Soyuz launch & ascent observations from International Space Station and from ground/airborne observers on December 15, 2015

Soyuz TMA-19M 2015/12/15 11:03:09 UTC from Baykonur

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September 24, 2016
FINAL REV 1

All media please verify any material prior to quotation or other reference utilization
Satellite watching is more than just ‘point sources’
Sometimes it can be pretty awesome......

SKY SPIRALS
[left] Opened thrust dump ports
[below] Post insertion prop dump
1986 US East Coast, China, Australia

NORWAY, 2009, Russian Bulava SLBM
Sometimes it can get eerie and unearthly....

BRIEF EXPANDING SPIRAL FROM ICBM WARHEAD’S SPIN-UP MOTORS
[RUSSIAN ‘TOPOL’ ICBM SHOWN HERE]

https://www.youtube.com/watch?v=aPcMfip0URU
OVERVIEW

• Soyuz TMA-19M launch of Dec 15, 2015, created possibly most diverse collection of visual imaging observations of large-booster exoatmospheric plume effects ever recorded

• SW Siberia ground observations included both opportunistic imaging and apparently a few well-prepared instrumentation setups

• Result – acquisition of most high-quality stage-3 shutdown/separation sequences ever made [to my knowledge] by private parties

• Lineation patterns and evolution of main stage plumes still not well understood, help needed [more]
• Best-ever visual/dynamic characterization of post stage-3 ‘Comma Cloud’ phenomenon
• Importance of Soyuz rocketcam launch views
• Subsequent identification of ‘Comma Cloud’ with deliberate O2 tank venting for disposal clearance
• Confirmation of criticality of solar back-lighting of plume components plus observer in darkness
• Confirmation of efficacy of image brightness enhancement to recover invisible plume traces
• Unique illumination, low phase angle rendezvous vehicle launch window, and visiting vehicle traffic model suggest similar visibility conditions only approximately once every two or three years
Profile [exaggerated vertical scale]

International Space Station orbiting at almost twice the insertion altitude of the Soyuz
Altitude versus elapsed time [ESA chart]

https://www.youtube.com/watch?v=AVvgpKt5uCA
Trajectory passes within sight of major cities in Western Siberia and Kazakhstan

-- WHEN PLUME IS SUNLIT AND GROUND DARK, HIGHLY VISIBLE --
In cities, crowds on the street.... WITH POCKETCAMS

http://www.youtube.com/watch?v=3ilgesHH9fg
Topol missile watched in Astrakhan -- June 7, 2012
.... And widespread dashcams
[this example – Omsk, Topol missile]

- Price 2 999 р.
- Угол обзора: 120° (по диагонали)

[Image of a dashcam]

http://omsk.rbt.ru/cat/audio/videoregistratory/mystery_mdr-800hd/?gclid=CLaDz-693rsCFU5a3godWTSAdQ
Rocket launch observations from space

• December 15, 2015 was ‘perfect storm’ of separate factors that created rare spectacle
• Several memorable precedents exist
• But as a rule,
  – Full daytime launches, while trails are noticeable especially on horizon aren’t very bright
  – Full dark launches create visible flares but localized
  – Crews are only looking outside a fraction of the time
Previous on-board sightings

- Dozen examples of ISS crews observing scheduled Soyuz & Progress launches but all were full-daylight or full-dark
- Russian Salyut & Mir crews report twilight pluming over South African missile range [1980s] – connection still unclear
- Malenchenko reported seeing ascent plumes only
- Search continues for more anecdotal events
ISS EXAMPLE OF DAYLIGHT ASCENT PLUME AT HORIZON

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

ISS EXAMPLE OF DAYLIGHT ASCENT PLUME AT HORIZON

ISS026E027223
Progress M-22 launch, 2014 Feb 5 16:23 gmt [sunset 12:58 gmt]

• Observed by Rick Mastracchio
THIS particular “space spectacular”: Launch [11:03:09 GMT] was pre-sunset [12:03 GMT sunset, sun azimuth 237°]
Stage-1 [4 strap-ons] jettison [118 sec]; NW horizon out Soyuz window still sunlit
Viewing regions

Depending on season and on launch time relative to sunset, different longitudinal bands on Earth’s surface have optimal illumination conditions for best observation:

– Observer in darkness
– Object in sunlight

This time, appropriate conditions were met east of launch area, on ground, in the air, and in space.
Ground view [December 15, 2015]

From aboard the space station
Evening twilight visibility of ascent plume

As with observing artificial satellites, the target must be high enough to be sunlit while the observer is far enough into night for the sky to be dark.
Onboard Observation Opportunity

• In full daylight, plume doesn’t stand out; in full darkness, it’s invisible aside from engine glow

• Backlit plume illumination with ground in shadow is statistically rare, twilight much longer in May-August

• Backlit plume illumination with space station in shadow is even more rare – only a few cases known

• Traditional rendezvous profiles often launched 1000’s of km behind target, often over the horizon, therefore unseeable

• HOWEVER -- Newly-introduced ‘fast rendezvous’ profile provides closer ISS range at launch [small phase angle]

• AND -- Cupola [installed 2010] provides awesome wide-angle field of view, with seven 80-cm-square windows

• AND – Six-person crew provides more opportunistic eyeballs scanning the sky for serendipitous surprises
“Phase angle” measures how big a ‘lead’ the target is when the chaser is launched. This is crucial for an event to be visible from space since anything more than 1000-2000 km away is over the horizon – so the smaller the phase angle, the better for visibility.
“Fast Rendezvous” and “Cooperative Target”

Faster arrival is desirable for crew comfort and for maximizing crew utilization for mission.

Chaser is NOT flying ‘faster’, it gets to the space station SOONER because the overtaking distance at launch is adjusted to be SHORTER than what was standard in the past. This required active modulation of station altitude and also good modeling of atmospheric decay rates, so it’s not trivial to set up.

To achieve this quick trip, the station essentially is deliberately flown into the hunter’s gunsights.
Further reading on ‘fast rendezvous’

• **NBC [Mar 27, 2013]** Space station shifts its orbit to make speedy crew rendezvous possible

• **NBC [Mar 28, 2013]** Revised ride to space station may be faster – but it's also less comfortable
  - http://science.nbcnews.com/_news/2013/03/28/17503284-revised-ride-to-space-station-may-be-faster-but-its-also-less-comfortable?lite

• Spectrum magazine 1 Aug 2012 -- **Russia Tests Quick Trip to Space Station**

• SEPTEMBER 2015 – ‘NPR’ FALSELY BLAMES SOYUZ RENDEZVOUS DELAY ON HUMAN SPACE POLLUTION [read comments]= [completely misunderstands nature of ‘fast rendezvous’ profile, very amusing and frustrating exchanges]
ISS relative position for December 15, 2015 launching

- The station was orbiting in a 402.41 by 415.29-kilometer [avg 409 km], inclination 51.66°.
- At launch, ISS about 1000 km [9°] ahead
- Soyuz performed 525 sec ascent
- Reached 200.75 – 253.08 km [avg 227 km]
- At orbital insertion, Soyuz TMA-19M was 28.1° [3100 km] behind ISS.
- Delta-height 182 km [so catchup ~ 1800 km/rev]
Sequence of images to be shown

- Views from ISS
  - Live External CCTV
  - Handheld digital camera in cupola
  - Russian segment imagery [not seen]
- Particular ascent events observed
- Comparisons to selected other viewpoints
- Views from aircraft
- Views from ground
- CGI of dynamic events
- Insights into events based on multiple viewing angles
- Other manifestations from other vehicles
Recognize – TWO types of plumes

• Endoatmospheric [below ‘Karman line’]
  – Combustion products stopped by air drag
  – Plume material suspended in air
  – Track quickly sheared by crosswinds

• Exoatmospheric [above ‘Karman line’]
  – Combustion particles in free ballistic flight
  – Can take several minutes to ‘fall’ into atmosphere
  – Ejection speed approx 3,000 meters/sec
  – Ground speed of source up to 8,000 meters/sec
  – Doesn’t behave like any familiar earthside plume
  – All familiar ‘plume behavior’ experience is useless
“Three-dimensionalization”

• What is the plume shape we’re looking at?
• Interpreting 2-D white blobs into 3-D shapes is a challenge
• Rocket plume can be seen from front, or oblique, or side
• Think of it as translucent badminton shuttlecock
MOSCOW ‘TsUP’ [CONTROL CENTER]
Relative positions and lighting

Line of ‘terminator’ showing sunlit/dark surface

ISS at Soyuz launch is at nose of shuttle graphic [sorry, old display software!]

ORBITAL PATH OF ISS ACROSS LAUNCH SITE

X = Baykonur
Summary of 113 ISS images

• NASA photo #
  - ISS046e001355  11:06:07  02:57
  - Initial plume broadening  11:06:30  03:21
  - 2\textsuperscript{nd} stage shutdown  11:08:00  04:51
  - 3\textsuperscript{rd} stage shutdown  11:12:00  08:51
  - ISS046e001467  11:13:14  10:05

Compared to timeline, camera clock may be \textasciitilde 10 seconds late.
Events preceding first ISS images

- Escape tower jettison
- Launch shroud jettison
- Boosters separation
Vehicle at time of first ISS image

can now enter the crew compartment through the small windows
Ascent mostly covered by ISS photographs
[begins after stage-1 jettison, just prior to crossing Karman boundary where engine plume widens spectacularly]

118 sec – Stage 1 sep
285 sec – Stage 2 cutoff
525 sec – Stage 3 cutoff
177 sec – First image
605 sec – Last image
LIVE TV IMAGE FROM ISS
11:09:00 approx

For unknown reason, TV image transmitted upside down
TV image versus crew handheld image [estimated time]

ISS046E001402  11:09:30
International Space Station
“Cupola” observation module

Astronaut Scott Kelly on watch

Earth is 'down', below ISS
What creates visible streaking?

Rocketcam from unmanned Soyuz launch from Kourou in 2014 suggests visible features form at the boundary of multiple engine plumes rather than along centerline. Actual process remains puzzling. KEY FEATURE SEEMS TO BE ILLUMINATION BY SUNLIGHT [not a factor in this view].
Soyuz from ISS
[liftoff at 11:03:10]

11:06:07, 11:06:31, 11:07:21,
approx 04:43, 3rd stage ignition
[brief burst of ISS onboard TV]
ISS TV captures rocket plume profile above horizon; compare 70-mm photo of Russian missile plume, 2012 [right]
RUSSIAN WEBSITE SHOWS ROCKET PLUMES EXPANDING ABOVE KARMAN LINE

http://bashny.net/uploads/images/00/00/01/2014/06/18/258e5746ce.jpg
Typical early plume as seen from ground [broadens above Karman line]
What are they seeing?

4 engines of stage-2, 3
ISS 1383  11:07:54
end of stage-2 firing

LOOKING BACKWARD, HEAD-ON VIEW AS SOYUZ FALLS BEHIND
Time/altitude of separation

- 2nd Stage separation
- 3rd Stage ignition
- 4:48 min
- 210 km
- 170 km
The rocket is already at an altitude of 170 km.

Altitude: 170km
Speed: 13250km/h

T+00:04:48.36
Stage-3 ignition -- 1384   11:07:58

Soyuz is doing 3600 m/sec,
ISS about 8000 m/sec.
Plume particles relative
to Soyuz fall behind
by about -3000 m/sec

LOOKING BACKWARD,
HEAD-ON VIEW AS
SECOND STAGE PLUME
FLIES AWAY FROM START
OF THIRD STAGE PLUME
Stage-3 plume expansion – 1386 11:08:04

LOOKING BACKWARD, HEAD-ON VIEW AS THIRD STAGE PLUME EXPANDS WHILE GROWING MORE DISTANT
Ground views [earlier launches]: Third stage ignition as second stage plumes drop behind.

https://www.youtube.com/watch?v=ZwMoXv3vKpY at 17:50

Also see https://www.youtube.com/watch?v=0Yo8f7fQFO8
THIRD STAGE BURN
Scott Kelly @StationCDRKelly
#Soyuz blasts through the atmosphere on its way to @Space_Station! #SoyuzTMA19M
[Image# ISS046e01388 just after stage-3 ignition]
Post stage-3 shutdown, complex maneuvers

- Stage-3 performs backaway thrusting [creates ‘headlight illusion’ to ground observers]
- Soyuz spring slight posigrade separation
- Soyuz performs attitude maneuvers
- Ejected propellant creates curved plume cloud
Once on the desired orbit approximately 9 minutes into the launch
Third stage separation

T+00:08:57.56

https://www.youtube.com/watch?v=vHWDNrrfI

Sep to pluming, 3 seconds; Scene cuts after 4 sec [total duration unknown]
CGI of plume appearance

YOUTUBE: “Soyuz Launch Sequence Explained”

Animation of Soyuz propellant venting for post third-stage shutdown, nicely showing accurate plume orientation before stage tumble begins [image is somewhat overbrightened for clarity]

https://www.youtube.com/watch?v=W-lgeyzd25M
Thrust vector approximately through empty stage center of mass
Oxygen vent line

Сопла увода
[dump nozzle]
View of vent during booster rollout

Common souvenir of Baykonur

<<Снять перед стартом>>

REMOVE BEFORE FLIGHT

[my collection retrieved from flame pit]
Videos of separation

• Soyuz animation
  • https://www.youtube.com/watch?v=lVlzwTc0xis
  • https://www.youtube.com/watch?v=uJPB-F8C168
    16:10 animation
  • https://www.youtube.com/watch?v=BWSD8xvl4TY
11:12:07 post-shutdown “comma” flare

ISS046e001427

SOYUZ IS 3100 KM BEHIND ISS OVERTAKING AT 0.3 KM/SEC
Photo iss046e001427  11:12:07 bright

TOTALLY BLACK SKY ALLOWS USE OF OVERBRIGHTENING TO BRING UP FAINT PLUME TRACES
Identical “comma” flare imaged from ISS on earlier [Gerst] accidental observation of Soyuz booster navsat launch from Plesetsk [2014 June 15]

Over-brightening shows traces of former plume dispersal
Soyuz TMA-19M ALSO observed by ‘Aleksey’ in Novokuznetsk

Stabilized zoomed view of 3rd stage cutoff followed by ‘comma cloud’ formation and dissipation – BEST!!

https://www.youtube.com/watch?v=DKW0bzYTNTw
This shows a VERY complex sequence of plume dynamics. It overlaps much of the Gerst still sequence from aboard the ISS. When compared to the Kelly sequence on 2015 Dec 15 it provides even MORE insight into plume.

https://www.youtube.com/watch?v=wfPXJliQCU0
An earlier notorious “comma cloud” -- ”TOMSK, SIBERIA, 2006”

Unmanned ‘Soyuz’ booster launch September 14, 2006, at 13:41 GMT carrying Kosmos-2423 from Baykonur, passed over Tomsk ten minutes later [56.50 N, 84.99 E, just NE of Novosibirsk]. Local sunset was 13:42 [8:42 PM], local news accounts placed sighting at “about 8:45”. Widely reported in the national news media the following day as a UFO despite timely official notice of launch. All UFO website reports omitted mention of launch date/time. Tomsk media coverage [in Russian] http://www.tv2.tomsk.ru/video-chas-pick/zdes-ne-proletalo-nlo-chto-videl-tomsk-proshloj-nochyu

https://www.youtube.com/watch?v=YG-3S2WKP6Y
“COMMA CLOUD” FEATURE

Soyuz-TMA-M (Baykonur, 2015) [left, right] ISS view, Novokuznetsk
Soyuz-GLONASS (Plesetsk, 2013) [left, right] ISS view, Omsk view

TOMSK 2006
Confirmed by NASA JSC PAO

- [If I’d listened to live NASA launch commentary Dec 15 I’d have learned it THEN]
- NASA: “The third stage performs an avoidance maneuver by opening a valve in its liquid oxygen tank to steer well clear of the Soyuz spacecraft.”

- Scroll down to “Launch-Coverage Expedition-46-prelaunch-broll and launch 328134”
- Footage of interest begins at 01:25:02 thru 1:29:21
Stage shutdown, plumes depart
Dec 15 Soyuz flare clouds //
image 1439, 11:12:34
image 1464, 11:13:05
Post-firing – overbright / 1465 at 11:13:08
Ground view of 3\textsuperscript{rd} stage shutdown & separation

- Complex post-sep flare plumes also observed with high-quality videos and still imagery from the ground, both from off to the side and also almost directly below.
- Six Novokuznetsk videos show shutdown/separation from below and abeam allowing precise timing of flarings – 5 seconds post burnout coast, 10 seconds active ‘comma’ flare development.
- IMAGES IN DETAIL WITH ANALYSIS LATER IN THIS PRESENTATION
- [https://www.youtube.com/watch?v=gg4sR-R99u0](https://www.youtube.com/watch?v=gg4sR-R99u0) and [https://www.youtube.com/watch?v=OGvYOJ7oWVY](https://www.youtube.com/watch?v=OGvYOJ7oWVY) are spectacular.
- [MVI 2639by](https://www.youtube.com/watch?v=6kcBeicMfCA) also.
- [https://www.youtube.com/watch?v=co3zA4WLjuE](https://www.youtube.com/watch?v=co3zA4WLjuE) not too shabby.

Николай Сергеевич, Ступень от ракеты в Междуреченске
Location of ground reports/videos

WHY NO IMAGES FROM SOUTH OF TRACK?
Ground-based side view of stage-3 shutdown, separation flare [time exposure ~ 5 sec]

http://siberiantimes.com/upload/information_system_52/3/8/6/item_3862/information_items_3862.jpg
Local news coverage in southwest Siberia

“In fact, the local media in many regions had alerted Siberians to the expected rocket display in advance, and it didn't disappoint.”

Amazing light show as Soyuz rocket takes British and US astronauts to space

By The Siberian Times reporter
16 December 2015

Siberian night sky illuminated by launch from Baikonur in Kazakhstan.

Soon after blast-off, their Soyuz TMA-19M rocket made a spectacular journey across the Siberian night sky. Picture: Alexey Malitsky

Russian commander Yuri Malenchenko arrived at the International Space Station with astronauts Major Tim Peake, from the United Kingdom, and Tim Kopra, from the US.

But soon after blast-off, their Soyuz TMA-19M rocket made a spectacular journey across the Siberian night sky, with a dazzling display caught on camera by residents in Kemerovo and Altai regions, as well as the republic of Altai and.

European Space Agency website -- During the Principia launch on 15 December, Lufthansa pilots Michael Schwarz and Frank Barma were lucky enough to see the launch of Tim Peake, Tim Kopra and Yuri Malenchenko from the cockpit. They managed to snap these pictures of the Soyuz rocket ascending to space.

At the time these pictures were taken, Lufthansa flight LH 713 was above Russia, approx 100 km east from Novosibirsk. The Boing 747 was enroute from Seoul to Frankfurt.

Novosibirsk sunset 16:00 [gmt + 6]
At 17:03 local [launch], sun azimuth 240, el -8
Moon azimuth 199, el 19

NOTE: No personal account from Schwarz or Barma found so far. Main question: were they advised in advance to keep an eye out for the scheduled launch, or was the sight a surprise and they happened to have a camera ready?

http://blogs.esa.int/tim-peake/2015/12/17/lufthansa-pilots-snap-principia-launch-from-the-skies/
Movement right to left over 3 images

Line up via horizon and cloud features
Lufthansa 747
photo 1 of 3
[westbound
dead ahead]

[stock photo]
Moon azimuth from Novosibirsk region, airliner location marked

Flight path of Soyuz ascent
Compare to this ground view, same time and close location

Compare to near-simo ISS view
Lufthansa 3
Some media reports call it a ‘UFO’

“НЛО» в небе над Черногорском?

Жители Черногорска накануне вечером были взбудоражены появлением в небе над городом яркого светящегося объекта, оставлявшего за собой блестящий хвост.


Появление в черногорском небе яркой «медузы» - это всего лишь эффект выхлопных газов работающей ракеты, подсвеченных на больших высотах Солнцем.

«Медузу» в ночном небе наблюдали жители Черногорска, Абакана, Минусинска, Новосибирска, Омска, Новокузнецка, Кемерова и других сибирских городов.

“Inhabitants of Chernogorsk, Abakan, Minusinsk, Novosibirsk, Omsk, Novokuznetsk, Kemerovo, and other Siberian cities saw it.”

Additional ground videos
Ground view from near Novosibirsk

В Новокузнецке летало НЛО — очевидцы
16 декабря 11:51
NOVOKUZNETSK ‘UFO’

http://vashgorod.ru/novosibirsk/news/34870
Yesterday evening many Biyskites observed the spectacular launch of spaceship Soyuz TMA-19M.

Вчера вечером многие бийчане наблюдали зрелищный запуск космического корабля «Союз ТМА-19М»

Бийск [Biysk]

Good video viewed through tree limbs
https://www.youtube.com/watch?v=Eehx-plfByE&feature=player_embedded#t=13

Жители Хакасии гадают, что пролетело в ночном небе над республикой

Khakassia residents wonder what flew through the night sky over the republic

Запуск пилотируемого космического корабля
Launching of a manned space ship
"Союз ТМА-19М“ // from Aleksey T_YMA_N in Рубцовск

Rubtsovsk [southern area of observation zone]

https://www.youtube.com/watch?v=EYC1bG3gJ3g
запуск космического корабля Союз 15.12.15г.

Алекситос // Съемка г. Белокуриха.
‘Aleksitos’, in Belokurikha, ascending plume, moon on left

https://www.youtube.com/watch?v=3o3IgWJUnak
Detailed observation of **third stage shutdown and Soyuz separation**, from directly off to the side

- Пролет Союз тмa-19 над Новокузнецком
- Fly-past of Soyuz tma-19 over Novokuznetsk
- Роман Смирнов [Roman Smirnov dashcam video]
- [https://www.youtube.com/watch?v=cGp82gMO6xc](https://www.youtube.com/watch?v=cGp82gMO6xc)
- Published on Dec 15, 2015 / Novokuznetsk
- ~2:05 clears clouds in southwest
- 4:32 3rd stage shutdown over the moon
- 4:38 separation plume ignition

SMIRNOV’S DASHCAM DATA READ-OUT BOX [clock good to 3-4 secs]
Soyuz appears from behind low cloud bank to southwest

https://www.youtube.com/watch?v=cGp82gMO6xc
Soyuz 3\textsuperscript{rd} stage approaches moon
When 3<sup>rd</sup> stage shuts down, sky near the moon goes dark.

BUT - with image manipulation, invisible plume shows up.
Post-sep flare begins [4:46 into video]

Video shows detailed development of pluming around Soyuz, paralleling plume dispersal recorded from in front by ISS crew.
Passes above moon in the south, light goes out for 5 seconds, then resumes for exactly 20 seconds.
Polёт ракеты в небе над Новокузнецком Точилино
Flight of a rocket in the sky over Novokuznetsk-Tochilino
Novokuznetsk – 2nd video same angle on moon --

Five seconds between stage shutdown and flare.
Stable medium zoom tracking

Станислав я
https://www.youtube.com/watch?v=gg4sR-R99u0
Ridder, Kazakhstan

- Прохождение ракеты "Союз" над Риддером.15.12.2015г
- Юрий Болденков [Yuriy Boldenkov]
- https://www.youtube.com/watch?v=Tl6lWwFWcQ8

Located in far northeast corner of Kazakhstan near Russian Chinese, and Mongolian borders
Soyuz rises into sight [photographer was clearly waiting for it and knew where to look]
Passing directly overhead, 3rd stage shutdown and plume drops behind

Post-separation “comma cloud”
“Orbiter 2010” game
[https://www.youtube.com/watch?v=f4hVNNYyFws]
Anton Sergeyev [Антон Сергеев]

https://www.youtube.com/watch?v=ya_xTsseCxc&feature=youtu.be 02:28
Extremely realistic prop venting except... vent vector SEEMS different on rocketcam.
Dump duration 15 seconds!
[third stage does two full tumbles]

Ground observations of spiral in profile do suggest horizontal alignment is accurate.

https://youtu.be/ya_xTsseCxc
Other ground observations

• Пролет ракеты «Союз ТМА-19М» над г. Усть-Каменогорском 15 декабря 2015 г.
  https://www.youtube.com/watch?v=RPxPTMY7dHYTbs

• Запуск Союз ТМА-19М 15 декабря 2015 года.
  Roman Kirsanov in Biysk Altai Territory
  https://www.youtube.com/watch?v=SI07hw-WMuQ

• https://www.youtube.com/watch?v=mpbIDx7Fzxo

• НЛО В НОВОКУЗНЕЦКЕ // viktor vladimirovij
  https://www.youtube.com/watch?v=KqzXi5EuRrQ

• Полёт ракеты «Союз ТМА-19М» Денис Инякин
  Юг Кемеровской области.
  https://www.youtube.com/watch?v=ZRSbuxvuFa8
Abakan, Russia [абакан] – 5 [...] sec exposure

http://www.politonline.ru/media/22884559.html
Degtyarev video [Алексей Дегтярев]

Time exposure captures 5-sec flare gap

“Oleg Petrov” [location unknown] uploaded many satellite/astronomy videos

https://www.youtube.com/watch?v=KTme3zGuG5k
Enhancing future observations

- Advertise beauty and engineering significance of plume shape & dynamics
- Appreciate rarity of lighting & locational context
- Image continuously including 30+ seconds after apparent shutdown; don’t forget to log location, azimuth/elevation
- The darker the sky, the more that dimmed plume structure can be extracted by image manipulation
- Develop efficient search strategy for finding private postings on youtube.com and rutube.ru and elsewhere
- Search on UFO bulletin boards and CGI/gamer sites
- Obtain specs, operational details from actual missions
- ROCKETCAMSS!!!!!
Summation/implications

• Degree to which booster performance is detailed in plume dynamics -- **remarkable**
• Synoptic multi-site stereo views -- **synergistic**
• Additional Soyuz rocketcam videos highly desirable [thru end of stage-3 sep thrusting]

• Once visual manifestations better calibrated against KNOWN booster profile, **future** video of non-well-documented missile events elsewhere can allow extraction of performance insights
• **Specific US intel groups knew this for decades**
• **UFO enthusiasts remain excitedly clueless**
Further spaceflight visual reports

• California Trident missile freakout [Nov 7, 2015]
  http://satobs.org/seesat_ref/misc/misperceiving_missiles.pdf

• Russian ICBM tests with evasive warheads [ISS observation]

• Plesetsk launch observed from ISS

• Norway spiral [December 2009] was Bulava ICBM
  http://spectrum.ieee.org/aerospace/military/russias-ailing-icbm-program

• Misperceptions of satellite reentry fireball swarms

• Cross-country visual reports of STS-72 reentry

• Soviet massive ‘space war game’ triggered June 1982 UFO flap in China