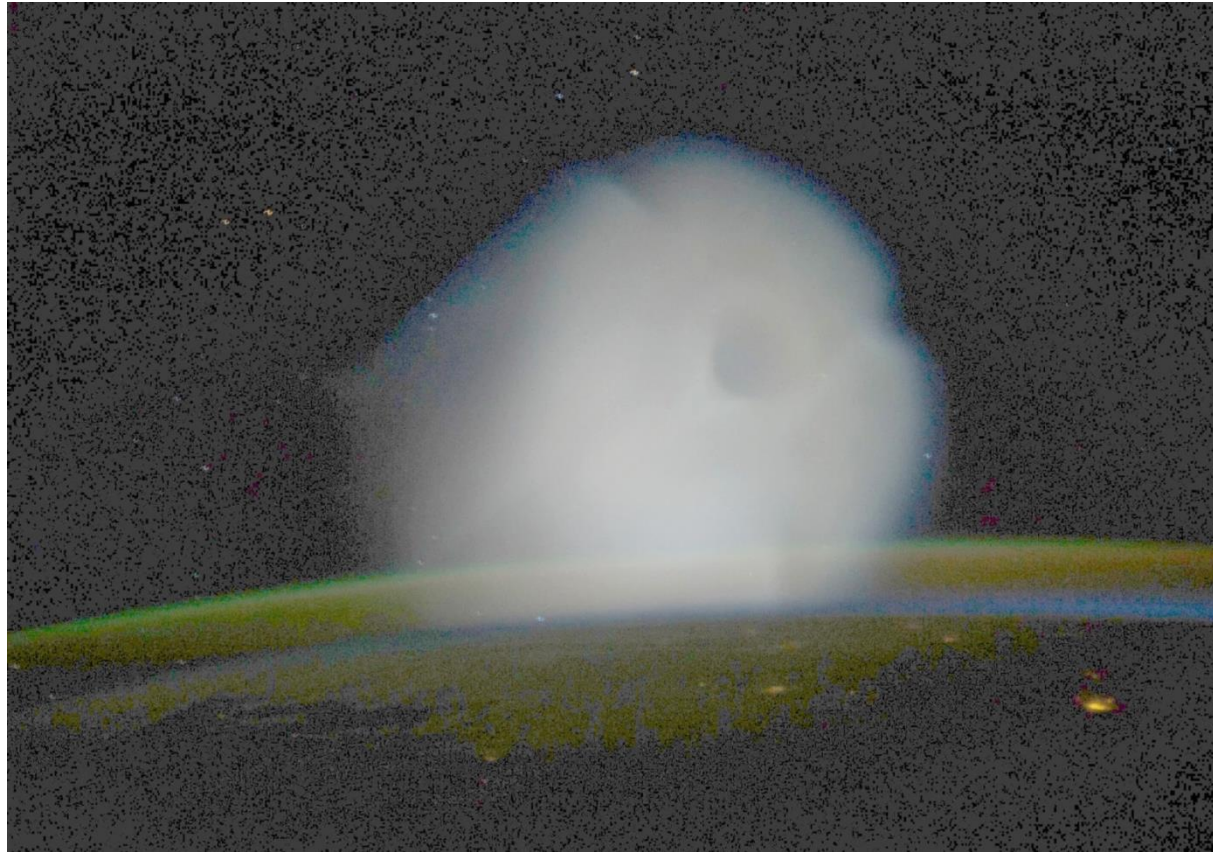


Russian Missile Launch Viewed October 10, 2013, from ISS Cupola

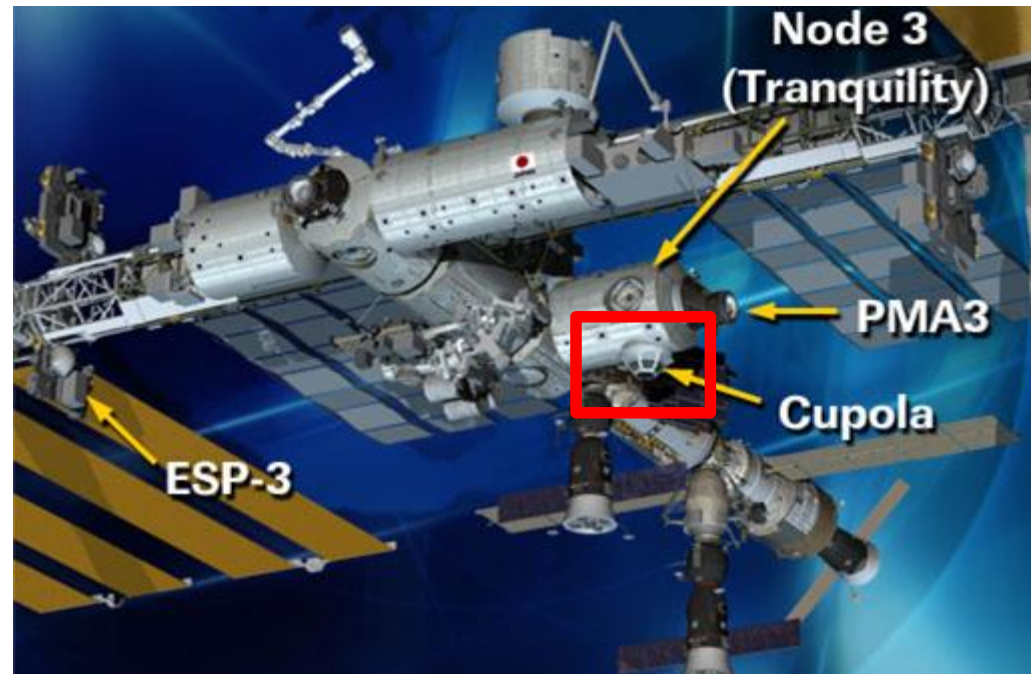


James Oberg // September 21, 2015 // DRAFT-1

overview

- Serendipitous reward of cupola use
- Exemplary crew reaction to the unexpected
- Extremely rare technological event involving upward-tilted solid-fuel plume 200 km long
- Images provided unique insights into Russian military missile research, including nuclear warhead bus configuration and sequencing
- Demonstration of proper NASA transparency

International Space Station “Cupola” observation module



Earth is 'down',
below ISS



Luca Parmitano on watch

Pre-launch interview in Houston, Parmitano and Oberg one-on-one

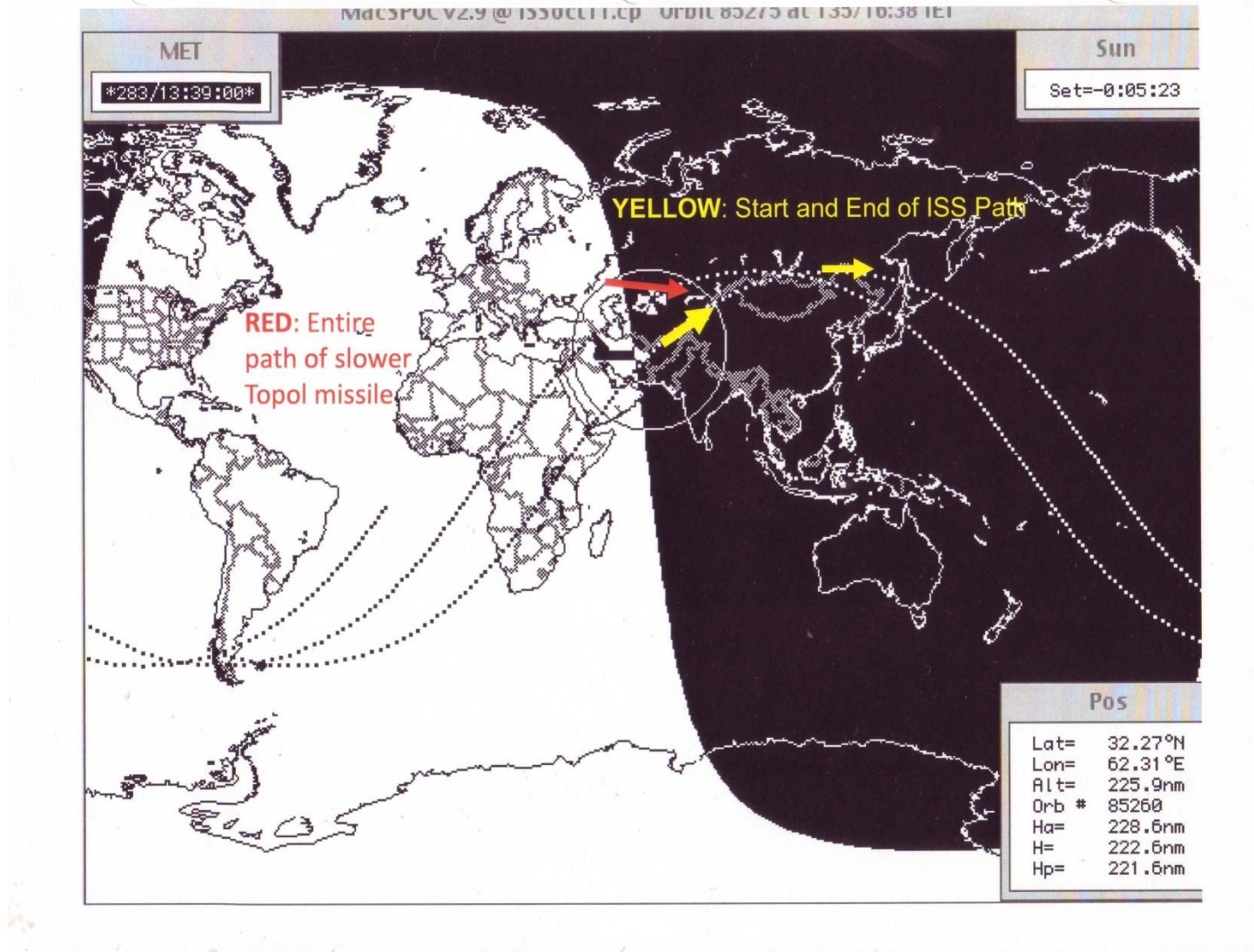


Unusual out-the-window apparitions – not discussed.

What happened:

- Fortuitous combination of station position, special illumination, and crewman observation
- Rare missile event in special military program creating plume tilted UPWARDS to the rear
- Caught by surprise, exemplary crew reaction to capture once-in-a-lifetime observation
- Widespread observation and imagery from observers on the ground in Russia, Kazakhstan, Uzbekistan
- Images crucial to characterizing trajectory and timeline of Russian nuclear weapon system aimed at the USA
- Most spectacular rocket launch EVER observed from International Space Station

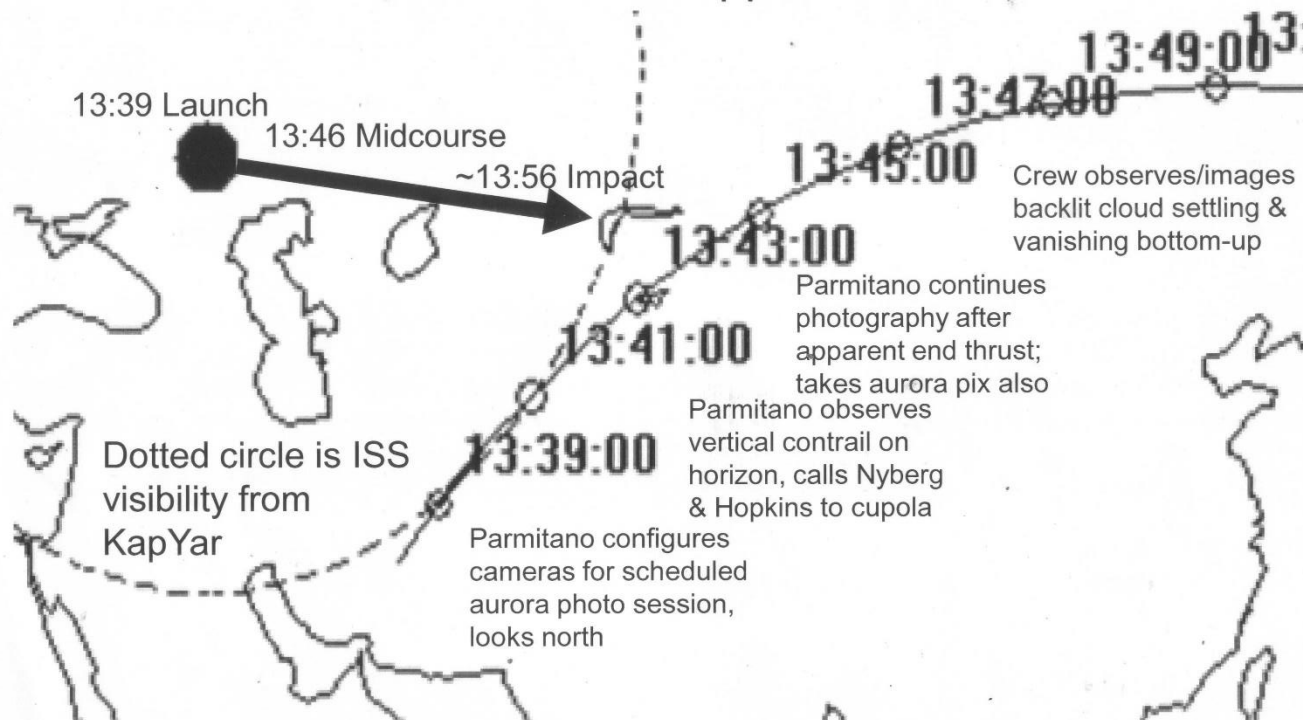
Rare illumination alignment – ISS just entered shadow, missile plume seen on western horizon backlit by sun



[DETAILED TIME-TAGGED RELATIVE MOTION ON NEXT PAGE]

Topol and ISS Relative Motion [October 10, 2013]

Note: ISS horizon is approx 2300 km



- Initial climb-out was precisely on NW horizon as viewed from ISS
- Midcourse dynamic events viewed in west [backlit by setting sun]

ISS orbiting at 8 km/sec, missile reached top speed of 6 km/sec, exhaust velocity of 3 km/sec meant plume was MUCH slower



Topol launch in 2005 from Kapustin Yar

- Missile is just emerging from erected transport tube
- Debris above fireball are jettisoned support brackets
- Transport tube erector strongback is visible
- Silo basing system emplaces transport tube into prepared below-ground well
- Transport tube system even for silos allows rapid reload



Luca Parmitano on October 10, 2013

Fortuitous ISS observation of 'Topol' ICBM test flight from Kapustin Yar. Two separate phases observed – first, initial ascent right on horizon [seen ~5 min after launch], then brief gap [1-2 minutes] to summon crewmates to the cupola, then second phase showing post-third-stage shutdown and exhaust plume dispersal aft and canted slightly upwards [unusual!!].



Ascent trail

Suspended zig-zag trail caused by crosswinds below von Karmen line [~ 100 km], is setting behind Earth horizon as viewed from the eastward orbiting space station, with setting sun just below western horizon.




First image [left], last image [right].

Horizon is 2300 km away.

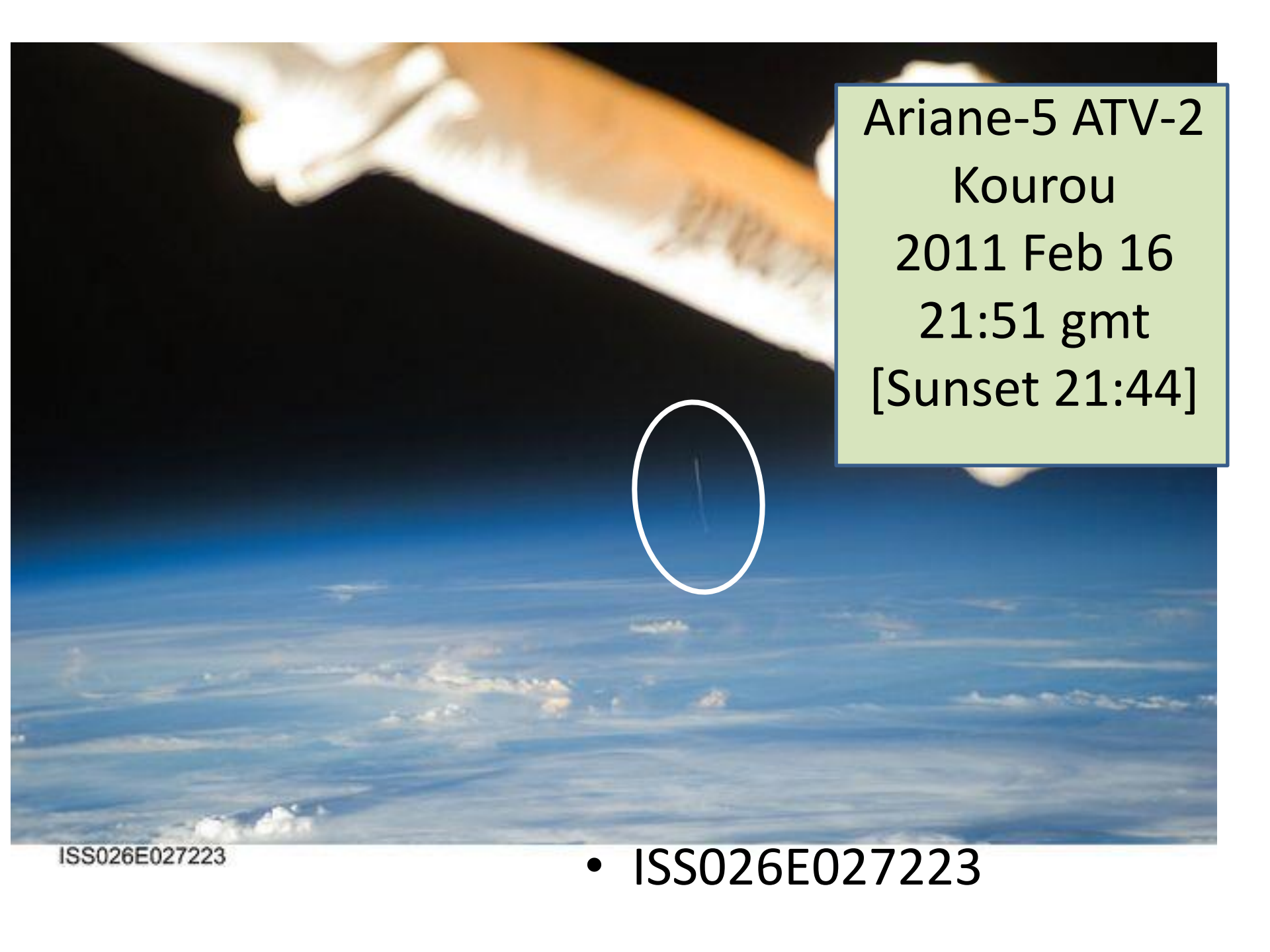
Extraordinary luck, excellent reflexes

- Rocket launches regularly observed from ISS but daylight views show dim smoke trail and night launches show wide diffused light glare.
- Twilight launches with rocket backlit by sun and station in darkness are quite rare – probably only a handful in last half century
- Examples of more common imagery follow

<http://www.space.com/25201-soyuz-launch-photos-expedition-39.html>



Astronaut Rick Mastracchio, aboard the International Space Station, tweeted this photo of the Soyuz rocket launching the Expedition 39 crew from Kazakhstan to the station on March 25, 2014 [21:17 gmt].
[sunset 14:05, sunrise 01:41]



Ariane-5 ATV-2
Kourou
2011 Feb 16
21:51 gmt
[Sunset 21:44]

ISS026E027223

• ISS026E027223

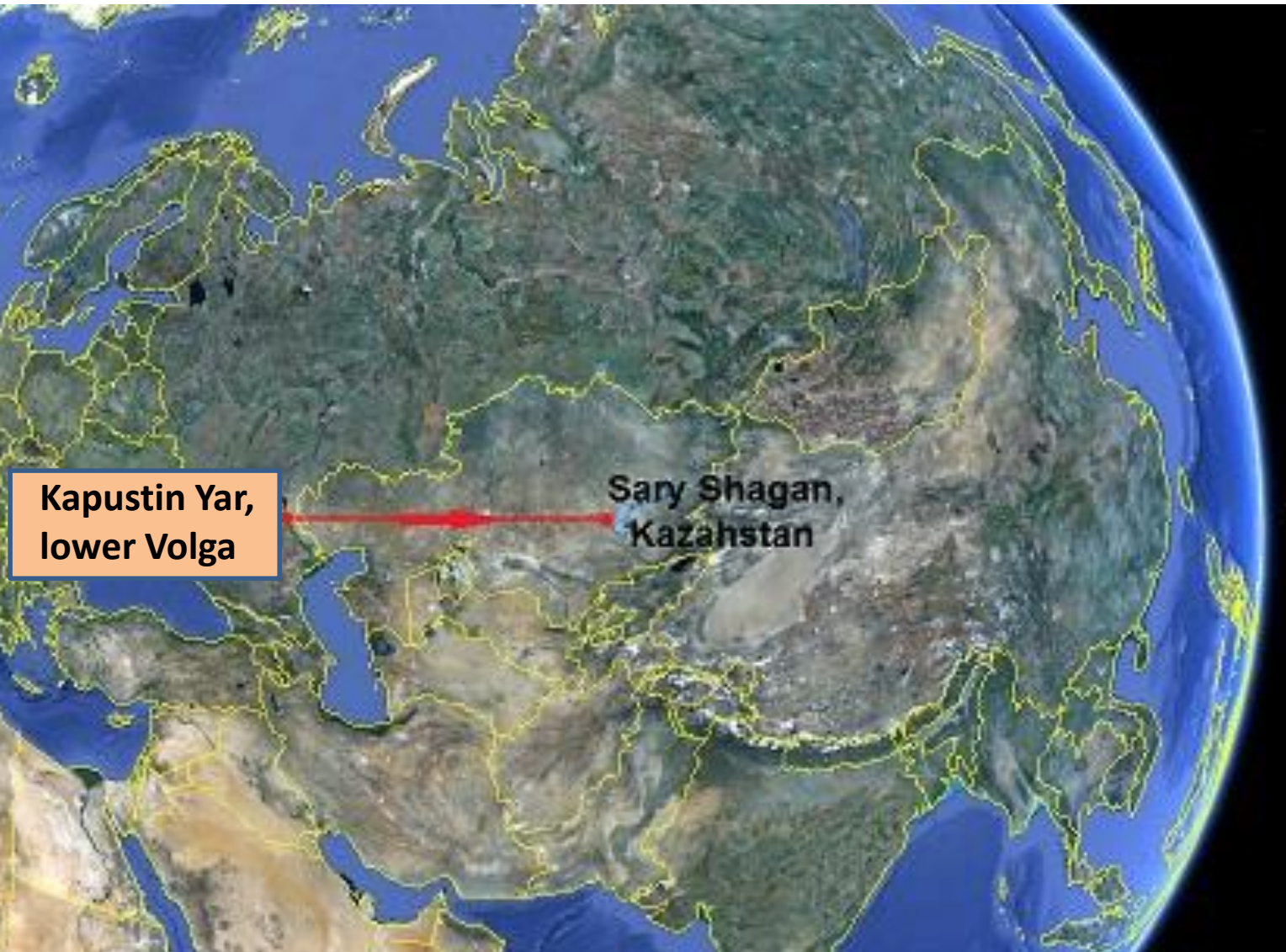
Soyuz Launch, Baykonur
2012 Oct 23 10:51 gmt
[sunset 13:49 gmt]



Follow-on plume views
possible – seeking them now

MISSILE GROUND TRACK

Kapustin Yar to Sary Shagan



What the Expedition-37 crew saw

- Parmitano spotted ascent plume [not imaged until 1-2 minutes after cessation of thrusting]
- Called fellow astronauts Hopkins and Nyberg into cupola, observed post-shutdown plume from third stage 60-second horizontal burn
- No indications the three Russians saw anything





@astro_luca

Luca Parmitano

Follow @astro_luca

A missile launch seen from space: an unexpected surprise!

<http://t.co/mbWI209ELv>

October 11, 2013 6:47 am via web Reply Retweet Favorite

"An immense cloud forms outside the atmosphere after the disintegration" of a missile stage



- Luca Parmitano / ESA via Twitter
<http://pic.twitter.com/PshgE1W7CJ>

Mike Hopkins tweets one of Luca's shots, upside down.



@Astrollini

Mike Hopkins

 Follow @Astrollini

Saw something launch into space today. Not sure what it was but the cloud it left behind was pretty amazing

<http://t.co/dPJc9XXDZm>

October 10, 2013 9:21 pm via web [Reply](#) [Retweet](#) [Favorite](#)



- Hopkins tweet rotated with horizon at bottom

Parmitano's blog description:

- I am in Cupola again and I am setting-up a camera on a window overlooking the north. The Station is operating under working hours so all the lights are on. My next Crew Earth Observation target is the Aurora Borealis. **To avoid reflections from the Station's lights I build a tent to obscure the area around the camera.** I have already entered all required parameters in the camera, including the estimated time of the aurora. With a little luck I should be able to photograph the sequence even without being physically present behind the camera: at that moment I will be engaged in another activity.
- [more]

Parmitano 2 of 4

- Sunset is fast approaching. The gold and orange light that reflects off the solar panels attract my attention and I cannot look away until my eyes focus on an image that is foreign to nature: **smoke emerges straight and clear on the horizon**, accentuated by the last rays of the Sun. Nature does not like straight lines, and this inconsistency has guided my vision. I'm looking at a launch of something, I do not know what and I do not know where, but it is definitely a launch. I do not know what my chances are of seeing the launch of a suborbital object when I did not know the launch details beforehand but instinctively I would say they are very slim: an extraordinary case of being in the right place at the right time!

Parmitano 3 of 4

- Karen and Mike are above me in Node3, and I dare to look away for a moment to call them. They both float into the Cupola and we share the little space to observe the object as it follows its path through the upper layers of the atmosphere. **Its trail is now at the mercy of the stratospheric winds which distort the shape, transforming it into a series of segments that twist,** starting from the ground till it reaches the blackness of the stellar vacuum. I take one of the cameras and hope that the automatic settings will be enough to take good pictures, despite the light from the sunset starting to fade. I stop shooting only when the Sun is completely gone, but I do not stop looking. The object disintegrates before our eyes, and hundreds, probably thousands of kilometres away, we see a cloud of transparent white gas expand growing ghost-like, in all directions until it flattens when it meets the atmosphere.

Parmitano 4 of 4

- We wonder what we just witnessed, but even Houston ground control fails to explain.
- In the evening, we discover that it was the test launch of a Russian intercontinental missile launched from Kazakhstan. All three of us are surprised by the incredible coincidence that allowed us to observe such a rare event. We are not sure what to think. For my part, I am pleased to add another valuable piece to the only true collection I have, the only one that is worth anything: my memories.

Internet within hours

BAD ASTRONOMY

THE ENTIRE UNIVERSE IN BLOG FORM

OCT. 11 2013 11:58 AM

No, This Isn't a Movie: Russian Missile Lights Up Space Station's Sky

By Phil Plait



NANCY ATKINSON – UNIVERSE TODAY – UFOS – 10/11/13 1:00pm

39,473 🔥 84 💬

What on Earth created this bizarre jellyfish-cloud outside the ISS?

- http://www.slate.com/blogs/bad_astronomy/2013/10/11/russian_topol_missile_test_spotted_from_iss.html
- <http://io9.com/what-on-earth-created-this-bizarre-jellyfish-cloud-outs-1443885400>
- <http://www.universetoday.com/105457/missile-launch-creates-weird-cloud-seen-in-space/>

Monday morning – US media catches up

▶ **UFO? Astro ghost? Find out what that spooky space cloud really was**

Alan Boyle, Science Editor, NBC News

Oct. 14, 2013 at 3:19 PM ET



Astronauts See Strange Cloud in Space from Missile Launch (Photos)

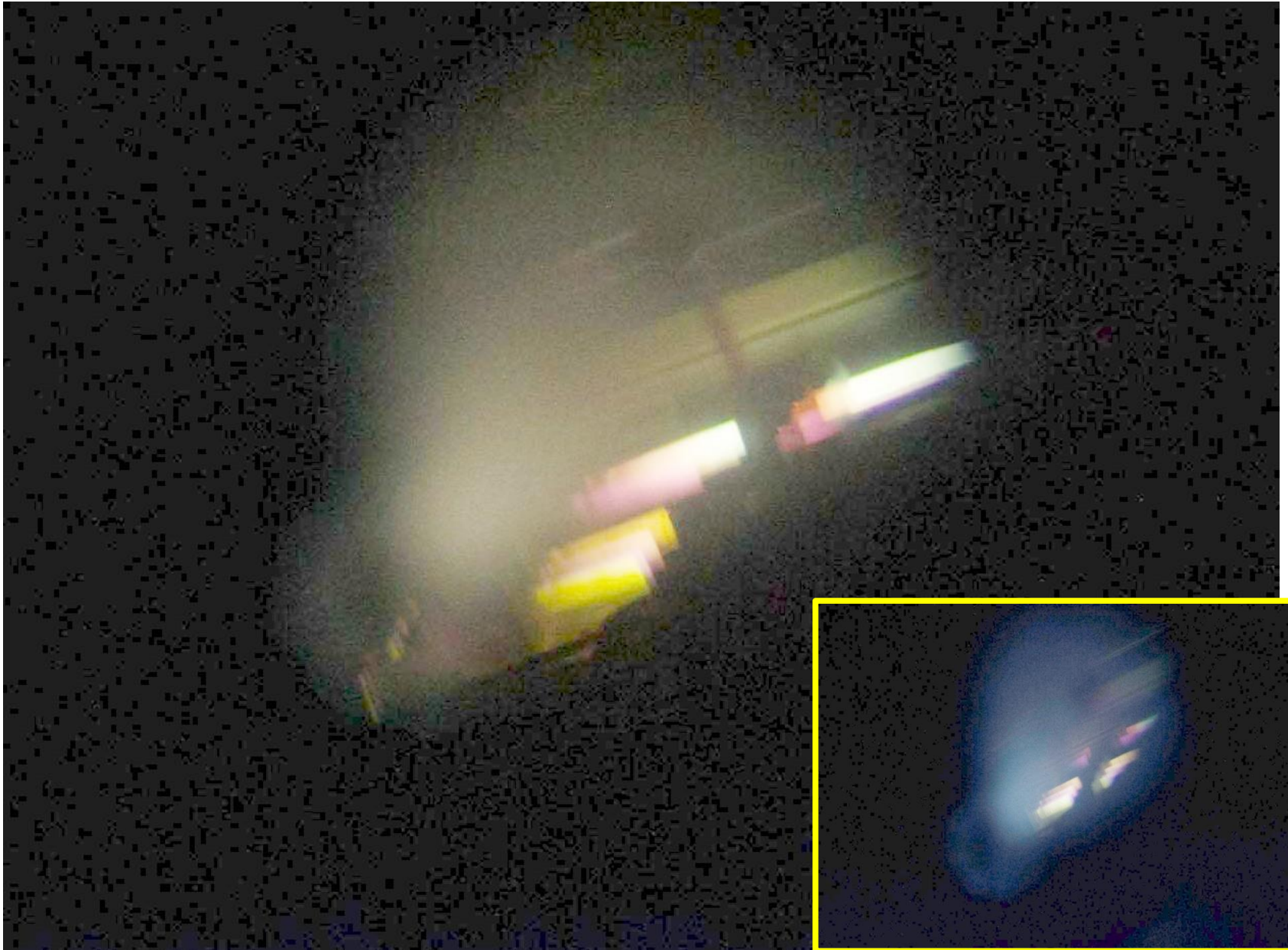
by Miriam Kramer, Staff Writer | October 14, 2013 05:32pm ET

Mystery missile – 137 images!!

- 203 -- 224 contrail
- 225 – 233 v. dim with in-cabin reflections
- 234 – 248 dim shapeless cloud
- 249 – 331 bright sharper with steady shape
- 322 – 323 aurora
- 324 – 328 cloud completing setting
- 329 – 331 aurora
- 332 – 339 cloud completed setting

FOIA filed with NASA-JSC to release all images plus photo data including clock time of exposure, exposure settings, other encoded technical specifications, plus crew written descriptions, along with all [if any] communications between MCC-H and Russian space officials about this and similar crew observations.

Second sequence begins [time gap unknown]

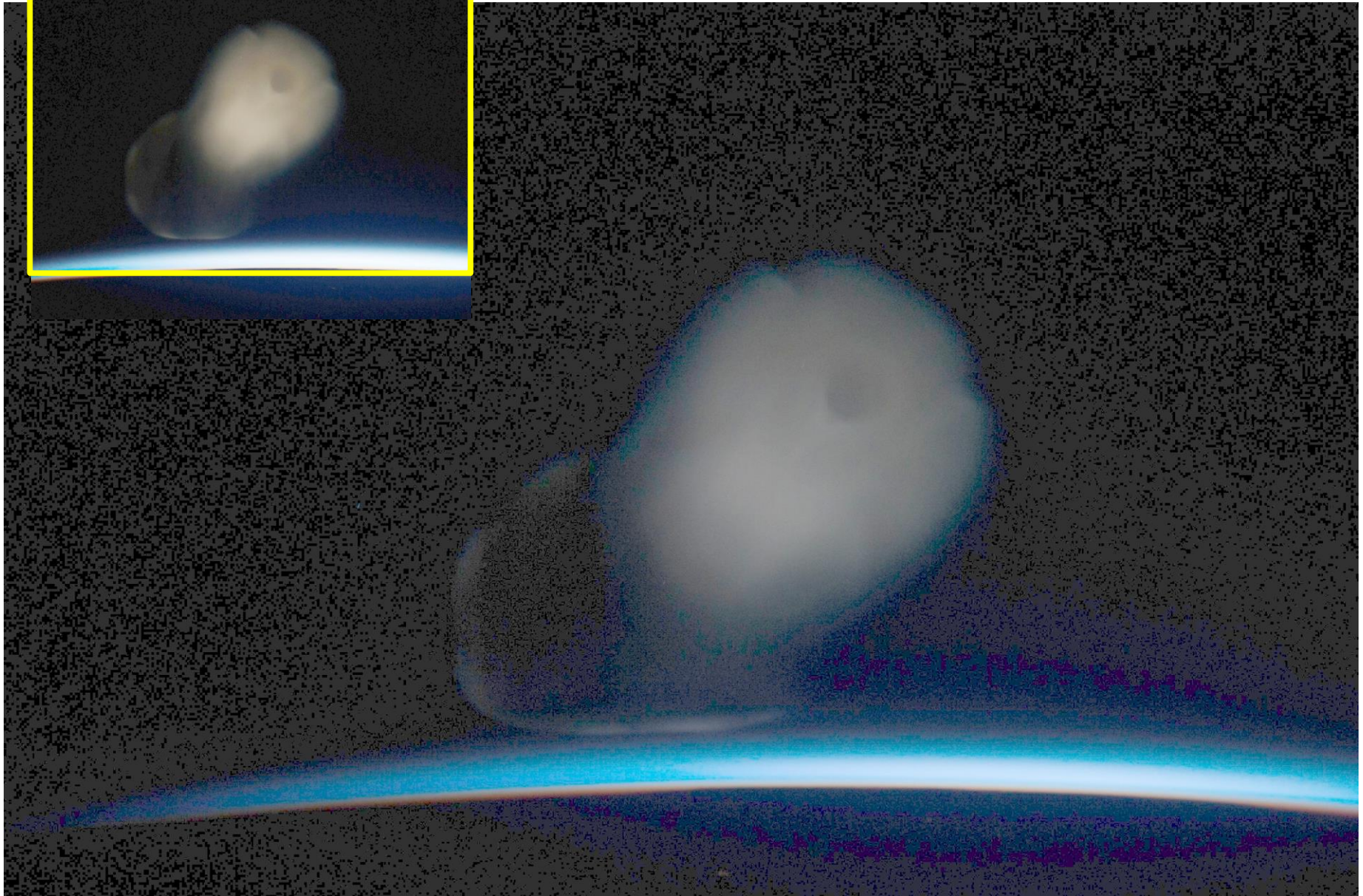


ISS 'cloud' sequence starts with spiral ring already just deployed
[overbrightened; cabin reflections on earliest shots]



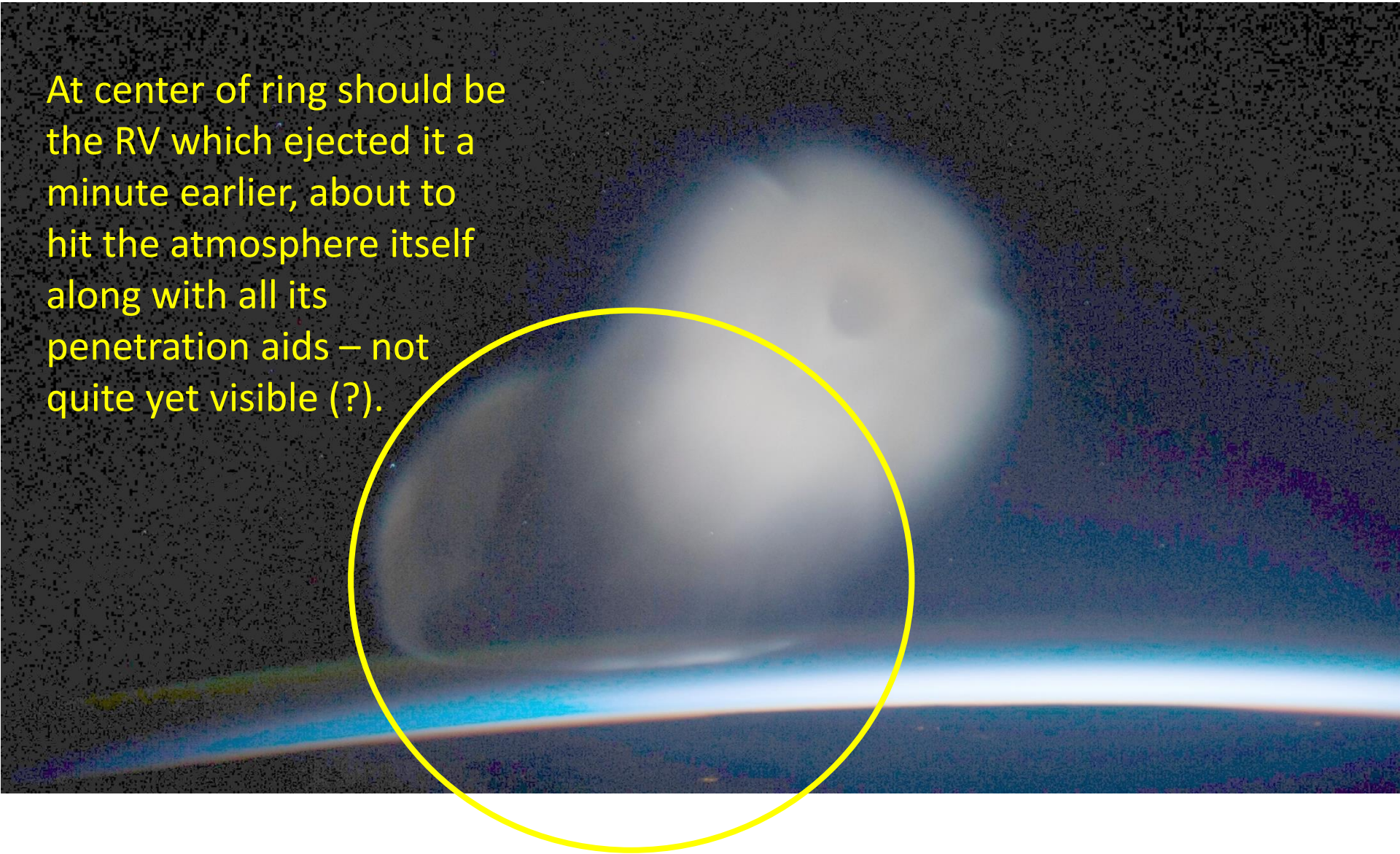
- View is from front $\sim 45^\circ$ off +V vector
- Trailing edge is sharp, although dimmed by thinning
- Persistent feature is black circle at center of aft end
- Sharper images show outer aft circumference indentations apparently at 90° intervals
- Steady-state persistence suggest these are plume shadowing features related to vehicle/thruster structural features

Ring expulsion [brightness enhanced]



Terminal descent as spinup ring's bottom flattens as it encounters upper atmosphere

At center of ring should be the RV which ejected it a minute earlier, about to hit the atmosphere itself along with all its penetration aids – not quite yet visible (?).



Ground view of
same propulsive
event from Russia,
Omsk region



- <http://www.superomsk.ru/upload/medialibrary/2ee/2eec15301cf783c41bf87d50e5b6a9a0.jpg>

Vitaliy Davidenko [[Виталий Давыденко](#)] -- Omsk video tripod mounted zoomed, with overhead street wires to allow precise motion analysis of cloud post spiral. 41 seconds, until full fade.



<https://www.youtube.com/watch?v=DmkliggobNg>

Spiral from Tashkent, Uzbekistan



Clearly indicates object diving onto target

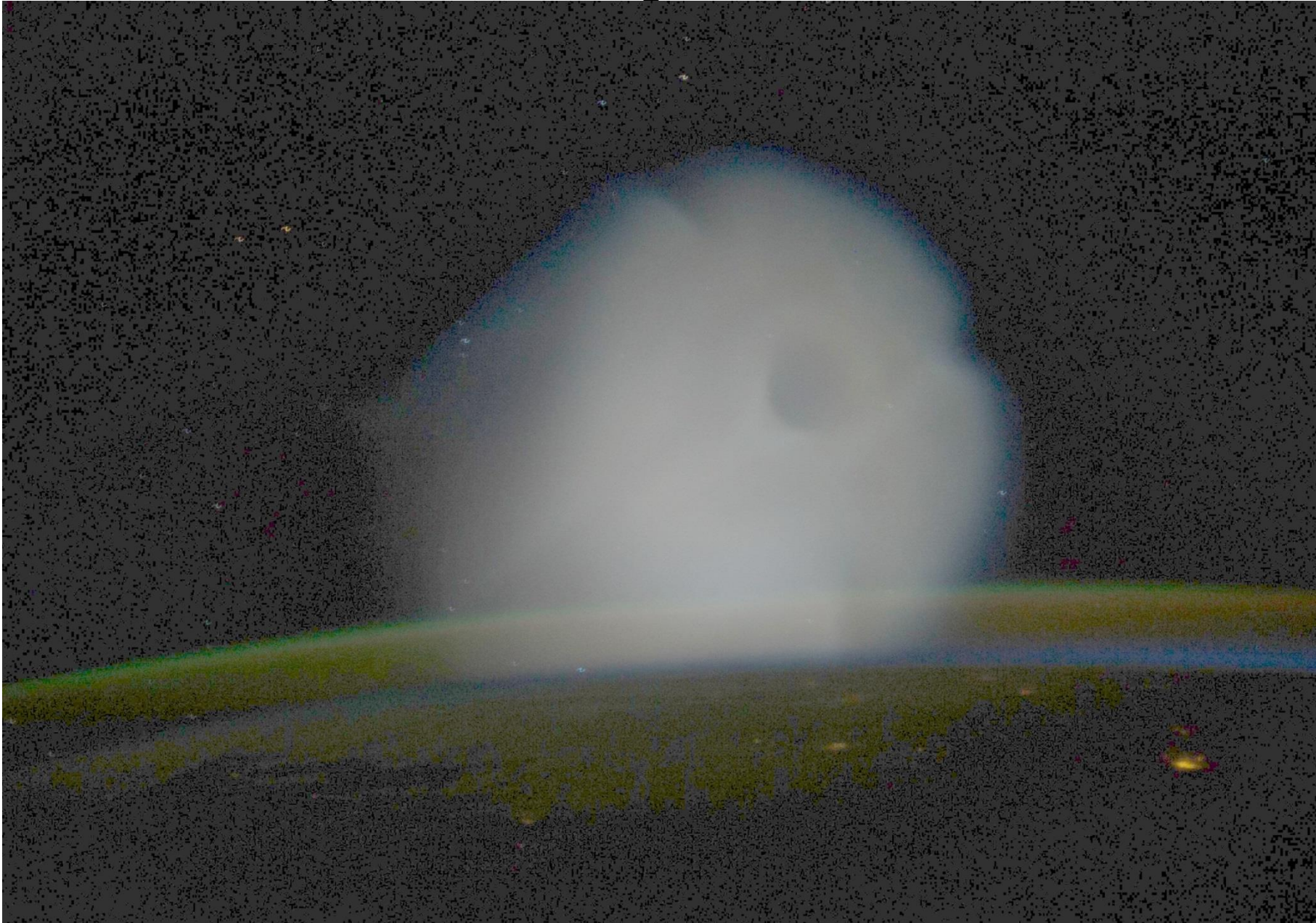
Estimated velocities

- 2nd stage cutoff 3500 m/sec, alt ~200 km, climb angle ~45 deg
- 180 second coast to ~450 km altitude
- NOTE: Nominal ISS altitude is 400 km
- Horizontal velocity ~2500 m/sec
- Third stage burn takes it from 3500 m/sec to 6000 m/sec in 60 sec [4 G's accel]
- NOTE: ISS orbital velocity ~8000 m/sec
- Exhaust velocity [$I_{sp} = \sim 300 \text{ sec}$] = ~3000 m/s

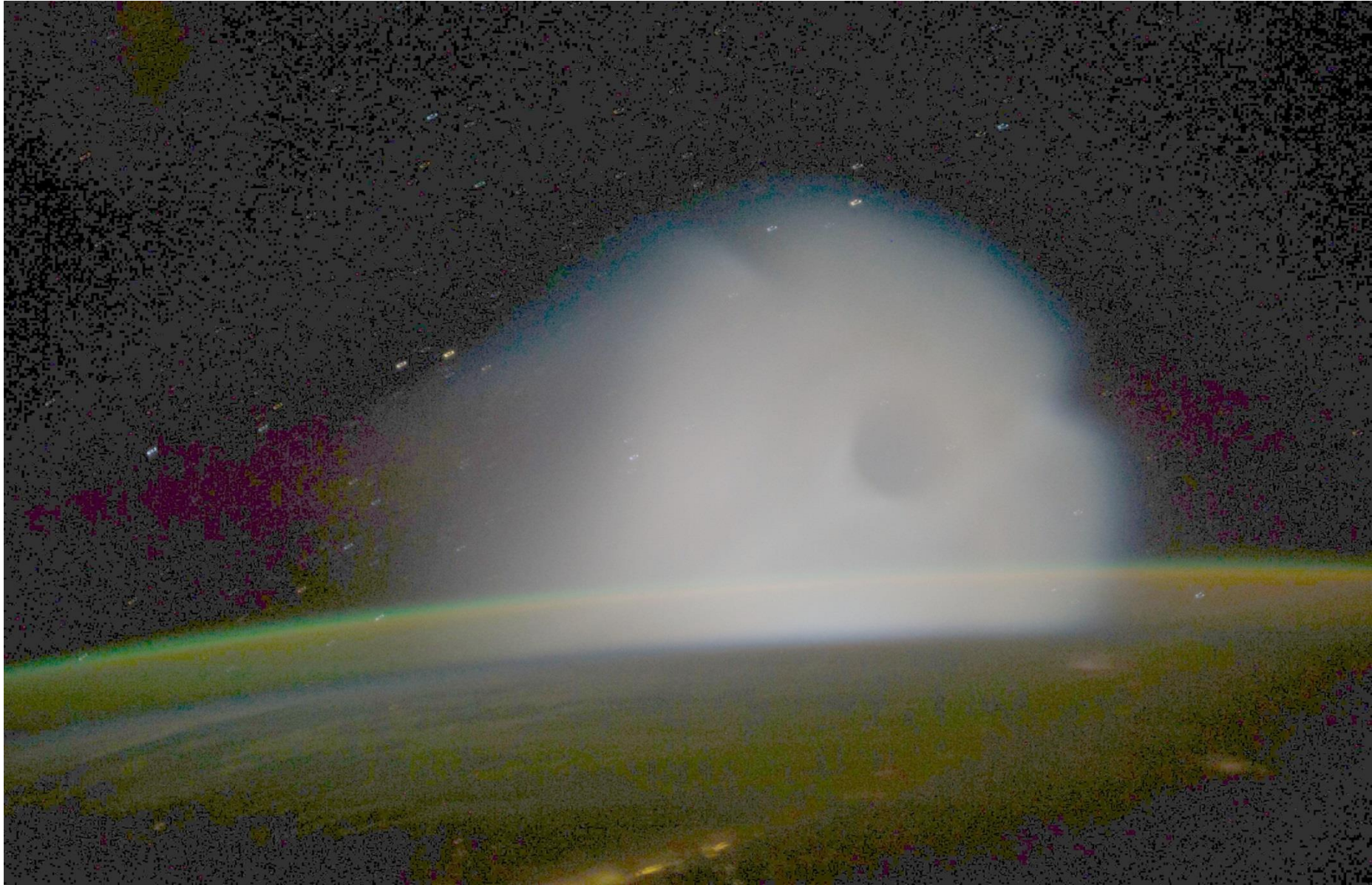
Free-fall motion of plume particles

- Third stage burn vector depressed $\sim 15\text{-}20$ deg
- Initial plume particle horizontal vel = ~ 2900 m/s
- Initial plume particles actually pushed backwards
- Plume width $\sim 20\text{-}25$ deg so upper plume particles have vertical component $\sim 700\text{-}800$ m/s, will free-fall rise >60 sec by about 20 km
- As 3rd stage accelerates plume will 'paint forward' as tail remains stationary while expanding, and plume will thin gradually as particle horizontal velocity gets larger due to faster-moving point of origin
- At end of burn, apex of plume appears to sharply truncate and expand ['blunt tip'] while still lengthening
- This is exactly what is seen in side views from ground

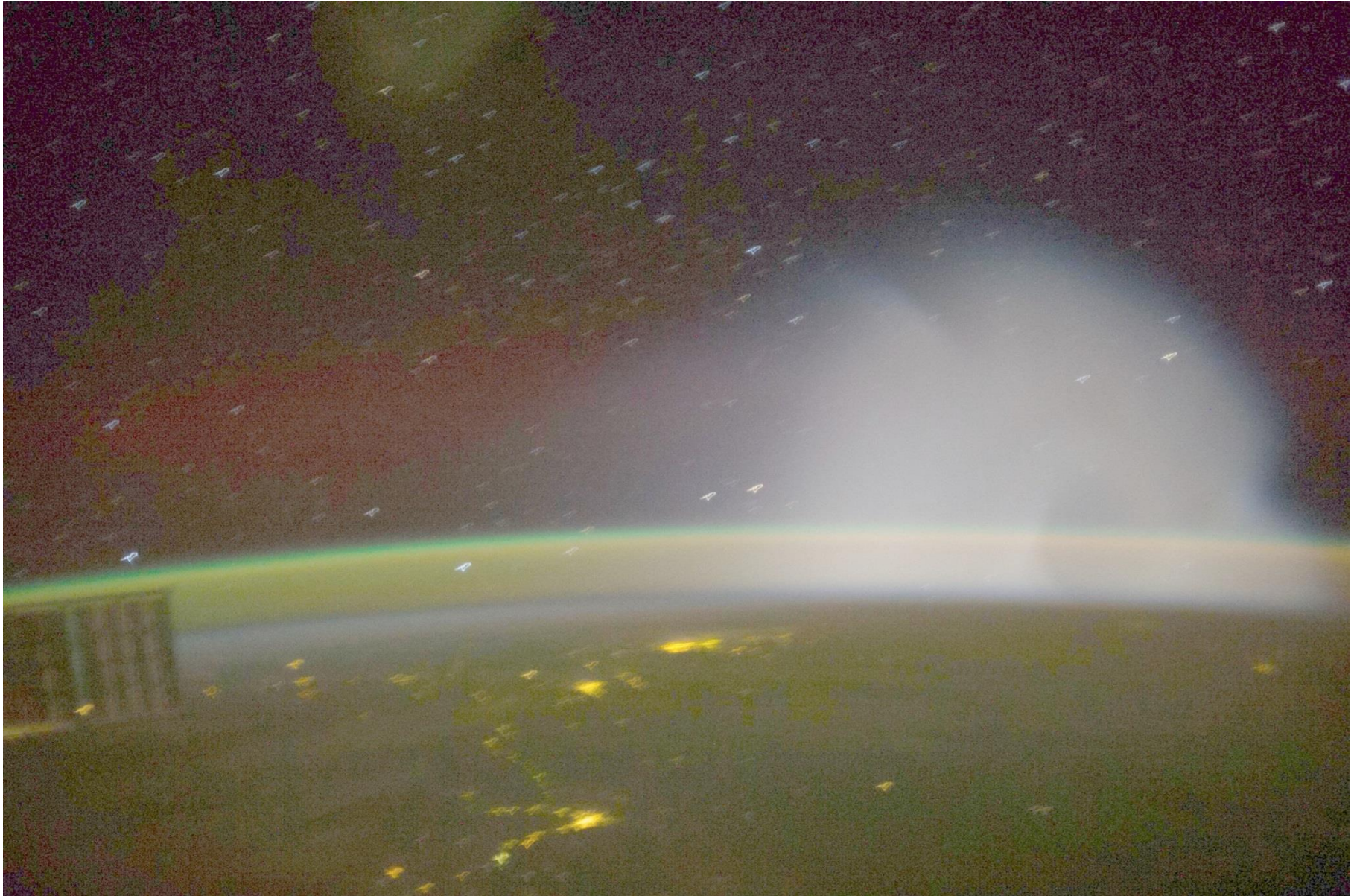
ISS view -- plume cloud begins to set behind horizon



Plume cloud continues to set behind horizon



Setting [continued], ISS structure appears



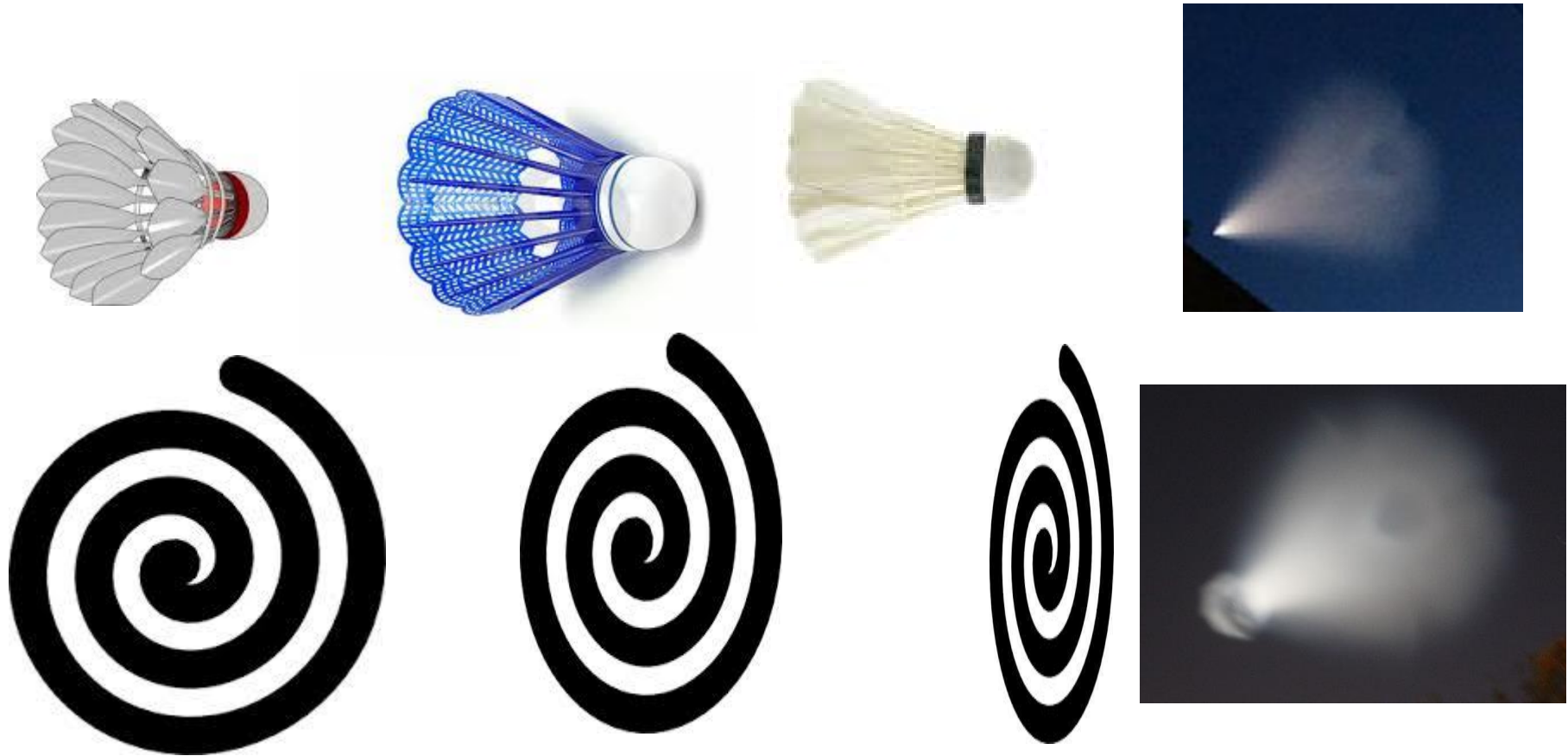
Continued.....



Final shot [#136]

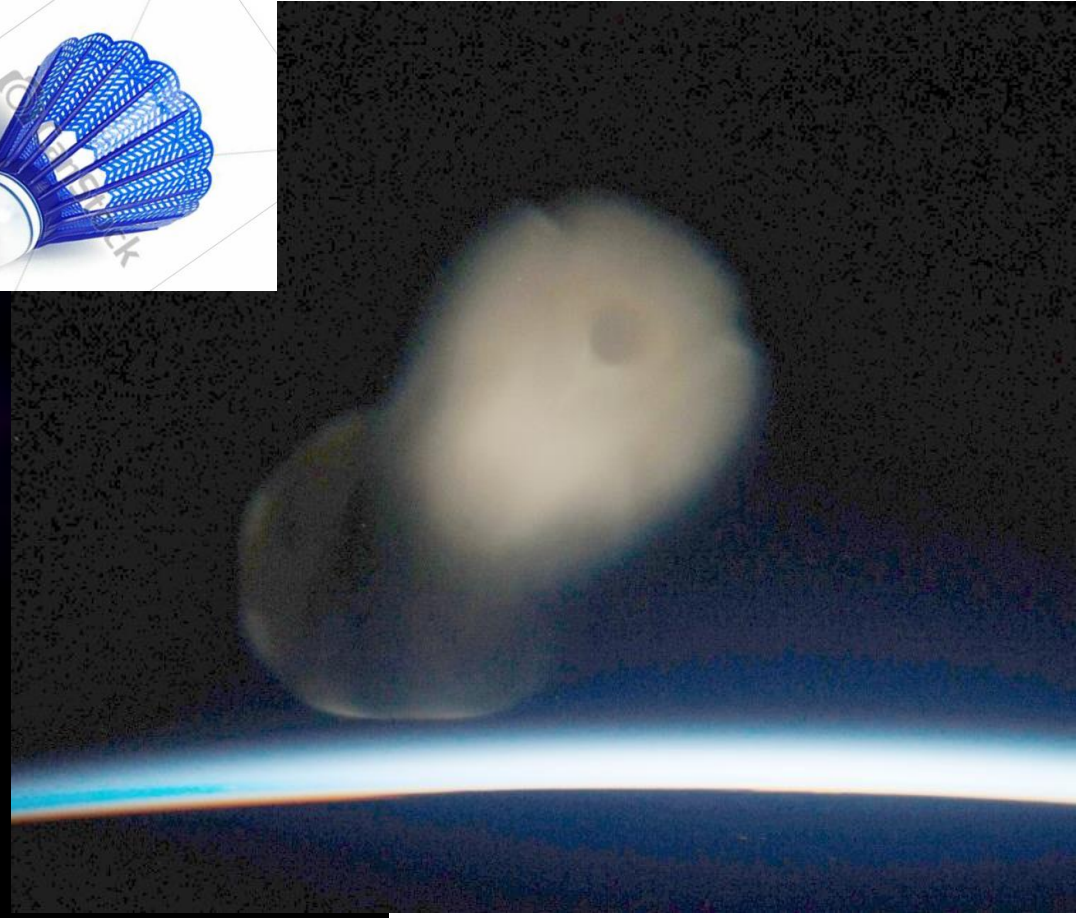


Visualizing the 3-D plume structure



Three dimensional 'shuttlecock' from different angles,
then briefly surmounted by rotating flat spiral that
expands into segmented circle and fades

Simo front view of post-spiral plume



- [left] Astana, ground
- [right] ISS, 440 kilometers
- See also Chelyabinsk viewpoint <http://www.youtube.com/watch?v=IIOmLxScS30>

Topol trajectory – Kapustin Yar to Sary Shagan [from Russian newspaper, 2005]



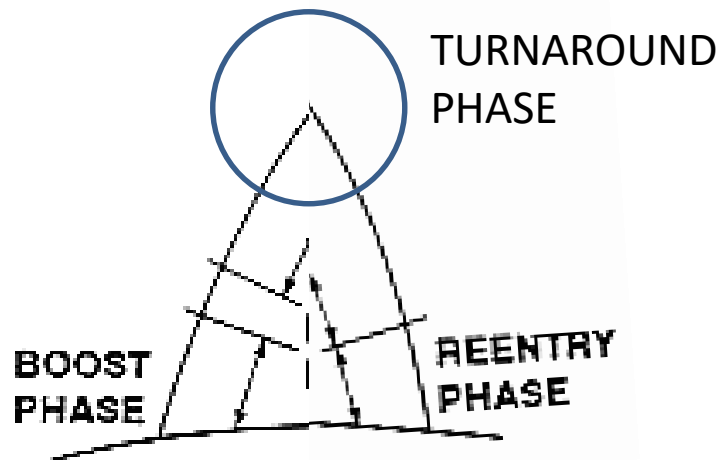
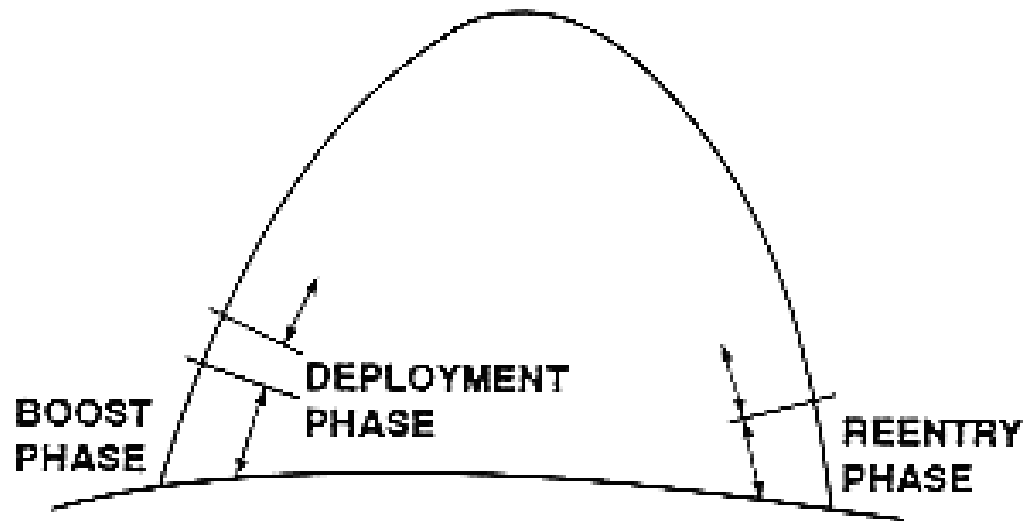
- 1. Rocket launch and climb-out
- 2. Separation of first stage
- 3. Separation of second stage
- 4. Deployment of maneuverable warhead module
- 5. Warhead altitude maneuver
- 6. Warhead course maneuver
- 7. Warhead dodges enemy missiles
- 8. Sidestep defenses
- 9. Detonation

US analog – VAFB launch

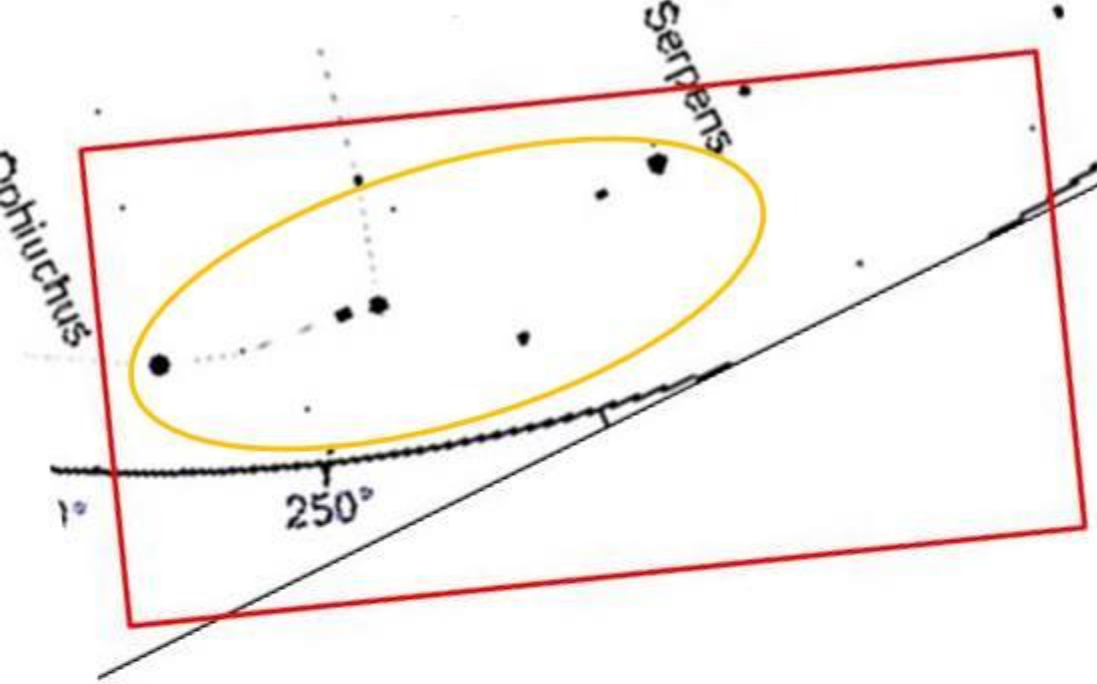


- Image copyright Rick Scott
- Plume slopes down as US rocket continues to climb to orbit
- ISS view of Russian missile shows it DIVING onto radar range
- Entire plume is created, lingers [>200 km long]
- Dissipates for several minutes as it falls back into atmosphere

How the shorter range is performed



Normal high-G ascent for first two stages, then insert 180-second delay as stack coasts higher, conduct 3rd stage burn angled downwards to get on nominal end-of-mission profile.



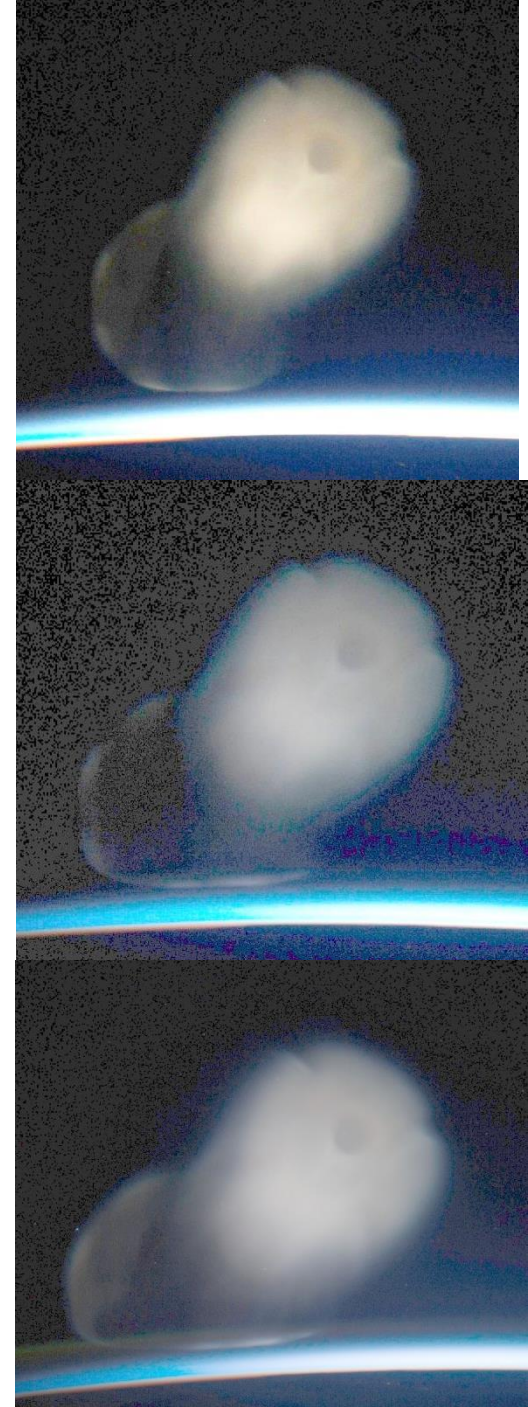
© Luca Parmitano / ESA

Star match-up
verifies ISS-cloud
viewing azimuth
and also provides
angular scale for
images, which
when combined
w/ range [based
on occultation by
horizon] gives
absolute scale
[yellow oval
narrow diameter
is 10 deg].

End-of-thrust spiral view from ground and ISS



- [Above] Omsk view shortly after spiral ejection with fan front falling behind [moon in lower left]
- [Right] ISS sequence [bright enhanced] with ejected ring apparently impacting atmosphere





Posting at space exploration group



New Russian ICBM Test -- Visible as UFO?

page: 1

★★★★★★★★★
posted on Oct, 10 2013 @ 02:50 PM

 link  quote  reply

Russia just test fired a Topol icbm from the Kapustin Yar range on the lower Volga, to the Shary Shagan impact zone in Kazakhstan. In the past such launches have been seen over a wide area, as far away as Israel and Syria, and reported as UFOs.

This launch occurred about an hour before sunset at the launch site, so it would have been much harder to see. Regions farther east, where the sun had already set [say, around Omsk] would have darkened western skies but a back-sunlit launch contrail and then the typical brief spiral of warhead bus spinup.

If the weather was clear, we might expect some spectacular videos to show up on youtube and rutube. Keep an eye out for them.

In cities, crowds on the street....



<http://www.youtube.com/watch?v=3ilgesHH9fg>

Eye/camera directions allow estimate of object elevation

KY-SS family of Topol launches

1. 2005 Nov 01 1710 gmt [sunset + 4h33m]
2. 2007 Dec 08 14:43 gmt [sunset + 1h41m] ???
3. 2009 Dec 10 1235 gmt [sunset + 34m] SEEN
4. 2010 Dec 05 1911 gmt [sunset + 7h09m]
5. 2012 Jun 07 1739 gmt [sunset + 43m] SEEN
6. 2013 Oct 10 1339 gmt [sunset - 39m] SEEN +ISS
7. 2013 Dec 27 1730 gmt [sunset + 4h33m]
8. 2014 Mar 04 1810 gmt [sunset + 3h25m]
9. 2014 May 20 1708 gmt [sunset + 31m] SEEN
10. 2014 Nov 11 ???? [rumored failure]
11. 2015 Aug 22 1513 gmt [sunset - 45m] SEEN

ISS sighting was third case where such a flight had been widely seen and taped

- 2009 Dec 10 1235 gmt, third mission, by coincidence one day AFTER sensational “Norway spiral UFO” freaked out entire world, so the NEW “spiral UFO’ from Russia was widely interpreted in that context.
- 2012 Jun 07 1739 gmt, 5th mission, was seen throughout southern Russia, Caucasus, Iran, as far south as Syria, Israel, and Jordan, and final spiral was particularly clear.
- 2013 Oct 10 1339 gmt, sixth mission, was widely seen in Urals, Volga valley, eastwards into Kazakhstan and Uzbekistan, and most amazingly, by chance, by the crew of the International Space Station, who took photographs of ascent plume and of post-spiral plume dissipation.

Two visible phases of flight

Launch on the lower Volga River,
two minute ascent. smoke trail

Three minutes later, Kazakhstan,
fan-shaped cloud grows for 60
seconds, then spits spiral, fades.

NO VISIBLE CONNECTION BETWEEN
TWO WIDELY-SEPARATED APPARITIONS



Uniqueness of KYSS plume

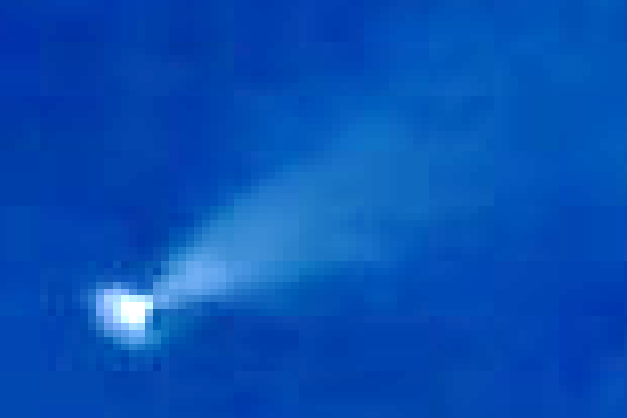
- Under post-sunset illumination conditions, pops out suddenly in front of witnesses who have NEVER seen anything remotely like it in their lives
- Seen from side as expanding triangular shape, often with distinct features [e.g, hole in tail]
- Plume is high [1200-1500 km] and already fast [~ 4 km/sec] horizontal, slight DOWNWARD pitch, but at great distances its angular rate is low
- Exhaust velocity approx 2800 m/sec, so during 60-second burn, reaches length of ~ 165 km with fading but still discernable trailing edge
- After relatively slow, level movement, terminates with sudden spiraling 'starburst' or 'splash', and then vanishes within seconds, without a trace

Apparition is entire thruster plume

- What is being seen is the sunlit cloud of expelled combustion products for the full burn
- Rocket with typical missile 'specific impulse' of 290 sec ejects at speed of approx 9,000 ft/sec
- 60-second firing creates cloud > 100 miles long
- Plume is longer and thinner in front because missile is continuously accelerating at 100 ft/s/s so actual length is closer to 140 miles
- At burn start, already moving approx 12,000 f/s so even ejected combustion products move fwd

Spiral Concluding Phase

- Thrusting and lengthening of gown from the head, visible tapering and hollow center
- Brief [1-2 second] dynamic spiral [more than one trail] with small gap to point of fan
- Expanding spiral ring and rapid separation of spiral center from blunt head of fan
- Rapid dimming with expansion of combustion products fan



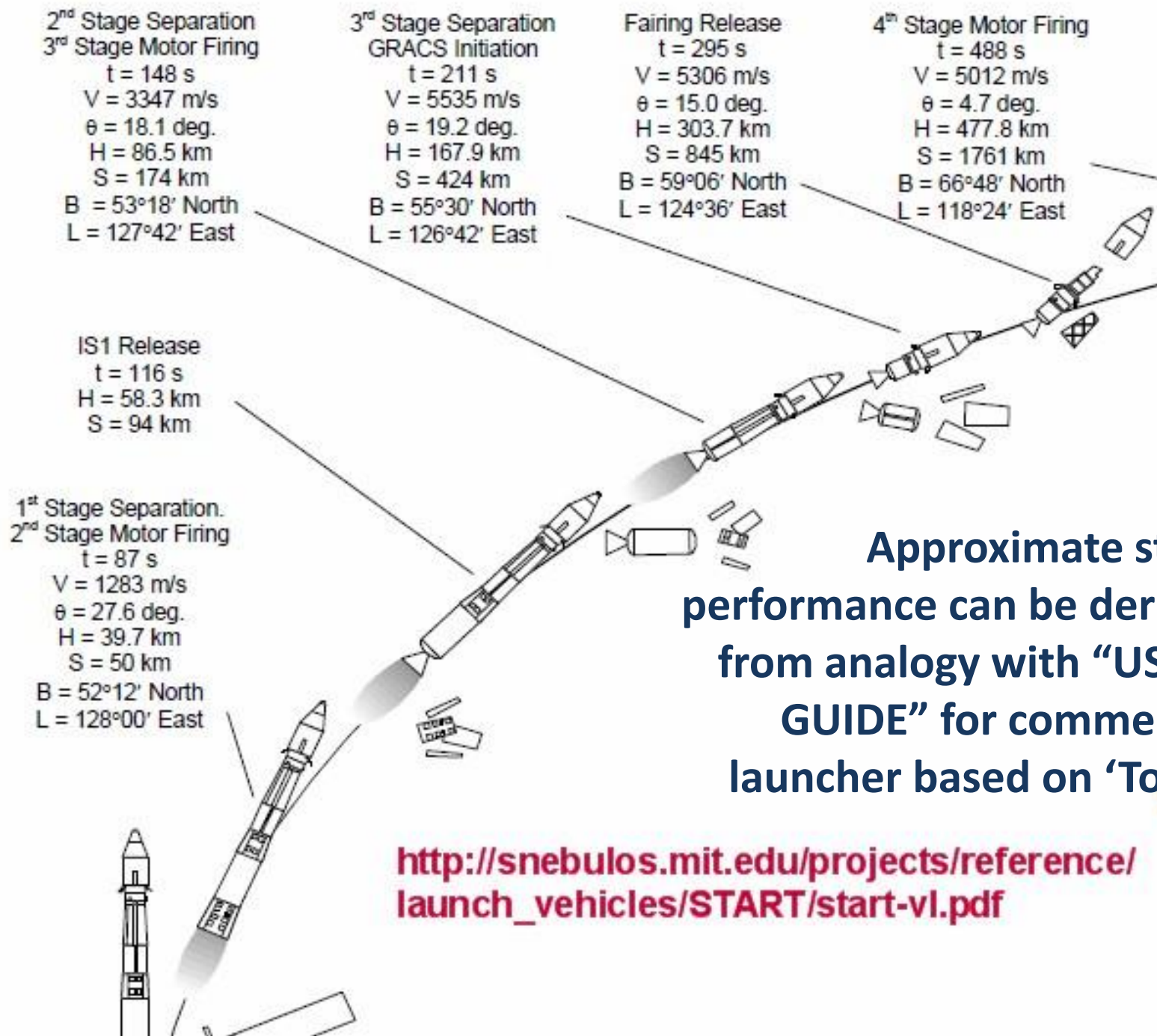
“Aguarius21” – best images of spiral EVER
[8 seconds of spinup motor]



Triple plume completes about one full rev prior to fade-out
<https://www.youtube.com/watch?v=AHX6IU7NcO0>

US ICBM equivalent spin-up maneuver





Approximate stage performance can be derived from analogy with “USERS GUIDE” for commercial launcher based on ‘Topol’

http://snebulos.mit.edu/projects/reference/launch_vehicles/START/start-vl.pdf



Commercial model of 'Topol' ICBM

Small satellite launcher
configuration carries fourth
stage plus bus and payload,
a bit heavier than original
nuclear warhead cargo

In the late 1990s there
were 4 successful flights

- http://snebulos.mit.edu/projects/reference/launch_vehicles/START/start-vl.pdf

“Topol-Start” three-stage performance

1st Stage Separation.

2nd Stage Motor Firing

$t = 87 \text{ s}$

$V = 1283 \text{ m/s}$

$q = 27.6 \text{ deg.}$

$H = 39.7 \text{ km}$

$S = 50 \text{ km}$

2nd Stage Separation

3rd Stage Motor Firing

$t = 148 \text{ s}$

$V = 3347 \text{ m/s}$

$q = 18.1 \text{ deg.}$

$H = 86.5 \text{ km}$

$S = 174 \text{ km}$

3rd Stage Separation

$t = 211 \text{ s}$

$V = 5535 \text{ m/s}$

$q = 19.2 \text{ deg.}$

$H = 167.9 \text{ km}$

$S = 424 \text{ km}$

Flight phase max G-load

longitudinal/lateral

$nx1$

$ny1, nz1$

1 TLC Erection and Launch

2.8

2.0

2 1st Stage Motor Burning

5.15

0.7

3 2nd Stage Motor Burning

6.5

0.6

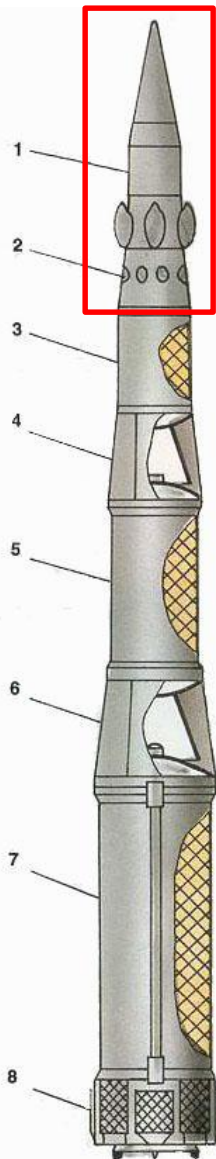
4 3rd Stage Motor Burning

6.5

0.4

Heavier front end, so third-stage burnout velocity, altitude, and range are somewhat lower than the ICBM configuration. Various stage guidance options will create different altitudes, downrange distances, and flight path angles.


Topol stages, without warhead



Конструктивно-компоновочная
схема ракеты РС-12М:

1 - головная часть; 2 - переходной отсек; 3 - маршевый РДТТ III ступени; 4 - соединительный отсек II ступени; 5 - маршевый РДТТ II ступени; 6 - соединительный отсек I ступени; 7 - маршевый РДТТ I ступени; 8 - хвостовой отсек I ступени.



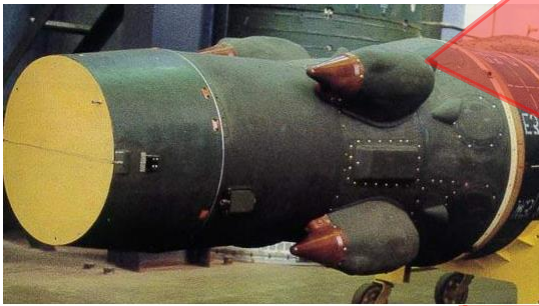
- Three stages PLUS 'battle stage'
- Four circumferential thruster units
- Warhead to be mounted at right 

Thrusters [?] on ICBM 'battle stage' [different missile]

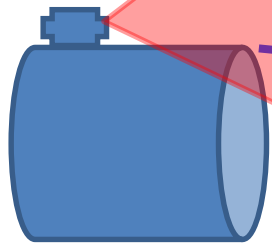


- Via Ed Kyle

Partial shadowing of stage thruster plumes -- notional

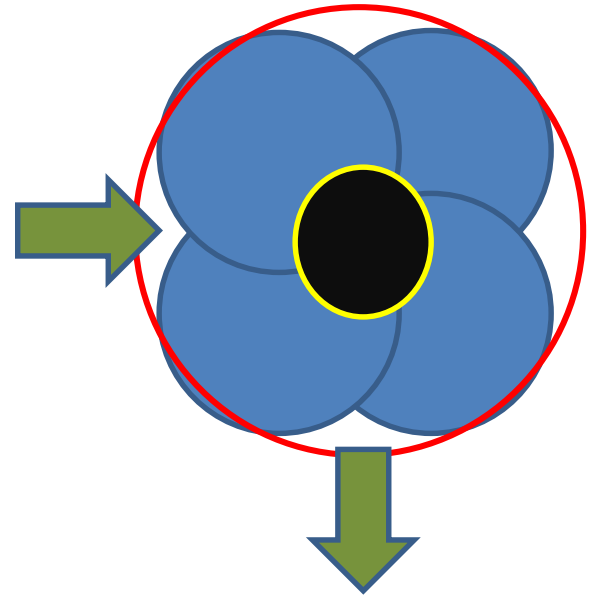


Thruster and plume



Region shadowed by stage aft structure

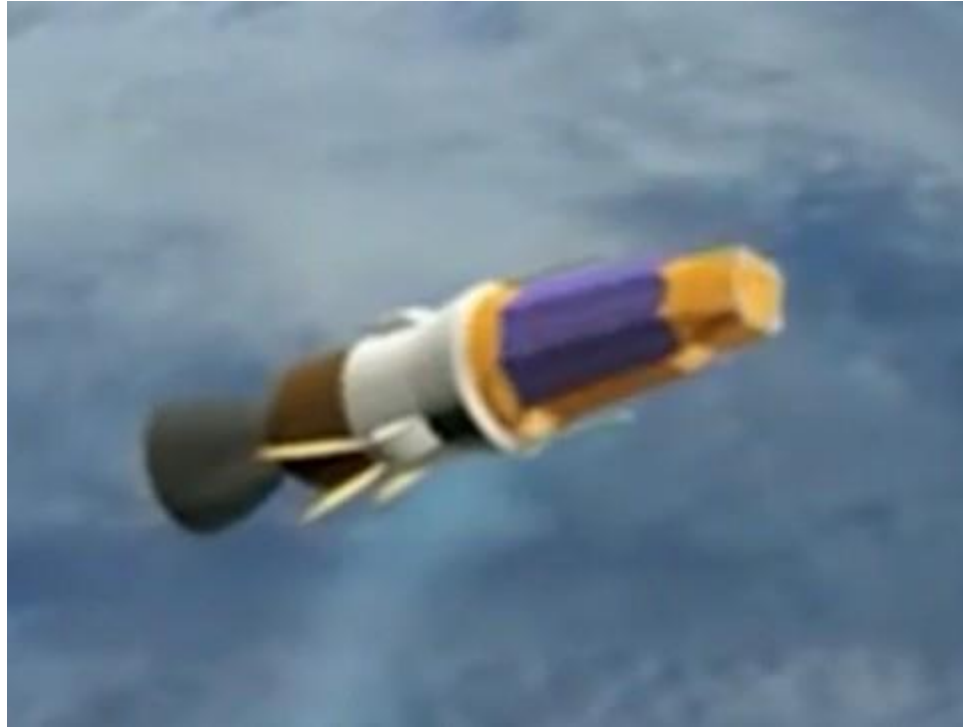
... times four
waist-mounted
thruster units,
each shadowed
by aft structure



- Similarities between observed cloud shape and thruster layout on Topol ICBM 'battle stage' are compelling
- Degree to which eyewitness videos and reports can characterize performance of top secret weapons system is amazing



Commercial version bus propulsion



Animation from commercial launcher derivative suggests firing scheme that could give rise to plume eclipse 'cut-outs' similar to those observed

ISS imagery camera metadata

iss037e009203.NEF

GMT: 2013:10:10 13:45:27
MODEL: NIKON D3S S/N: 2008337
NASA SN and Temp: NASA#2008337
Firmware: Ver.1.00 Image Size: 4288x2844
Compression: Nikon NEF Compressed Exposure Program: Program AE
Shutter: 1/60 Aperture: 5.6
Meter Mode: Multi-segment Shooting Mode: Continuous
ISO Speed: 200 AF Area Mode: Single Area
Focal Length: 800.0 mm
Lens ID: AF-I Nikkor 400mm f/2.8D IF-ED + TC-20E
DOF: 1.16 m (46.74 - 47.90)
Focus Mode: Manual Focus Distance: 47.32 m
Subject Distance Range: Unknown
Compensation: 0 Noise Reduction: Off
Whitebalance: Auto
Flash: No Flash; Flash Mode: Did Not Fire
Flash Commander Mode: Off; Flash Compensation: 0
Flash Control Mode: Off
Flash Group A Control Mode: Off; Flash Group B Control Mode: Off
Self Timer Time: 10 s

88.0 E
46.5 N
417 km

di.
c

iss037e009204.NEF
2013:10:10 13:45:27

iss037e009205.NEF
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FRAME-BY-FRAME 1

FRAME-BY-FRAME 2

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