

Forensic Analysis of Satellite Images Released by the Russian Ministry of Defense

A bellingcat Investigation

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Summary

The subjects of the Bellingcat investigation team's forensic investigation were two of six satellite photos released by the Russian Ministry of Defense in an international press conference following the downing of Malaysia Airlines Flight 17 on 17 July 2014 in eastern Ukraine. The images were subsequently published on the MoD's official website.

One of the pictures, Picture 5, was republished on 1 August 2014 on the official web page of the MoD as a higher-quality version called Picture 5-analytics. This image was also analyzed.

The satellite photos were presented to the public at an international press conference on 21 July 2014 and published simultaneously on the Russian MoD's official website.

The forensic analysis conducted by the Bellingcat investigation team clearly and undoubtedly demonstrates that the dates of the satellite photos have been falsified, and that the photographs were digitally modified using Adobe Photoshop CS5 software.

Introduction

On 21 July 2014 at a special briefing for domestic and international press,¹ the Russian Ministry of Defense (MoD) published satellite images² of various locations in eastern Ukraine that purported to show Ukrainian air defense activity on 17 July, the day Malaysian Airlines Flight 17 (MH17) was shot down. Below is the official English translation provided by the MoD on its website:

According to our information on the day of the accident the Ukrainian Armed Forces deployed 3 to 4 artillery battalions of Buk-M1 missile system not far from Donetsk. The system allows hitting the targets on the distance up to 35 kilometers and on the altitude to 22 kilometers. Why did the Ukrainian Armed Forces deploy these air defense units in the Donetsk region? As we know militants don't have aircrafts. On the scheme we can see that both projected impact point and the airway are inside the air defense battle zone of the Ukrainian Armed Forces' Buk-M1 missile system. We have satellite photos of the Ukrainian Air Defense systems deployed in the South-East of the country.³

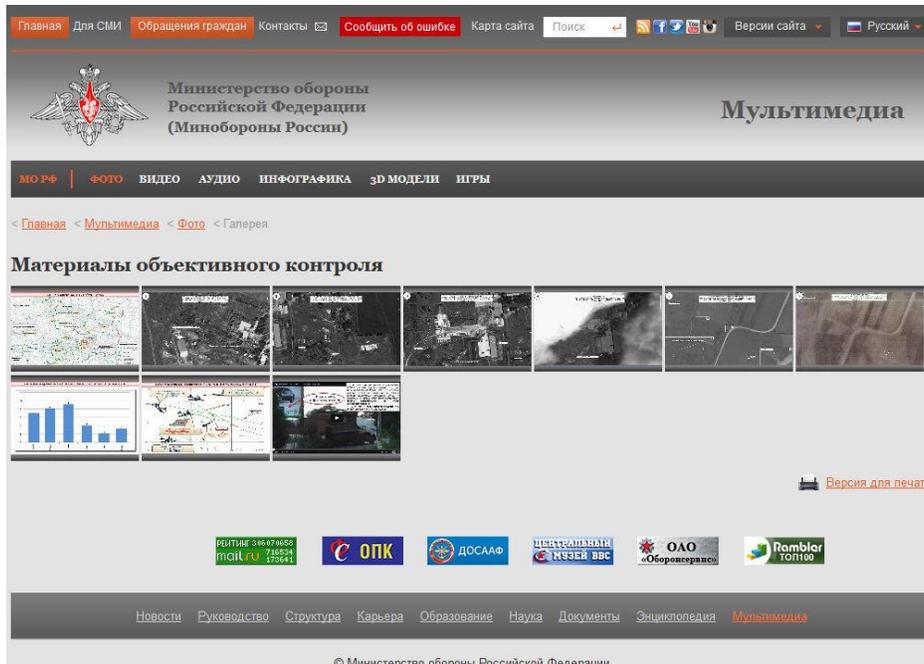
In the interest of clarity, the Bellingcat investigation team has provided what we believe is a more accurate English translation:

According to our data, on the day of the downing of MH17 a grouping of anti-air defense systems of the В С У [Armed Forces of Ukraine] were near the town of Donetsk, numbering three or four anti-aircraft rocket divisions of the Buk-M1 complex. These complexes are capable of striking targets up to a distance of 35km and up to a height of 22km. Why and against whom did the Ukrainian authorities deploy such a powerful grouping of anti-air defenses near Donetsk? It is known that the separatists do not have aviation. On the map it is visible that the flight path, as well as the proposed location of where the Boeing was struck, fall within the area of activities of the Buk-M1 SAM system of the Ukrainian armed forces. We have satellite imagery of particular deployment locations of the air defense of the Ukrainian army in the southeast of the country.

¹ http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews

² <http://stat.multimedia.mil.ru/multimedia/photo/gallery.htm?id=17402@cmsPhotoGallery>

³ http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews



Russian MoD webpage entitled "Материалы объективного контроля" (material for objective control)

On 30 July 2014, Ukrainian news agency UKRINFORM published analysis⁴ of the satellite imagery conducted by the Security Service of Ukraine (SBU). The SBU judged that the satellite photos published by the Russian MoD on 21 July 2014 were faked.

In response, the Russian MoD published its own analysis on 1 August 2014 contradicting the SBU's findings.⁵ Included in this analysis was a higher quality version of Picture 5 than that which was published at the 21 July press conference.⁶

On 5 May 2015, the Russian newspaper *Novaya Gazeta* published a report authored by a group of Russian military engineers that sought to identify what caused the crash of MH17. One of the report's main conclusions was that the crash was the result of a surface-to-air missile fired by a Buk-M1 missile system. The authors of the report also sought to determine a probable location of the missile launch site. In doing so, they based their judgments on, among other things, the satellite images published by the Russian MoD.

⁴ http://www.ukrinform.ua/rus/news/kak_genshtab_rf_za_4_dnya_sfalsifitsiroval_snimki_po_boingu_1653774

⁵ <https://web.archive.org/web/20140801134454/http://mil.ru/analytics.htm>

⁶ http://mil.ru/files/morf/2014-08-01_analytics_06.jpg

Satellite Images Published by the MoD on 21 July 2014

This section consists of all six satellite photographs released by the MoD during the 21 July 2014 briefing, along with each photograph's accompanying description as translated into English by the MoD. The times listed in the captions are in 24-hour notation.

The first 3 photos are dated July 14, 2014. On the first photo you can see the Buk missile systems deployed 8 kilometers north-west to Luhansk. On the photo you can see clearly a self-propelled launch system and 2 loading vehicles.⁷



Picture 1 – file name "mh17_brief_02-900.jpg,"⁸ dated 14 July 2014, 11:31

On the second photo you can see radars deployed 5 kilometers north to Donetsk. We can see 2 radars, different equipment and facilities.⁹



Picture 2 – file name "mh17_brief_03-900.jpg,"¹⁰ dated 14 July 2014, 11:40

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https://web.archive.org/web/20140721191232/http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews

⁸ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_02-900.jpg

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https://web.archive.org/web/20140721191232/http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews

¹⁰ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_03-900.jpg

On the third photo we can see air defense equipment deployed north to Donetsk. You can see clearly self-propelled launch system with turned launch shoe and near 60 units of military and special-proposed equipment, mounted defilades and facilities.¹¹



Picture 3 – file name “mh17_brief_04-900.jpg,”¹² dated 14 July 2014, 11:40

Here you can see a photo of the same area on July 17. Draw your attention that the anti-aircraft system is absent on this photo.¹³



Picture 4 – file name “mh17_brief_05-900.jpg,”¹⁴ dated 17 July 2014, 11:32

On the fifth photo we can see Buk-M1 artillery battalion deployed 50 kilometers east to Donetsk and 8 kilometers south to Shakhtarsk. We can answer: why the battalion was deployed near to the territory controlled by militants just before the accident?¹⁵

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https://web.archive.org/web/20140721191232/http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews

¹² http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_04-900.jpg

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https://web.archive.org/web/20140721191232/http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews

¹⁴ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_05-900.jpg

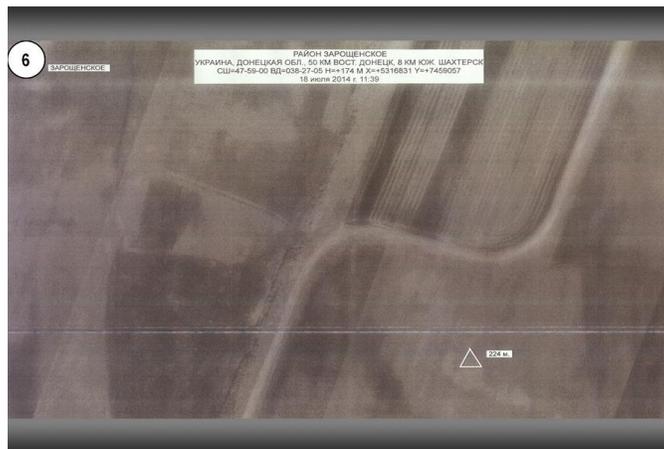
15

https://web.archive.org/web/20140721191232/http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews



Picture 5 – file name “mh17_brief_06-900.jpg,”¹⁶ dated 17 July 2014, 11:32

On the photo of same area dated July 18 (picture No. 6) we can see that the battery left the occupied position.¹⁷



Picture 6 – file name “mh17_brief_07-900.jpg,”¹⁸ dated 18 July 2014, 11:39

¹⁶ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_06-900.jpg

¹⁷ https://web.archive.org/web/20140721191232/http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews

¹⁸ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_07-900.jpg

Subjects of Analysis, Objective, and Methods

The subjects of this forensic investigation were two of the satellite photographs (Pictures 4 and 5) released during the MoD press briefing. The two images purport to link a Ukrainian air defense brigade near Donetsk with the downing of MH17.

According to the MoD, Picture 4 should prove that at least one self-propelled Buk missile launcher and three technical support vehicles were no longer present on the Ukrainian military base north of Donetsk on 17 July 2014.

Furthermore, Picture 5, according to the MoD, should prove that on 17 July 2014, two self-propelled Buk missile launchers and an additional Ukrainian military vehicle were stationed south of the village Zaroschinskoe. The MoD published a higher-quality Picture 5 on its official website on 1 August 2014. This version of Picture 5 will also be analyzed.

The aim of the study is to determine the authenticity of the images' contents and assess the accuracy of the statements made by the MoD about the images.

The analysis of the photographs utilized the following methods:

Source analysis: Source analysis determines the origin of the images to be examined. This ensures that the images being analyzed have originated in an official MoD publication to rule out any modifications by a third party, which would interfere with the results of additional analyses.

Metadata analysis: Metadata yields additional information about an image that may reveal that it has been modified. It is particularly important that the source of the image has been identified before conducting metadata analysis so that tampering by a third party can be ruled out.

Error level analysis (ELA): Error level analysis (ELA) identifies areas within an image that are compressed at different levels. With JPEG images (the format of the photographs under consideration here), the entire picture should be at roughly the same level of compression. If a section of the image is at a significantly different error level, then it likely indicates a digital modification.

Reference analysis of image content: Reference analysis compares the contents of an image with other information sources for plausibility. For instance, the verifiable image contents in Pictures 4 and 5 include the dates of the images, the locations of the images, and the geography, buildings, vehicles, and other details captured in the images. This analysis used historical satellite imagery from Google Earth as reference images.

Forensic Analysis of the MoD's Picture 4

Picture 4 released by the MoD shows military unit A-1428, one of the three Ukrainian anti-aircraft missile battalions north of Donetsk in Avdeevka.¹⁹ The MoD time stamped the satellite photo as 17 July 2014 at 11:32 (the time zone is not specified).



Picture 4; source: MoD²⁰

Source Analysis

Picture 4 was shown in a presentation at a press conference held by the MoD on 21 July 2014; it was published the same day on the MoD's website. The source of Picture 4 examined here is the official website of the MoD so that any digital modification by a third party can be excluded.²¹

¹⁹ <http://wikimapia.org/16956839/ru/%D0%97%D0%B5%D0%BD%D0%B8%D1%82%D0%BD%D0%BE-%D1%80%D0%B0%D0%BA%D0%B5%D1%82%D0%BD%D1%8B%D0%B9-%D0%B4%D0%B8%D0%B2%D0%B8%D0%B7%D0%B8%D0%BE%D0%BD-%E2%80%93%D0%B2%D0%BE%D0%B9%D1%81%D0%BA%D0%BE%D0%B2%D0%B0%D1%8F-%D1%87%D0%B0%D1%2>

²⁰ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_05-900.jpg

²¹ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_05-900.jpg

Metadata Analysis

The following information is among the metadata gathered from Picture 4.

```
Timestamp: 2014-07-21 16:14:42 GMT [i.e., the time uploaded to the server]22
File
File Type                JPEG
MIME Type                image/jpeg
Exif Byte Order         Little-endian (Intel, II)
Image Width             900
Image Height            600
Encoding Process       Baseline DCT, Huffman coding
Bits Per Sample         8
Color Components        3
Y Cb Cr Sub Sampling   YCbCr4:4:4 (1 1)

Adobe Save-for-Web (Ducky)
Quality                  75%

XMP
XMP Toolkit             Adobe XMP Core 5.0-c060 61.134777,
                        2010/02/12-17:32:00
Creator Tool            Adobe Photoshop CS5 Windows

Instance ID  xmp.iid:    7F6E5F0F10F011E4A6FDE4E5EAFB205A
Document ID  xmp.did:    7F6E5F1010F011E4A6FDE4E5EAFB205A
Derived From Instance ID xmp.iid: 7F6E5F0D10F011E4A6FDE4E5EAFB205A
Derived From Document ID xmp.did: 7F6E5F0E10F011E4A6FDE4E5EAFB205A

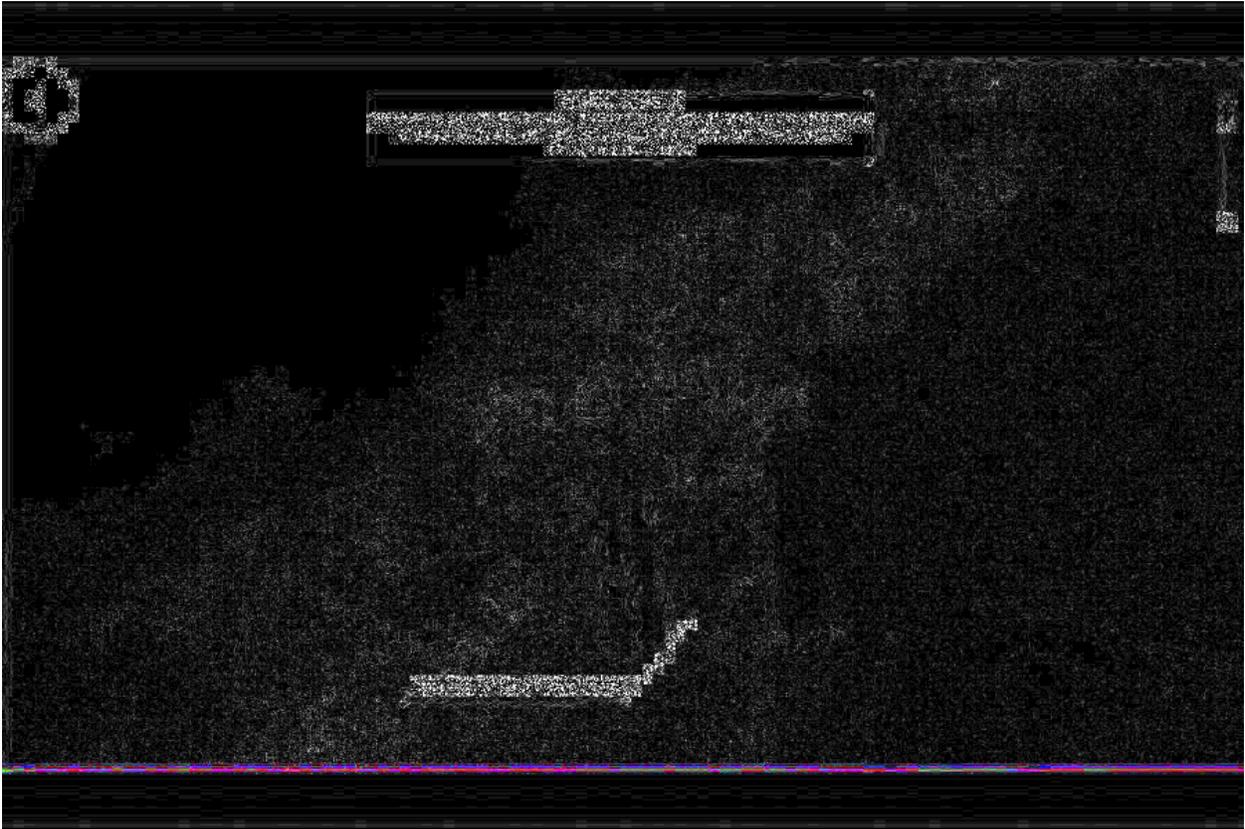
APP14
DCT Encode Version 100
APP14 Flags 0          [14], Encoded with Blend=1 downsampling
APP14 Flags 1          (none)
Color Transform        YCbCr
Composite
Image Size             900x600
Megapixels             0.540
```

The metadata analysis above shows that Picture 4 has been processed with Adobe Photoshop CS5. After processing, the image was scaled down to a size of 900x600 pixels and saved with a compression quality of 75% as a new image.

²² <http://fotoforensics.com/analysis.php?id=69e6e2335bfb39859e4f9177537a8cc06a31129d.171805>

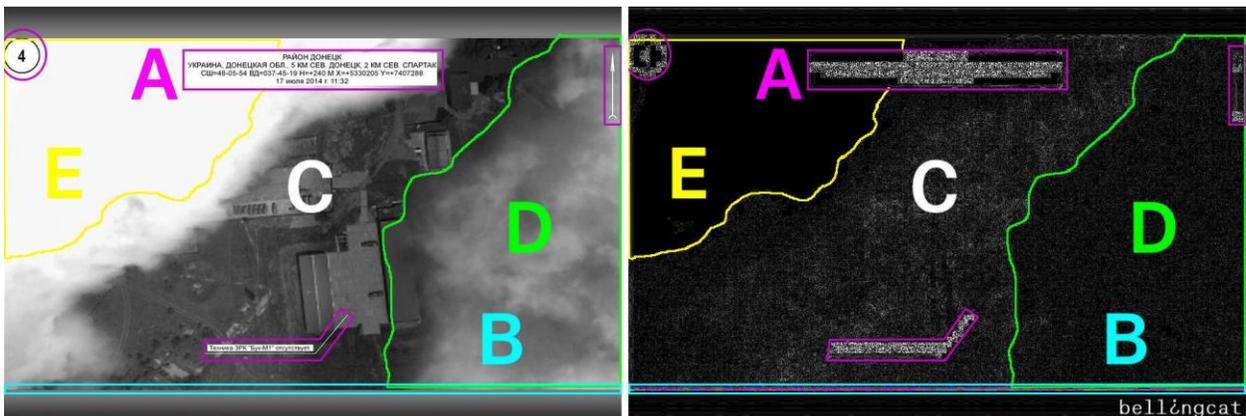
Error Level Analysis (ELA)

This section presents the findings of the ELA conducted on Picture 4.



ELA, Picture 4²³

The ELA for Picture 4 shows five areas with significantly different error levels.



Five areas with significantly different error levels

²³ <http://fotoforensics.com/analysis.php?id=6ec70e5d81c2f491b2e66b6e23a79bcf45ac9042.82841&show=ela>

- Area A: Additional image elements and labeling
- Area B: A colored error level at the bottom
- Area C: Image content with ground pattern, soil structures, and vehicles
- Area D: Cloudiness on the right in the picture
- Area E: Cloudiness on the left in the picture

The heightened error levels of areas A and B can be explained by the added image elements and labeling. The colored line in area B indicates that the photograph was covered with a strip on the bottom. The darkness in area E is probably caused by an enhancement of the photograph's brightness and contrast, as this area is overexposed. The increased error levels in all of these areas are innocuous.

The difference in the error levels between areas D and C cannot be explained by the image's content. While error level differences may be caused by blurry image content, the clouds on the right side are sharply defined structures, so the error levels should not exhibit any significant deviations from the central part of the image in this field.

For comparison, below is a photo from Google Earth of a similar cloud in a different area:



Reference photo from Google Earth with ELA²⁴

This comparison photo shows how cloud cover very similar to that seen in Picture 4 causes no significant differences in error levels. Therefore, it is highly likely that the cloud in Picture 4 is not part of the original image and was added later.

²⁴ <http://fotoforensics.com/analysis.php?id=eaabdfd2530f7846bbe110453825589a77d89242.296729>

Reference Analysis

In order to determine the date of Picture 4, we will first evaluate Picture 3, as the MoD uses Picture 3 as a reference for Picture 4 ("here you can see a photo of the same area on July 17").

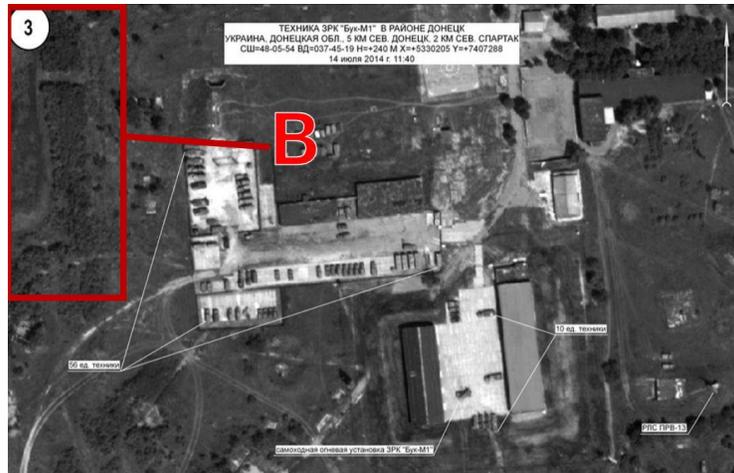
Picture 3, according to the MoD, is dated 14 July 2014 and shows military unit A-1428.



Picture 3; Source: MoD²⁵

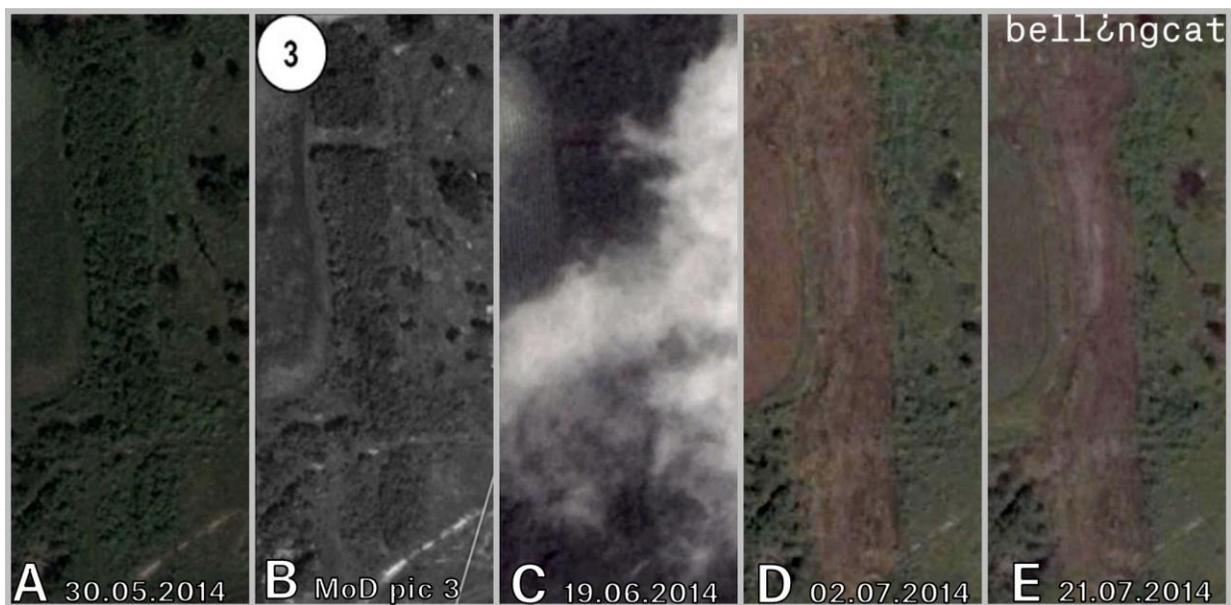
We have compared this image with Google Earth satellite imagery taken at different dates. The historical imagery depicts a significant change in the vegetation in the upper-left corner, which we have labeled "B."

²⁵ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_04-900.jpg



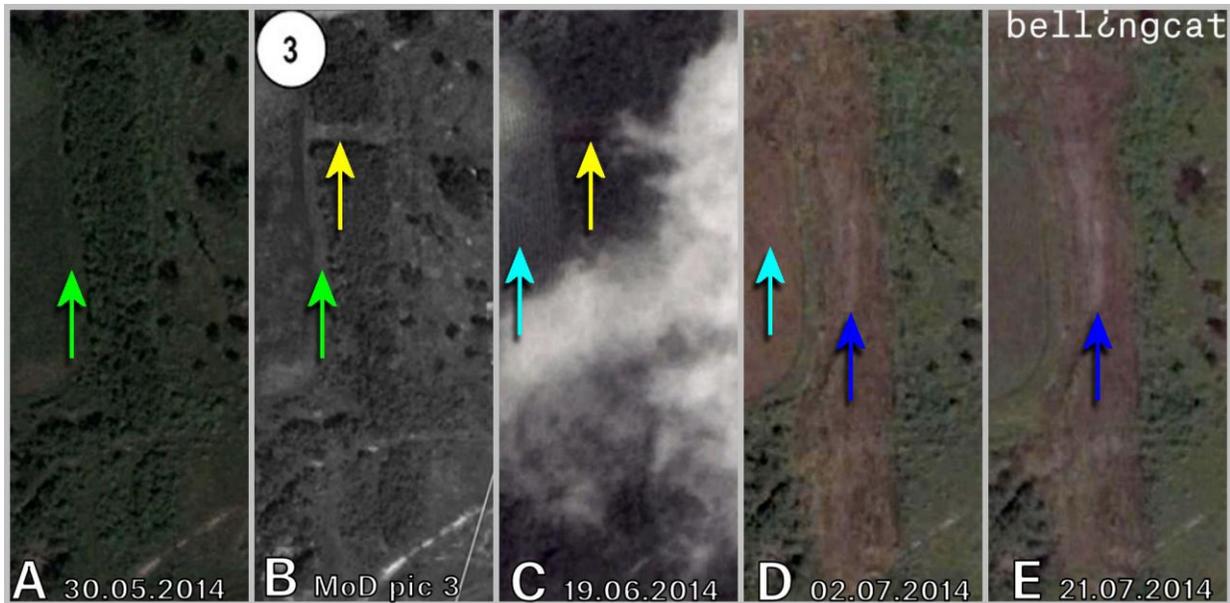
Picture 3 – B marks the vegetation

Comparing area B with historical satellite imagery of the same location allows us to situate the MoD's Picture 3 chronologically and determine its approximate date.



Figures A through E – area B from Picture 3 and historical photos from Google Earth

- Figure A: Area B – Satellite photo from Google Earth on 30 May 2014
- Figure B: Area B – Picture 3 from the MoD, dated 14 July 2014
- Figure C: Area B – Satellite photo from Google Earth on 19 June 2014
- Figure D: Area B – Satellite photo from Google Earth on 2 July 2014
- Figure E: Area B – Satellite photo from Google Earth on 21 July 2014



Figures A through E - Visible changes in area B from Picture 3 marked with arrows

The soil structures on the left side of the vegetation in Figure B closely correspond with those of Figure A (green arrows). The path cut through the vegetation in the center of Figure B corresponds with the same path seen in Figure C (yellow arrows). In Figure C, however, the field on the left side of the image displays a pattern of vertical lines that cannot be seen in Figure B (light blue arrows). Figures D and E show further significant changes in the soil structures, which are also not present in Figure B (blue arrows).

Picture 3 can therefore undoubtedly be dated to a period falling between 30 May 2014 and 19 June 2014.

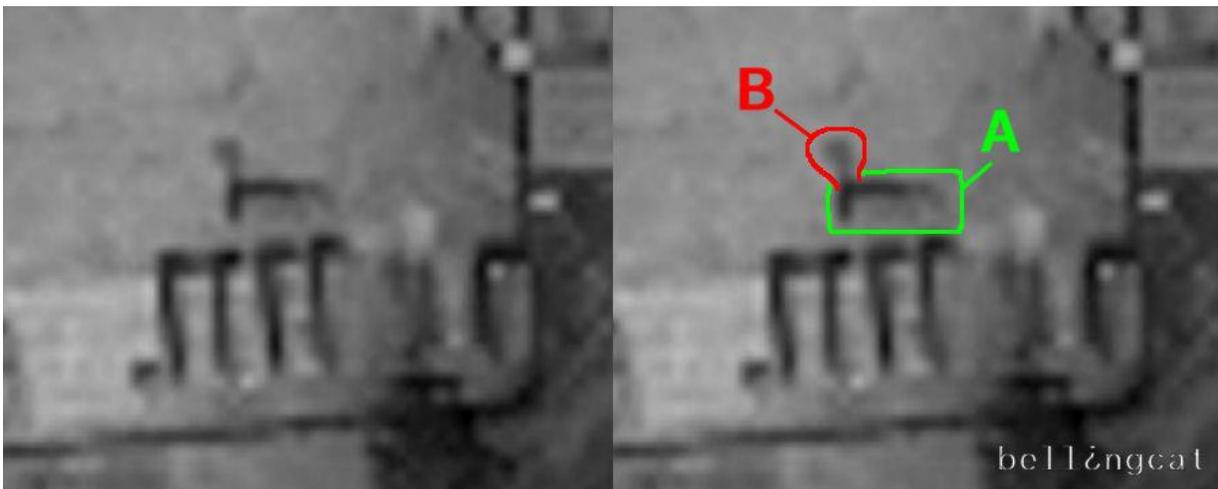
With Picture 3 dated, our report turns to Picture 4, which, according to the MoD, was taken three days after Picture 3 on 17 July 2014. As with our analysis of Picture 3, we compared Picture 4 with a set of historical Google Earth satellite photos in order to determine an approximate date.

Compared with historical satellite images, Picture 4 exhibits a striking change in the center of the photo, which we have labeled, "A."



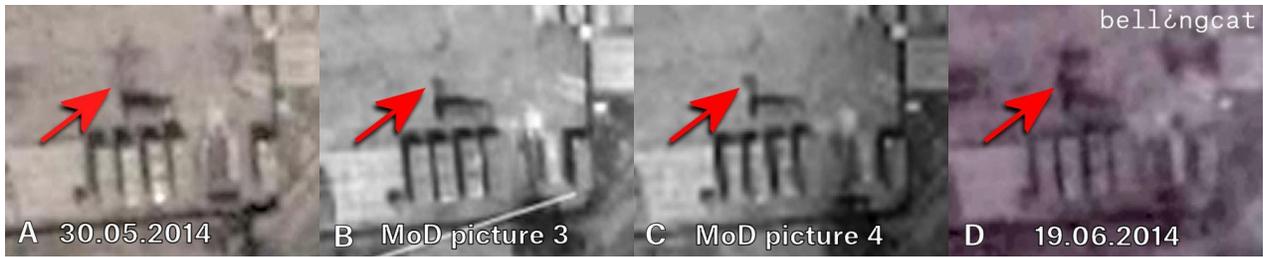
Picture 4 - A marks the area to be examined

Several military vehicles are visible in this area, including a vehicle that is perpendicular to four other vehicles:



Detail from Picture 4 from the MoD; perpendicular vehicle (A) that is leaking fluid (B)

A liquid (presumably oil) appears to be leaking from the perpendicular vehicle. It is common knowledge that a leaking liquid tends to pool, and that, over time, the pool grows as more liquid is added. This simple fact allowed us to classify the satellite images chronologically.



Figures A though D – Picture 3 and Picture 4 from the MoD compared with satellite images from Google Earth

- Figure A: Area A – Satellite photo from Google Earth on 30 May 2014
- Figure B: Area A – Picture 3 from the MoD, dated 14 July 2014
- Figure C: Area A – Picture 4 from the MoD, dated 17 July 2014
- Figure D: Area A – Satellite photo from Google Earth on 19 June 2014

The red arrow in each of the figures above shows the location of the pool being formed by liquid leaking from the vehicle. In Figure A, the vehicle is present, but there is no leaked liquid visible. Figures B and C show the vehicle next to the leaked liquid, with the pool in Figure C already visibly larger. In Figure D, the pool has increased significantly.

There is also a remarkable change visible in the middle of area C in Picture 4:



Picture 4 - C marks the area to be examined

Note the changes in the vegetation in area C over time:



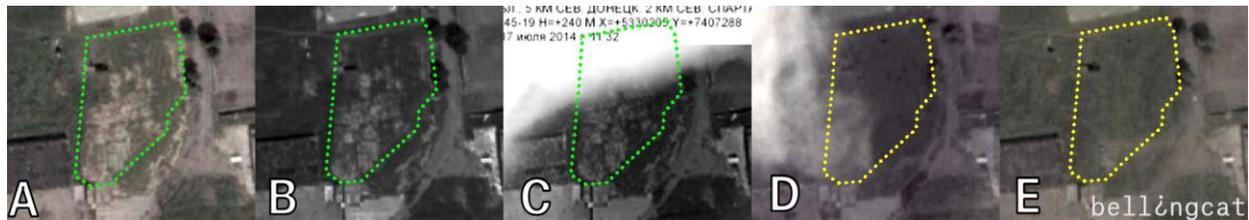
30 May 2014

MoD's Picture 3

MoD's Picture 4

19 June 2014

2 July 2014



30 May 2014

MoD's Picture 3

MoD's Picture 4

19 June 2014

2 July 2014

- Figure A: Area C – Satellite photo from Google Earth on 30 May 2014
- Figure B: Area C – Picture 3 from the MoD, dated 14 July 2014
- Figure C: Area C – Picture 4 from the MoD, dated 17 July 2014
- Figure D: Area C – Satellite photo from Google Earth on 19 June 2014
- Figure E: Area C – Satellite photo from Google Earth on 2 July 2014

In figures A, B, and C, the area showing conspicuous soil structures (green outline) is clearly recognizable. In figures D and E these soil structures (yellow outline) are no longer present. The ground at this point is evenly covered with vegetation.

It can therefore be stated unequivocally that Picture 4 from the MoD was taken at least one day before the satellite image from 19 June 2014. At least one day has had to have passed between Picture 3 and Picture 4 as well, because the pool in area A has significantly increased.

Given the above, it is clear that Picture 3 was taken during a between 31 May 2014 and 17 June 2014, and Picture 4 was taken between 1 June 2014 and 18 June 2014.

Summary of Picture 4 Forensic Analysis

On the basis of source analysis, any digital modification by a third party can be excluded.

The Bellingcat investigation team's forensic analysis revealed that Picture 4 was digitally modified with Adobe Photoshop CS5 software. It is highly probable that clouds were digitally added on the left and right sides of the image, which obscured details that could have been used for additional comparisons with historical imagery.

The comparison of the contents of Picture 4 with historical satellite imagery from Google Earth conclusively demonstrates that Picture 4 was taken between 1 June 2014 and 18 June 2014.

Forensic Analysis of the MoD's Picture 5

Picture 5 published by the MoD shows an 800m wide and 540m long area south of the village Zaroschinskoe in eastern Ukraine.²⁶ The MoD time stamped the photo as 17 July 2014 at 11:32 (the time zone is not specified).



Picture 5; Source: MoD²⁷

Source Analysis

Picture 5, like Picture 4, was shown in a presentation at a press conference held by the MoD on 21 July 2014; it was published the same day on the MoD's website. The source of Picture 5²⁸ examined here is the official website of the MoD so that any digital modification by a third party can be excluded.

²⁶ <http://wikimapia.org/#lang=de&lat=47.982953&lon=38.452272&z=18&m=b>

²⁷ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_06-900.jpg

²⁸ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_05-900.jpg

Metadata Analysis

The following information is among the metadata gathered from Picture 5.

```
Timestamp: 2014-07-21 16:29:04 GMT [i.e., the time uploaded to the server]29
File
File Type                JPEG
MIME Type                image/jpeg
Exif Byte Order          Little-endian (Intel, II)
Image Width              900
Image Height             600
Encoding Process         Baseline DCT, Huffman coding
Bits Per Sample          8
Color Components         3
Y Cb Cr Sub Sampling    YCbCr4:4:4 (1 1)

Adobe Save-for-Web (Ducky)
Quality                  75%

XMP
XMP Toolkit              Adobe XMP Core 5.0-c060 61.134777,
                        2010/02/12-17:32:00
Creator Tool             Adobe Photoshop CS5 Windows
Instance ID xmp.iid:    98C4BADF10F011E480A586B21D0B9AC8
Document ID xmp.did:    98C4BAE010F011E480A586B21D0B9AC8
Derived From Instance ID xmp.iid: 98C4BADD10F011E480A586B21D0B9AC8
Derived From Document ID xmp.did: 98C4BADE10F011E480A586B21D0B9AC8

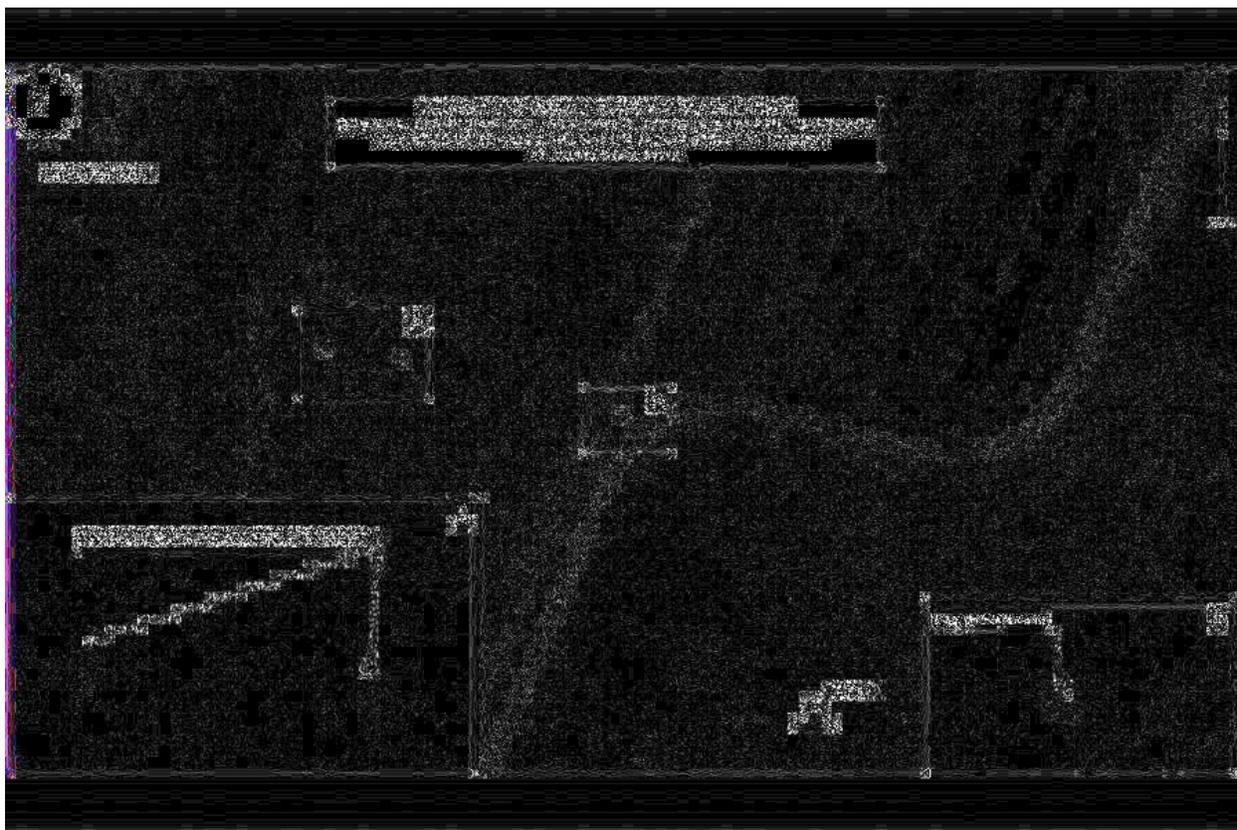
APP14
DCT Encode Version 100
APP14 Flags 0           [14], Encoded with Blend=1 downsampling
APP14 Flags 1           (none)
Color Transform         YCbCr
Composite
Image Size              900x600
Megapixels              0.540
```

The metadata analysis above shows that Picture 5 has been processed with Adobe Photoshop CS5. After processing, the image was scaled down to a size of 900x600 pixels and saved as a new image with a compression quality of 75%.

Error Level Analysis (ELA)

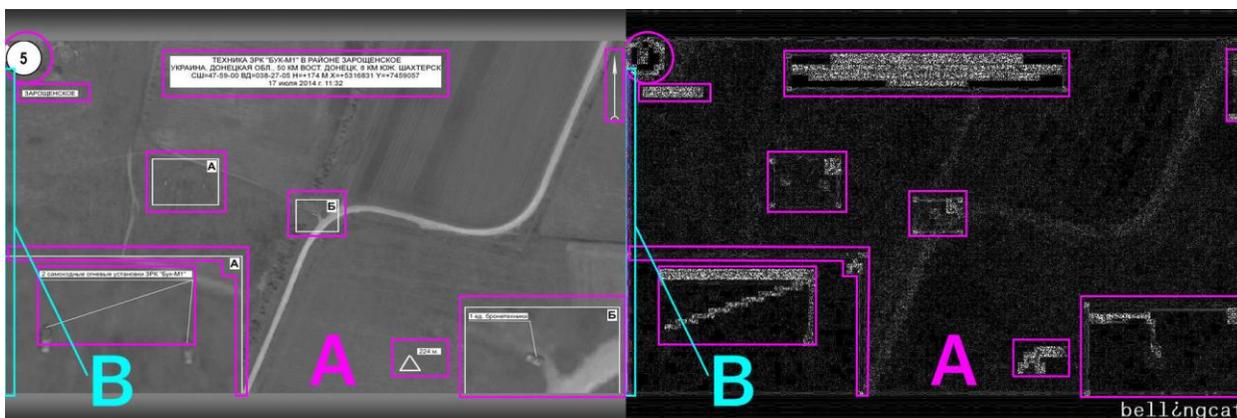
²⁹ <http://fotoforensics.com/analysis.php?id=2b8c6756d5fd31c161f7568d4dc4f361196eff77.88694&show=digest>

This section presents the findings of the ELA conducted on Picture 5.



ELA, Picture 5³⁰

The ELA for Picture 5 shows five areas with significantly different error levels.

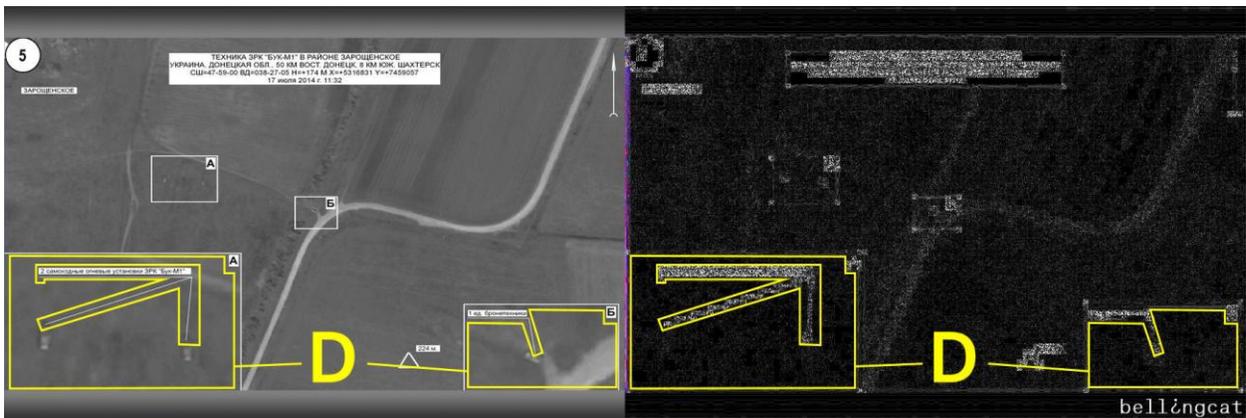


Areas A and B with different error levels

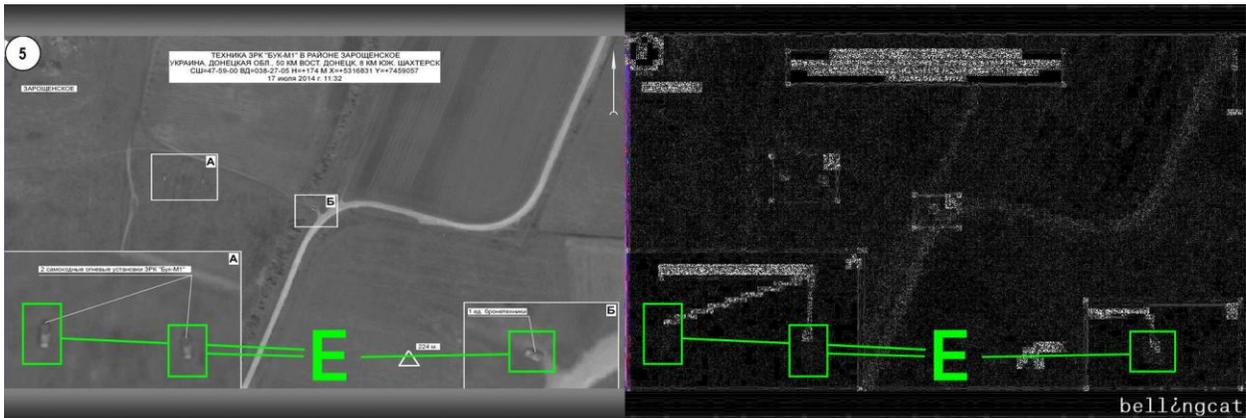
³⁰ <http://fotoforensics.com/analysis.php?id=2b8c6756d5fd31c161f7568d4dc4f361196eff77.88694>



Area C with different error levels



Area D with different error levels



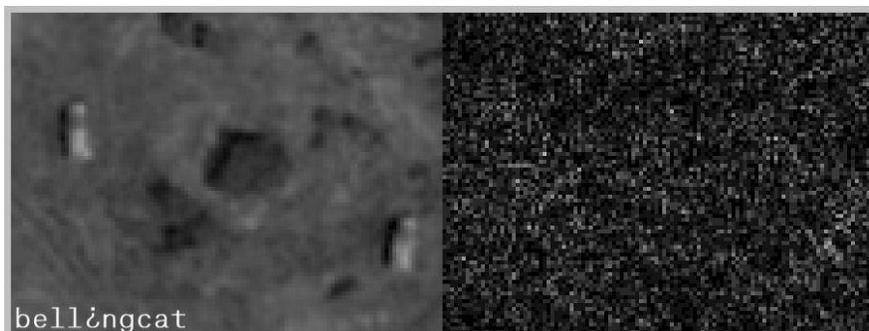
Area E with different error levels

- Area A: Error levels of additional image elements and labeling
- Area B: A colored line on the left
- Area C: Image content with soil structures and vehicles
- Area D: Magnified image details
- Area E: Vehicles in the image details

The error levels of areas A and B can be explained by the added image elements and labeling. The colored line in area B indicates that the photograph was cropped on the left side.

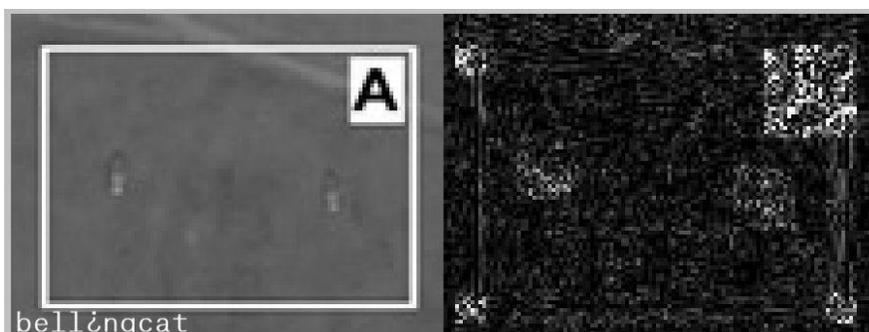
The ELA shows that the soil structures in area C have a much lower error level than the three vehicles present. As shown in our analysis of Pictures 3 and 4, all image content should present roughly the same error levels if the photo has not been altered.

For example, below is a detailed look at the error levels in a portion of MoD's Picture 2³¹ that shows military vehicles.



ELA of a section of Picture 2³²

By contrast, area C of Picture 5 shows soil structures with significantly lower error levels than the square area around the vehicles.



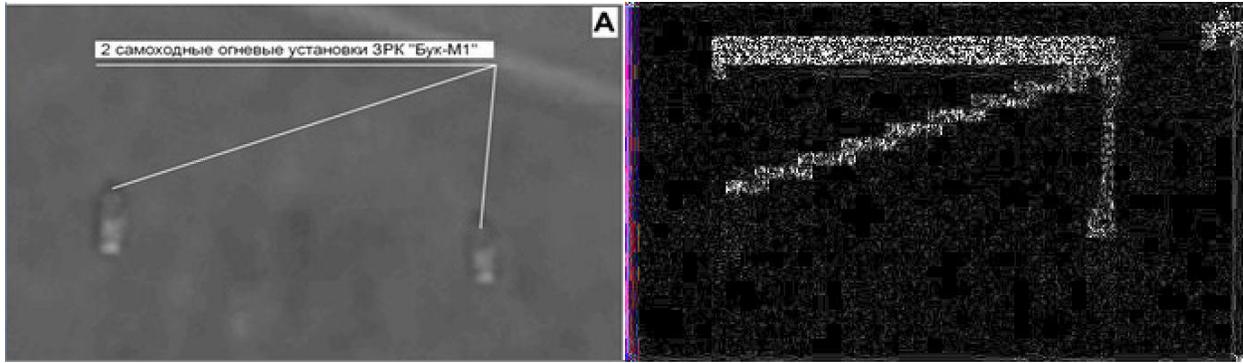
ELA of a portion of area C in Picture 5

Thus, we can say with a high degree of probability that the image content in area C has been digitally modified.

Another striking difference in error levels is evident in the magnified image details (area D).

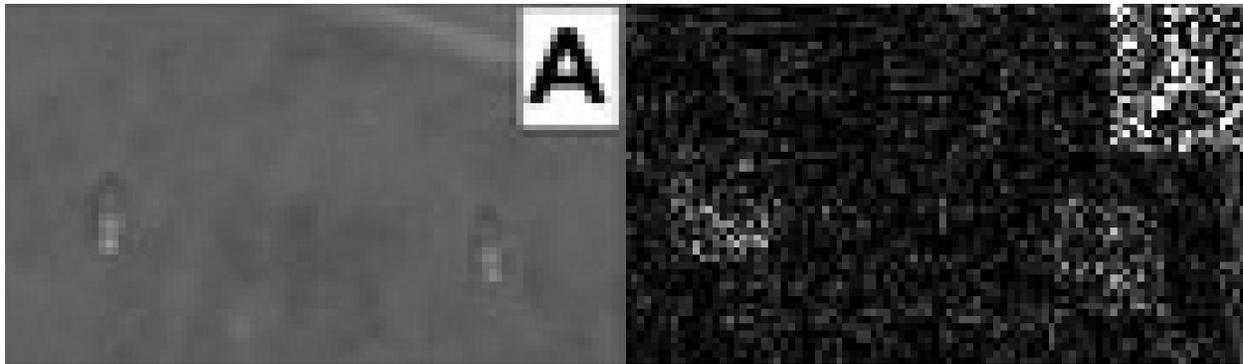
³¹ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_03-900.jpg

³² <http://fotoforensics.com/analysis.php?id=e107d94eba4b9cd7a07bd61c87b5f2a6efaeb9ac.125856&show=ela>



ELA of area D in Picture 5

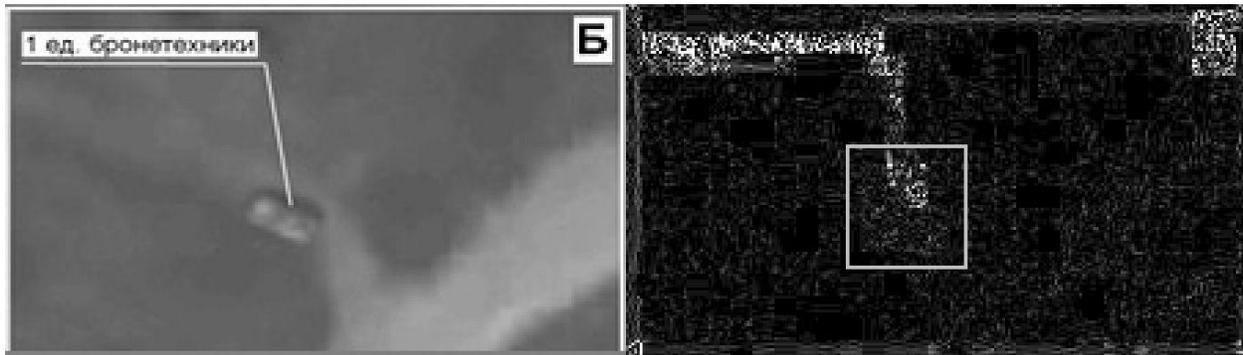
The difference in error levels becomes clearer when the area under consideration is enlarged.



ELA of enlarged area in Picture 5

Now the higher error levels surrounding the vehicles is clear. That area D was digitally modified is unquestionable.

Once more, the magnified image details of the vehicles in area E exhibit very different error levels than the surrounding soil structures, as this enlarged images shows.



ELA of an enlarged area E in Picture 5

Higher error levels are clearly visible in the square shown around the vehicle. It is highly probable, therefore, that the image content in area E has been digitally modified.

Reference Analysis

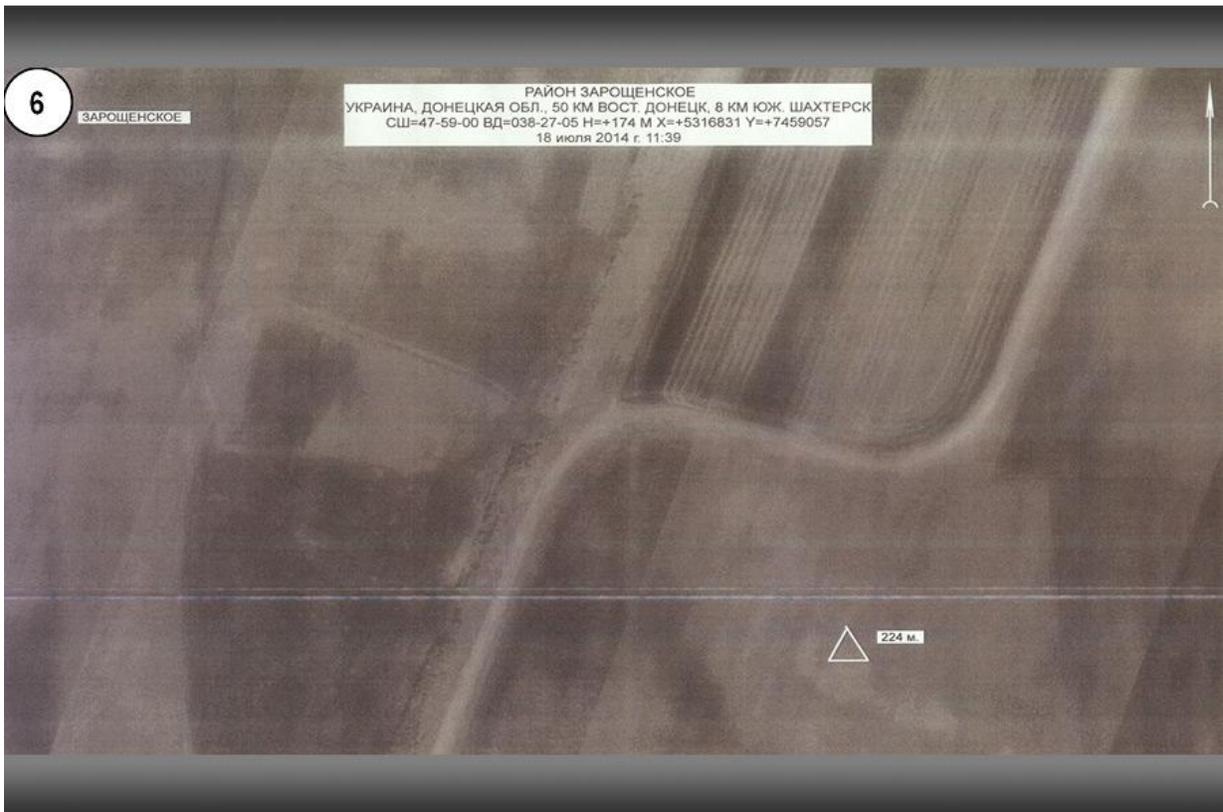
Picture 5, according to the MoD, is dated 17 July 2014:

*On the fifth photo we can see Buk-M1 artillery battalion deployed 50 kilometers east to Donetsk and 8 kilometers south to Shakhtarsk. We can answer: why the battalion was deployed near to the territory controlled by militants just before the accident?*³³

Establishing an accurate date of Picture 5 is therefore crucial to determining the veracity of the MoD's statement.

In order to determine the date of Picture 5, we will first evaluate Picture 6, as the MoD uses Picture 6 as a reference for Picture 5. Picture 6 according to the MoD, was taken on 18 July 2014, a day after Picture 5:

*On the photo of same area dated July 18 (photo No. 6) we can see that the battery left the occupied position.*³⁴



Picture 6; Source: MoD³⁵

³³

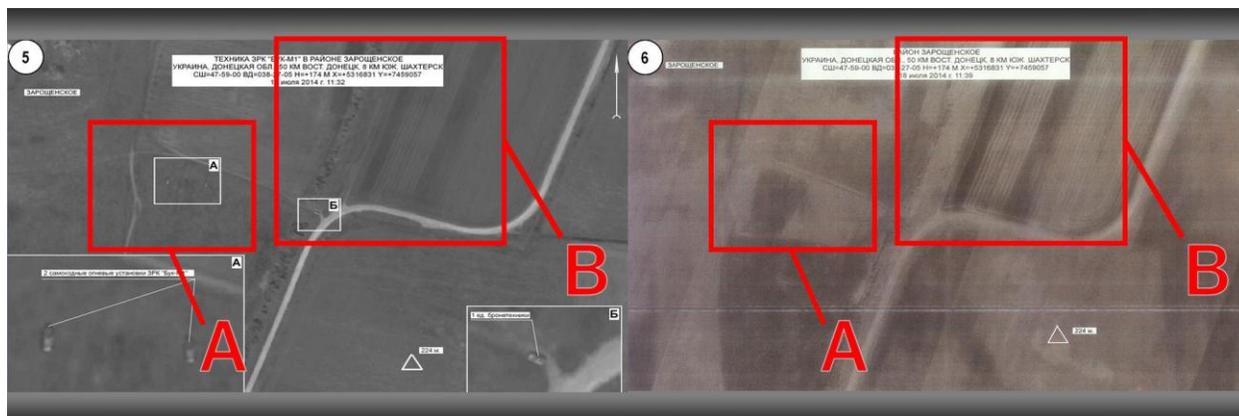
https://web.archive.org/web/20140721191232/http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews

³⁴

https://web.archive.org/web/20140721191232/http://function.mil.ru/news_page/country/more.htm?id=11970654@egNews

³⁵ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_07-900.jpg

A close examination of Pictures 5 and 6 shows distinct changes in the soil structure of two areas, which we have marked "A" and "B."



Pictures 5 and 6 – A and B mark the different soil structures

We have heightened the contrast in areas A and B to show the differences more clearly:



Area A, Picture 5

Area A, Picture 6

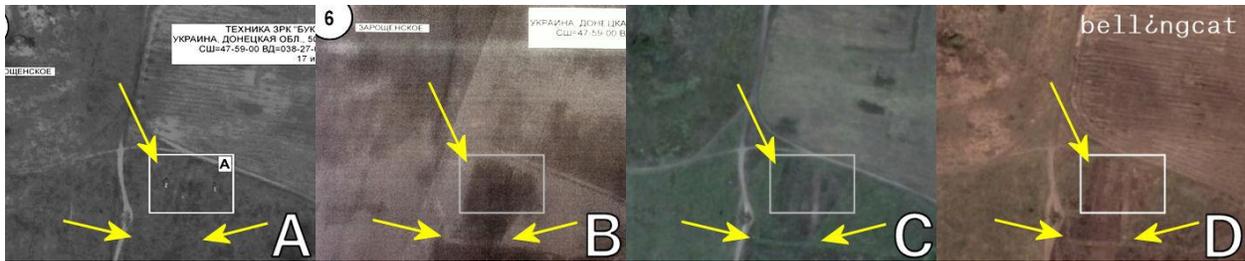
Area B, Picture 5

Area B, Picture 6

Area A shows the location where vehicles identified by the MoD as Ukrainian Buk missile launchers are present. The soil structure in this area displays significant differences from the same area in Picture 6.

Area B in Picture 5 shows an area of a field that is very dark in color. The same area in Picture 6, by contrast, is much lighter than the surrounding soil structures.

Comparing areas A and B in Pictures 5 and 6 with historical satellite imagery of the same location allows us to situate the Pictures 5 and 6 chronologically and determine their approximate dates.



MoD's Picture 5

MoD's Picture 6

16 July 2014

13 September 2014

- Figure A: Area A – Picture 5 from the MoD, dated 17 July 2014
- Figure B: Area A – Picture 6 from the MoD, dated 18 July 2014
- Figure C: Area A – Satellite photo from Google Earth on 16 July 2014
- Figure D: Area A – Satellite photo from Google Earth on 13 September 2014

The Google Earth satellite imagery from 16 July 2014 and 13 September 2014 show seasonal changes in vegetation. The soil structures, however, are largely unchanged.

The MoD's Picture 6 shows the same soil structures as those in the two Google Earth images, while Picture 5 clearly shows an altered soil structure. This verifies that Picture 5 was taken before Picture 6 and before the Google Earth imagery captured on 16 July and 13 September.



MoD's Picture 5

MoD's Picture 6

16 July 2014

13 September 2014

- Figure A: Area B – Picture 5 from the MoD, dated 17 July 2014
- Figure B: Area B - Picture 6 from the MoD, dated 18 July 2014
- Figure C: Area B - Satellite photo from Google Earth on 16 July 2014
- Figure D: Area B - Satellite photo from Google Earth on 13 September 2014

Comparing area B with Google Earth imagery reveals conspicuous differences in the soil structures. In Picture 5 (Figure A), we have marked three dark areas with yellow arrows.

Picture 6 (Figure B) shows that the section marked by the leftmost arrow is already significantly lighter, while the middle and the right portions still appear dark. In the Google Earth satellite images taken 16 July 2014 (Figure C) and 13 September 2014 (Figure D), all three areas appear as lightly colored soil structures.

We can therefore conclude beyond a doubt that Picture 6 was not taken after 15 July 2014, and Picture 5 was not taken after 14 July 2014. The MoD-provided dates for Picture 5 (17

July 2014) and Picture 6 (18 July 2014) can be discounted, as it is clear that both photos were taken at earlier dates.

Summary of Picture 5 Forensic Analysis

On the basis of source analysis, any digital modification by a third party can be excluded.

The Bellingcat investigation team's forensic analysis revealed that Picture 5 has been digitally modified with Adobe Photoshop CS5 software. We assess with a high degree of probability that a number of areas of the original satellite image were digitally altered.

The comparison of Picture 5 with historical satellite pictures from Google Earth conclusively demonstrates that Picture 5 was taken prior to 15 July 2014.

Forensic Analysis of the MoD's Picture 5-analytics

The high-resolution "Picture 5-analytics," published by the MoD on 1 August, is a modified version of the original Picture 5. It shows an area approximately 830m wide and 600m long south of the village Zaroschinskoe in eastern Ukraine.³⁶ The photo is dated by the MoD as 17 July 2014 at 11:32. As opposed to the originally published Picture 5, this version shows a larger area and the number 4 in the top-left corner.

Presumably it is an earlier version of Picture 5.



Higher-quality version of Picture; Source: MoD³⁷

Source Analysis

The higher-quality Picture 5-analytics was published on 1 August 2014 on the MoD's website. The source of Picture 5-analytics³⁸ examined here is the official website of the MoD so that any digital modification by a third party can be excluded.

³⁶ <http://wikimapia.org/#lang=de&lat=47.982953&lon=38.452272&z=18&m=b>

³⁷ http://mil.ru/files/morf/2014-08-01_analytics_06.jpg

³⁸ http://mil.ru/files/morf/2014-08-01_analytics_06.jpg

Metadata Analysis

The following information is among the metadata gathered from Picture 5-analytics.

```
Timestamp: 2014-08-01 08:48:09 GMT (the time uploaded to the server)39
File
File Type    JPEG
MIME Type    image/jpeg
Image Width  1428
Image Height 876
Encoding Process    Baseline DCT, Huffman coding
Bits Per Sample    8
Color Components    3
Y Cb Cr Sub Sampling    YCbCr4:2:0 (2 2)

JFIF
JFIF Version 1.01
Resolution Unit    inches
X Resolution 220
Y Resolution 220

Composite
Image Size    1428x876
Megapixels    1.3

JPEG last saved at 95% quality (JPEG Standard)
```

The analysis above shows that no photo editing software information is included in the metadata of Picture 5-analytics. The picture was saved with a size of 1428x876 pixels and a compression quality of 95%.

It is unusual that a photo of an official government agency was published without metadata pertaining to the time the photo was taken, the location the photo was taken, and the creator of the photo.

³⁹ <http://fotoforensics.com/analysis.php?id=9c6a68976a91efe422070b61931ef74d63082930.224441&show=digest>

Error Level Analysis (ELA)

This section presents the findings of the ELA conducted on Picture 5-analytics.



ELA, Picture 5-analytics⁴⁰

A direct comparison of the error levels of Picture 5 and the higher-resolution Picture 5-analytics shows clearly lower error levels for Picture 5-analytics.

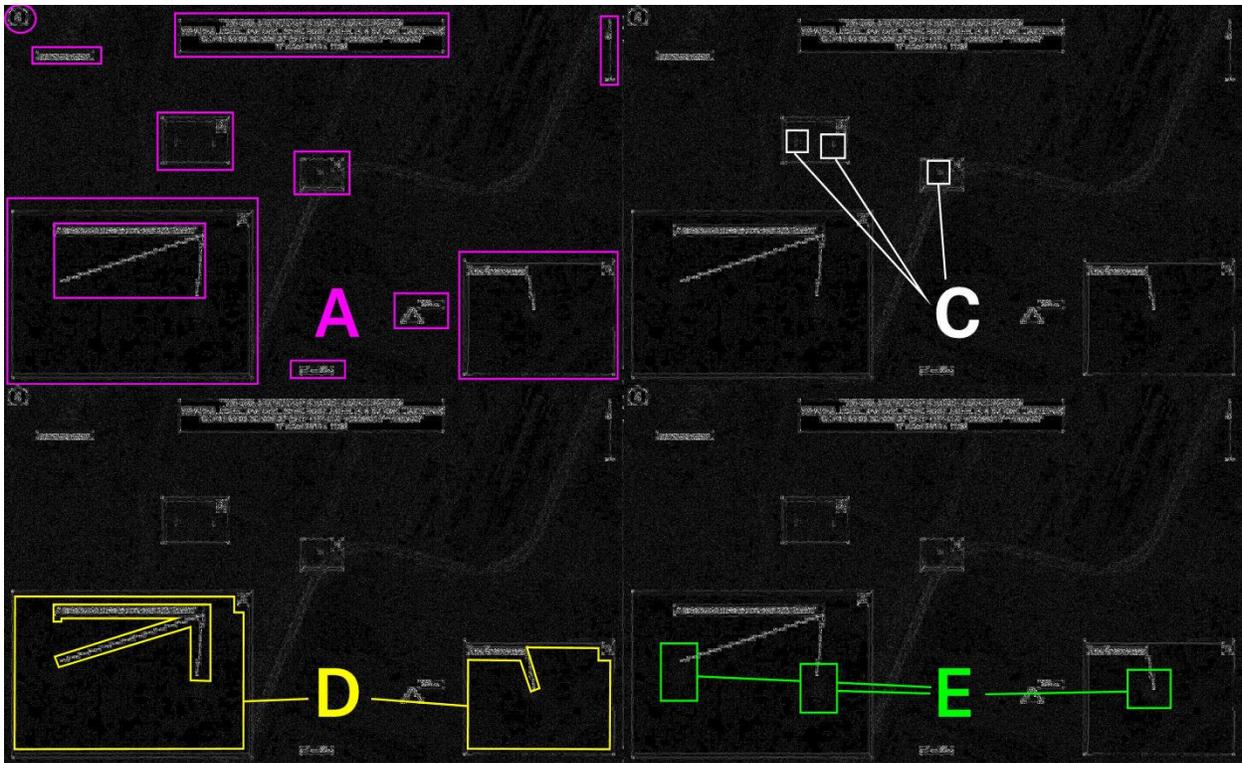
Higher error levels are always present in the original or primary picture. Every time an image is saved in JPEG format the error levels are reduced. If a picture that has been saved is saved once more, the error levels decrease again; the ELA becomes darker with every new save.

Given this, it can be derived that the high-resolution Picture 5-analytics was not saved from the original picture, but rather a saved version of the original picture.

Nevertheless, the ELA also shows a reduced average error level and higher image quality for some areas with significantly different error levels like the previously analyzed Picture 5. Notice that the colored stripe on the left side of Picture 5 is not present in this version, meaning that Picture 5-analytics was not cropped on the left.

Hence, the digital changes present in the picture must have already been carried out before this version.

⁴⁰ <http://fotoforensics.com/analysis.php?id=2b8c6756d5fd31c161f7568d4dc4f361196eff77.88694>



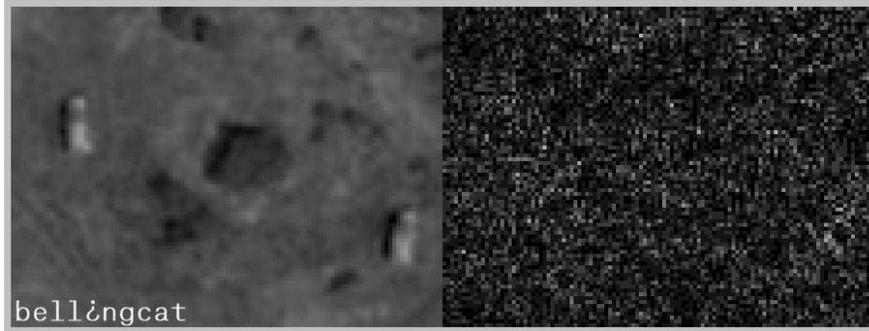
Areas A, C, D and E with differing error levels

- Area A: Error level of additional image elements and labeling
- Area C: Image content with soil structures and vehicles
- Area D: Magnified image details
- Area E: Vehicles in the image details

The error levels of area A can be explained by the added image elements and labeling.

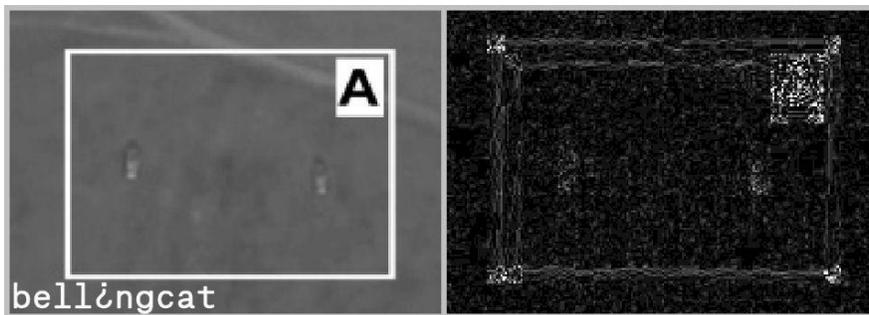
The ELA shows that the soil structures in area C have a much lower error level than the three vehicles present. As shown in our analysis of Pictures 3 and 4, all image content should present roughly the same error levels if the photo has not been altered. Again, below is a detailed look at the error levels in a portion of MoD's Picture 2⁴¹ that shows military vehicles.

⁴¹ http://stat.multimedia.mil.ru/images/military/military/photo/mh17_brief_03-900.jpg



ELA of a section of Picture 2⁴²

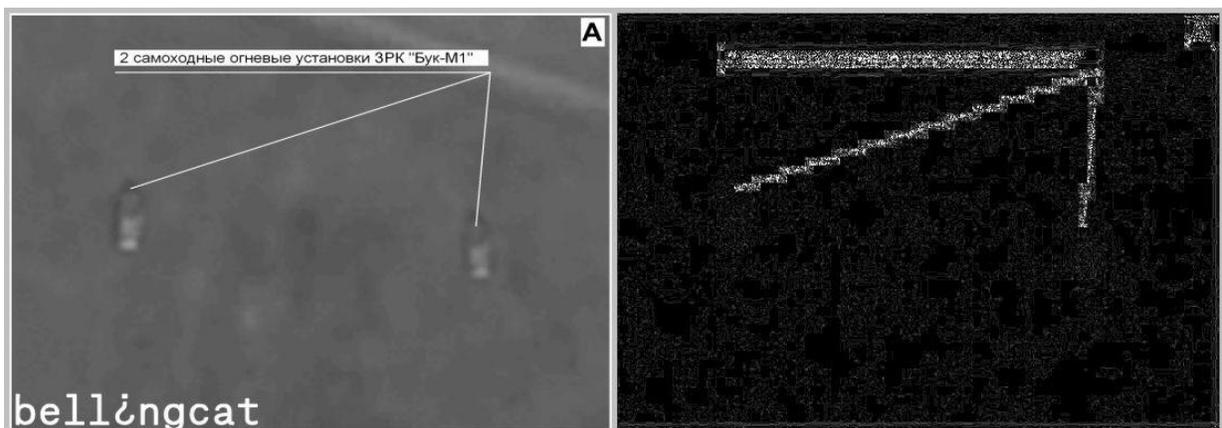
By contrast, area C of Picture 5 shows soil structures (like in Picture 5) with significantly lower error levels than the area around the vehicles.



ELA of a portion of area C in Picture 5

Thus, we can say with a high degree of probability that the image content in area C has been digitally modified.

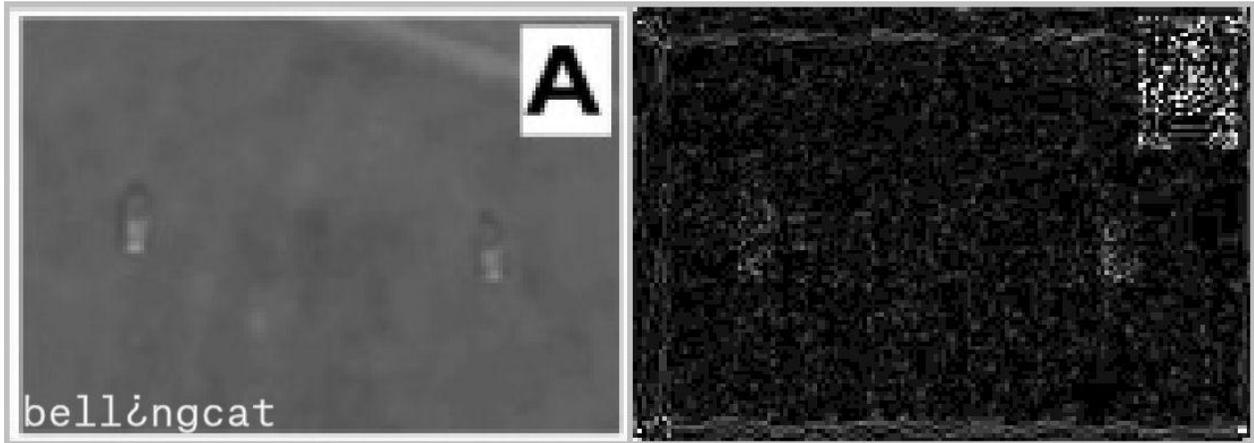
As with Picture 5, there is a striking difference in error levels evident in the magnified image details (area D).



ELA of area D in Picture 5

⁴² <http://fotoforensics.com/analysis.php?id=e107d94eba4b9cd7a07bd61c87b5f2a6efae9ac.125856&show=ela>

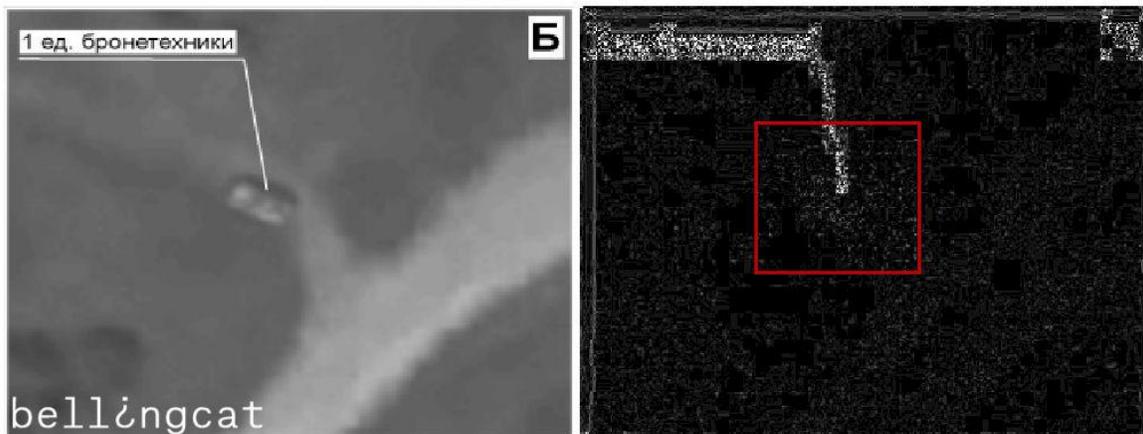
The difference in error levels becomes clearer when the original area A under consideration is enlarged.



ELA of enlarged original area A in Picture 5-analytics

Now the higher error levels surrounding the vehicles is clear. That area D was digitally modified is unquestionable.

Once more, the magnified image details of the vehicles in area E exhibit a very different error level than the surrounding soil structures, as this enlarged images shows.



ELA of area E in Picture 5-analytics

A higher error level is clearly visible in the square shown around the vehicle. It is highly probable, therefore, that the image content in area E has been digitally modified.

Reference Analysis

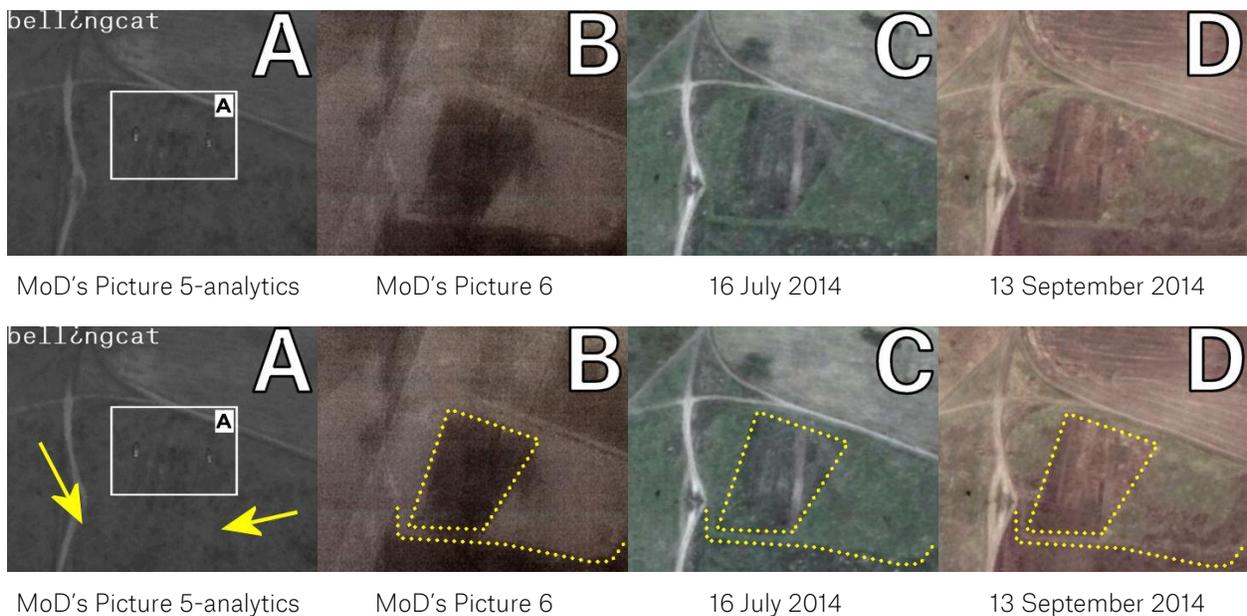
Picture 5-analytics, published 1 August 2014, is dated 17 July 2014 by the MoD, just like the earlier published Picture 5.

Picture 6 was determined in the previous section to be taken prior to 16 July 2014.

Comparing two sections of Picture 5-analytics with the same areas in Picture 6 and historical satellite photos from Google earth allows us to determine the approximate date of Picture 5-analytics.

We have heightened the contrast in areas A and B to show the differences more clearly.

Comparison of section A:



- Figure A: Area A – Picture 5-analytics from the MoD, dated 17 July 2014
- Figure B: Area A – Picture 6 from the MoD, dated 18 July 2014
- Figure C: Area A – Satellite photo from Google Earth on 16 July 2014
- Figure D: Area A – Satellite photo from Google Earth on 13 September 2014

The Google Earth satellite imagery from 16 July 2014 and 13 September 2014 show seasonal changes in vegetation. The soil structures, however, are largely unchanged.

The MoD's Picture 6 shows the same soil structures as those in the two Google Earth images, while Picture 5 clearly shows an altered soil structure. This verifies that Picture 5 was taken before Picture 6 and before the Google Earth imagery captured on 16 July and 13 September.

Comparison of section B:

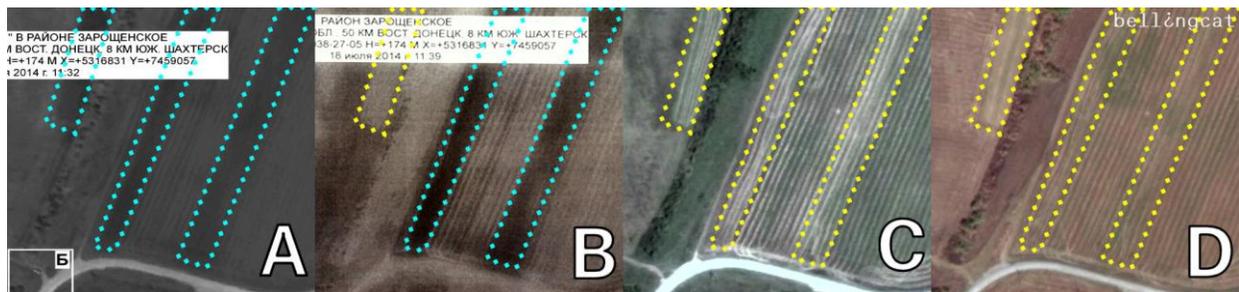


MoD's Picture 5-analytics

MoD's Picture 6

16 July 2014

13 September 2014



MoD's Picture 5-analytics

MoD's Picture 6

16 July 2014

13 September 2014

- Figure A: Area B – Picture 5-analytics from the MoD, dated 17 July 2014
- Figure B: Area B – Picture 6 from the MoD, dated 18 July 2014
- Figure C: Area B – Satellite photo from Google Earth on 16 July 2014
- Figure D: Area B – Satellite photo from Google Earth on 13 September 2014

Comparing area B with Google Earth imagery reveals conspicuous differences in the soil structures. In Picture 5-analytics (Figure A), we have marked three dark areas with light blue lines.

Picture 6 (Figure B) shows that the leftmost section is already significantly lighter (yellow outline), while the middle and the right portions still appear dark (light blue outlines). In the Google Earth satellite images taken 16 July 2014 (Figure C) and 13 September 2014 (Figure D), all three areas appear clearly as lightly colored soil structures (yellow outlines).

We can therefore conclude beyond a doubt that Picture 6 was not taken after 15 July 2014, and Picture 5-analytics was not taken after 14 July 2014. The MoD-provided dates for the higher-resolution Picture 5-analytics (17 July 2014) and Picture 6 (18 July 2014) can be disregarded, as it is clear that both photos were taken at earlier dates.

Summary of Picture 5-analytics Forensic Analysis

On basis the source analysis, any digital modification by a third party can be excluded.

The Bellingcat investigation team's forensic analysis revealed that Picture 5-analytics deviates in some areas from the Picture 5 originally published by the MoD. Picture 5-analytics is larger than the Picture 5, and it is labeled with number 4. It is unquestionably not the primary picture source, because its error levels are lower than Picture 5.

The ELA of Picture 5-analytics exhibited the same discrepancies that were already ascertained in Picture 5 in the previous section. It is highly probable that some areas of the primary satellite photo were digitally modified.

The comparison of Picture 5-analytics with historical satellite pictures from Google Earth proved beyond a doubt that the satellite photo in the Picture 5-analytics was taken prior to 15 July 2014.

Modified Versions of the MoD's Picture 5

Using a reverse image search, we found three other sources for the MoD's Picture 5 in which the same image is in a higher resolution and a different compression. The following analysis is intended to clarify the origin of these versions of the images and identify similarities and differences with the image published by the MoD.

Source One: Blog "KAVKAZPRESS.RU"

The Russian blog, "KAVKAZPRESS.RU,"⁴³ published on 21 July 2014⁴⁴ the text of the press conference and the images provided by the MoD. Picture 5 here has the filename "B6.jpg"⁴⁵ and has a resolution of 1149x649 pixels.



Figure B6.jpg; Source: KAVKAZPRESS.RU⁴⁶

The metadata⁴⁷ contains no evidence pertaining to the source of the image. It is worth noting that the timestamp⁴⁸ of the image is dated prior to the timestamp of the original image provided by the MoD.

Time stamp: Picture 5 (MoD)	2014-07-21 16:29:04 GMT
Time stamp: B6.jpg (KAVKAZPRESS.RU)	2014-07-21 15:36:36 GMT

⁴³ <http://kavkazpress.ru>

⁴⁴ <http://kavkazpress.ru/archives/13381>

⁴⁵ <http://kavkazpress.ru/wp-content/uploads/2014/07/B6.jpg>

⁴⁶ <http://kavkazpress.ru/wp-content/uploads/2014/07/B6.jpg>

⁴⁷ <http://fotoforensics.com/analysis.php?id=22b267a2b67abd4d2a8d6ed911d8f54fe6c09ac9.130783&show=meta>

⁴⁸ <http://fotoforensics.com/analysis.php?id=22b267a2b67abd4d2a8d6ed911d8f54fe6c09ac9.130783&show=digest>

This blog, therefore, has published the images from the press conference prior to their publication on the MoD's website.

Source Two: Novaya Gazeta

The Russian newspaper *Novaya Gazeta*⁴⁹ published on 5 May 2015 an article entitled "It was a BUK-M1."⁵⁰ The article includes an ostensibly leaked report authored by Russian military engineers about the cause of the crash of MH17 on 17 July 2014. The report includes the satellite images from the MoD press conference.

Picture 5 included in the report has the filename "1430846768_925256_89.png"⁵¹ and has a resolution of 1134x640 pixels. There are clear differences between this image and the MoD's original Picture 5. It can therefore be considered to be a modified version.

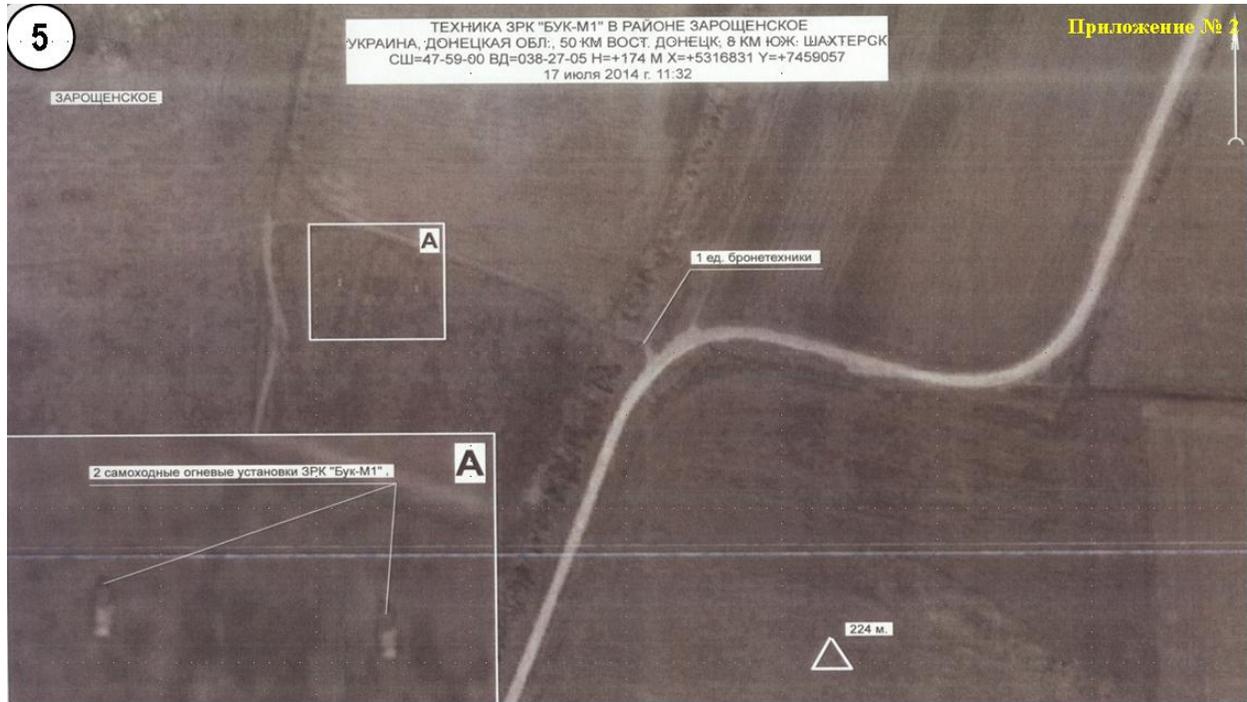


Figure 1430846768_925256_89.png;⁵² Source: *Novaya Gazeta*

The metadata⁵³ in this image contains no indication of the source of the image. It is apparent that a change (possibly only in the metadata) has taken place through software from the cloud service YANDEX.DISK.

Two things are striking in this version of the image. First, the enlarged detail box B showing a military vehicle in the MoD's original Picture 5 is completely absent. Second, a colored strip was superimposed onto the image that has no relation to the image's content.

The horizontal strip can be seen along the bottom fifth of the image, including in the enlarged detail box A. (Because colored strip runs through detail box A, we can be certain

⁴⁹ <http://www.novayagazeta.ru>

⁵⁰ <http://www.novayagazeta.ru/inquests/68332.html>

⁵¹ http://www.novayagazeta.ru/storage/c/2015/05/05/1430846768_925256_89.png

⁵² http://www.novayagazeta.ru/storage/c/2015/05/05/1430846768_925256_89.png

⁵³ <http://fotoforensics.com/analysis.php?id=e38404683701987d2680a01fbb1dcd8cd91ded91.987588&show=ela>

that it was not part of the original satellite image.) The purpose of these image modifications remains unclear.

The image content in this version exhibits the same structural differences that have been described in the section on the forensic analysis of Picture 5.

Conclusion

The subjects of the Bellingcat investigation team's forensic investigation were two of six satellite photos released by the Russian Ministry of Defense in an international press conference following the downing of Malaysia Airlines Flight 17 (MH17) on 17 July 2014 in eastern Ukraine. The images were subsequently published on the MoD's official website.

One of the pictures, Picture 5, was republished on 1 August 2014 on the official web page of the MoD as a higher-quality version called Picture 5-analytics. This image was also analyzed.

The Russian MoD stated at the press conference that the satellite photos show the activities of Ukraine's air defenses on the day that MH17 was shot down. In particular, Picture 5 purported to show the presence of two Ukrainian Buk missile launchers south of the village Zaroschinskoe that were within firing range of MH17. And Picture 4, according to the MoD, revealed the absence of a Buk missile launcher at military unit A-1428, north of Donetsk.

Our forensic analysis of all three images clearly and unequivocally shows that these images have been altered. In each of the pictures, significant image content has been digitally modified with a high level of probability. Pictures 4 and 5 were shown to have been digitally modified using Adobe Photoshop CS5 software.

In addition, all three satellite images were shown to have been photographed before 17 July 2014. The MoD's Picture 4 was taken sometime between 1 June 2014 and 18 June 2014, and the MoD's Picture 5 and Picture 5-analytics were taken prior to 15 July 2014.

That the MoD inadvertently ascribed incorrect dates to the photographs it released can be excluded. On 21 July 2014, the Russian Ministry of Defense presented digitally modified and falsely dated satellite images to the international public in order to implicate the Ukrainian army in the downing of MH17. Later, on 1 August 2014, the MoD again published digitally altered and falsely dated satellite imagery with the release of Picture 5-analytics.

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