Object K: Identification and feature analysis

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Executive Summary

Despite increasing awareness of the dangers posed by debris and international efforts to coordinate debris mitigation standards, the risk to continuity of space-based services and to physical assets in space continues to rise. The US Department of Defence uses Space Surveillance Network (SSN) sensors all over the world, including Australia, to track tens of thousands of pieces of debris in orbit.¹ The US DoD’s SpaceTrack catalogue is used widely by the commercial, government and research sectors to track satellites and is used for critical functions such as conjunction alerts (warnings that two space objects might collide) among others.

Among the pieces of debris and other objects in space are unidentified objects; human-made objects that sit in orbit and are tracked using ground-based sensors, but about which very little is known. Are they debris or functioning satellites? How big are they? And do they pose a risk to surrounding satellites?

The United States’ Space Force 18th Space Squadron has listed approximately 343 objects in Low Earth Orbit (LEO) that remain unidentified.² Understanding where these objects came from and characterising their attributes is critical. If they are debris, identification can determine whether they pose a threat to the space environment, how the creation of similar types of debris can be mitigated in future, and offer a path forward for debris removal and management. If they are functioning satellites, they can be correctly identified and attributed to their launching state, which is important for international law.

HEO Inspect, proprietary software developed by HEO Robotics, offers a way to identify these previously unknown objects by conducting a visual inspection in orbit using cameras on satellites and analysing the resulting images. Over the past 12 months, HEO Robotics has been imaging large unknown objects to refine analysis technology and develop identification capability. In 2021, HEO Robotics imaged an unidentified object called Object K (NORAD ID: 48257). Originating from a known Chinese launch of a Long March 6 (Chang Zheng 6) rocket,³ the mission Object K is associated with was reported to have carried a payload of nine known satellites (COSPAR: 2021-033).⁴ Object K was a tenth, unexpected, object that reached orbit. It has been tracked by the United States Space Command’s 18th Defence Squadron since launch, but until now there has been an absence of information regarding its characteristics.

² Current as at 17 August 2022
³ Also known as 长征六号运载火箭, LM 6 or CZ 6
⁴ https://www.nasaspaceflight.com/2021/06/long-march-6-nine-satellites/
On the basis of multiple visual inspections over the past year using HEO Inspect, open source research, and analysis including 3D modelling, HEO Robotics has identified Object K as being one half of the payload fairing of the Long March 6 rocket launched in April 2021. HEO Robotics will continue to inspect Object K, including conducting spectral analysis and employing machine learning, to learn more about how the creation of similar types of debris can be mitigated in future.

HEO Robotics recommends that the US DoD SpaceTrack catalogue should be updated to list the object name for NORAD ID 48257 as “CZ-6 R/B Payload Fairing Deb” rather than “Object K” and the object type field should read “Debris”, rather than “Unknown”.

### Parent Launch Details

The “parent launch” refers to the launch associated with Object K.

The three stage Long March 6 launch (COSPAR: 2021-033) was conducted on April 27, 2021 11:20 Beijing Time from the Taiyuan Satellite Launch Center, China. The Shandong Province Government was reportedly the primary customer of the mission. The mission was likely successful, with the first stage of the CZ-6 reportedly landing in the north eastern region of China.

There is no official data on the length of each stage of the rocket, but HEO Robotics has

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estimated the dimensions (Figure 1)\(^6\) based on open source data which suggests the overall height of this class of rocket is approximately 29.3m.\(^7\)

There are ten objects associated with this launch. All ten objects are still officially unidentified according to SpaceTrack, the US Department of Defence’s tracking platform.

Open source data indicates that nine of the objects which were deployed from this launch are research satellites, with uses including IoT technology testing, real-time imaging, and remote sensing.\(^8\) The available data shown in the Table 1 (drawn directly from HEO Inspect) combined with open source information has led HEO Robotics to conclude that the two “large” objects (Object A and Object D) are likely to be Qilu 1 and Qilu 4.\(^9\) The six medium-sized objects (Objects B, C, E, F, G, H, J) are likely to be the other six reported satellites. The last, tenth object from the launch is Object K. Since Object K remains unidentified in open source data as well as in SpaceTrack, posing potential risk (either conjunctions with other space objects or risk to populated areas of Earth upon atmospheric reentry), HEO Robotics undertook to image and identify it, and to share the identification publicly.

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<th>Object Name</th>
<th>Country</th>
<th>Launch Date</th>
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### The Images

**The 2021 Mission**

HEO Robotics captured images of Object K using HEO Inspect software on July 21st, 2021. Figure 2 presents a recoloured image of Object K annotated with apparent dimensions and features.

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\(^7\) Chinese news reports that the Long March 6 has a height of approximately 29m (https://news.qq.com/a/20131219/013441_all.htm) Baike puts it more precisely at 29.287m (https://baike.baidu.com/item/%E9%95%BF%E5%8F%B7/1002189)

\(^8\) https://space.skyrocket.de/doc_lau_det/cz-6.htm

\(^9\) https://space.skyrocket.de/doc_sdat/qilu-1.htm; https://space.skyrocket.de/doc_sdat/qilu-4.htm
The dimensions and curvature of the object originally led analysts at HEO Robotics to believe that Object K may be part of Long March 6’s third stage. However, the feature outlined and marked “?” in Figure 2 was raised as a point of interest. This was thought to be due to a possible protrusion to the right of the object. HEO Robotics decided to conduct further inspections.

**The 2022 Mission**

On the 27th of April, 2022, HEO Robotics used HEO Inspect to successfully image Object K again. In this instance, the object’s rotation allowed the analysts at HEO Robotics to gain a better understanding of its dimensions, and enabled further attribution of its features. A recoloured image with apparent dimensions is shown in Figure 6.

As in the 2021 capture, the images present a continuous curvature along the width of the object. The feature of interest from the 2021 data set is no longer visible, although there are many light reflection features present. The new images show a longer, cylindrical object. Its length and width appear to be roughly 4.5m and 1.6m respectively, though both these values are likely to be less than the true values due to the viewing angle of the object. Notably, the curved shape of the 2021 mission in conjunction with the shadowing on the 2022 mission suggested to HEO analysts that the object was semi-cylindrical in shape and not a full cylinder as previously thought. The measured dimensions do not agree perfectly with any of the estimated rocket component dimensions seen in Figure 1, however it was determined that the payload fairing components best match the observed shape characteristics and agree with the measured dimensions within the uncertainty range due to image blur and viewing angle.

Based on the 2021 and 2022 data, HEO Robotics has concluded that Object K is one half of the Long March 6 payload fairing. Figure 3 shows an open source image of a Long March 6 payload fairing from a press release published by the China Aerospace Science and Technology Corporation reporting on the launch which produced Object K.10

![Figure 3. Open source image of the payload fairing from the launch which produced Object K (source: CASC)](http://www.spacechina.com/n25/n2014789/n2014804/c3189552/content.html)

**Other Missions in 2021 and 2022**

Due to the orbital geometry of Object K, each of the missions discussed above had passes in the following orbits where Object K was also imaged. Images from these passes have not been included in this report, but are available on request.

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10 [http://www.spacechina.com/n25/n2014789/n2014804/c3189552/content.html](http://www.spacechina.com/n25/n2014789/n2014804/c3189552/content.html)
Supporting Evidence

This section presents a possible explanation for the uniform light and shadow distribution across various sections of the object. Renderings produced by HEO Robotics, combined with the updated dimensions of the 2022 image, support an updated hypothesis that Object K has a semi-cylindrical shape. This analysis also suggests that the feature of interest in the 2021 dataset is likely a light feature, rather than a physical protrusion.

The 2021 Mission Comparison

The 2021 mission was compared against a series of semi-cylinder renders, showing that Object K is inverted and at a high angle to the camera. Additionally, some of the lighting features visible in the image, notably the brighter strip running lengthwise through the left side of the object and the brighter region to the upper right side of the object, were recreated in the renders; thus demonstrating that these are feasible lighting features when assuming a semi-cylindrical structure as hypothesised.

The 2022 Mission Comparison

The 2022 mission (Figure 6) was compared against a series of semi-cylindrical renders (Figure 7), possibly also showing object inversion and at a lower angle to the camera than the 2021 mission.

Figure 4. Object K captured on July 21, 2021
Image taken using HEO Inspect and powered by Satellogic

Figure 5. The 2021 Mission Object K Render 1

Figure 6. Object K captured on April 27, 2022
Image taken using HEO Inspect and powered by Satellogic

Figure 7. The 2022 Mission Object K Render 1
Preliminary Conclusions and Recommendations

HEO Robotics has drawn the following preliminary conclusions from the Object K analysis.

- Object K is one half of the payload fairing of the Long March 6 rocket body launched in April 2021.
  - This conclusion arises due to the dimensions and lighting being consistent with open source data pertaining to the Long March 6.
  - The unexpected orbital location could be due to a partial failure of a mission-standard explosive bolt component.
  - The other half of the payload fairing appears to have deorbited successfully.

- A feature that looked like it could have been a physical protrusion on the object appears, after further inspection, to be a lighting feature consistent with the semi-cylindrical shape.

- The rotation appears to be uncontrolled but slow in the few images captured.

Recommendation:

The US DoD SpaceTrack catalogue should be updated to list the object name for NORAD ID 48257 as “CZ-6 R/B Payload Fairing Deb” rather than “Object K” and the object type field should read “Debris”, rather than “Unknown”.

Further Considerations

HEO Robotics will continue to explore this object to build further confidence in this identification. Further imaging missions will be conducted as more cameras become available in the HEO Inspect imaging network and additional fly-by opportunities arise.

Extended analysis will also be conducted on the existing data presented in this report. HEO Robotics has collected images of Object K in several spectral bands and will perform a spectral analysis to explore material composition of the imaged object. In addition, HEO Robotics will continue to develop a more detailed 3D rendering of what the payload fairing looks like and use this along with both manual and machine learning techniques to match additional features against existing and new images, including any potential damage from an explosive bolt failure.

HEO Robotics will also continue to explore what lessons can be taken from Object K for the ongoing development of debris mitigation standards and practices, and for space environment stewardship generally.

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