

Falcon-9 stage 2 post-burn fuel dump observation from Australia May 10, 2018



Jim Oberg

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ROUGH REVIEW DRAFT

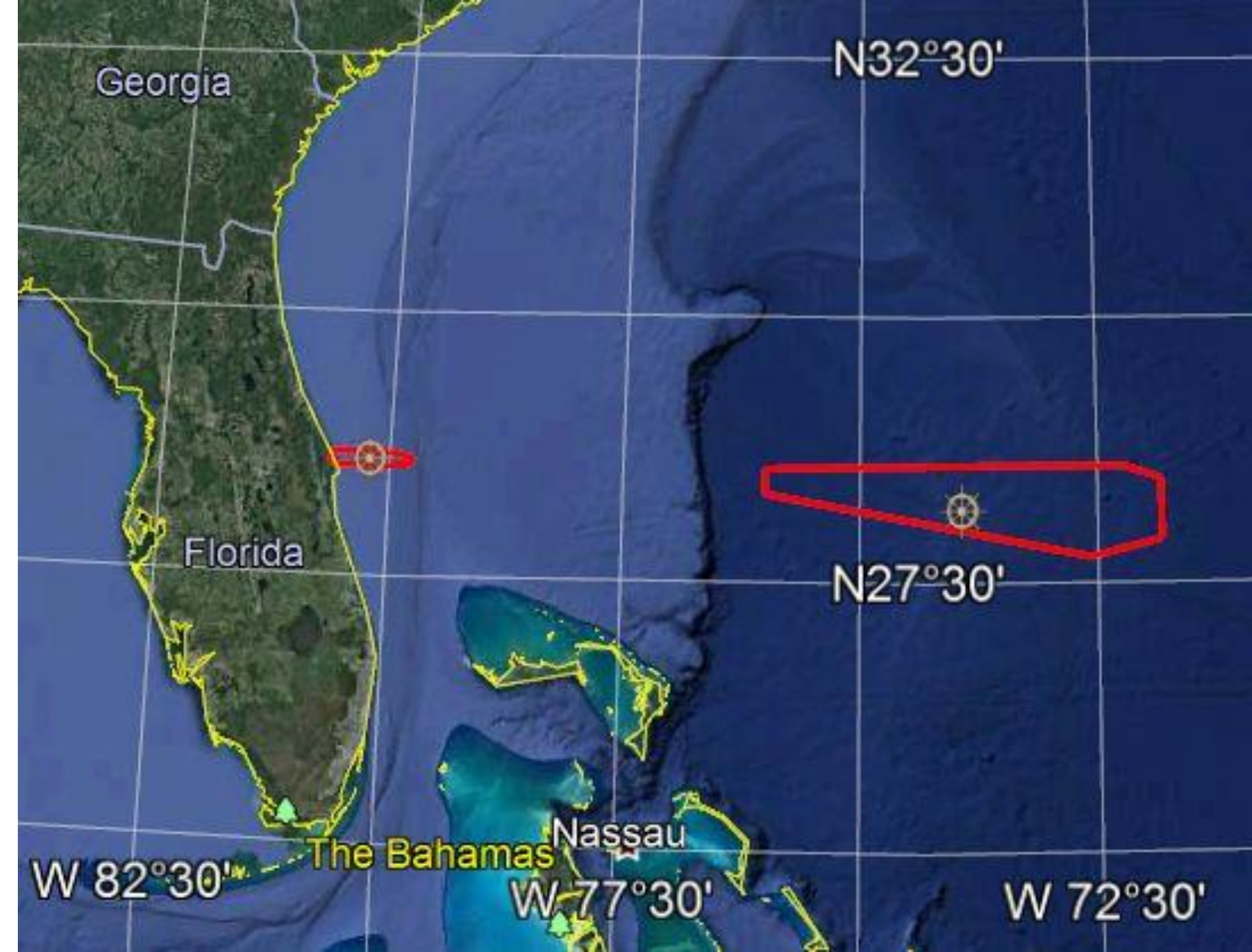
OUTLINE

- Accidentally-observed double-spiral fuel dump from Falcon-9
- Similarity to double-spiral observed on mysterious Zuma mission
- Preliminary results need rapid dissemination to sleuthing community
- Follow-up in progress, scheduled completion unknown
- **Ravi Jagtiani**and this establishes a spiral signature plume for stage 2 (it clearly wasn't zuma) passivation vents, almost like missile spin ups.

MISSION DESCRIPTION

- Updates <https://forum.nasaspaceflight.com/index.php?topic=45522.0>
- Falcon 9 Block 5 and Bangabandhu Satellite-1 went vertical on Pad 39A in Florida this morning. Now targeting liftoff at 4:42 p.m. EDT, 20:42 UTC – vehicle and payload look good, completing final check outs at the pad.
- **LAUNCH TIME:** May 10, 2018 at 17:47 EDT (2147 GMT).
- This launch has the second stage burn listed at 0:59.
- Bangabandhu Satellite-1 will be deployed into a geostationary transfer orbit (GTO) approximately 33 minutes after launch.

<http://www.spacex.com/sites/spacex/files/bangabandhupresskit5918.pdf>



STANDARD
DUE EAST
LAUNCH
TOWARDS
HIGH
ORBIT

MISSION ORBITAL PARAMETERS

00:27:38 2nd stage engine restarts

00:28:37 2nd stage engine cutoff (SECO-2)

00:33:38 Bangabandhu Satellite-1 Deployment

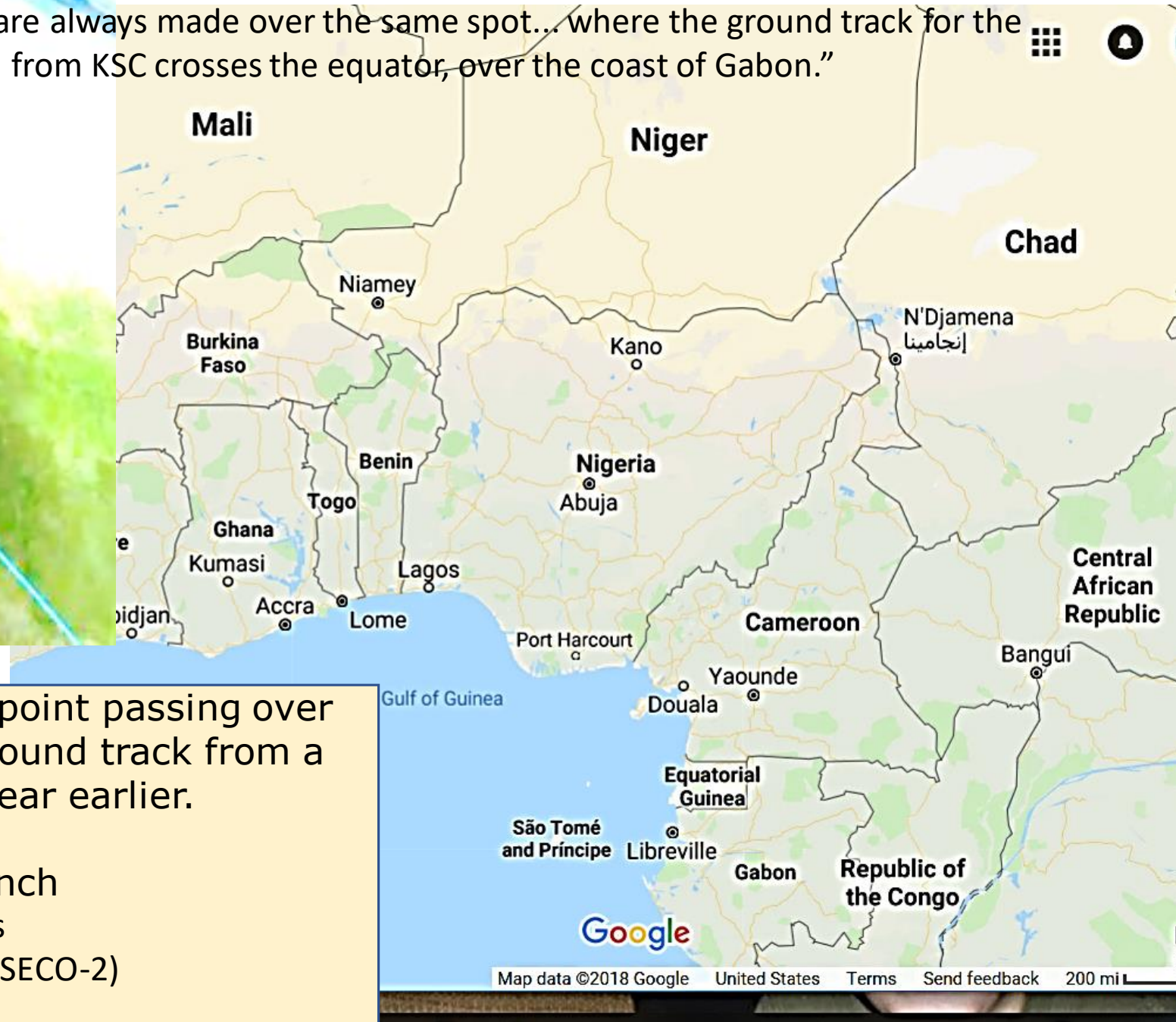
0 TBA - TO BE ASSIGNED

1 43463U 18044A 18131.91115988 -.000000088 00000-0 00000+0 0 9999

2 43463 19.3139 5.9439 7249088 179.1786 40.6444 2.29090380 00

2018-05-11 21:52:04.21 UTC - 308.49/35549.15km/19.3139°

“SpaceX GTO burns are always made over the same spot... where the ground track for the most optimal launch from KSC crosses the equator, over the coast of Gabon.”



Stage-2 relight at standard point passing over equator – this illustrative ground track from a previous similar mission a year earlier.

2018 May 10 2147 GMT launch

00:27:38 2nd stage engine restarts

00:28:37 2nd stage engine cutoff (SECO-2)

SPACEX LIVE LAUNCH COVERAGE 27M 38S

GTO INSERTION BURN STARTS

T+ 00:27:38

STAGE 2

TELEMETRY

SPEED

ALTITUDE



BANGABANDHU SATELLITE-1



SECOND STAGE ENGINE CUTOFF

SECOND STAGE ENGINE STARTUP 2

DEPLOY

SPACEX

SPACEX LIVE LAUNCH COVERAGE 28M 02S

GTO INSERTION BURN COMPLETED

T+ 00:28:02

STAGE 2	TELEMETRY
SPEED	ALTITUDE



BANGABANDHU SATELLITE-1

STARTUP MAX-Q STAGE 1 ENTRY BURN STAGE 1 LANDING
LIFTOFF MAIN ENGINE CUTOFF SECOND STAGE ENGINE CUTOFF

SECOND STAGE ENGINE CUTOFF

SECOND STAGE ENGINE STARTUP 2

DEPLOY

SPACEX

Hartebeesthoek
tracking station
should now
have AOS of the
vehicle.
[ACQUISITION
OF SIGNAL]



GROUNDTRACK
OF GTO ORBIT
LOOKS WEIRD
BECAUSE SAT
SLOWS AS IT
CLIMBS SO THE
EARTH'S
ROTATION RATE
SOON EXCEEDS
SAT GROUND
TRACK RATE,
CREATING AN
APPARENT
REVERSAL OF
MOTION IN
GEOCENTRIC
REFERENCE
FRAME



Photos taken
from here

TECH DATA FOR PRECEDING PAGE MAP

SATELLITE 43464 (18131.938: 53 min 59 s)					
TIME	Sat, 12/05/2018 03:07:11	Latitude [deg]	-16.46	Altitude [km]	12337.2
(UTC)	Fri, 11/05/2018 21:37:11	Longitude [deg]	114.63	Azimuth [deg]	355.5
Time Off	+13h 6m 42s (Past)	2458250.40083 JD		Elevation [deg]	66.7
Myanmar					

DEC J2000 [d m s]	-8 51 35	Sun El [deg]	-16.8 (Deep Night)
RA J2000 [h m s]	20 31 02	Loaded SAT	3
Magnitude	Undefined	Observer	(registered) 14547

Credit TBS

ACCIDENTAL CAPTURE OF DOUBLE SPIRAL

- Sandino Pusta to Perth Astrophotographers
- Yesterday at 6:01am
- Photos of rocket fuel dump from Falcon 9 launched 0400 12th May 2018 Perth time. I was doing a panoramic shoot when I noticed this swirl object. Didn't look bright on the naked eye. Thanks, Grahame and Luke for identifying this object.
- https://www.facebook.com/grahame.kelaher?fref=gs&hc_ref=ARTvnxlsF0efJWDMPSSAwyTiolrKiYq1xBgXDbeU87W4K43ReUYrF0Jt3hbWMcUe6_I&dti=340918889445429&hc_location=group



An amateur astronomer's routine sky survey photo



Sandino Pusta -- Wow, that is very interesting article you share on my photo. I have no knowledge about rocketry and it was just purely luck when I pointed the camera where the fuel dump. If you don't mind asking you sir, why did I saw/capture the fuel dump when I was located on the south west of Western Australia and the flight path more likely on Indonesia and Timor. Its far from Western Australia. Above the photo of flight path of F9 that was shared to me... The photos shared to Perth's Astrophotographers but my location was in Mount Hassell.

- TBS



In the webcast, SpaceX mentioned that the 2nd stage was spun up to a rotation of 1.5' per second prior to spacecraft separation - would this small spin cause the 'Zuma' like spiral fuel dump that Grahame captured in his photos, or is it more likely that this spiral fuel dump pattern is standard behaviour when bleeding down the propellant lines and tanks?

Paul G

<https://forum.nasaspaceflight.com/index.php?topic=42214.new#new1>



Assuming the camera time was correct of course; this is Perth local (+8)

ORBIT ESTIMATION

FIND_ORB Orbit Determination Software

Open... 2018-017A

Perturbers:

☐ Merc ☐ Mars ☐ Uranu
☐ Venu: ☐ Jupite ☐ Neptu
☒ Earth ☐ Saturn ☐ Pluto
☒ Moon ☐ Asteroids

All Perturbers Off

Epoch 2018 May 12

R1: 11571km AU
R2: 12833km AU

About...
Herget step
Full step
Vaisala
Auto-Solve
Save Residuals..
Save elements
Ephemeris...
Settings
Monte Carlo...
Stat Ranging
Simplex
Gauss

(null) 2018-017A
Perigee 2018 May 11.865134 +/- 0.00454 TT = 20:45:47 (JD 2458250.365134;
Epoch 2018 May 12.0 TT = JDT 2458250.5 Find_Orb
q 9605.25877 +/- 3508 (J2000 equatorial)
Peri. 203.90264 +/- 24
Node 8.19061 +/- 7
e 1.0118087 +/- 0.909 Incl. 17.03534 +/- 1.7
From 7 observations 2018 May 11 (4.8 min); mean residual 17".90

1805 11.89223	319	19 28 39.48	-07 27 15.4	5.1+	.90-
1805 11.89240	319	19 30 07.57	-07 28 30.8	20.8+	6.7-
1805 11.89258	319	19 31 37.03	-07 29 29.2	3.8-	5.9+
1805 11.89299	319	19 34 58.37	-07 32 01.6	37.9-	4.7+
1805 11.89336	319	19 37 58.62	-07 34 07.3	22.8-	3.7+
1805 11.89378	319	19 41 21.46	-07 36 27.7	43.1+	7.8-
1805 11.89557	319	19 54 27.81	-07 43 14.2	4.5-	1.1+

Αυξη ρεΓφύση

7 observations selected of 7
Mean RA residual 0.01 +/- 24.81; dec -0.00 +/- 5.04
2018 May 11 (4.8 min)
Version Mar 13 2016
No JPL DE ephemeris file loaded; using (slower) PS1996 series
See http://www.projectpluto.com/find_orb.htm#de_eph for
info on how/why to use JPL DE ephemerides

Here's a rough orbit determination using astrometry of the raw photos. Thanks Ravi for helping get the images to me. The result is a bit rough due to slight trailing of the stars, limited observation time span, and the approximate compensation for the amount the camera's clock was off, but it does roughly match the orbit of the spent upper stage.

Official TLE of the orbit. The argument of perigee, ascending node, and inclination are all roughly similar to the orbit computed from the images, but other factors like the eccentricity and apogee/perigee and orbital period are not well-confined by the limitations of the camera observations (which is why FindOrb shows the eccentricity as about 1 +/- 0.9!).

DISCUSSION

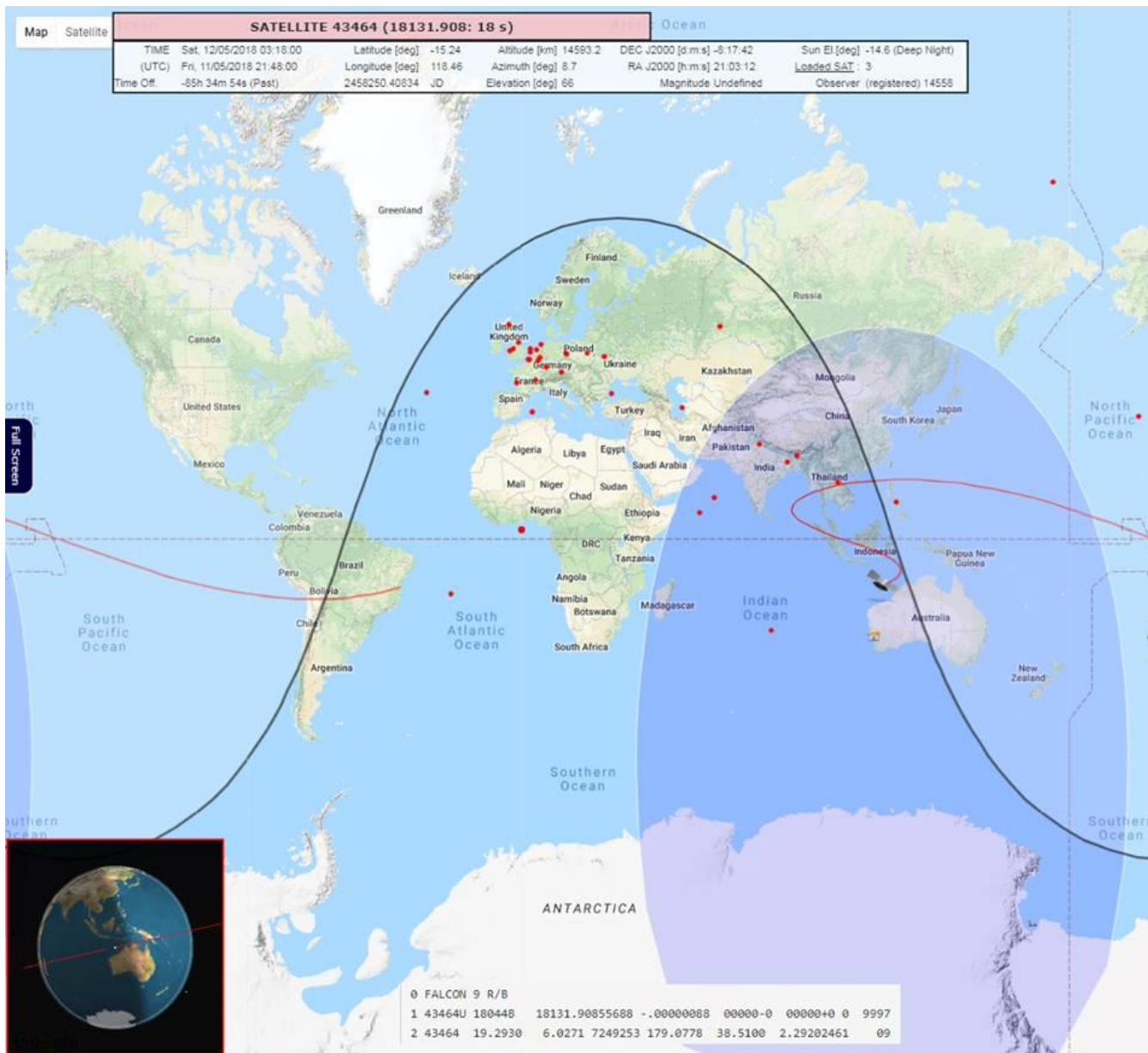
- Hi Ravi, I'll send a raw photo to your email.
Just wondering is there an anomaly with the flight, I read an article about falcon 9 fuel vent image vs zuma anomaly image, which both are different.
You accepted Sandino's request.
No, what's seen is a rocket spinning to void it's fuel by centrifugal force. hence the spiral which could be mistaken for a missile bus spin up. This is normal in these days.
cool, thanks. I've sent the photo to your email add provided
awesome, was there just 1 photo?
I managed to snapped 7 photos. You wanted them all?
was the spiral in all?
yup
yeah that would help
Also can you please explain how the time stamp works. Does it register only the start time of capture?.
Yes it only register the time of capture.
How long is the shutter open for?. It's a time lapse right?.
not a timelapse, I just did a series of photo. **Shutter speed was 10 sec** as I'm on 50mm lense.
I will include also a "plume"/"cloud" after the spiral.

On-line discussion

- [Αλεη ξεΓφυσον](#) Guidetoastronomy at gmail
- [η ξεΓφυσον Ravi Jagtiani](#) If wiki and spaceflightnow are accurate, then spacecraft sep happened at about 20:47, not 21:44.
<https://en.wikipedia.org/wiki/Bangabandhu-1>
Launch date 11 May 2018, 20:14 UTC
T+0:33:38: Bangabandhu 1 Separation
<https://spaceflightnow.com/.../falcon-9-launch-timeline.../>
If so, 21:24 for image start time seems reasonable.
- [avi Jagtiani](#) Awesome. I made a mistake adding.

On-line discussion 2

- [Λη ΓεΓΦυζον](#) Ok so here's a quick and rough orbit determination from the astrometry of his images:
<http://h.dropcanvas.com/2goew/bangabandhu1f9orbit.jpg>
I added 49 minutes to all of his EXIF times, but given that this is a fast mover and the imprecise nature of the timing info, slightly streaked stars, and given that I don't have his exact location (I used Perth Observatory as the location), the result has relatively high residuals in the astrometric measurements, particularly in right ascension (likely due to timing errors). Perigee distance for instance comes out as 9,605 km +/- 3508 km. But in general it is roughly consistent with the initial orbital elements of Bangabandhu-1.
- [Λη ΓεΓΦυζον](#) [Ravi Jagtiani](#) Ah, that makes the inclination a bit more accurate, but the uncertainty is still high along with the residuals, likely due to the trailed stars and uncertain timing. If I manually lined it up with astrometrica on one end of the star trails consistently through each image it might reduce the residuals a bit, but I think even the earlier determination is enough to say that it was the Falcon 9.



TBD

- At 21:48 UTC May 11th (orbital elements epoch). This is more like it. Altitude 14593 Km Az 8.7 Ev66

DISCUSSION

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- TBS