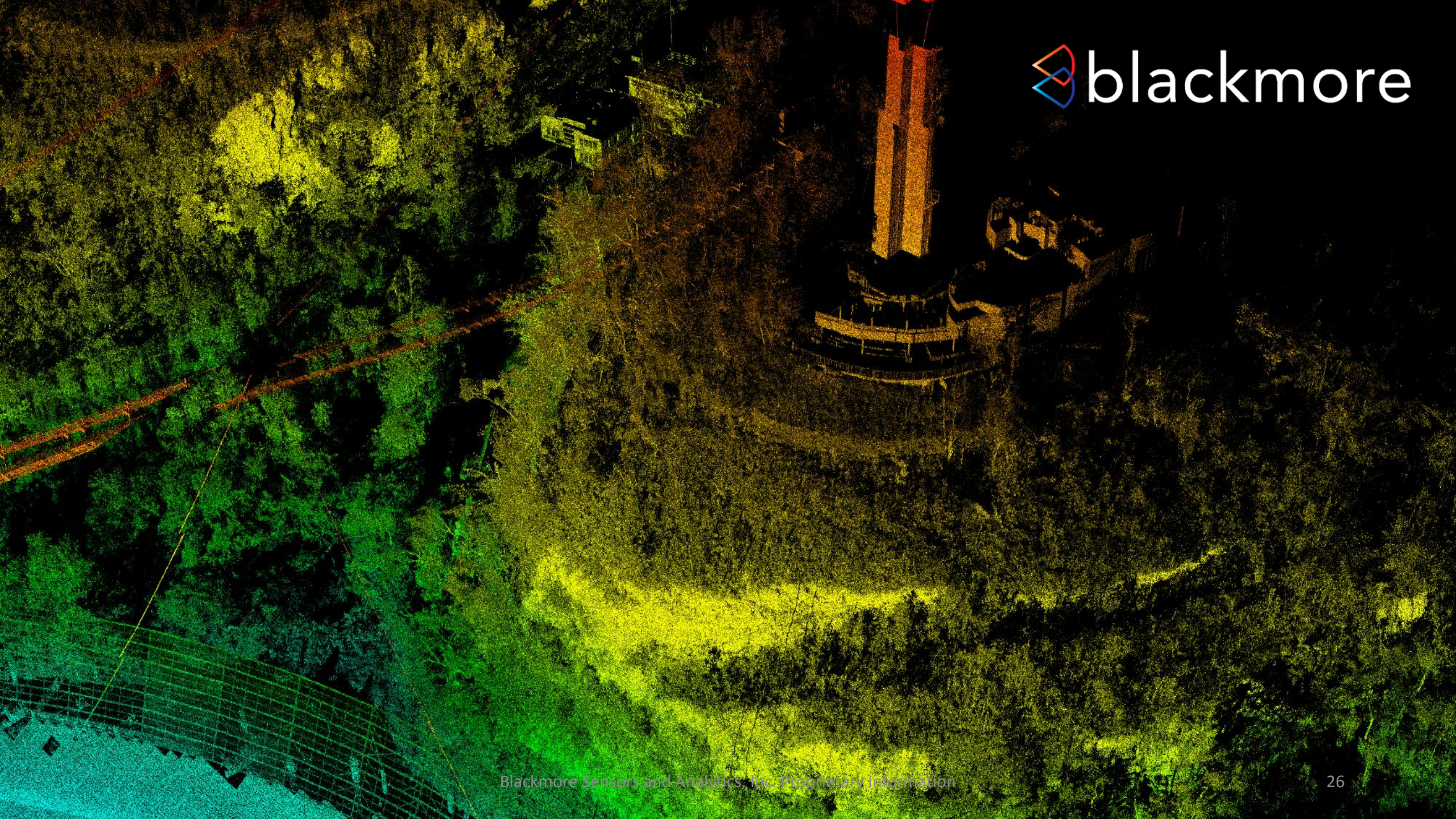
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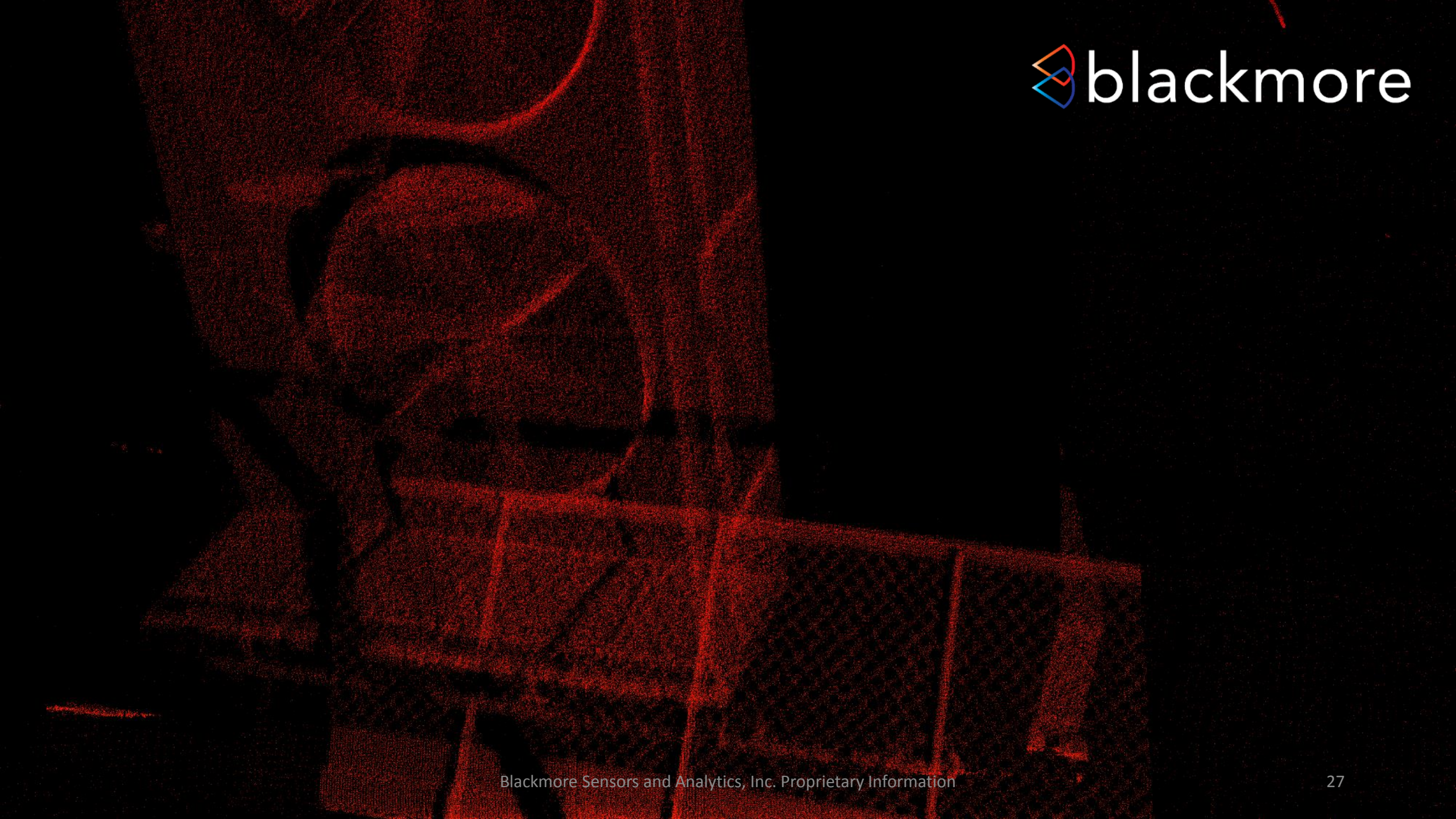
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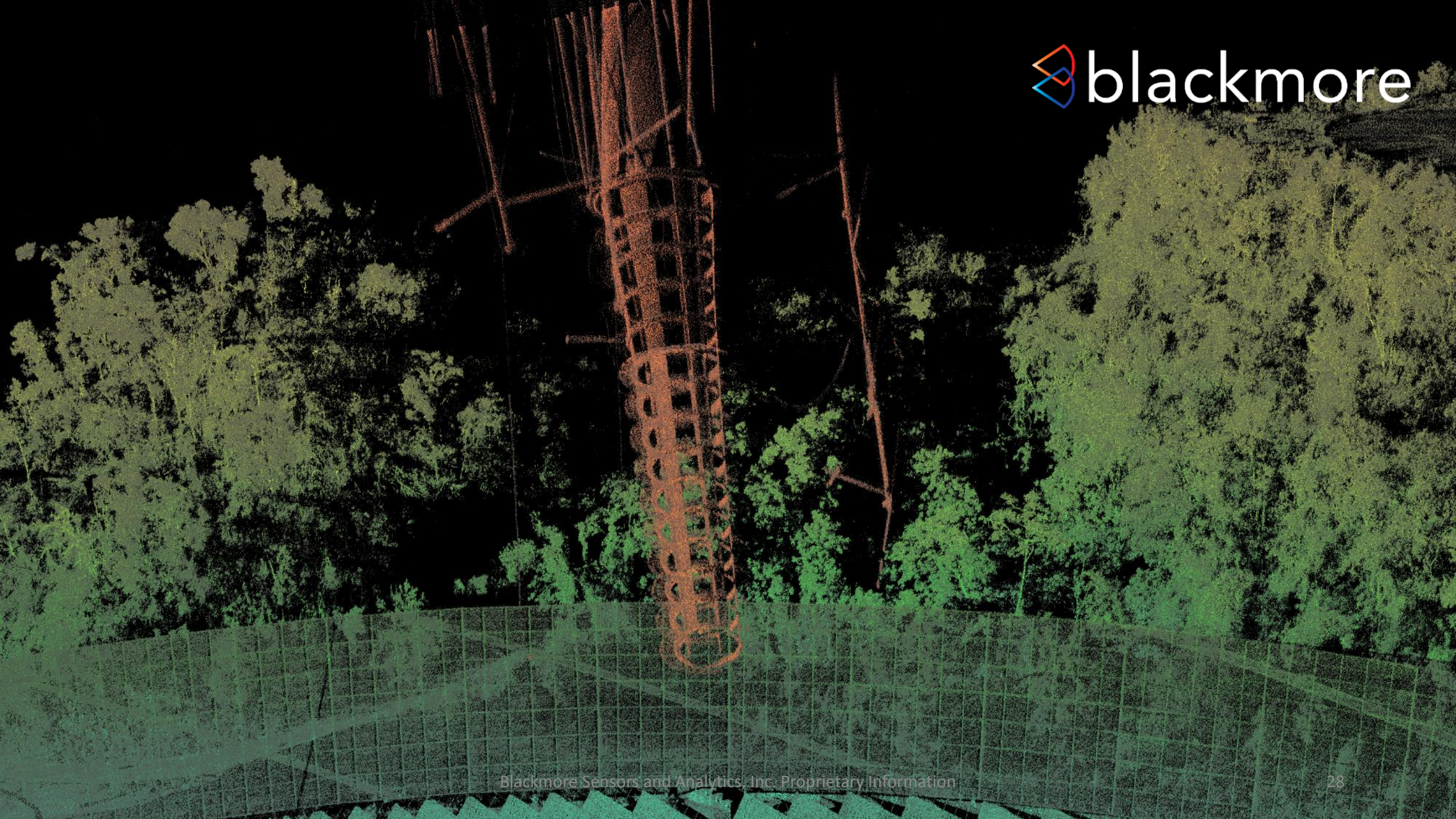
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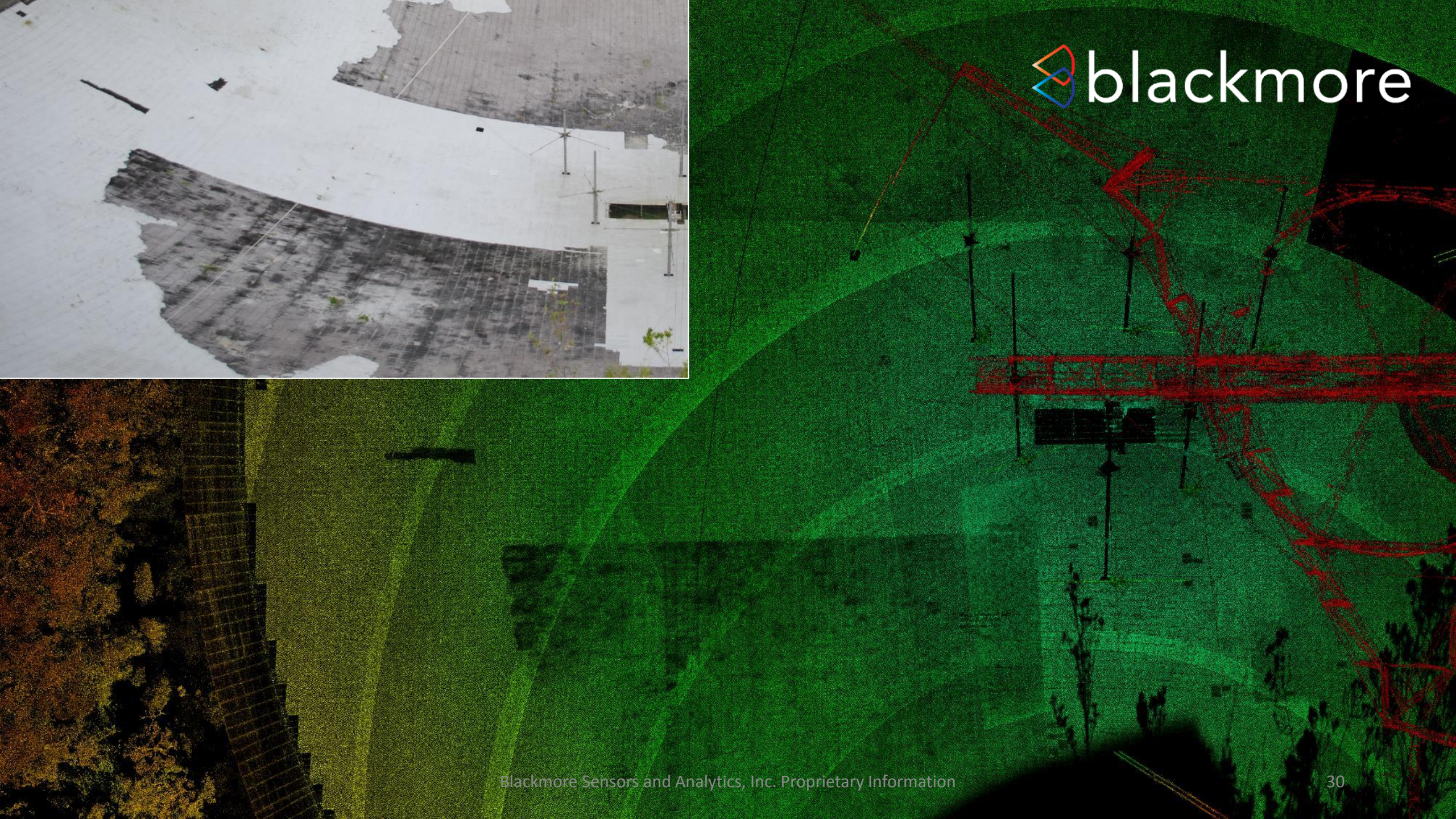
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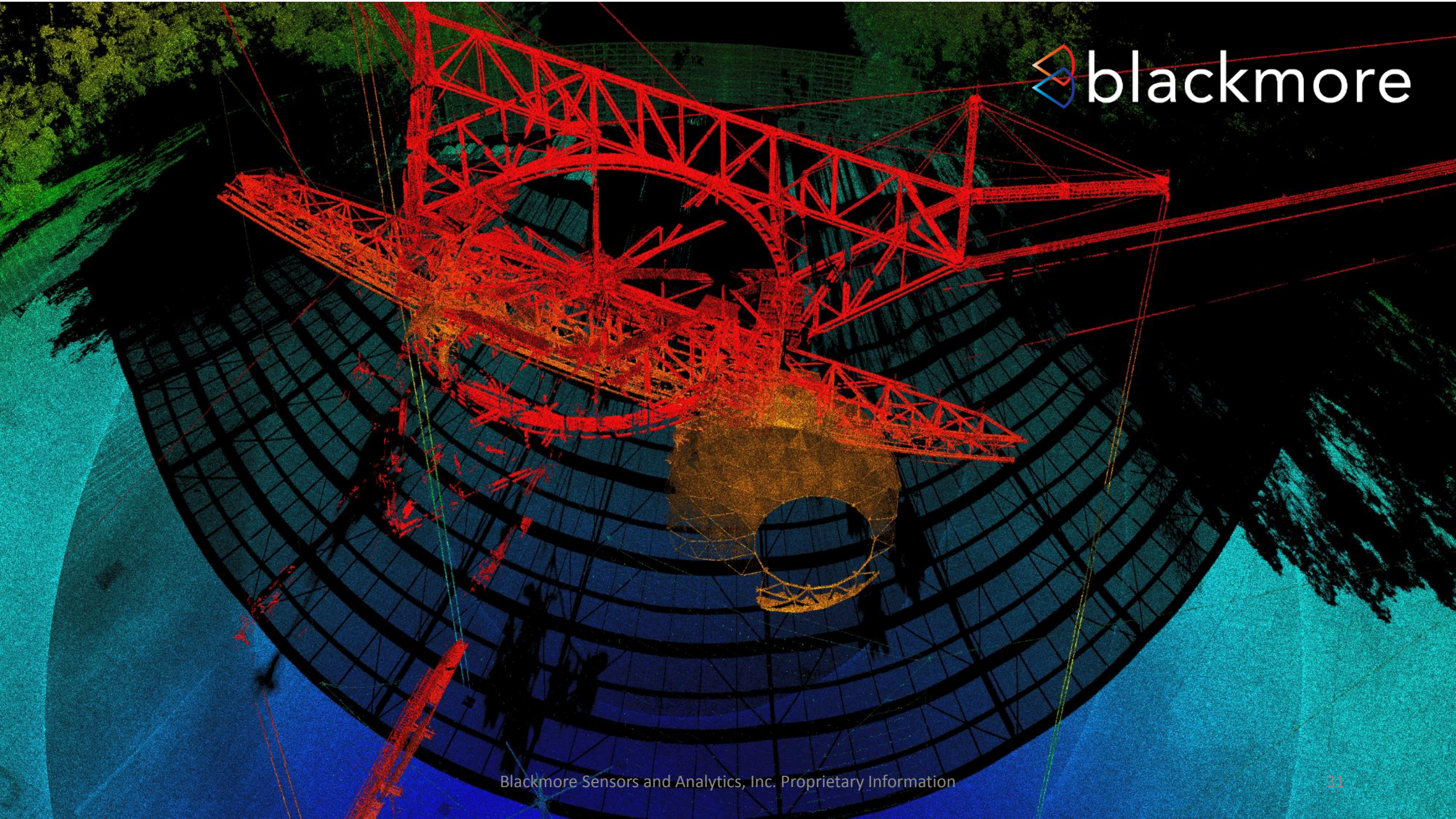
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Analysis

Analysis

- Analysis focused on radial deviation from the focal point of the spherical receiver

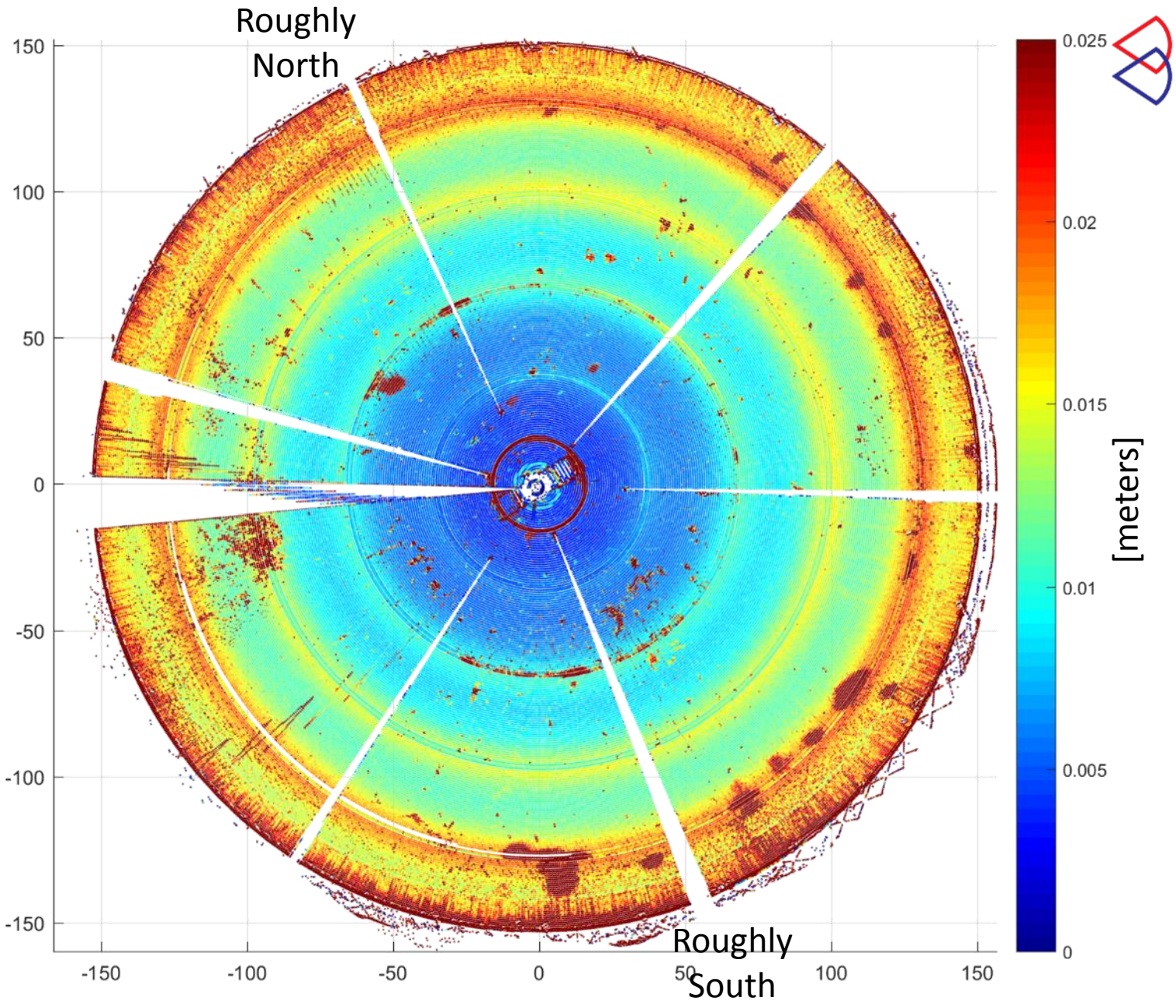
- This allows the lidar data to produce a “heat map” of possible aberrations that could guide calibration efforts
  - Workflow would include day by day checks of aberration during recalibration effort

- Data product would ultimately be converted into re-calibration instructions
  - i.e. “turn bolt #xx by ¼ revolution clockwise…”
  - Underlying tensioning cables would then correct the dish shape

Approach

- Points “on the dish” filtered to remove vegetation, ground, etc.
- Points voxelized in spherical coordinate system (focal point as origin) and averaged to reduce noise
  - Voxel patch size ~75cm x 75cm or about ¼ of panel surface area
- Averaged radius from dish focal point used as surface error metric

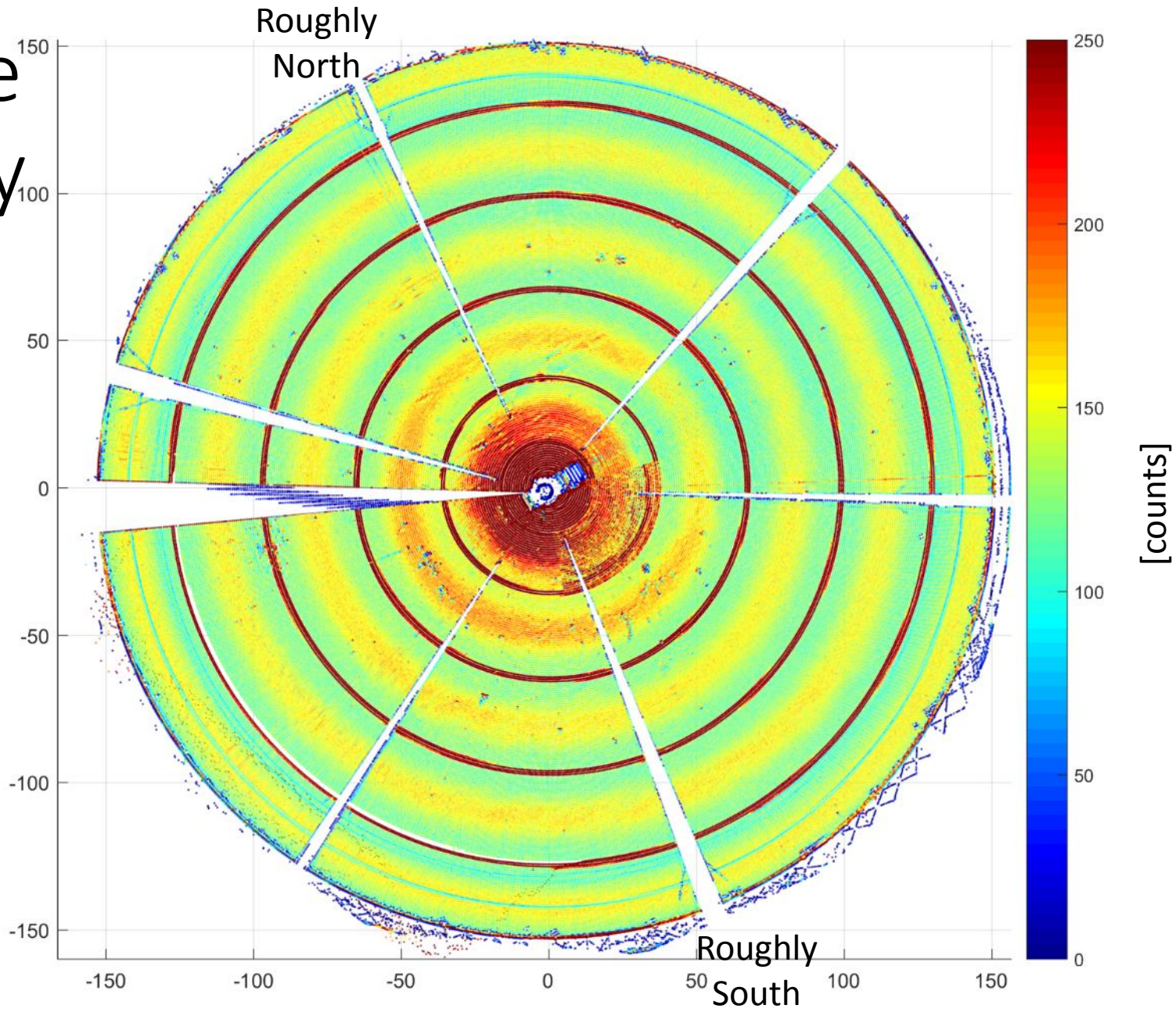
Noise



Standard deviation of the point by point radial estimates within each voxel

Approximately sub-cm noise with some exceptions at edge of dish and voxels locations with vegetation

Sample Density



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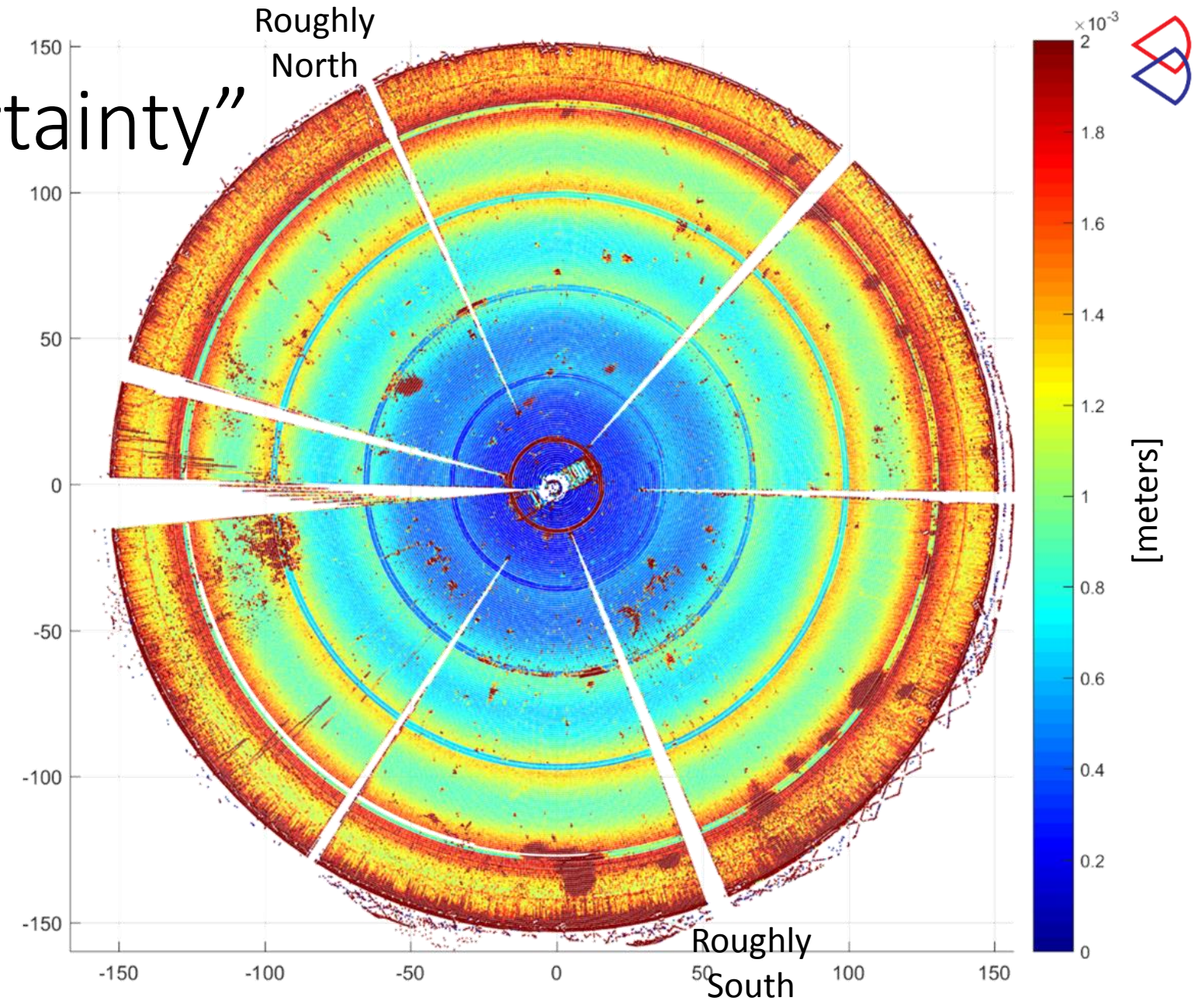
Number of points per voxel (~0.5m^2 patch)

Lines up with targeted point density for decent spatial averaging

“Uncertainty”



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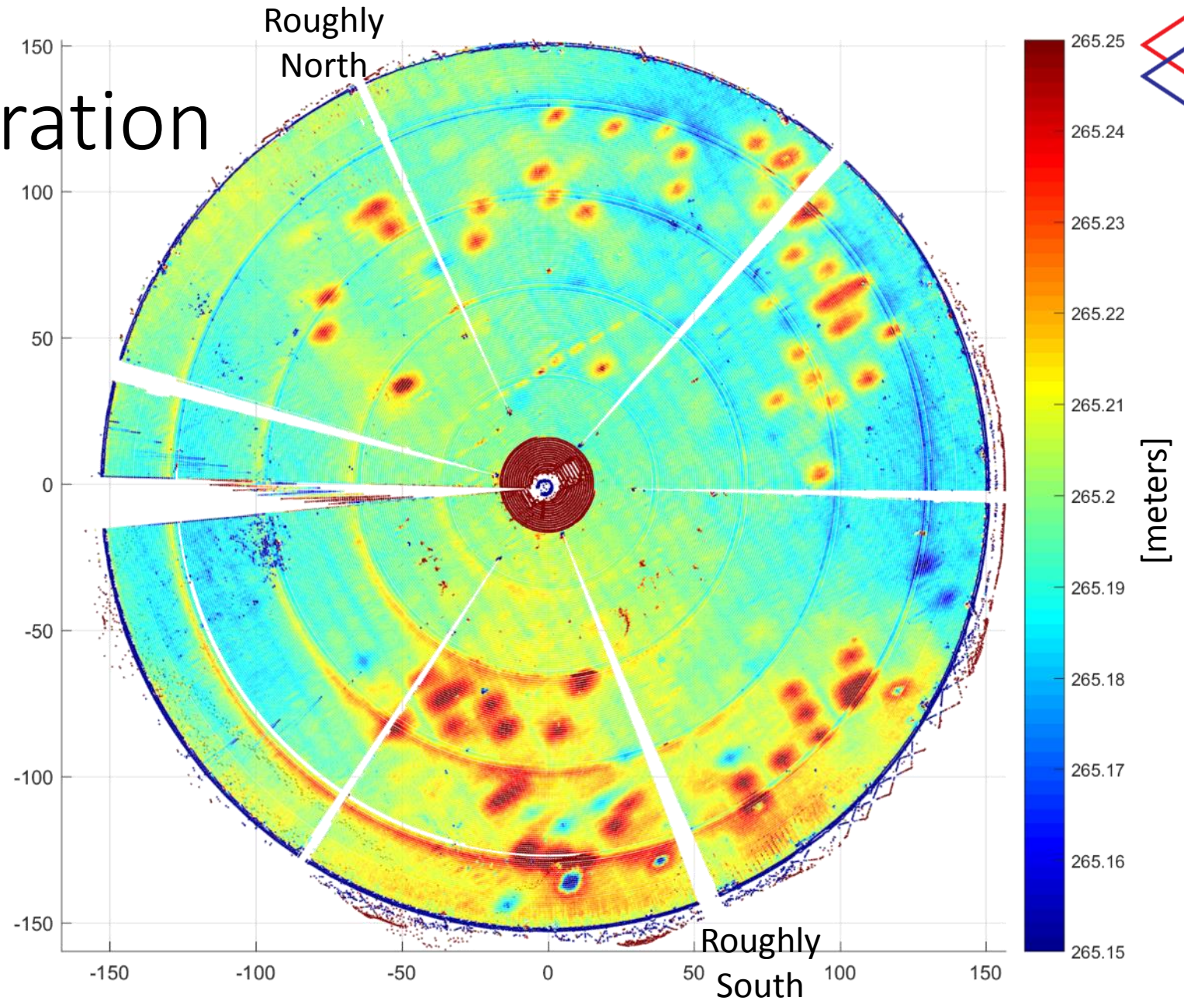
Standard deviation of point by point radial estimates within each voxel divided by the square root of the number of measurements with each voxel

Shows that estimates per voxel can approach sub millimeter level with tweaks

Aberration



Average deviation from 265.2m radius for each voxel

Complicated structure in the aberration heat map is not explained by lidar mis-calibration or vegetation features

Takeaways

- Calibration still needs to be fine tuned
  - Team is actively working on this for other efforts
- “Hot spots” correspond to vegetation in a few cases, but the majority seem to be real deviations
  - Would be good to understand if the pattern of hot spots corresponds to underlying cable structure / tie points
- 4GHz with this scan density seems to be a good start
  - Denser spatial sampling and higher bandwidth would further reduce the noise, but structure is present in the aberrations as it stands

Next Steps

- Blackmore can provide a quote for a system
- Quote would include integration of the analysis, survey, and workflow features into the GUI
  - Would work in conjunction with the team at Arecibo to perform “online” monitoring of the dish for re-calibration activities
  - Semi-permanent installation at A09 site would be a good option, especially if the height of the installation could be increased further
- Rough timeframe for a system would be late Q3