



'Comet-like' propellant dump observed from the British Isles

Between 05:05 and 06:10 UTC on 2014 Dec 13 a comet-like object moving northwards through Serpens and into Corona Borealis was widely observed from many parts of the British Isles. Of particular note was the rapid change in brightness (rising from invisibility to first magnitude before fading to below naked-eye visibility) and the speed with which it moved across the sky, covering almost 20° in just over an hour.

Earlier that morning at 03:19 an Atlas V-541 rocket was launched from Vandenberg AFB in California (Figure 1). The payload was NROL-35,¹ a classified US Signals Intelligence satellite which would be injected into a Molinya orbit by the hydrogen/oxygen fueled Centaur upper stage. In the days prior to the launch respected satellite observer and orbital analyst Ted Molczan used publicly available information to produce provisional orbital elements for the payload and booster, and posted them on the SeeSat L forum.²

On the same forum Cees Bassa noted that during previous similar launches the Centaur performed a CCAM (Collision and Contamination Avoidance Manoeuvre), and that a propellant dump had been observed from the ground. If the mission managers followed a similar routine this time then this phenomenon would be visible from Europe.³

On the morning prior to the launch I used Molczan's orbital elements and Bassa's predictions to produce ephemerides for several locations in mainland Britain and posted these on the BAA forum.⁴ Forecast observing conditions over much of the British Isles at the predicted time were excellent, but with south-

east England (and much of Continental Europe) under cloud.

Based on Bassa's predictions, the propellant dump was expected to become visible at 04:39, a few minutes after the booster rose above the eastern horizon at my location (Ravensmoor, Cheshire). Unsure of the maximum angular size of the potential plume, I decided to attempt to image the object using a tripod-mounted Canon 550D DSLR with a 75–300mm lens. I kept a close eye on the eastern horizon from 04:30 onwards and suddenly at 05:09 a small, faint cloud appeared. I started imaging with the lens at 300mm, ISO 6400 with 1s exposures at f/5.4. A montage of the photographs is shown in Figure 2.

Frame A was taken at 05:09:45. A period of approximately 30s had elapsed between first noticing the plume and taking this photograph. The diameter of this initial plume is estimated to be in the region of 160 km but its exact nature is uncertain. By this time the payload would have separated and the booster could be in the midst of, or indeed have completed, the CCAM manoeuvre. The plume may have been the result of hydrazine thruster firings, the de-orbit burn or a short vent of the propellants. My suspicion, based on the size and colour, is that this was the exhaust plume from the de-orbit burn.

Frame B in Figure 2 shows the initial plume plus the first stages of the second plume. Based on the brightness and longevity I am confident that this is the beginning of the propellant dump. The small size suggests the dump has only just started and is therefore a good guide for the position of the booster itself. Frame C shows a further expansion and fade of the initial plume while the second plume continues to brighten and expand, and Frame D shows the second plume just before some broken clouds obscured the view. Although slightly fainter, it is significantly larger. At this point the diameter of the second plume is estimated to be in the region of 210 km. Structure within the plume is evident with what appear to be multiple jets.

Although obscured for a short period the plume continued to be visible to the unaided eye until approximately 06:01:33 when

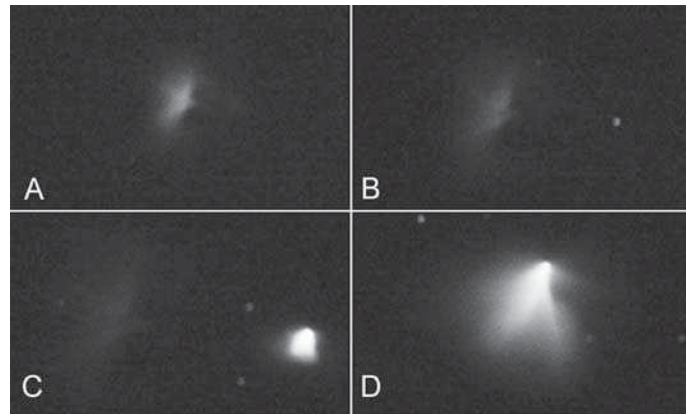


Figure 2. Montage of the plumes taken at the following times: **A:** 05:09:45, **B:** 05:11:11, **C:** 05:13:28, **D:** 05:19:21. All times UTC on 2014 Dec 13 from Ravensmoor, Cheshire. The field of view is approximately 1.1°×0.7°.

a very faint trace of it was detected in my north-east facing meteor camera at position RA 16h 22m, Dec +30° 53'.⁶

The orbit of the payload (re-designated USA 259) has now been characterised and hobbyist satellite observers are keeping track of it. The Centaur booster was scheduled to reach a de-orbit area south of Australia 12 hours after launch. Bassa has used the full set of DSLR images to estimate the Δv that must have been applied to the booster as part of the CCAM and de-orbit manoeuvre, and in addition produced a series of composite images and an animation.⁷

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References

- [1 http://spaceflightnow.com/tag/nrol-35/](http://spaceflightnow.com/tag/nrol-35/)
- [2 http://www.satobs.org/seesat/Dec-2014/0068.html](http://www.satobs.org/seesat/Dec-2014/0068.html)
- [3 http://www.satobs.org/seesat/Dec-2014/0071.html](http://www.satobs.org/seesat/Dec-2014/0071.html)
- [4 http://britastro.org/node/5886](http://britastro.org/node/5886)
- Cees Bassa, *pers. corresp.*, 2014 Dec 15
- [6 http://nemetode.org/](http://nemetode.org/)
- [7 http://www.satobs.org/seesat/Dec-2014/0230.html](http://www.satobs.org/seesat/Dec-2014/0230.html)



Figure 1. Launch of NROL-35 on an Atlas V-541 rocket, 2014 Dec 13 (NASA).

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