

# Magnetic alignment in cattle and deer

Lesson for sceptics (Part 1)

**Recently (August 2008 and March 2009, respectively), we published two papers which both triggered immense publicity and resonance all over the world:**

Begall S., Červený J., Neef J., Vojtěch O., Burda H. (2008):  
Magnetic alignment in grazing and resting cattle and deer.  
*Proceedings of the National Academy of Sciences USA*, 105(36): 13451-13455.

Burda H., Begall S., Červený J., Neef J., Němec P. (2009):  
Extremely low-frequency electromagnetic fields disrupt magnetic alignment of ruminants.  
*Proceedings of the National Academy of Sciences USA*, 106 (14): 5708-5713.

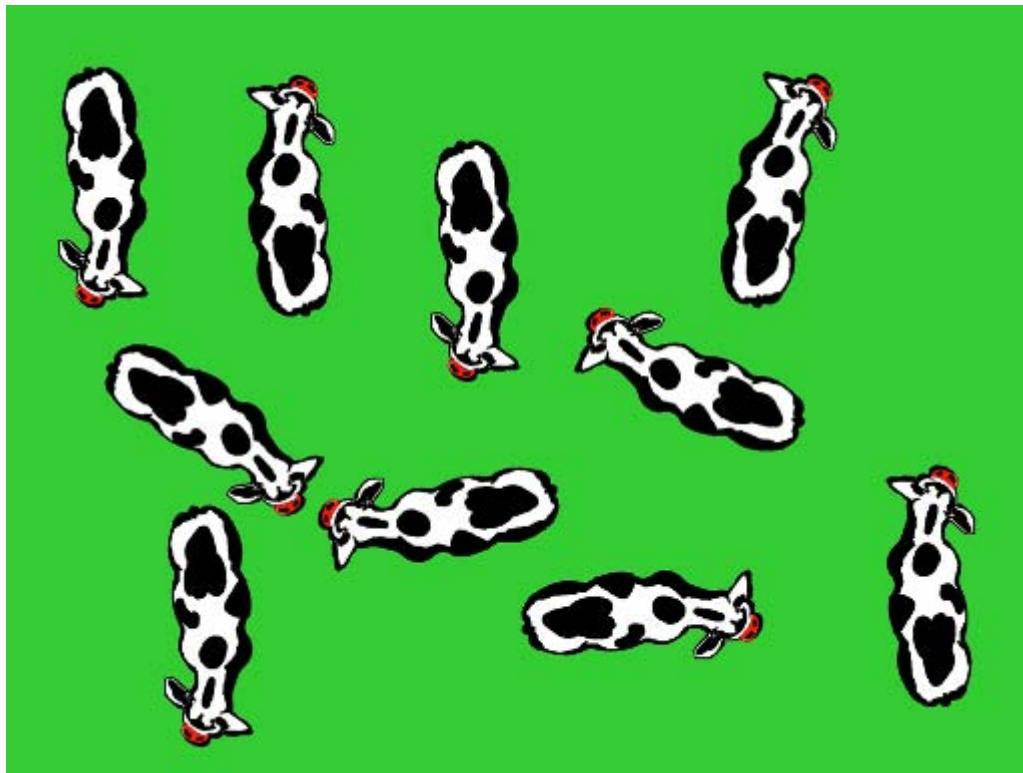
**We provide here abstracts of both papers.**

# Magnetic alignment in grazing and resting cattle and deer

Sabine Begall\*<sup>†</sup>, Jaroslav Červený<sup>‡§</sup>, Julia Neef\*, Oldřich Vojtěch<sup>†¶</sup>, and Hynek Burda\*

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Edited by Simon A. Levin, Princeton University, Princeton, NJ, and approved July 17, 2008 (received for review April 15, 2008)



We demonstrate by means of simple, noninvasive methods (analysis of satellite images, field observations, and measuring “deer beds” in snow) that domestic cattle ( $n = 8,510$  in 308 pastures) across the globe, and grazing and resting red and roe deer ( $n = 2,974$  at 241 localities), align their body axes in roughly a north-south direction. Direct observations of roe deer revealed that animals orient their heads northward when grazing or resting. Amazingly, this ubiquitous phenomenon does not seem to have been noticed by herdsman, ranchers, or hunters. Because wind and light conditions could be excluded as a common denominator determining the body axis orientation, magnetic alignment is the most parsimonious explanation. To test the hypothesis that cattle orient their body axes along the field lines of the Earth’s magnetic field, we analyzed the body orientation of cattle from localities with high magnetic declination. Here, magnetic north was a better predictor than geographic north. This study reveals the magnetic alignment in large mammals based on statistically sufficient sample sizes. Our findings open horizons for the study of magnetoreception in general and are of potential significance for applied ethology (husbandry, animal welfare). They challenge neuroscientists and biophysics to explain the proximate mechanisms.

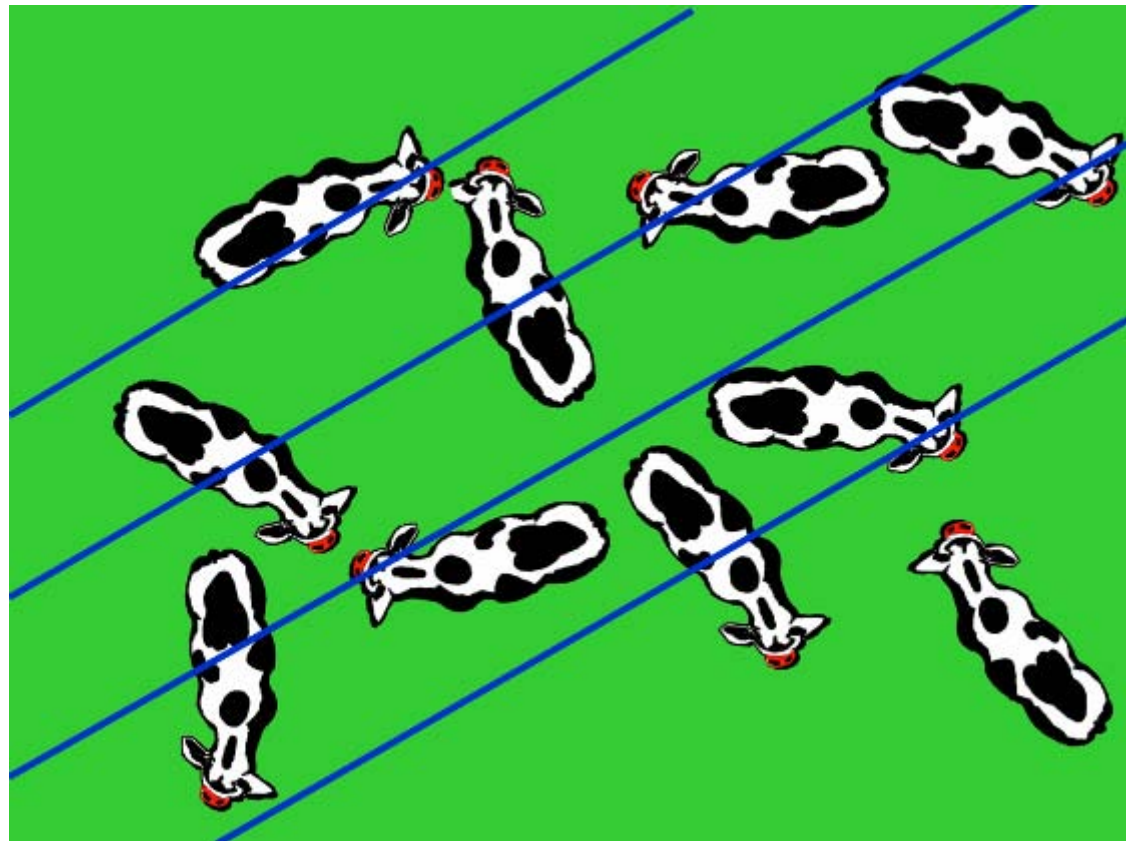


# Extremely low-frequency electromagnetic fields disrupt magnetic alignment of ruminants

Hynek Burda<sup>a,1,2</sup>, Sabine Begall<sup>a,1</sup>, Jaroslav Červený<sup>b,c</sup>, Julia Neef<sup>a</sup>, and Pavel Němec<sup>d</sup>

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Edited by Tim Guilford, Oxford University, United Kingdom, and accepted by the Editorial Board February 10, 2009 (received for review November 5, 2008)



Resting and grazing cattle and deer tend to align their body axes in the geomagnetic North-South direction. The mechanism(s) that underlie this behavior remain unknown. Here, we show that extremely low-frequency magnetic fields (ELFMs) generated by high-voltage power lines disrupt alignment of the bodies of these animals with the geomagnetic field. Body orientation of cattle and roe deer was random on pastures under or near power lines. Moreover, cattle exposed to various magnetic fields directly beneath or in the vicinity of power lines trending in various magnetic directions exhibited distinct patterns of alignment. The disturbing effect of the ELFMs on body alignment diminished with the distance from conductors. These findings constitute evidence for magnetic sensation in large mammals as well as evidence of an overt behavioral reaction to weak ELFMs in vertebrates. The demonstrated reaction to weak ELFMs implies effects at the cellular and molecular levels.

If you are interested in our studies, want to learn more, have doubts, ideas, please contact us and/or read the original articles.

Do not rely on secondary or tertiary articles in newspapers, magazines, internet news, blogs, radio, TV, etc., even if any of us is quoted as having said it - quotations are frequently torn out of the context, cut short etc.

If you do not have access to PNAS, feel free to contact us per email

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We shall send you a digital copy or a hardcopy reprint of the paper(s).

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PNAS magnetic alignment

Suche

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magnetic cows

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magnetische Kühe

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We have been very pleased that hundreds of people noticed our study, and wrote us emails and letters. Many people shared also their ideas, experience, know-how...

However, there were also many people who argued against our study and many of them do not seem to understand principles of science, animal husbandry or wildlife biology, or they do not have any expertise in ecology, ethology, sensory biology in general and magnetoreception in particular. Some of them ignored the statistics, and a few even do not know how to use Google Earth, who know cattle and deer only from pictures, who use arguments like „If I were a cow I would not do that ...“. This is sad, but it is a consequence of today's industrialized world and we have to tolerate it. However, we would like to try to shed light on some misunderstandings. The typical example to illustrate the case is the discussion forum of NATURE

<http://www.nature.com/news/2008/080825/full/news.2008.1059.html>

were wild, unfruitful speculations stopped only after we provided a detailed answer to all raised questions.

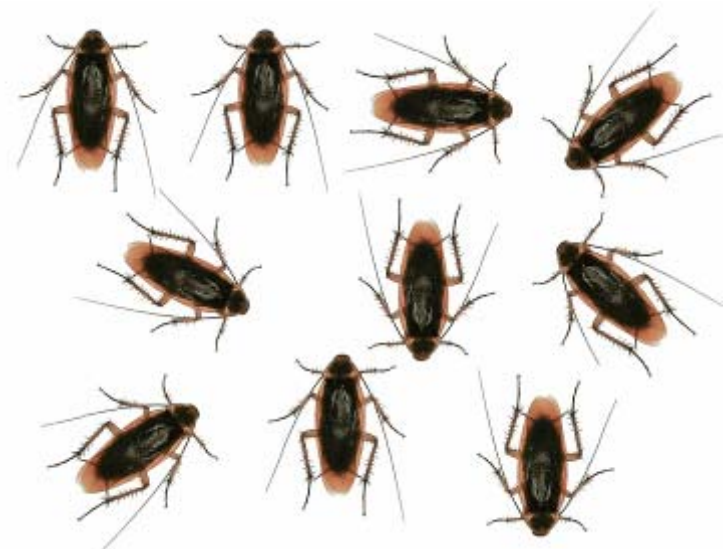
We hope you understand that we cannot be everywhere and get engaged in all the blogs and forums. That is why we decided to provide here some more supplementary information for all those who are interested.

Before we start our first lesson, let us stress out what we studied. We have studied

**magnetic alignment**

**i.e. a "spontaneous behavioural expression of magnetoreception that appears particularly in resting animals when body orientation is not controlled by other factors" (Wiltschko & Wiltschko, 2000).**

**it means, we do not claim that cattle and deer are slaves of the magnetic compass and that other factors (like wind, Sun position, slope, curiosity, etc.) do not have any effect upon body alignment of these animals. The question is, if these factors are not stressful, would these animals tend to prefer to align in any certain compass axis? Note that magnetic alignment is a statistical phenomenon. Not all the individuals show it at the same time.**



**The first lesson addresses the frequently raised claim that, Images of Google Earth do not have a sufficient resolution to recognize the cattle and/or to enable measuring its body axis orientation, and if so this measurement is subjective, not replicable.**

We provide here a sample of some few images from our collection. There are 75 herds depicted here, some of them divided into two screenshots. Not all herds consist of cattle (there are some horses as well), but it is a good exercise to learn how to distinguish.

We provide also geographic coordinates because in most cases, we provide just an overview of the pasture, but you can zoom even closer in the Google Earth and enlarge the animals (as is the case in Fig. 001).

The first screenshot and the subsequent pages show the mode of measurement. You should measure the degree of body axis in all the animals of each herd separately. We did not measure calves. You may compare the results you have got and the results your friend has obtained; or you may check how big is the error if you compare your own measurements carried out with a pause of one week between both measurements. Or send us your results so that we can compare it with ours and with results of other interested people who will respond.

Important message:

This sample - which represents just a small portion of our collection of screenshots is provided here for private purposes (i.e. for study) to all those people interested in the problem of magnetic alignment in cattle (and other animals).

Journalists etc. who wants to circulate these images should be aware that the **copy rights are with Google Earth™**.

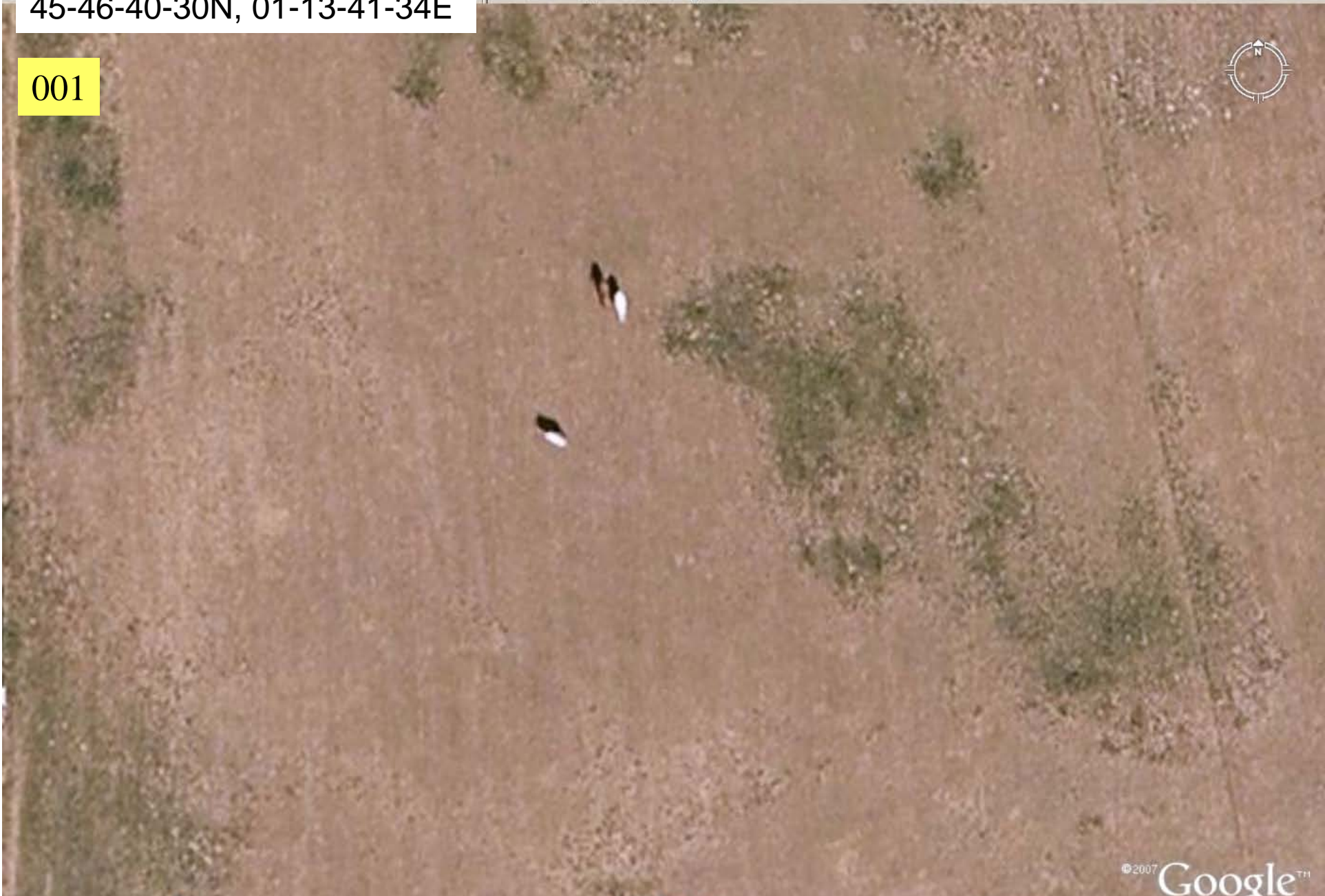
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45-46-40-30N, 01-13-41-34E



001



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20 m  
Pointer 45°46'40.30" N 1°11'41.18" E elev 265 m

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Streaming 100%

Eye alt 339 m

45-46-40-30N, 01-13-41-34E

001



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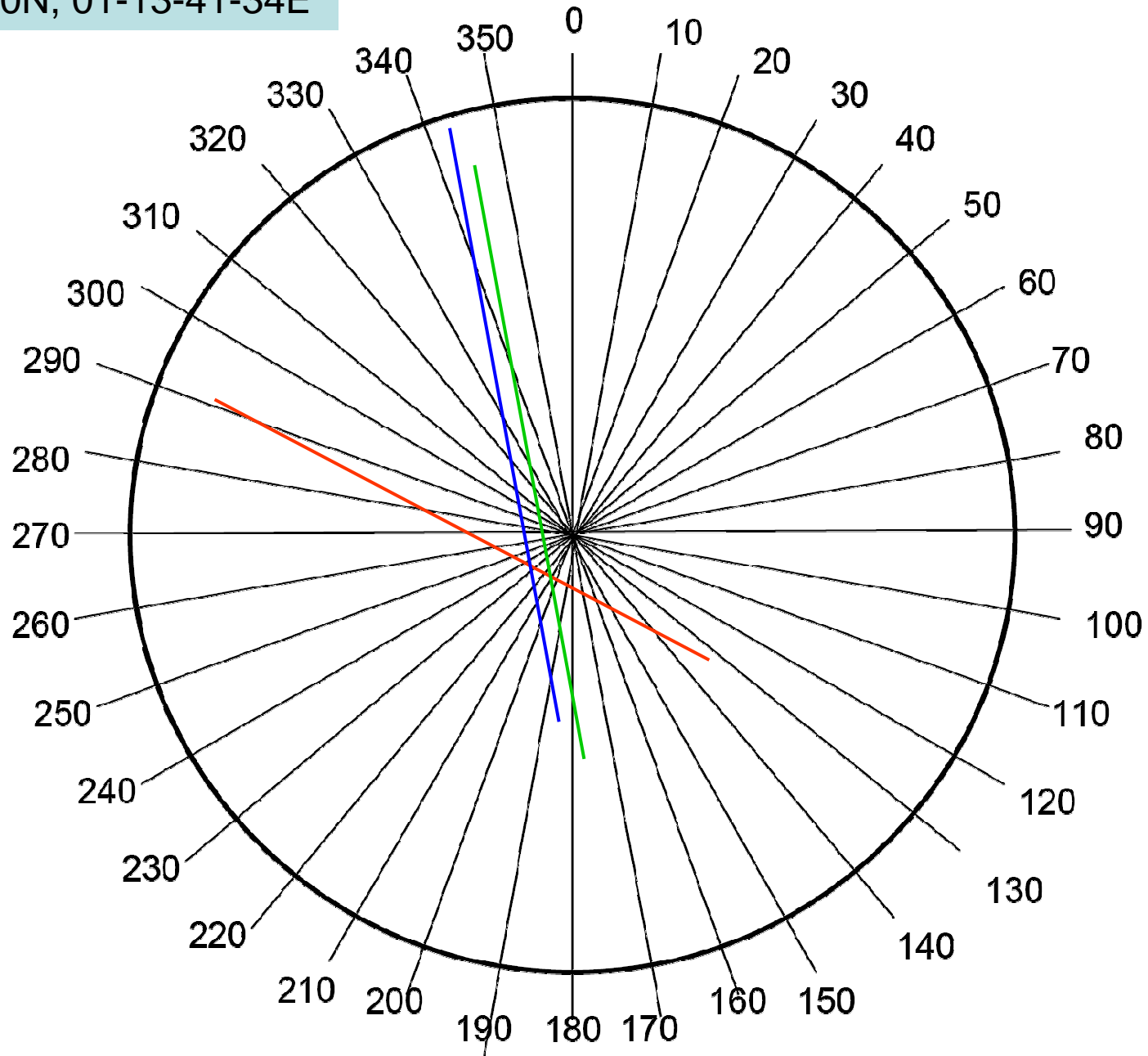
Pointer 45°46'40.30" N 1°11'41.18" E elev 265 m

Streaming 100%

Eye alt 339 m

45-46-40-30N, 01-13-41-34E

001





45-46-40-30N, 01-13-41-34E

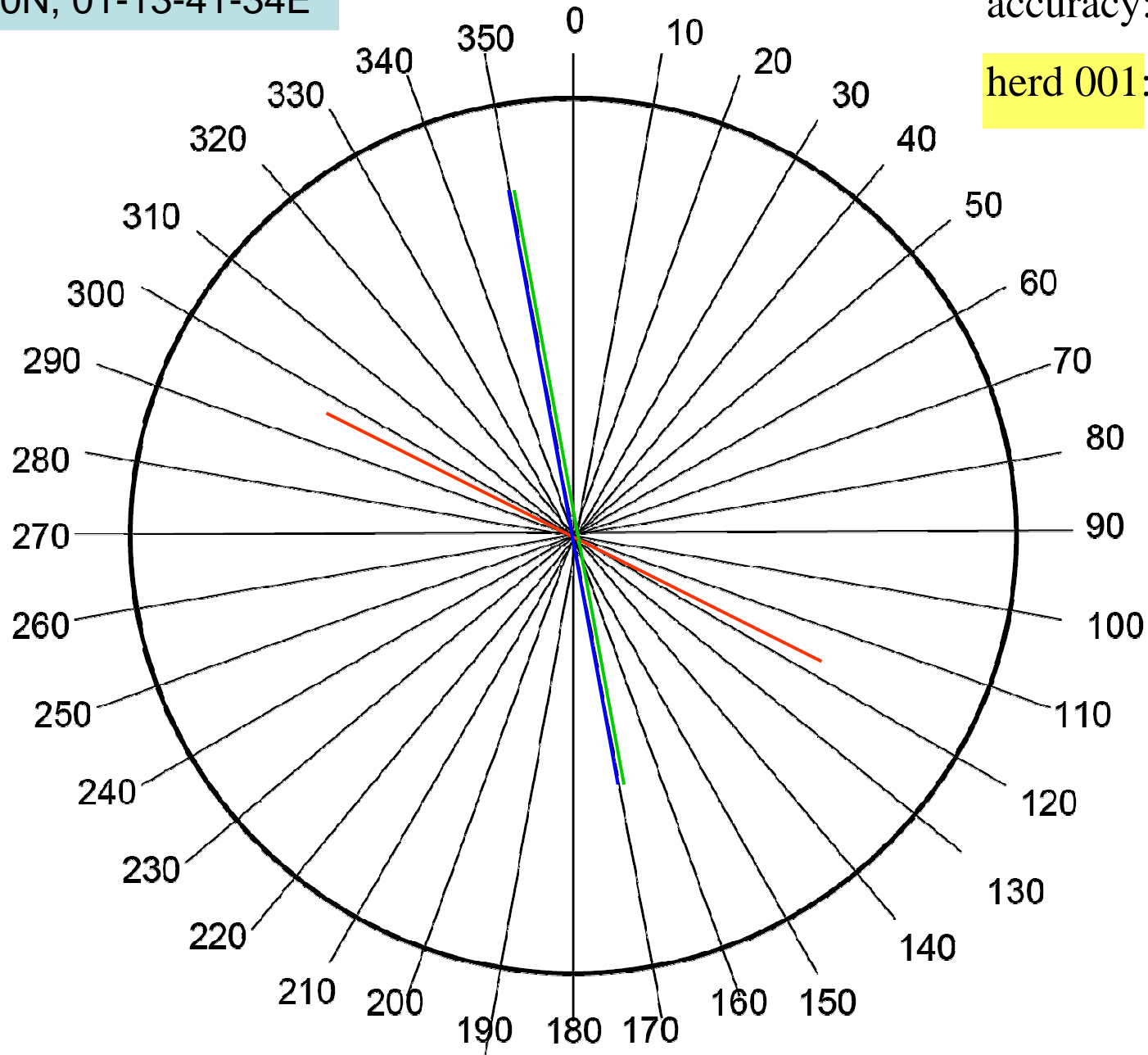
001

accuracy: 5°

herd 001: 170°

170°

115°

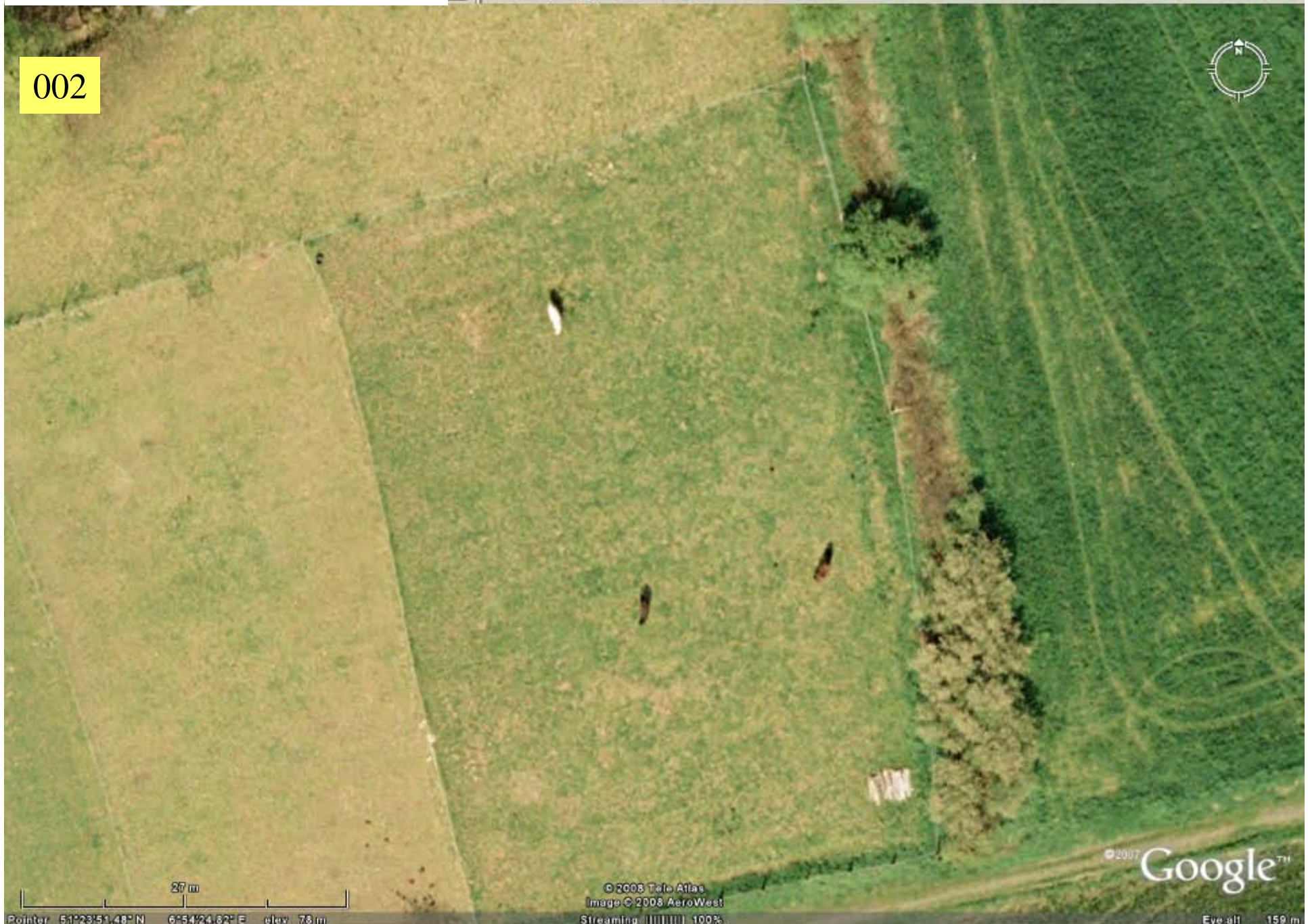




51-23-51-48N, 06-54-24-82E



002



27 m  
Pointer 51°23'51.48" N 6°54'24.82" E elev 78 m

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Eye all 159 m



51-23-37-71N, 06-55-35-96E

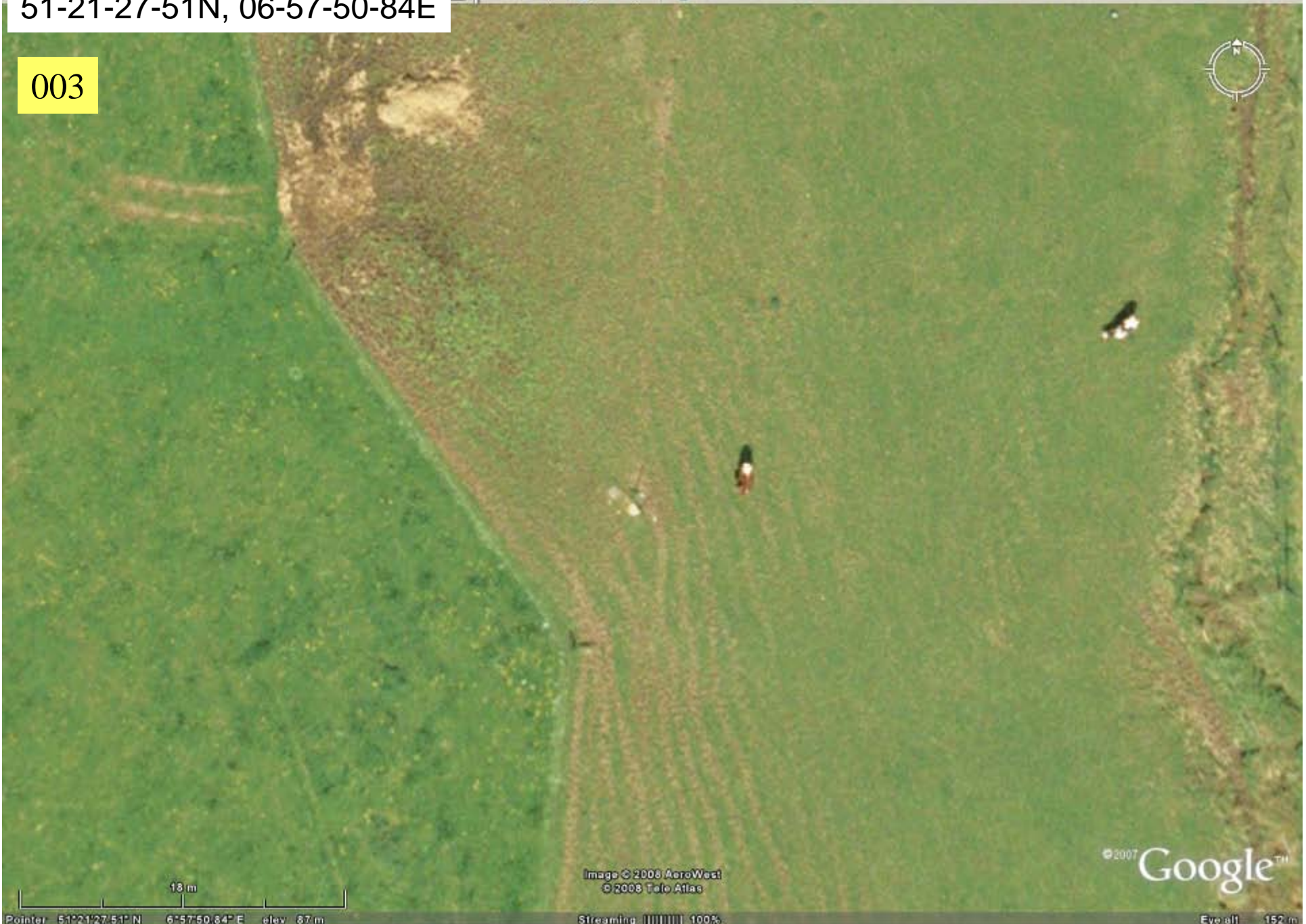
003





51-21-27-51N, 06-57-50-84E

003



18 m  
Pointer 51°21'27.51" N 6°57'50.84" E elev 87 m

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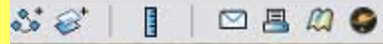
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Eye all 152 m



45-50-47-42N, 01-20-40-66E



004



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45-50-47-42N, 01-20-40-66E

004



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45-54-41-97,01-13-42-37E

005



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50-50-41-16N, 01-17-16-79W

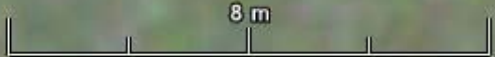


006



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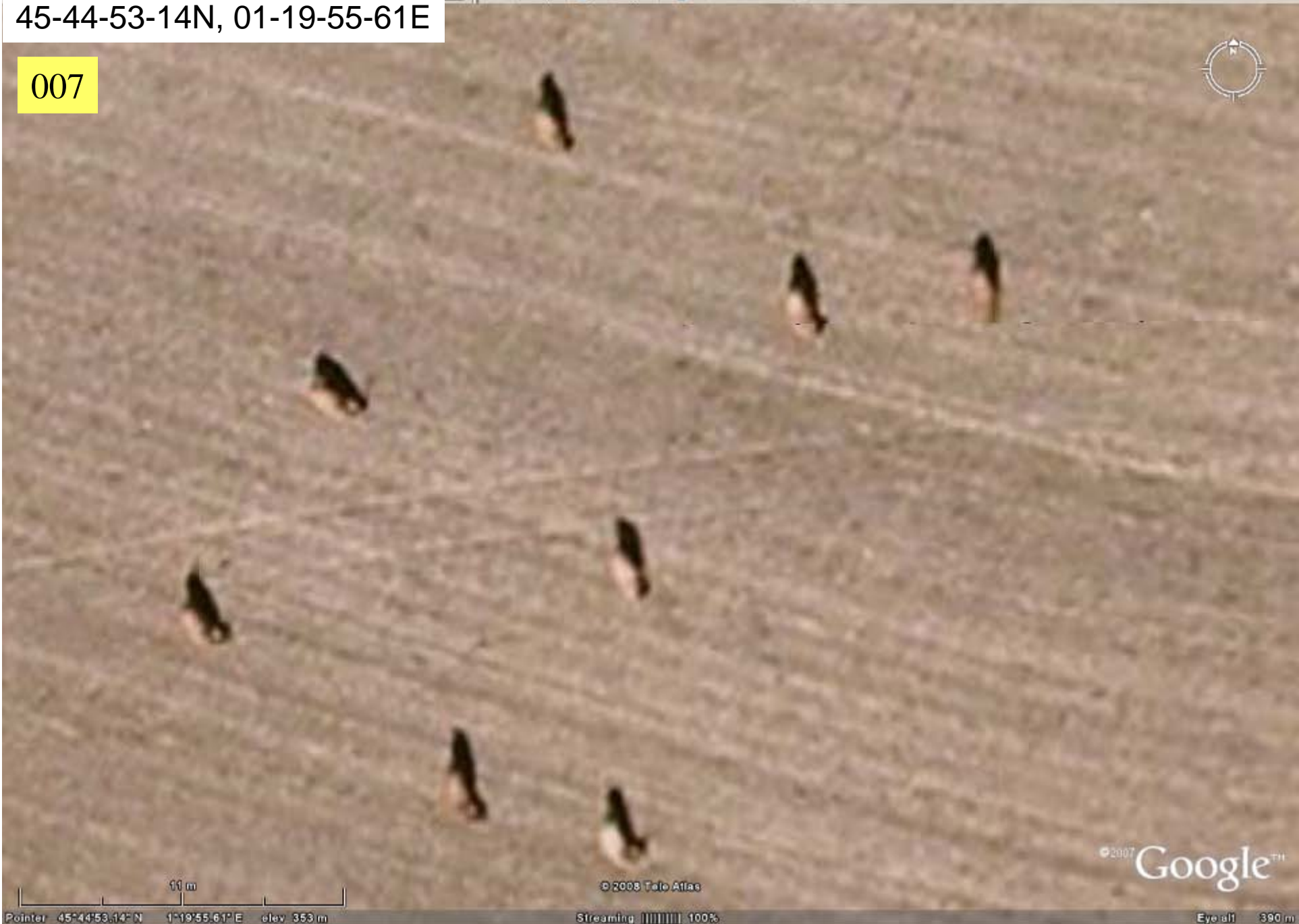
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45-44-53-14N, 01-19-55-61E

007





45-44-53-14N, 01-19-58-55E

008



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45-49-56-72N, 01-21-41-95E

009



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22 m  
Pointer 45°49'56.72" N 1°21'41.95" E elev. 351 m

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Eye alt 427 m



45-50-47-42N, 01-20-40-66E

010



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Pointer 45°50'47.42\" N 1°20'40.66\" E elev 321 m

Streaming 100%

Eye all 458 m

45-51-39-34N, 01-10-00-07E

011



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45-48-24-48N, 01-10-05-50E

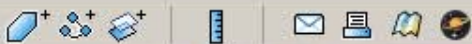
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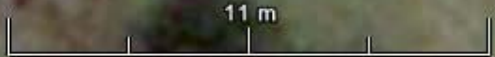
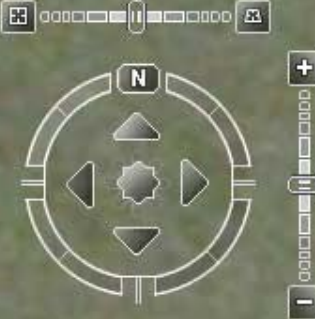
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51-32-37-79N, 02-35-58-05W



013



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45-45-31-12N, 01-20-11-56E

014





45-46-01-07N, 01-16-02-20E

015



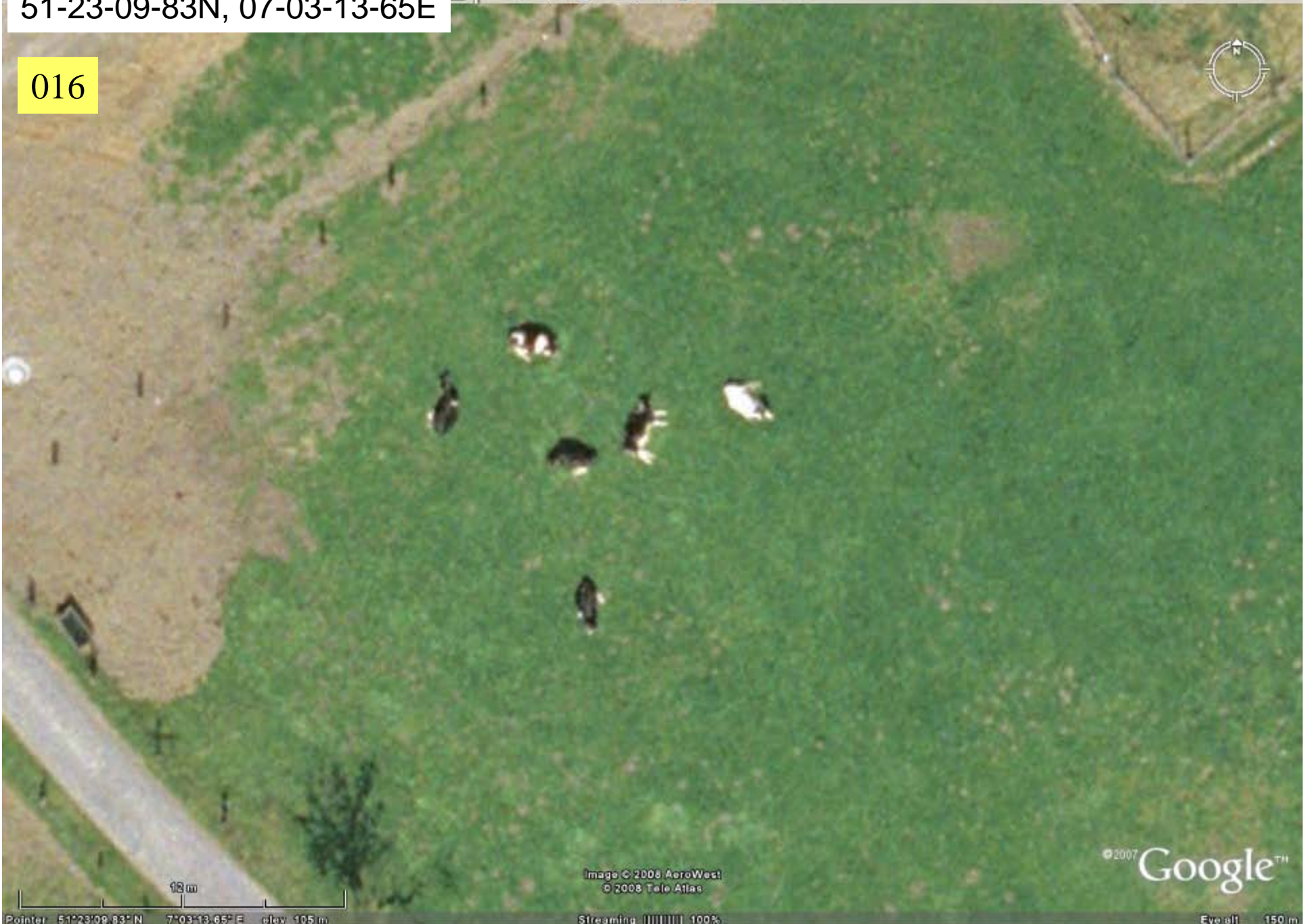
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51-23-09-83N, 07-03-13-65E

016



100 m  
Pointer 51°23'09.83" N 7°03'13.65" E elev 105 m

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Eye all 150 m



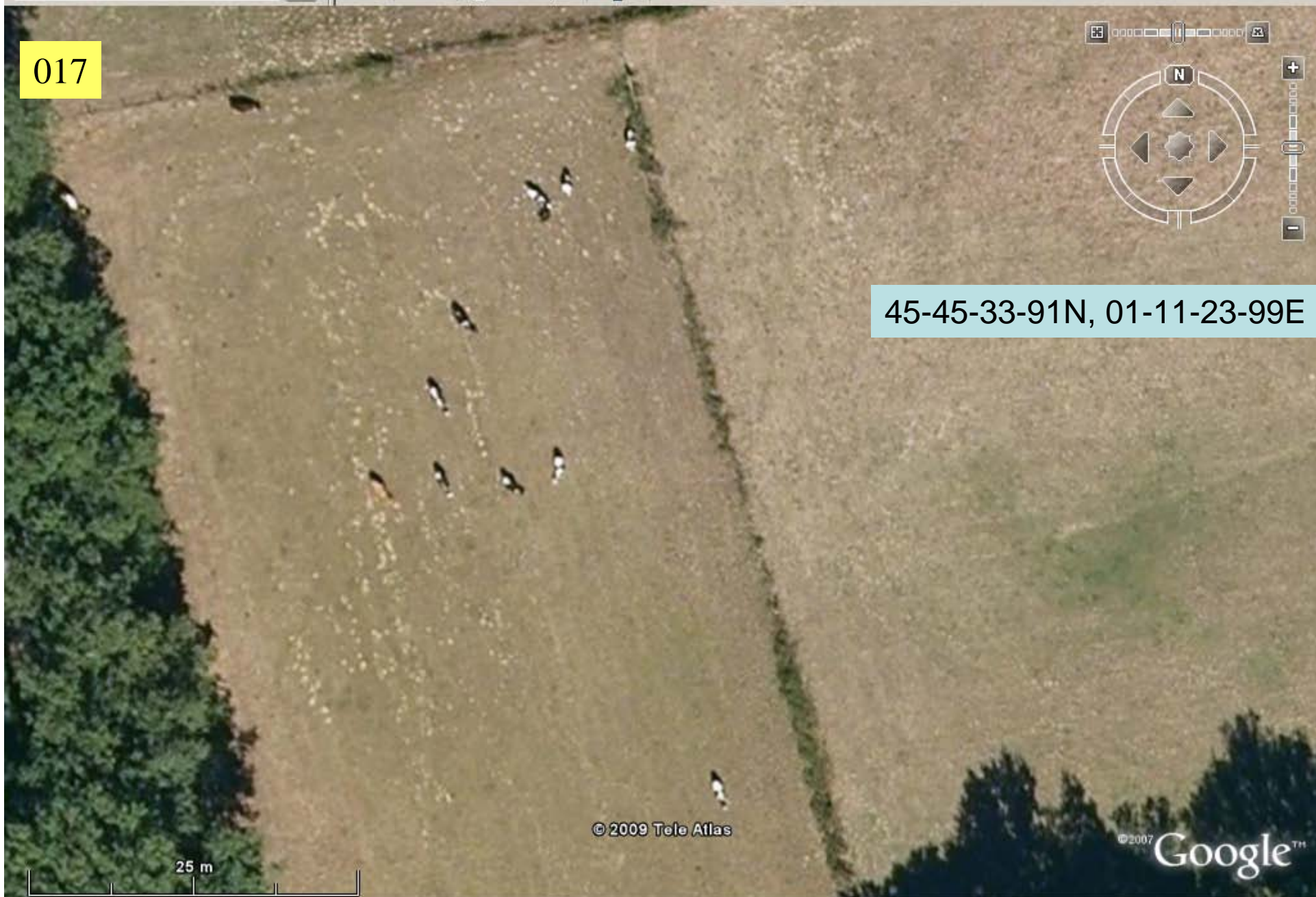
45°46'40.04 N, 1°11'40.68 E



017



45-45-33-91N, 01-11-23-99E



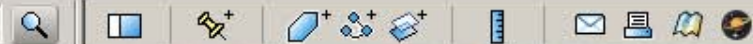
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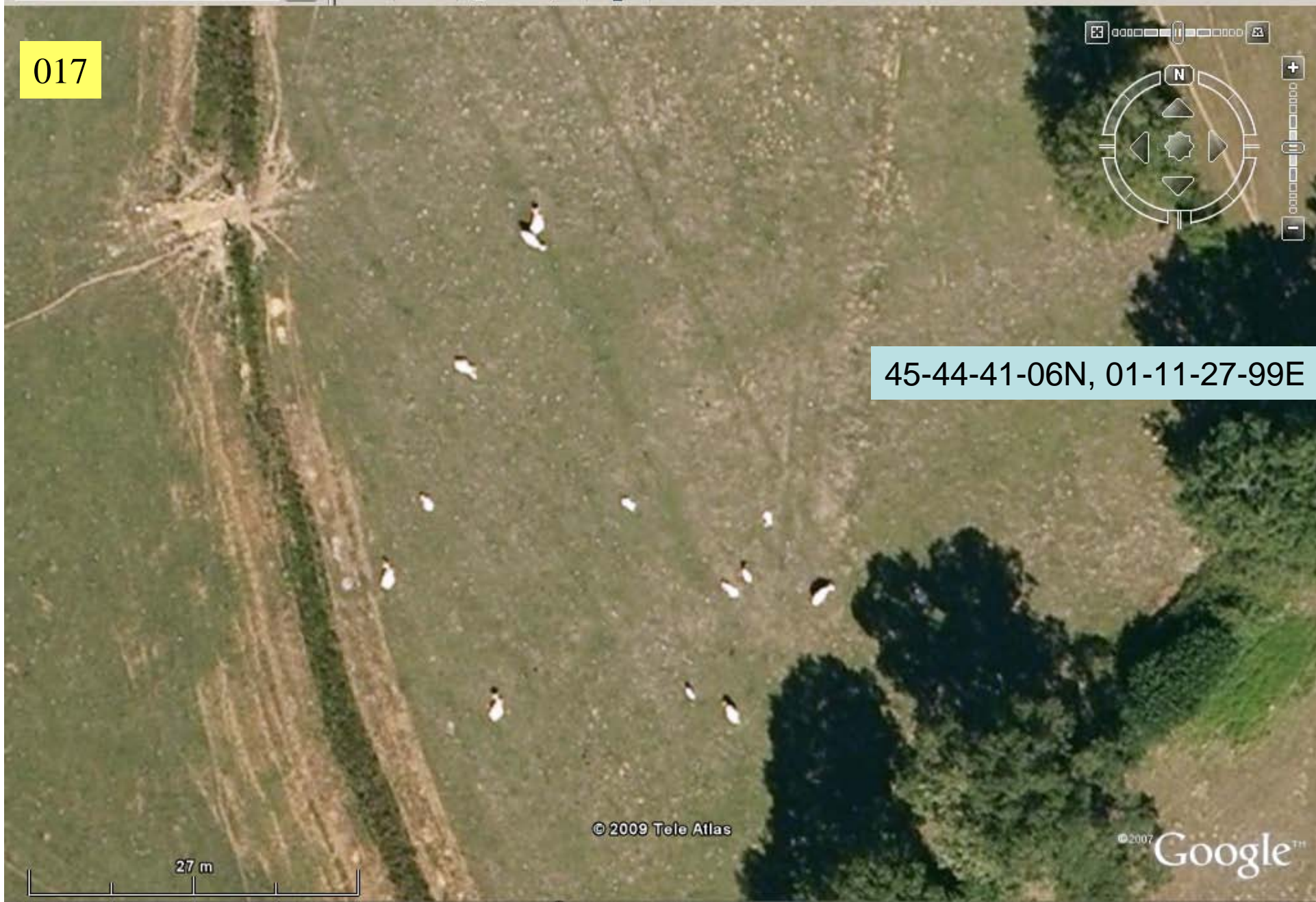
45°46'40.04 N, 1°11'40.68 E



017

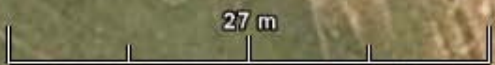


45-44-41-06N, 01-11-27-99E



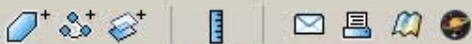
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51-33-03-94N, 06-51-03-35E



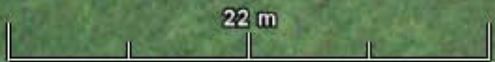
018



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Zeiger 51°33'03.94" N 6°51'03.35" O Höhe 68 m

Übertragung ||||| 100%

Sichthöhe 146 m



50-56-28-80N, 02-19-12-33



019



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57 m  
Zeiger 50°55'28.80" N 2°19'12.33" W Höhe 58 m

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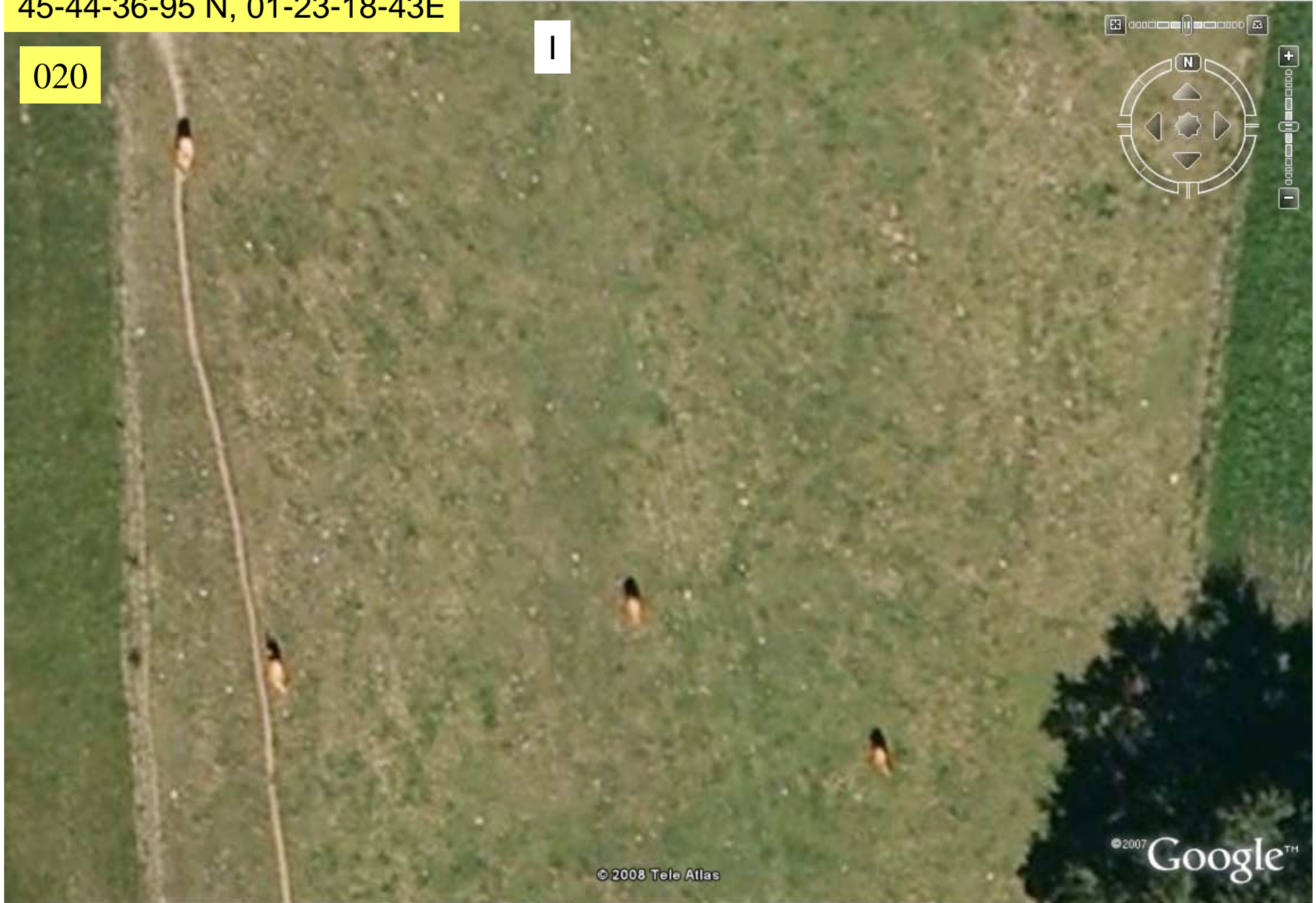
Sichthöhe 248 m



45-44-36-95 N, 01-23-18-43E

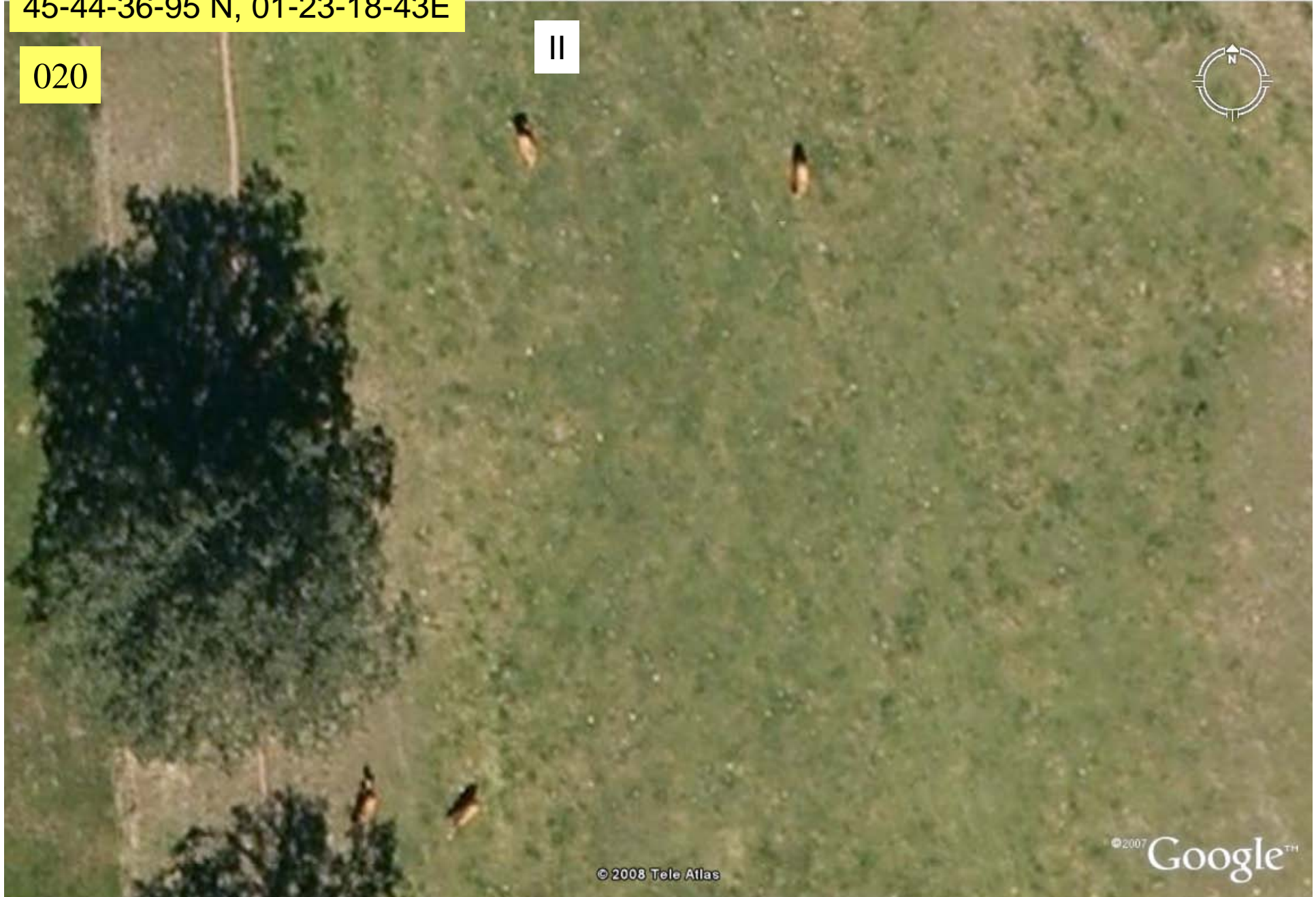
020

I



45-44-36-95 N, 01-23-18-43E

020



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51-32-26-93N, 06-52-24-21E



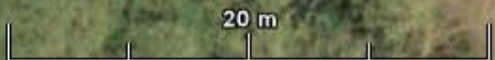
021



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Zeiger 51°32'26.93" N 6°52'24.71" O Höhe 61 m

Übertragung ||||| 100%

Sichthöhe 130 m



51-56-25-15N, 07-39-39-58E



022



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Zeiger 51°56'25.15" N 7°39'39.58" O Höhe 55 m

Übertragung ||||| 100%

Sichthöhe 100 m



52-01-23-00N, 07-33-06-00E



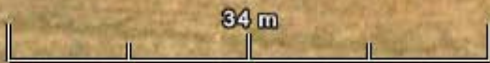
023



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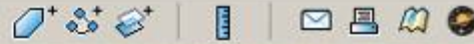
Zeiger 52°01'23.00" N 7°33'06.00" O Höhe 53 m

Übertragung ||||| 100%

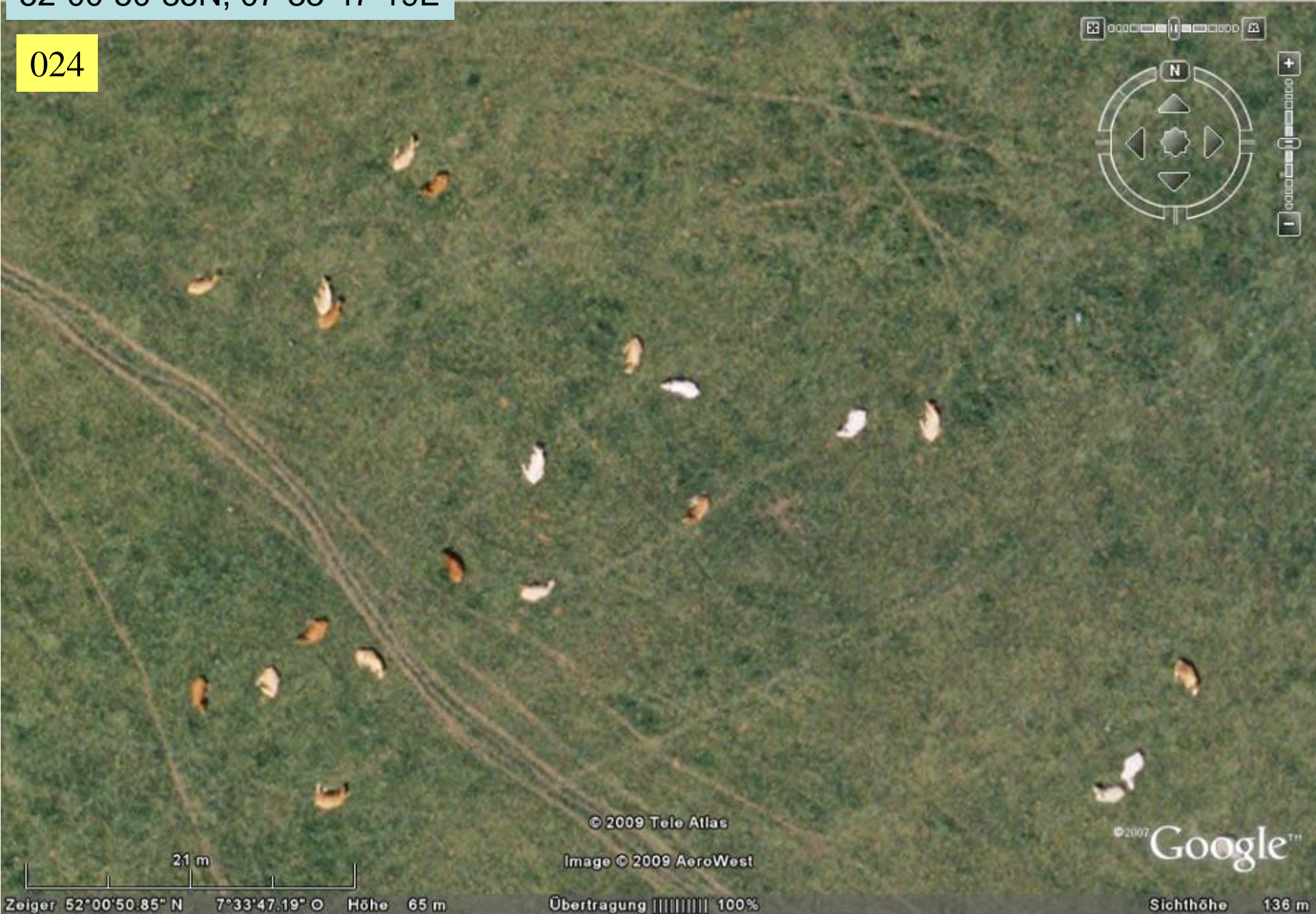
Sichthöhe 173 m



52-00-50-85N, 07-33-47-19E



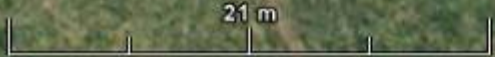
024



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Zeiger 52°00'50.85" N 7°33'47.19" O Höhe 65 m

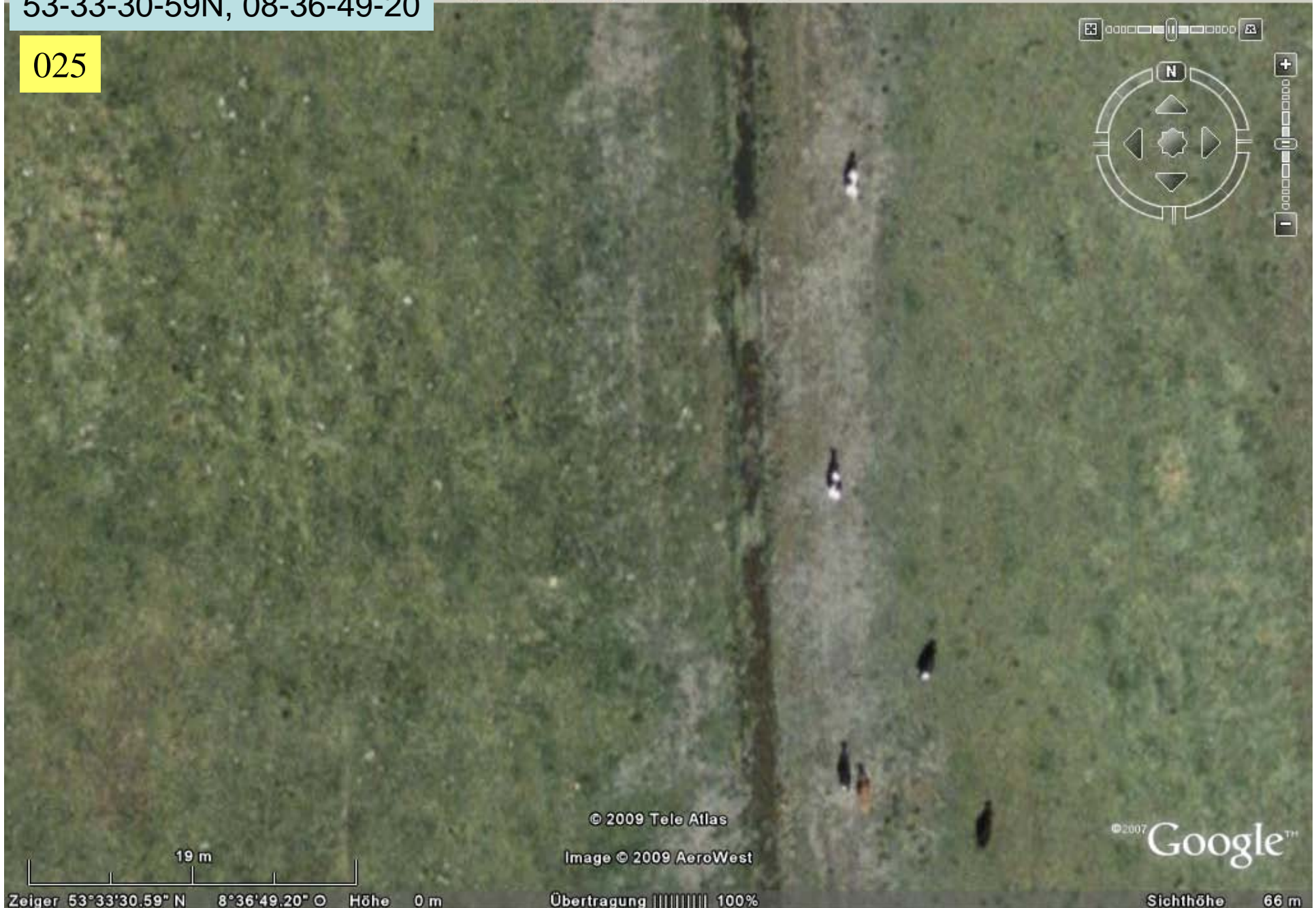
Übertragung ||||| 100%

Sichthöhe 136 m



53-33-30-59N, 08-36-49-20

025



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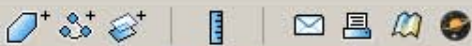
Zeiger 53°33'30.59" N 8°36'49.20" O Höhe 0 m

Übertragung ||||| 100%

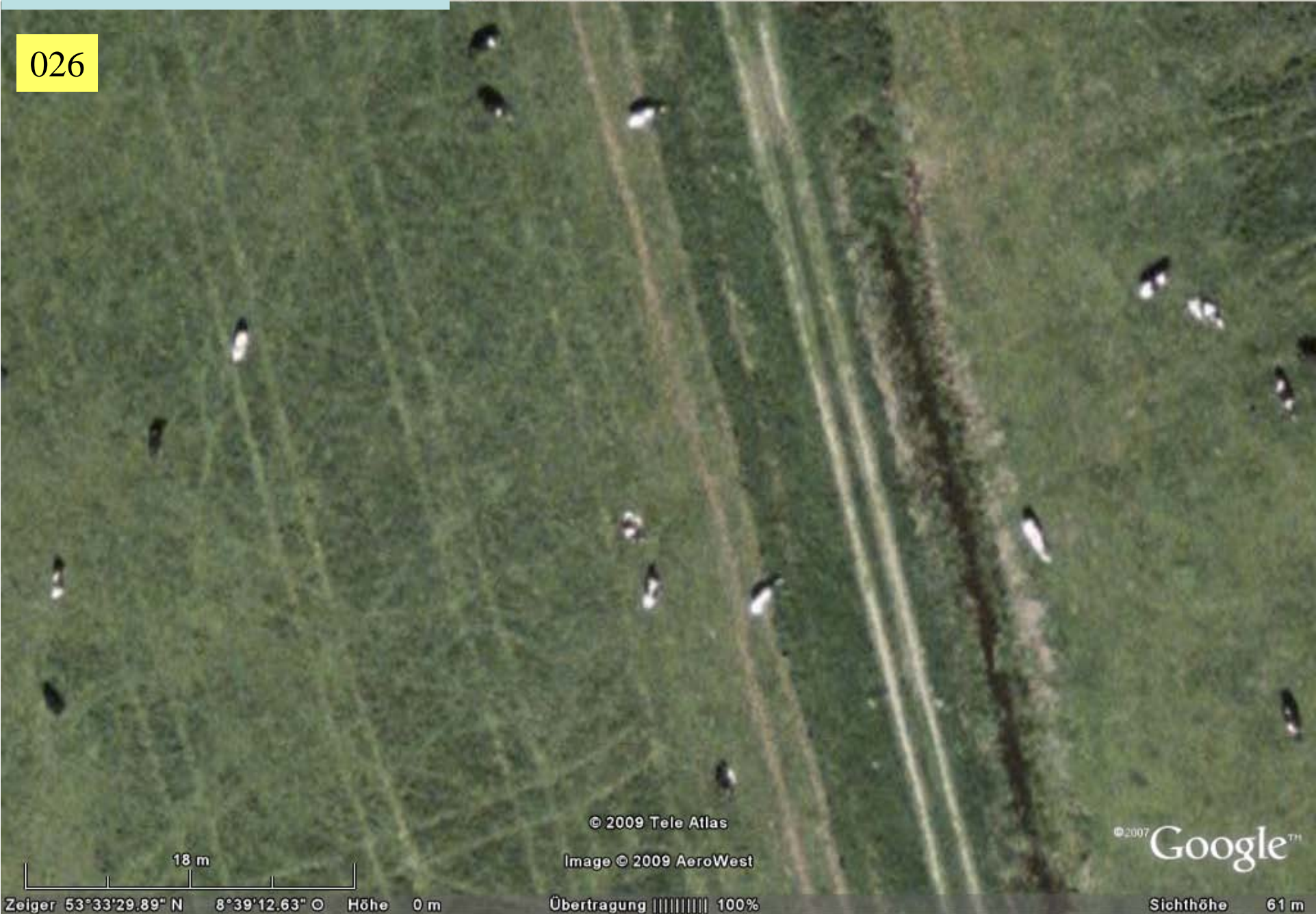
Sichthöhe 66 m



53-33-29-89N, 08-39-12-63E



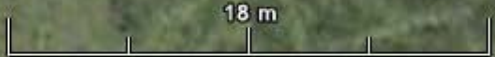
026



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Zeiger 53°33'29.89" N 8°39'12.63" O Höhe 0 m

Übertragung ||||| 100%

Sichthöhe 61 m



53-34-00-42-N, 08-36-57-04E



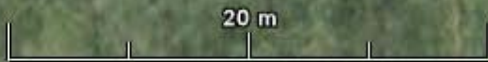
027



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Zeiger 53°34'00.42" N 8°36'57.04" O Höhe 0 m

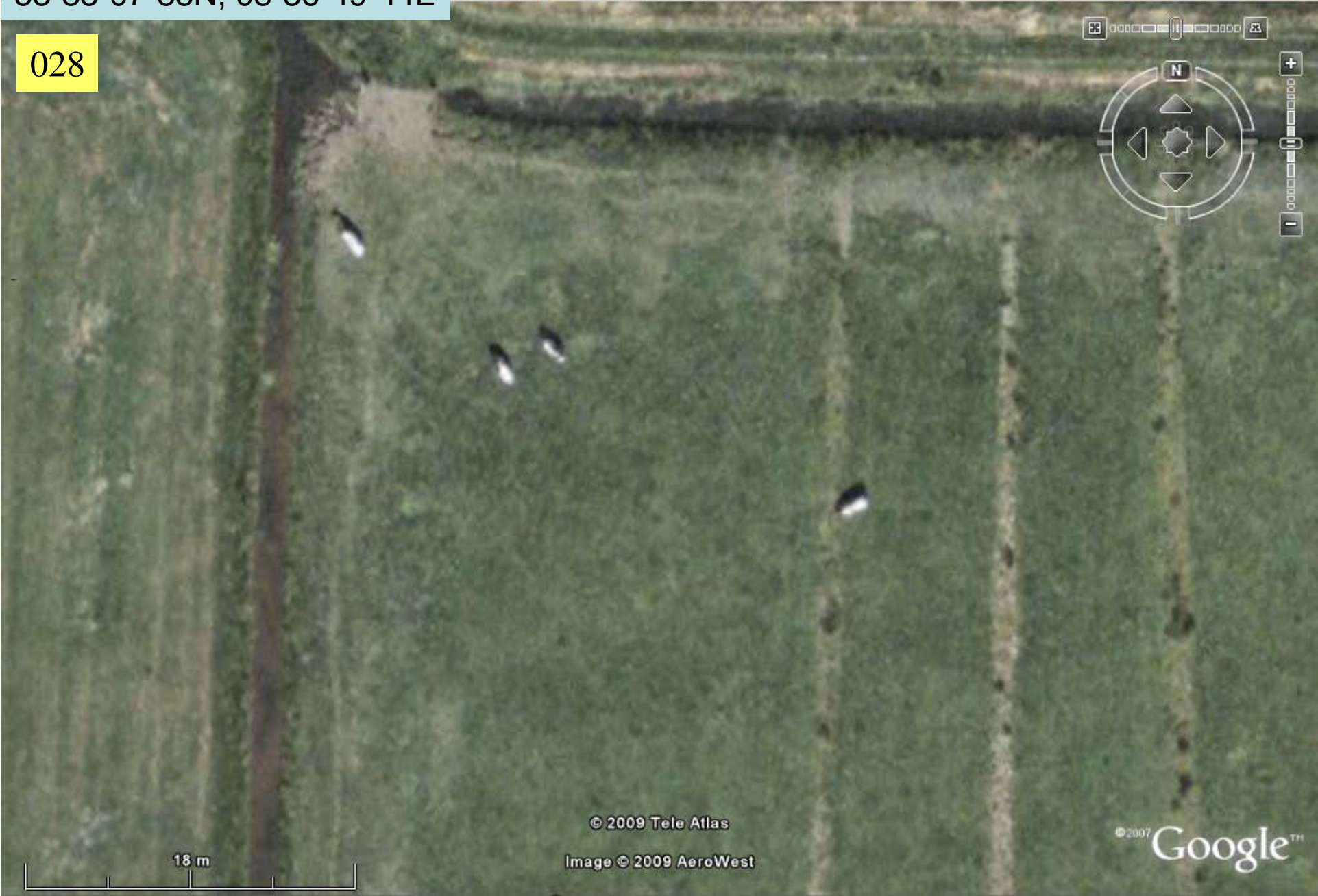
Übertragung ||||| 100%

Sichthöhe 71 m

53-33-07-88N, 08-36-49-44E



028



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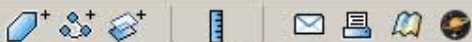
Zeiger 53°33'07.88" N 8°36'49.44" O Höhe 0 m

Übertragung ||||| 100%

Sichthöhe 63 m



50-46-25-27N, 04-29-17-72E

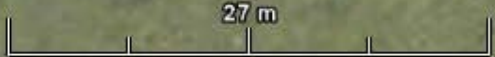


029



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Zeiger 50°46'25.27" N 4°29'17.72" O Höhe 85 m

Übertragung ||||| 100%

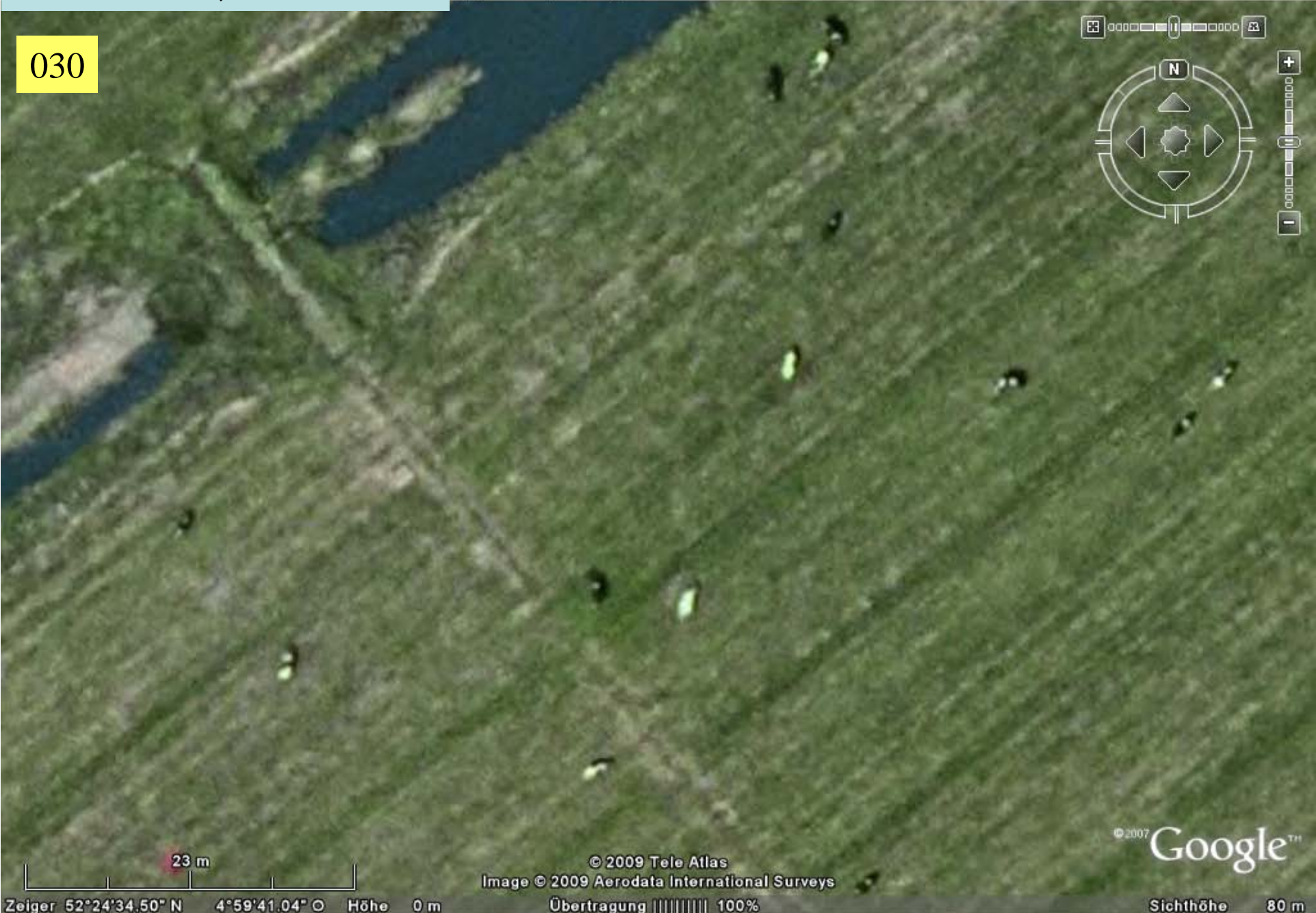
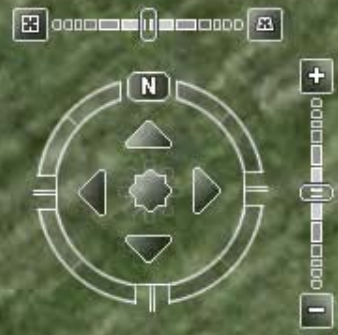
Sichthöhe 179 m



52-24-34-50N, 04-59-41-04E



030



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23 m  
Zeiger 52°24'34.50" N 4°59'41.04" O Höhe 0 m

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Übertragung ||||| 100%

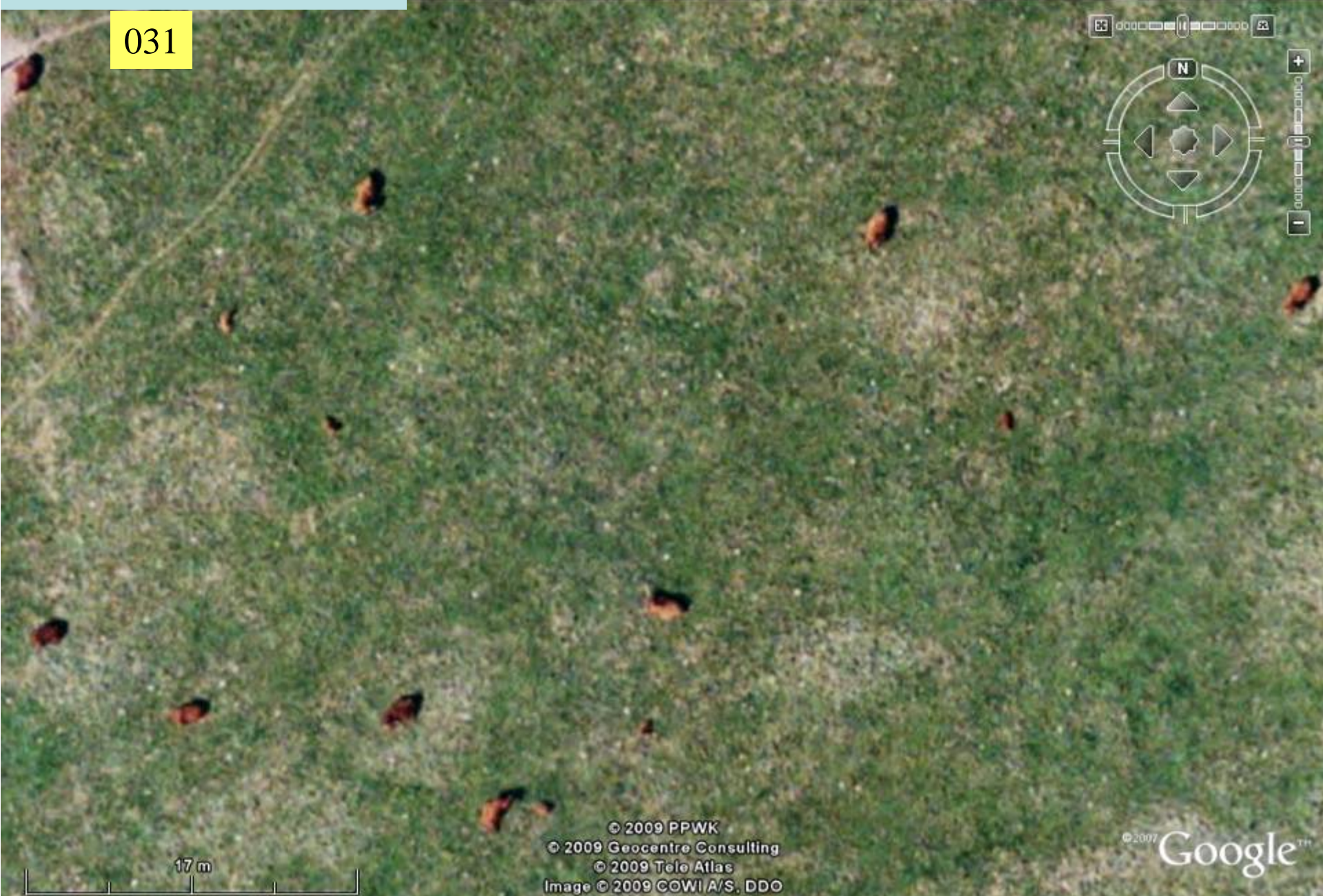
Sichthöhe 80 m



55-41-34-66, 12-20-31-97



031



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17 m  
Zeiger 55°41'34.66" N 12°20'31.97" O Höhe 23 m

Übertragung ||||| 100%

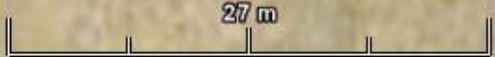
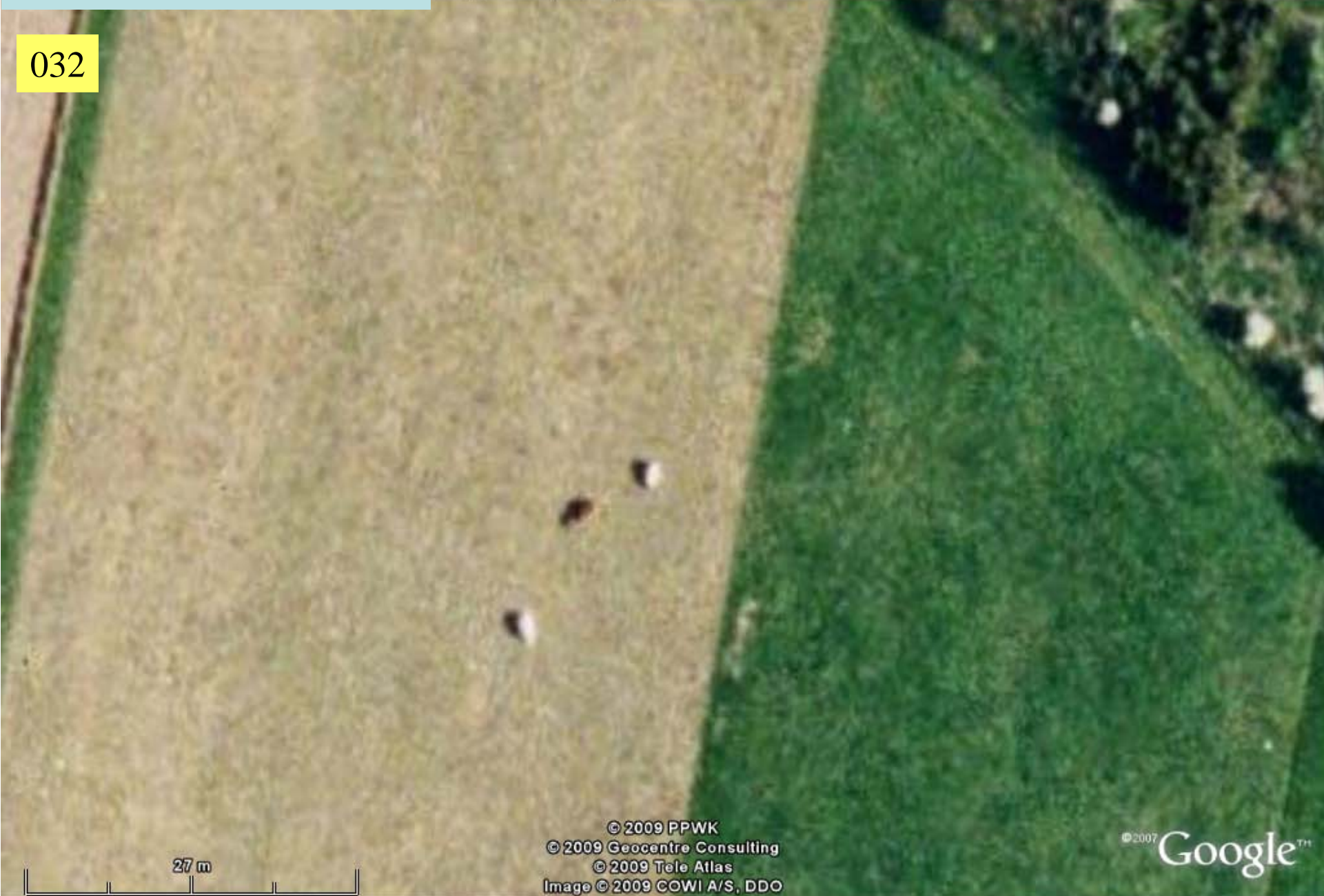
Sichthöhe 83 m



55-32-17-34N, 11-57-28-46



032



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Image © 2009 COWI A/S, DDO

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30-11-00-24N, 96-01-35-74W

033



Image Houston-Galveston Area Council

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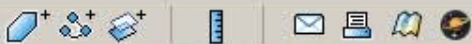
98 m

Zeiger 30°11'00.24" N 96°01'35.74" W Höhe 88 m

Übertragung 100%

Stellhöhe 205 m

51-22-23-26N, 07-05-49-54E



034

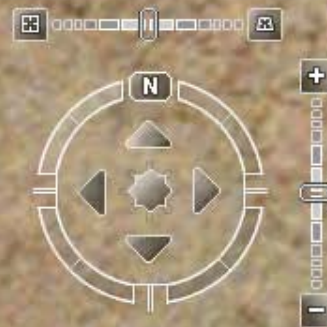


Image © 2009 AeroWest

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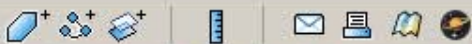
Zeiger 51°22'22.91" N 7°05'49.90" O Höhe 123 m

Übertragung ||||| 100%

Sichthöhe 160 m



51-22-17-61N, 07-05-49-12E



035

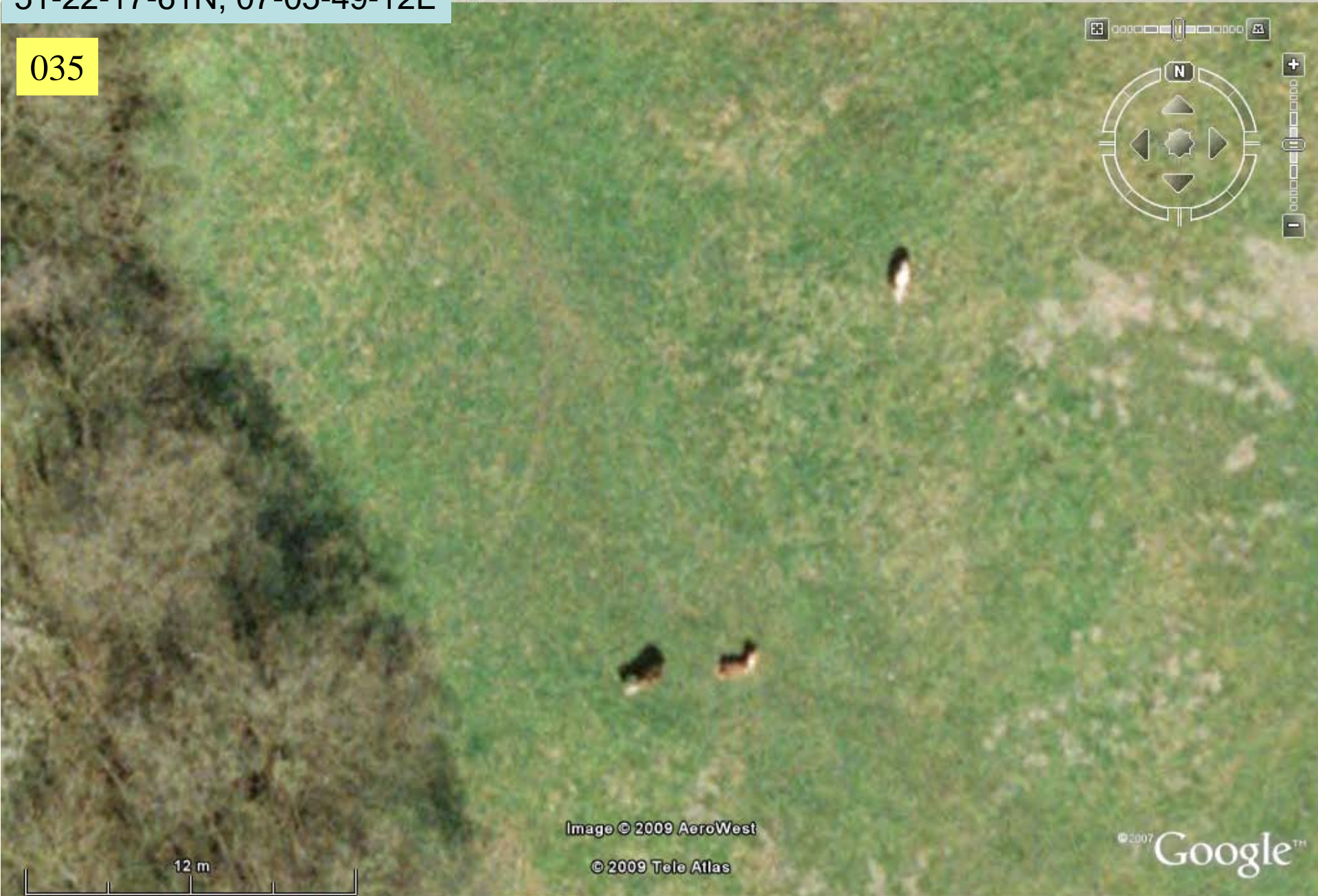
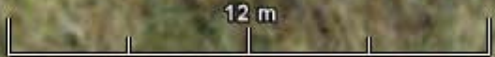


Image © 2009 AeroWest

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51-22-26-98N, 07-05-09-21E



036

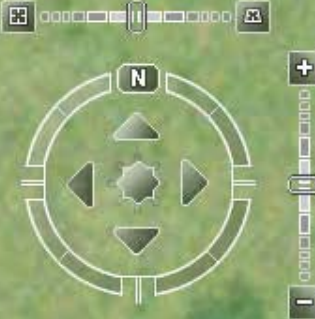
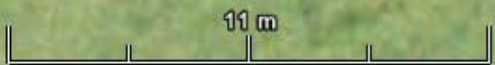


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51-22-23-12N, 07-05-10-96E



037

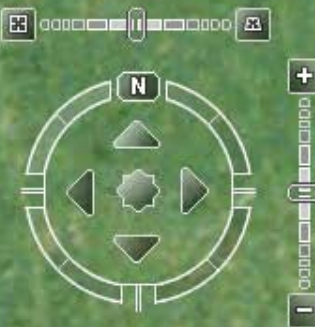


Image © 2009 AeroWest

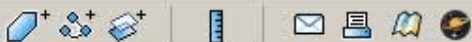
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51-22-24-39N, 07-02-12-22E



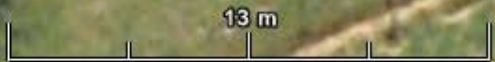
038



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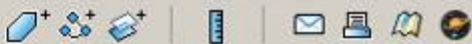
Zeiger 51°22'24.83" N 7°02'12.37" O Höhe 96 m

Übertragung ||||| 100%

Sichthöhe 147 m



51-22-41-84N, 07-00-27-01E



039

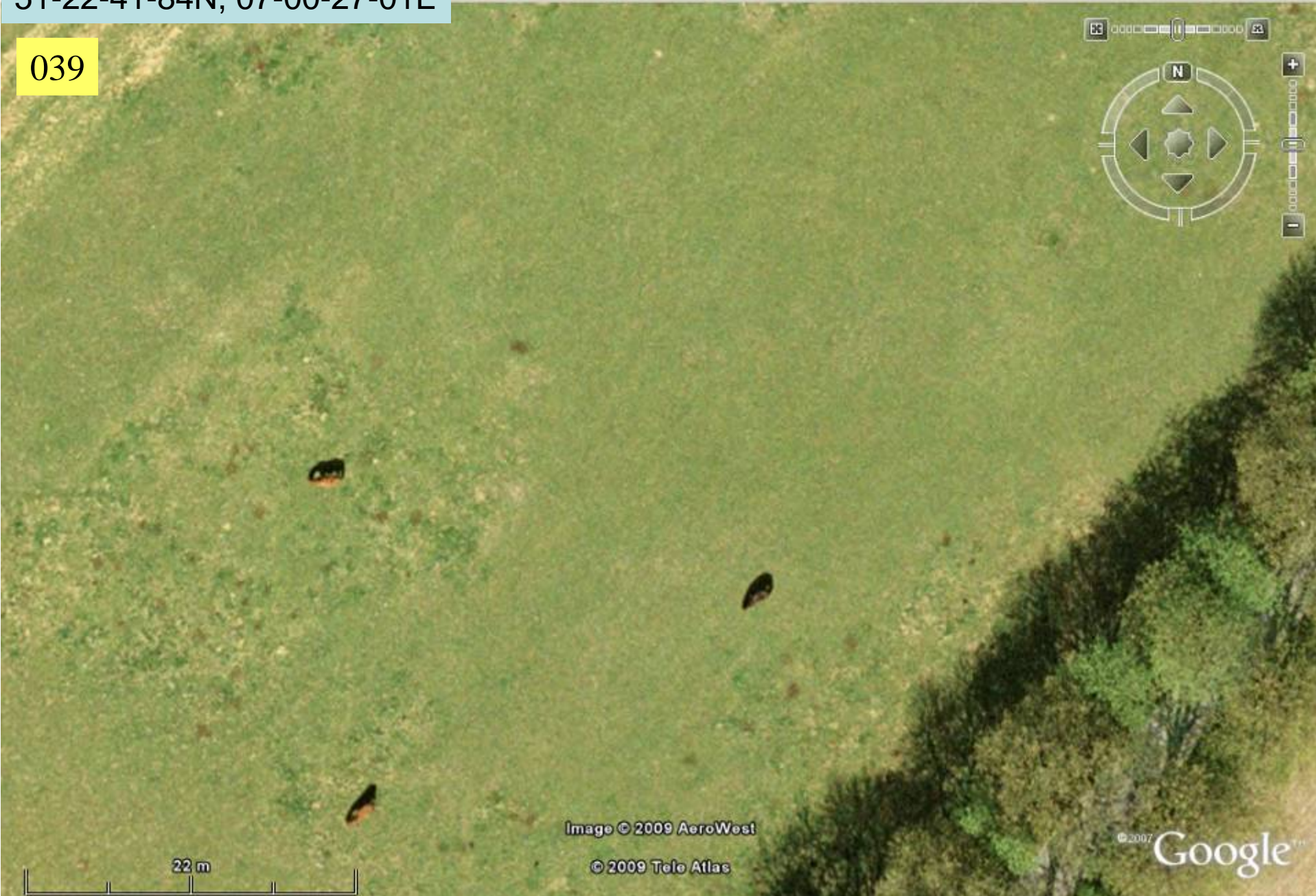
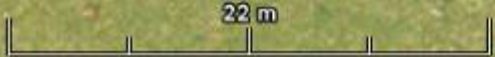


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51-22-34-99N, 07-00-17-56E



040



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51-22-59-52N, 06-59-06-97E



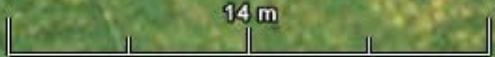
041



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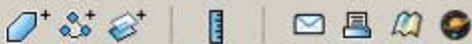
Zeiger 51°22'59.52" N 6°59'06.97" O Höhe 64 m

Übertragung ||||| 100%

Sichthöhe 110 m



51-22-21-08N, 06-58-21-15E



042



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52-33-49-20N, 06-12-42-90E

043



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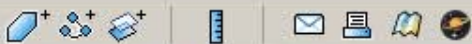
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26m

51°07'33.39" N 1°19'58.58" W Höhe 89m

Sichthöhe 179m

51-21-02-51N, 06-57-22-74E



044

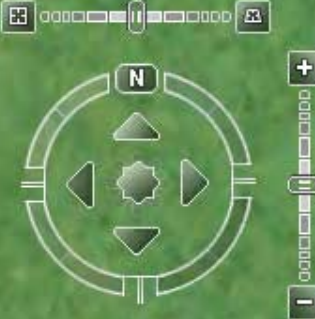
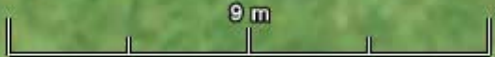


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51-23-48-63N, 06-57-08-09

045

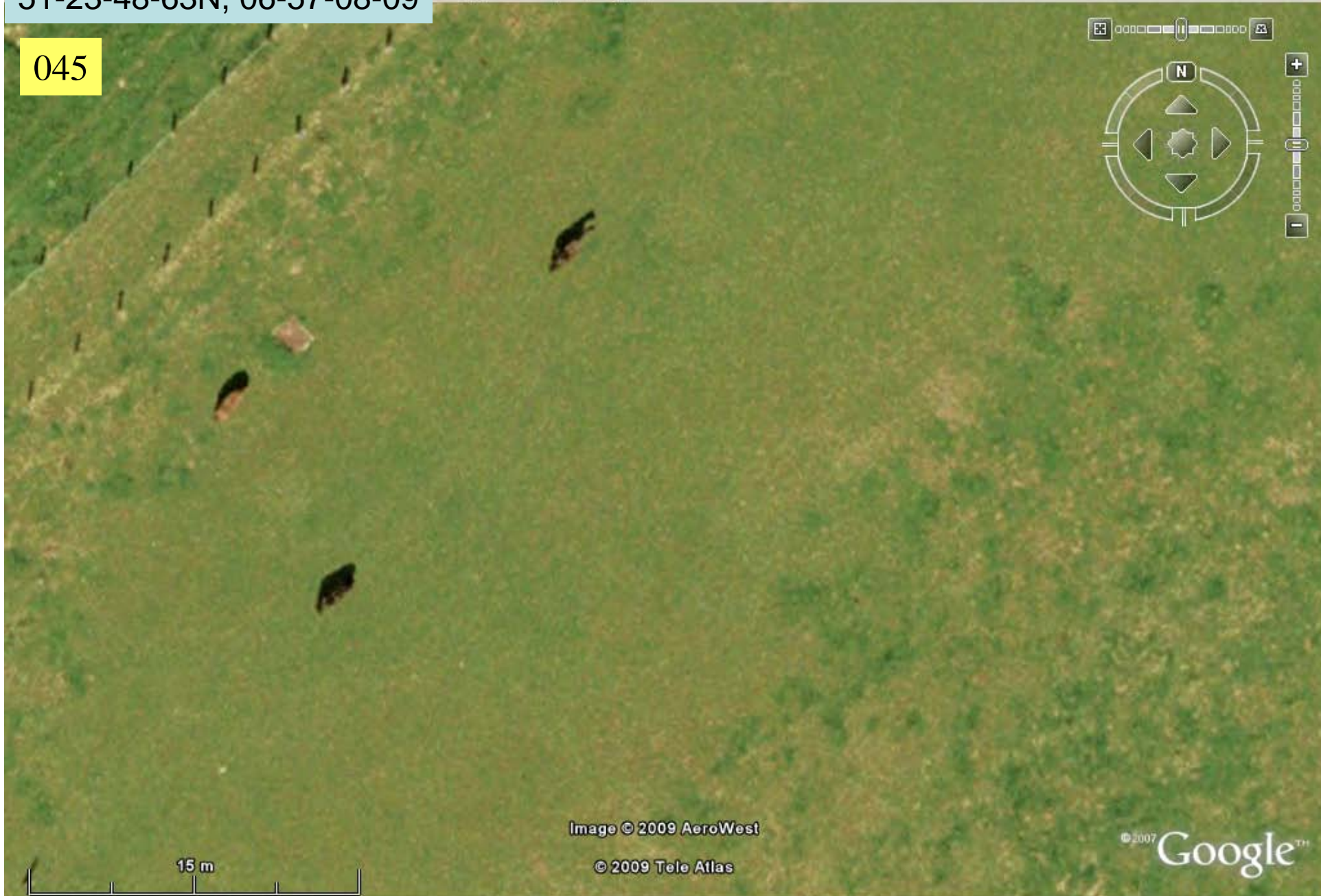


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Zeiger 51°23'49.11" N 6°57'08.17" O Höhe 151 m

Übertragung ||||| 100%

Sichthöhe 207 m



51-24-29-66N, 06-57-16-58E

046

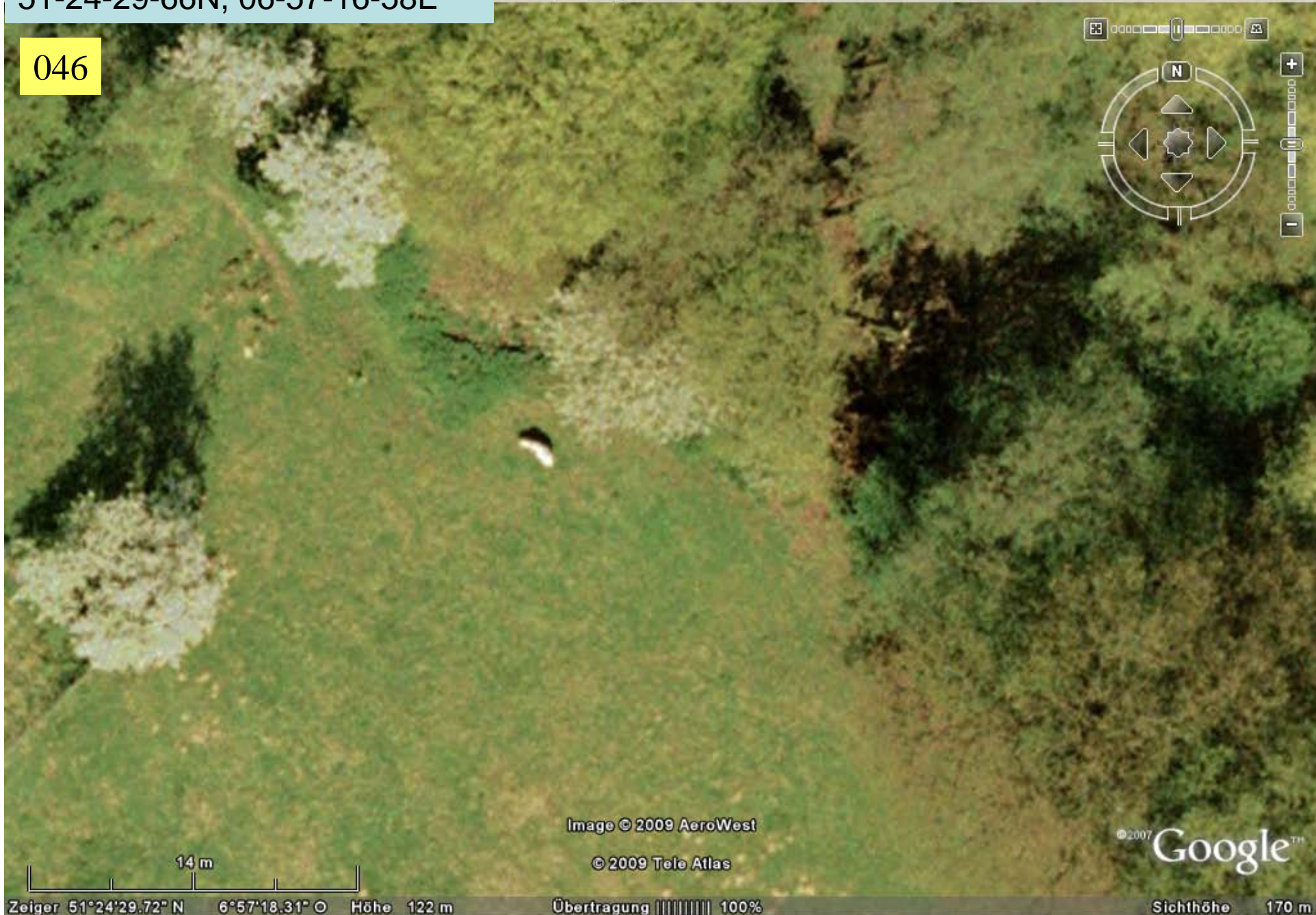


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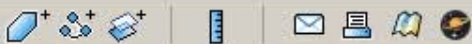
Zeiger 51°24'29.72" N 6°57'18.31" O Höhe 122 m

Übertragung ||||| 100%

Sichthöhe 170 m



51-24-47-29N, 06-57-47-56E



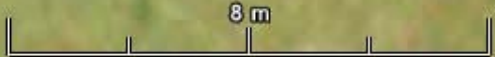
047



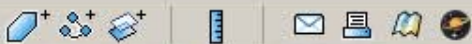
Image © 2009 AeroWest

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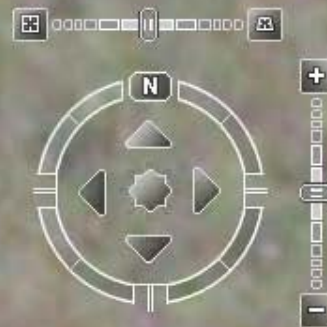
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50-50-31-25N, 01-17-07-96W

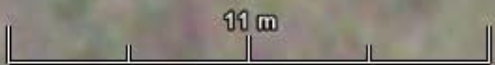


048



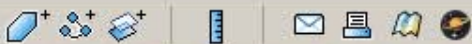
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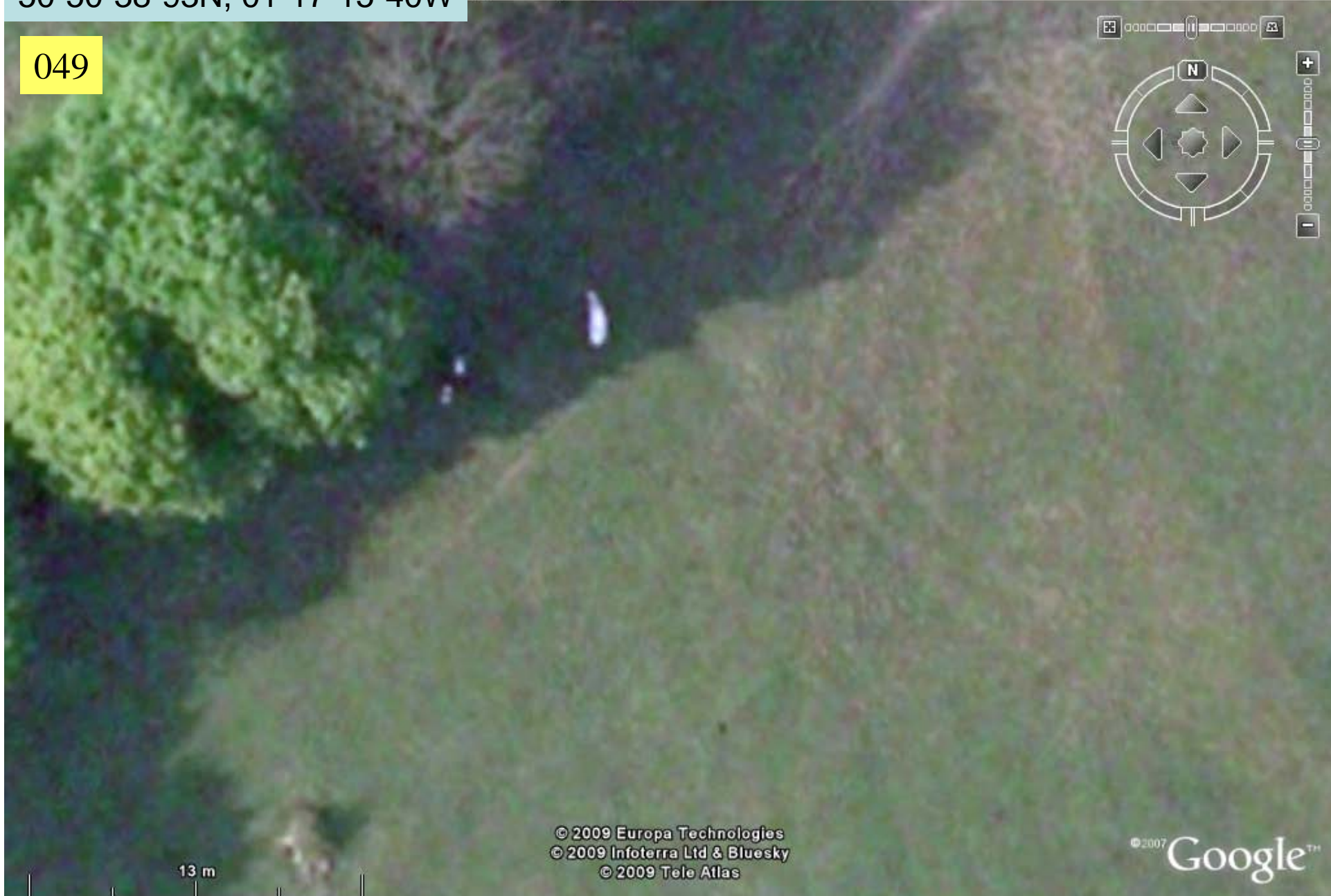
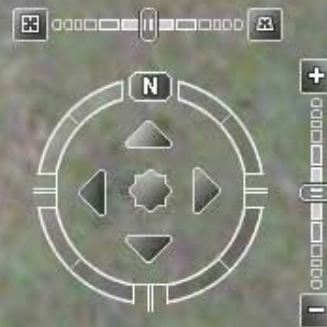




50-50-38-93N, 01-17-15-40W



049



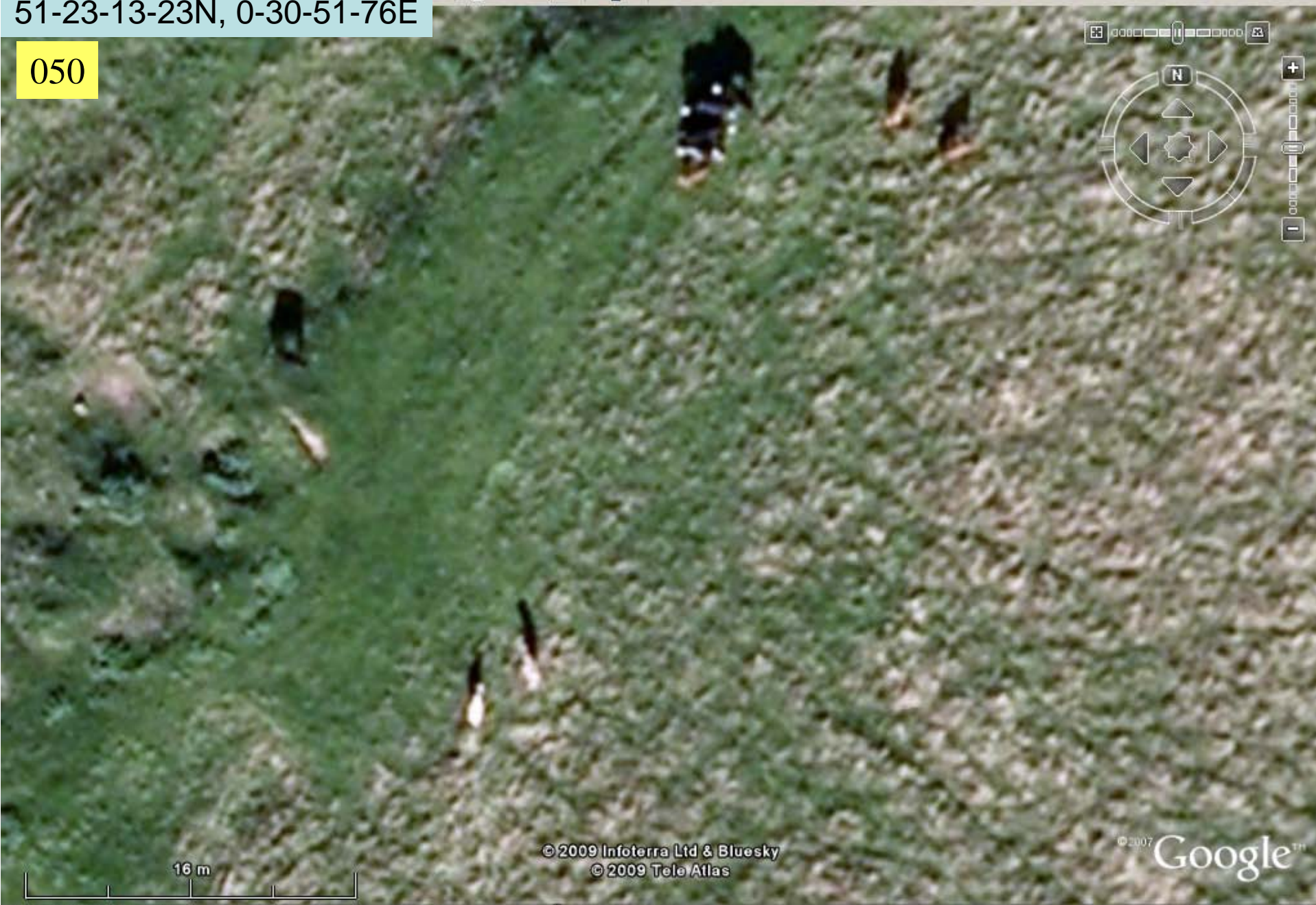
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050





51-26-07-56N, 0-29-13-76E

051

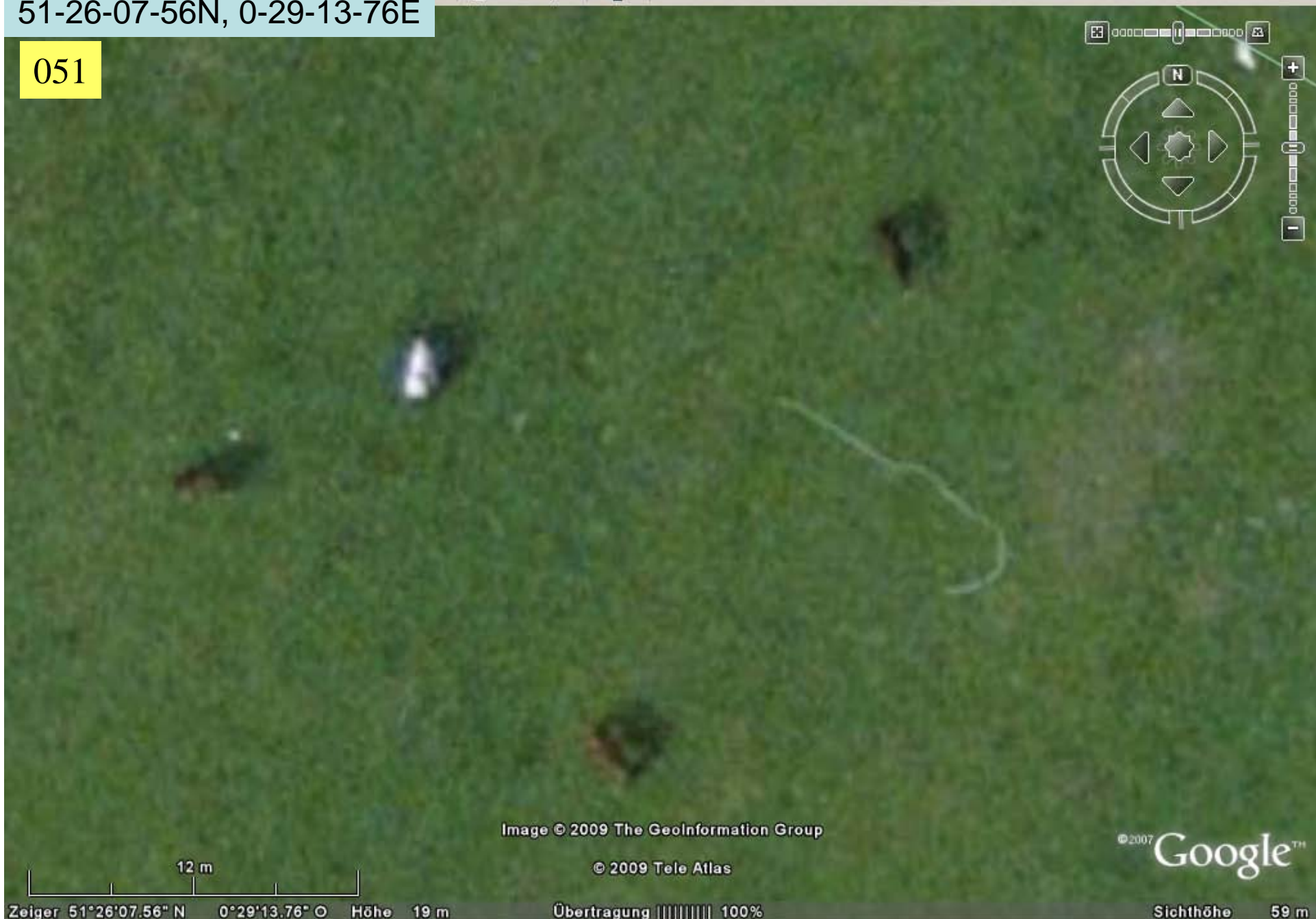


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51-26-14-62N, 0-29-12-93E

052

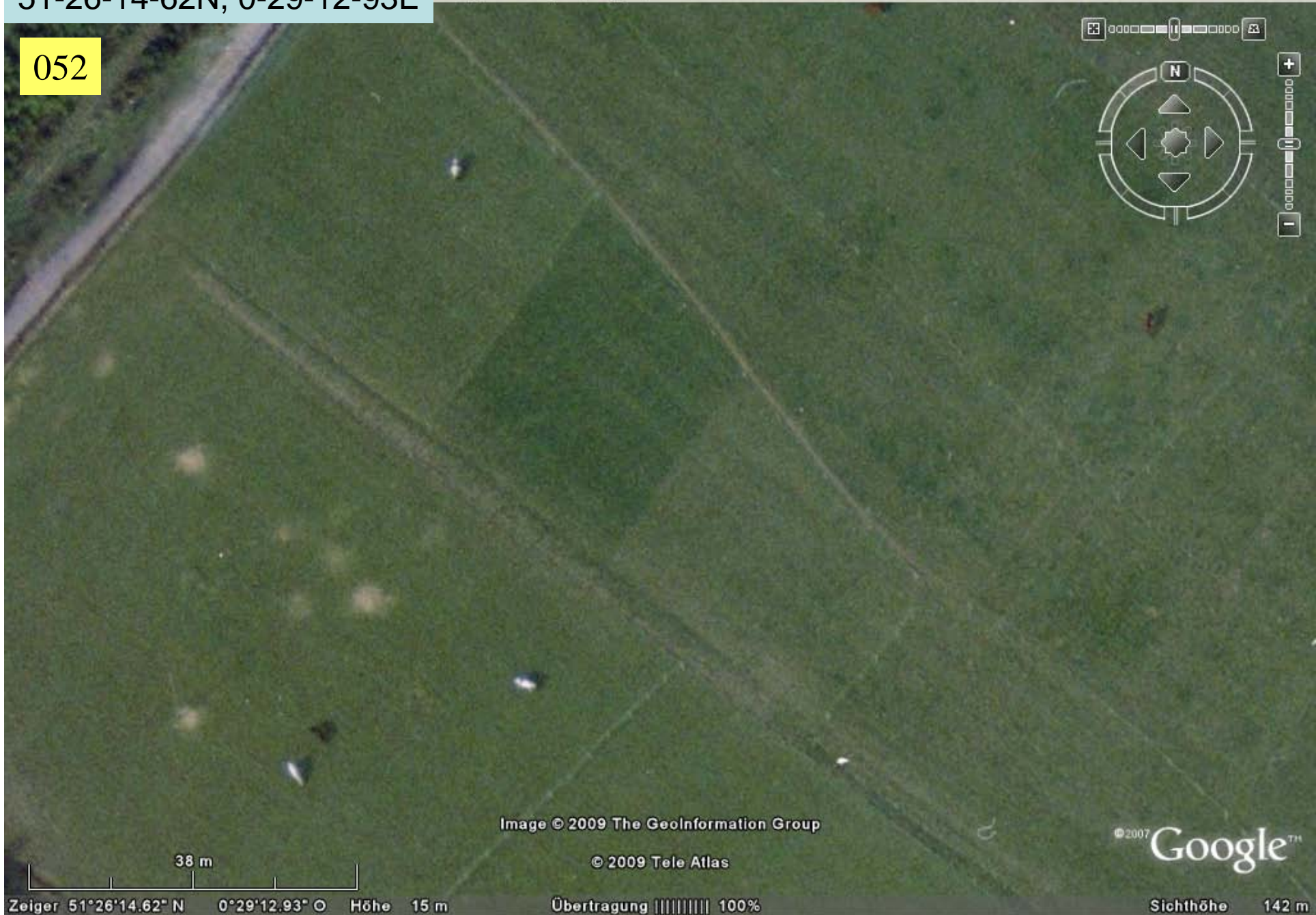


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Zeiger 51°26'14.62" N 0°29'12.93" O Höhe 15 m

Übertragung ||||| 100%

Sichthöhe 142 m



51-27-36-23N, 0-30-57-13E

053



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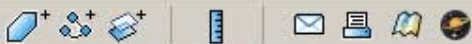


Zeiger 51°27'36.23" N 0°30'57.13" O Höhe 2 m

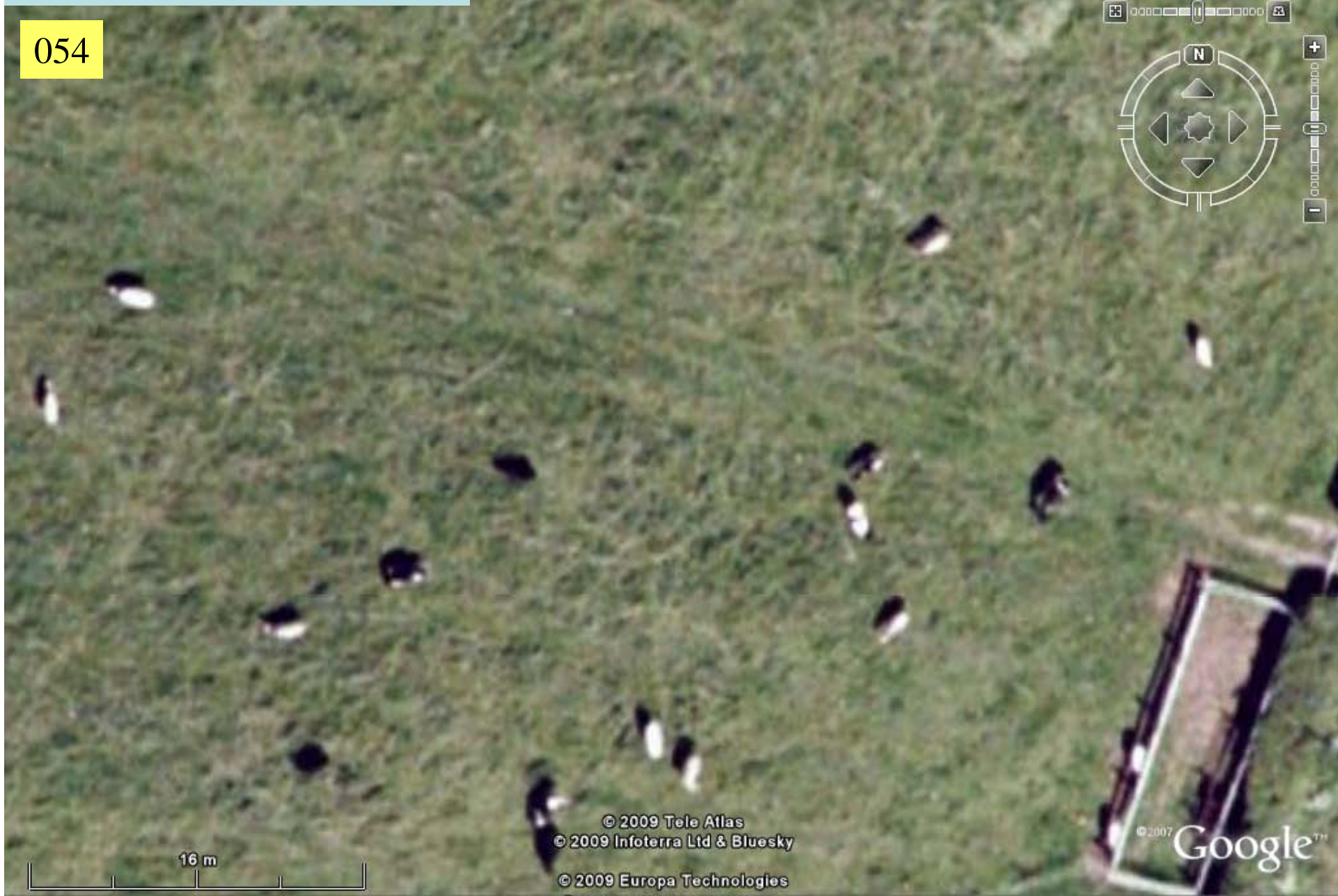
Übertragung ||||| 100%

Sichthöhe 49 m

51-34-18-12N, 02-34-01-10W



054



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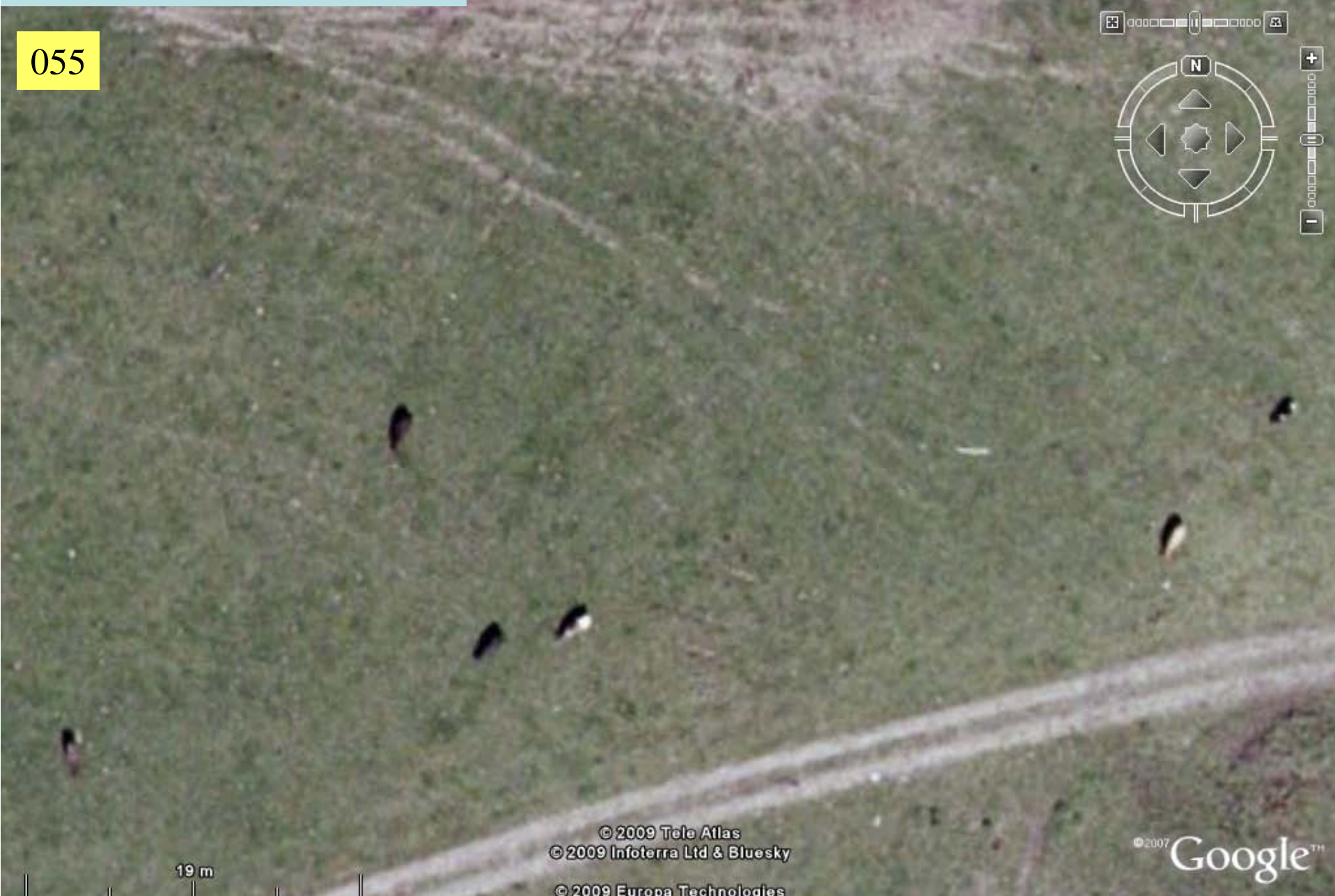
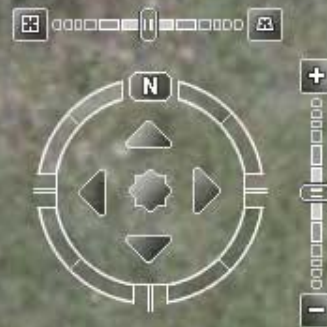




51-33-57-36N, 02-33-38-52W



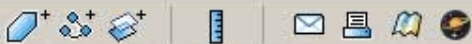
055



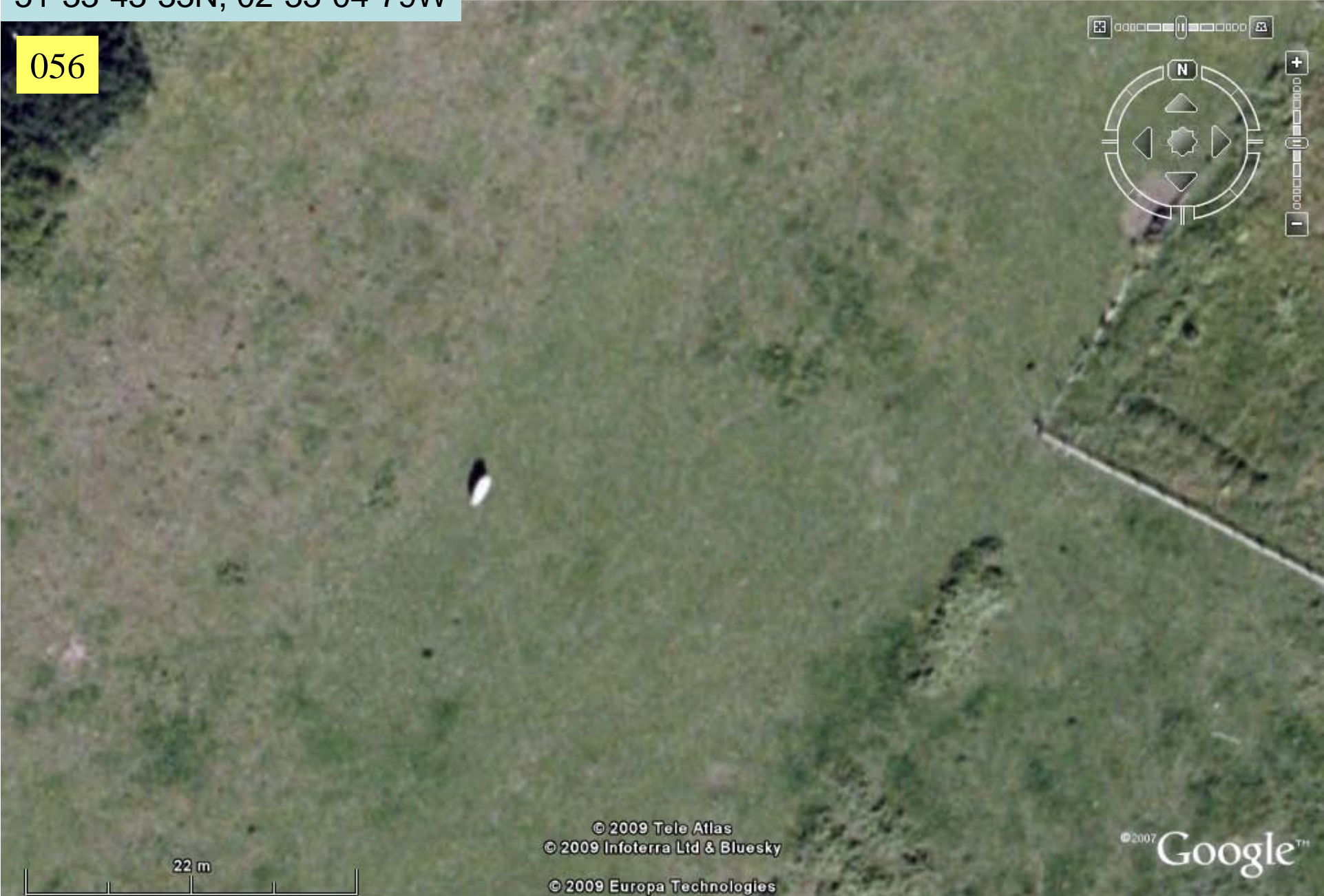
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51-33-43-33N, 02-33-04-79W



056



22 m  
Zeiger 51°33'43.33" N 2°33'04.77" W Höhe 83 m

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Sichthöhe 158 m



51-33-41-62 N, 02-30-39-61W

057



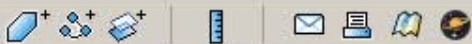
49 m  
Zeiger 51°33'41.62" N 2°30'39.61" W Höhe 68 m

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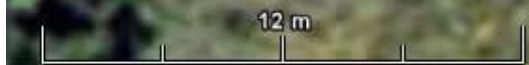
© 2007 Google  
Sichthöhe 235 m



51-33-39-38N, 02-28-10-95W



058

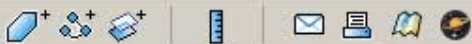


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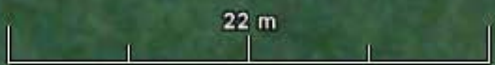
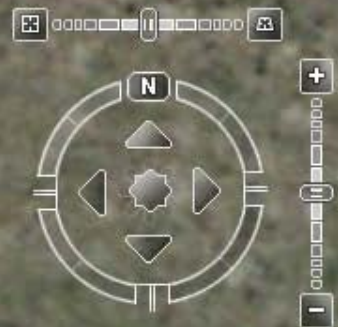
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51-33-12-80N, 02-28-12-65W



059



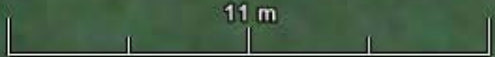
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51-33-12-80N, 02-28-12-65W



060



Zeiger 51°33'12.80" N 2°28'12.65" W Höhe 51 m

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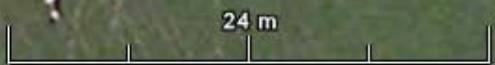
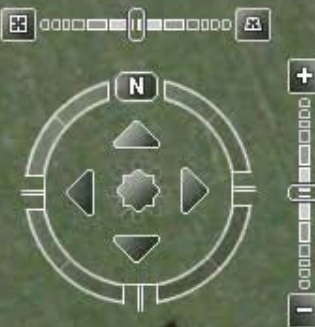
Sichthöhe 88 m



51-32-23-53N, 02-28-34-07W



061



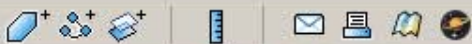
Zeiger 51°32'23.53" N 2°28'34.07" W Höhe 52 m

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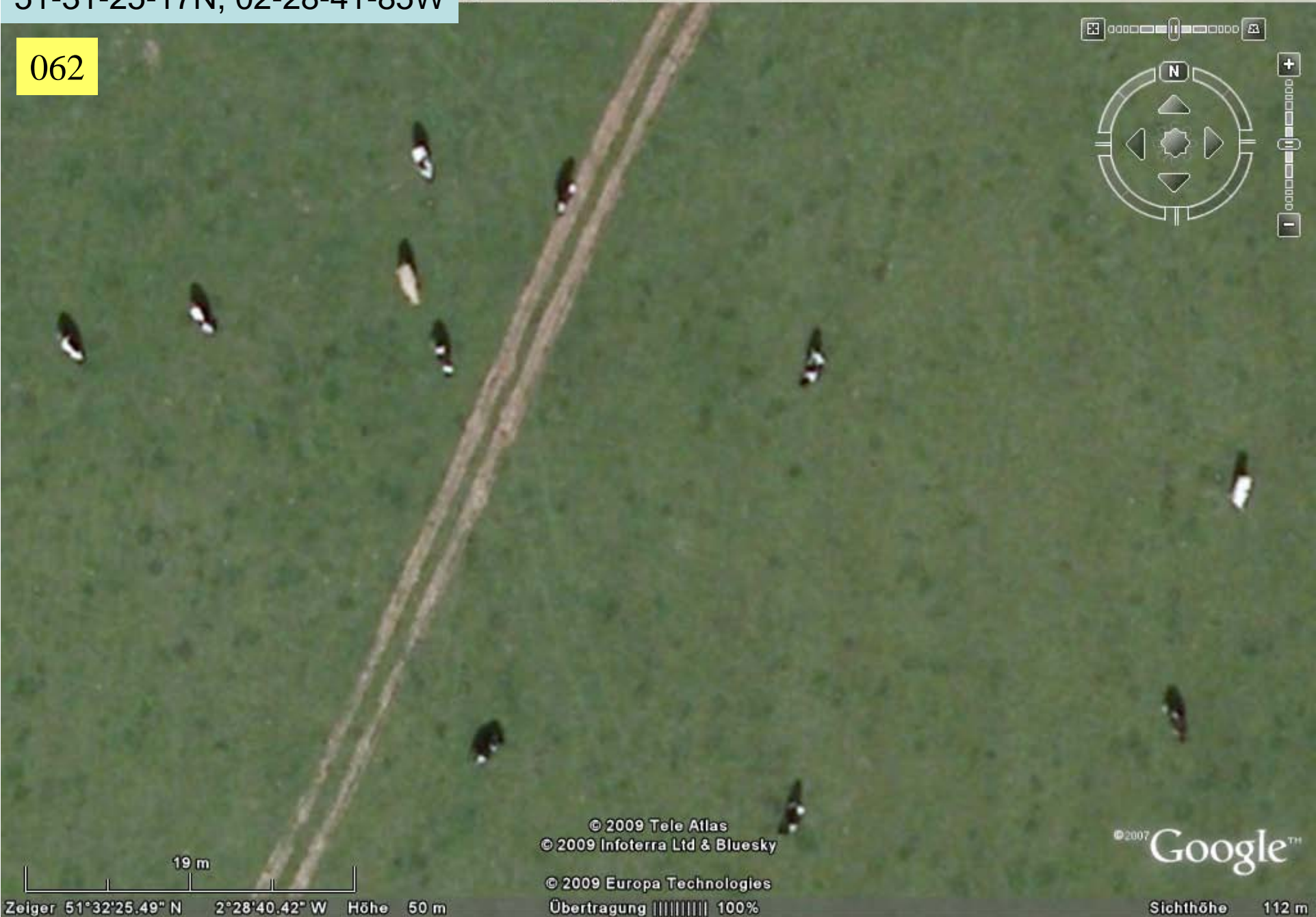
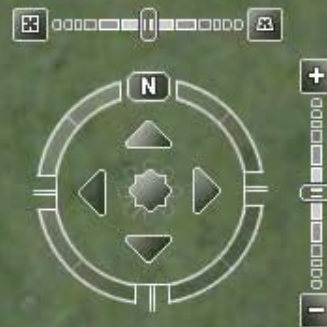
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Sichthöhe 133 m

51-31-25-17N, 02-28-41-85W



062



Zeiger 51°32'25.49" N 2°28'40.42" W Höhe 50 m

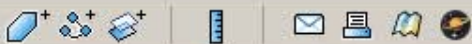
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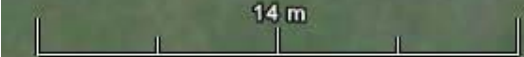
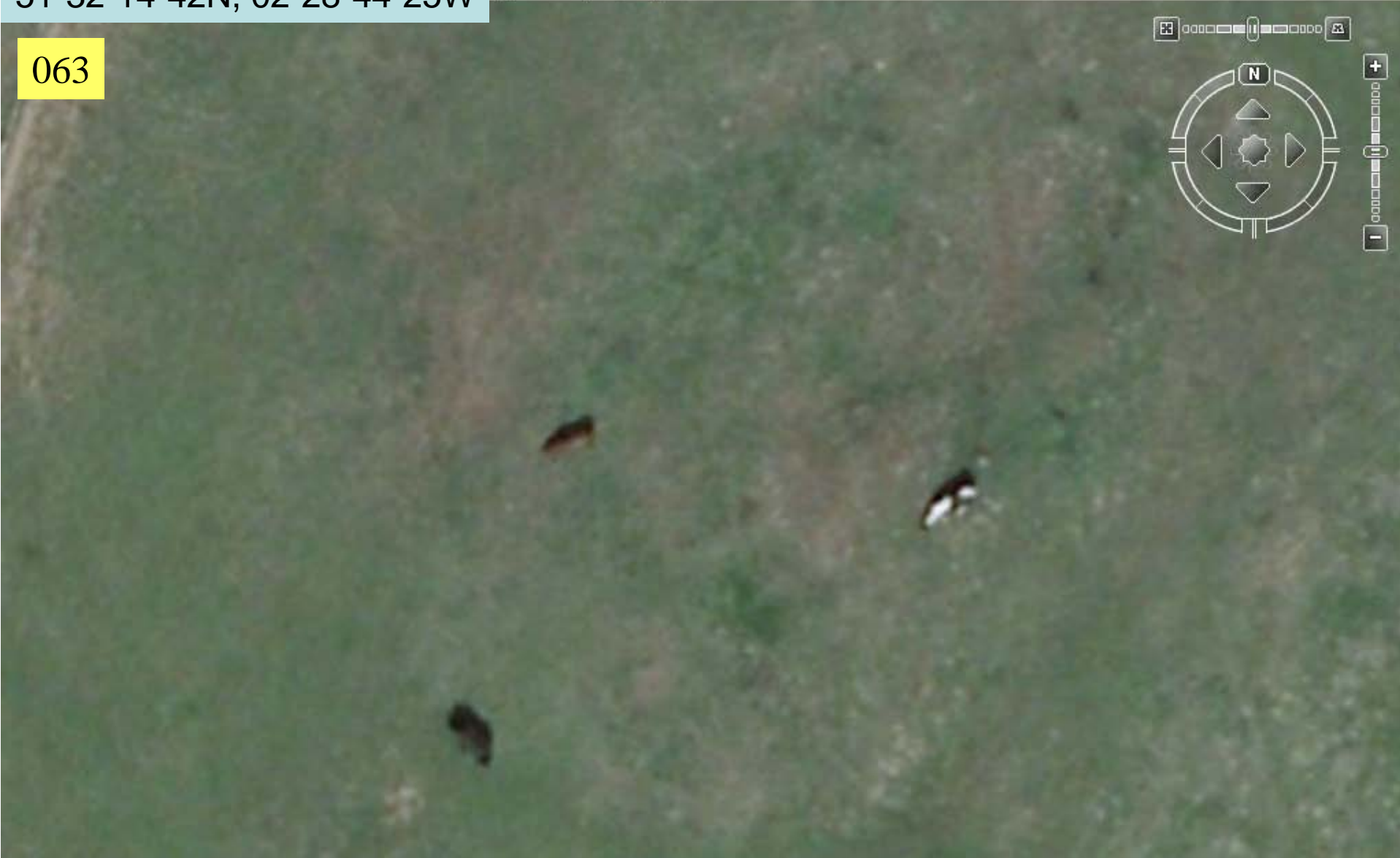
Sichthöhe 112 m



51-32-14-42N, 02-28-44-25W



063



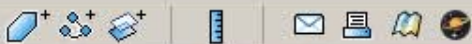
Zeiger 51°32'14.44" N 2°28'44.23" W Höhe 45 m

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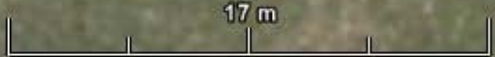
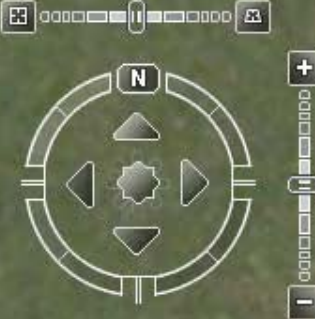
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Sichthöhe 90 m

51-31-53-51N, 02-29-19-94W



064



Zeiger 51°31'53.44" N 2°29'19.97" W Höhe 49 m

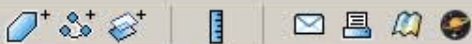
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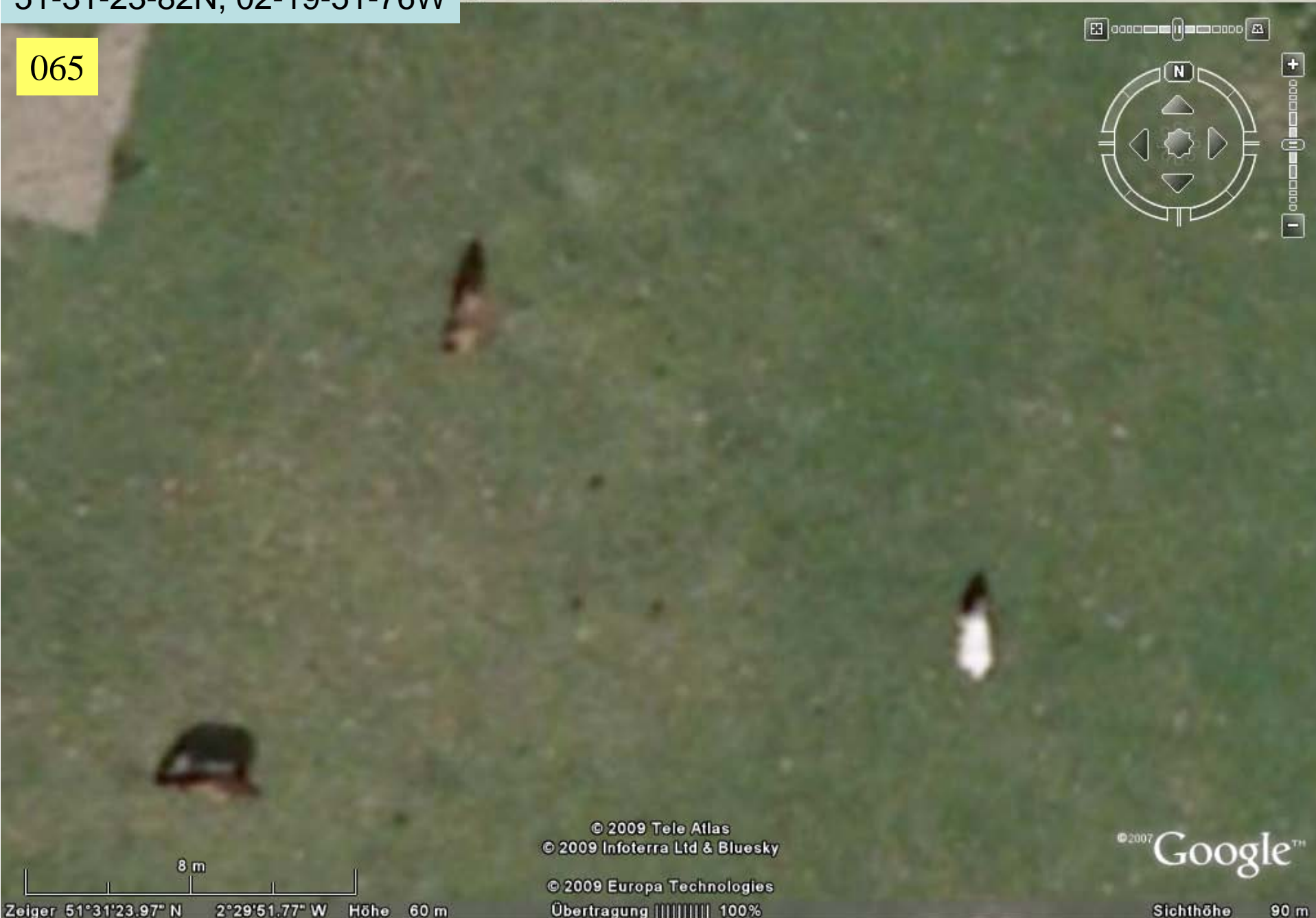
Sichthöhe 110 m



51-31-23-82N, 02-19-51-76W



065



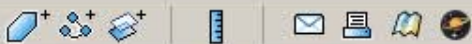
Zeiger 51°31'23.97" N 2°29'51.77" W Höhe 60 m

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Übertragung ||||| 100%

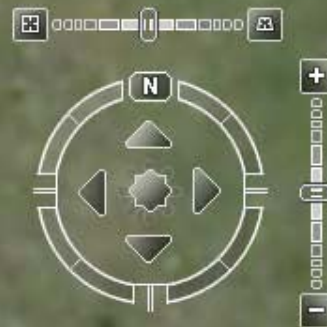
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Sichthöhe 90 m

51-31-19-63N, 02-29-47-44W



066



8 m  
Zeiger 51°31'19.64" N 2°29'47.55" W Höhe 52 m

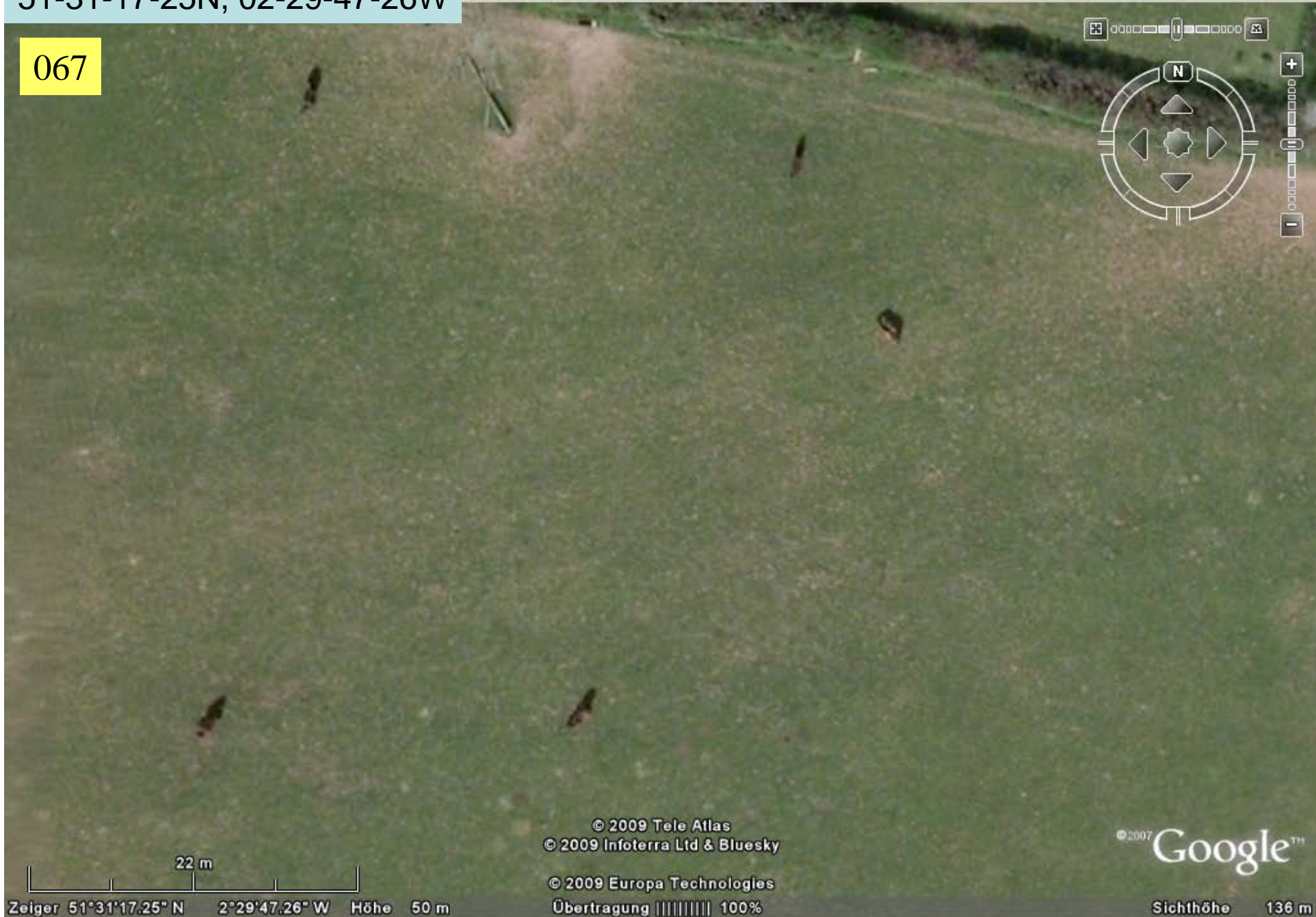
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Sichthöhe 84 m



51-31-17-25N, 02-29-47-26W

067



22 m  
Zeiger 51°31'17.25" N 2°29'47.26" W Höhe 50 m

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Sichthöhe 136 m

51-31-11-76N, 02-29-46-44W

068



11 m  
Zeiger 51°31'11.76" N 2°29'46.44" W Höhe 47 m

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Sichthöhe 90 m



51-30-24-96N, 02-29-43-09W



069



10 m  
Zeiger 51°30'24.92" N 2°29'43.05" W Höhe 46 m

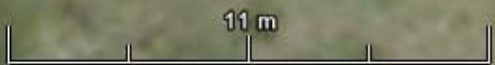
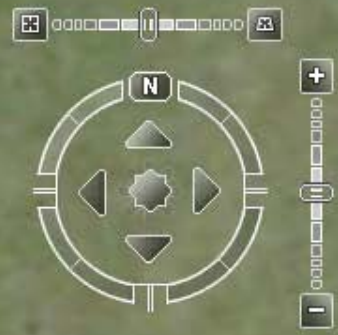
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Sichthöhe 78 m

51-30-44-79N, 02-27-48-44W



070



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Zeiger 51°30'45.22" N 2°27'48.14" W Höhe 60 m

Übertragung ||||| 100%

Sichthöhe 98 m

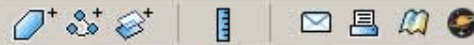


51-30-40-19N, 02-27-28-56W

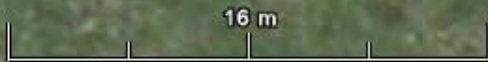
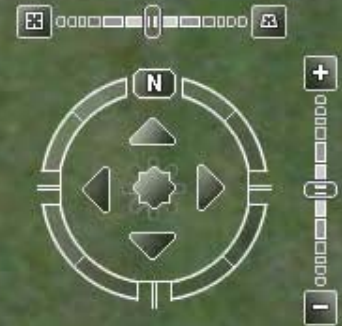
071



51-27-17-56N, 02-27-06-75W



072



Zeiger 51°27'17.65" N 2°27'06.13" W Höhe 70 m

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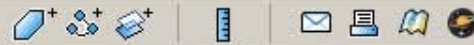
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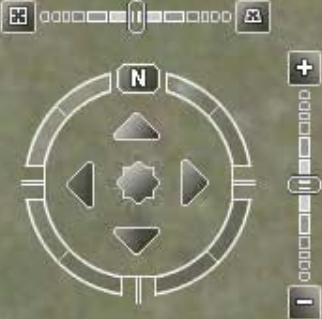
Sichthöhe 124 m



51-27-04-29N, 02-27-10-38W



073



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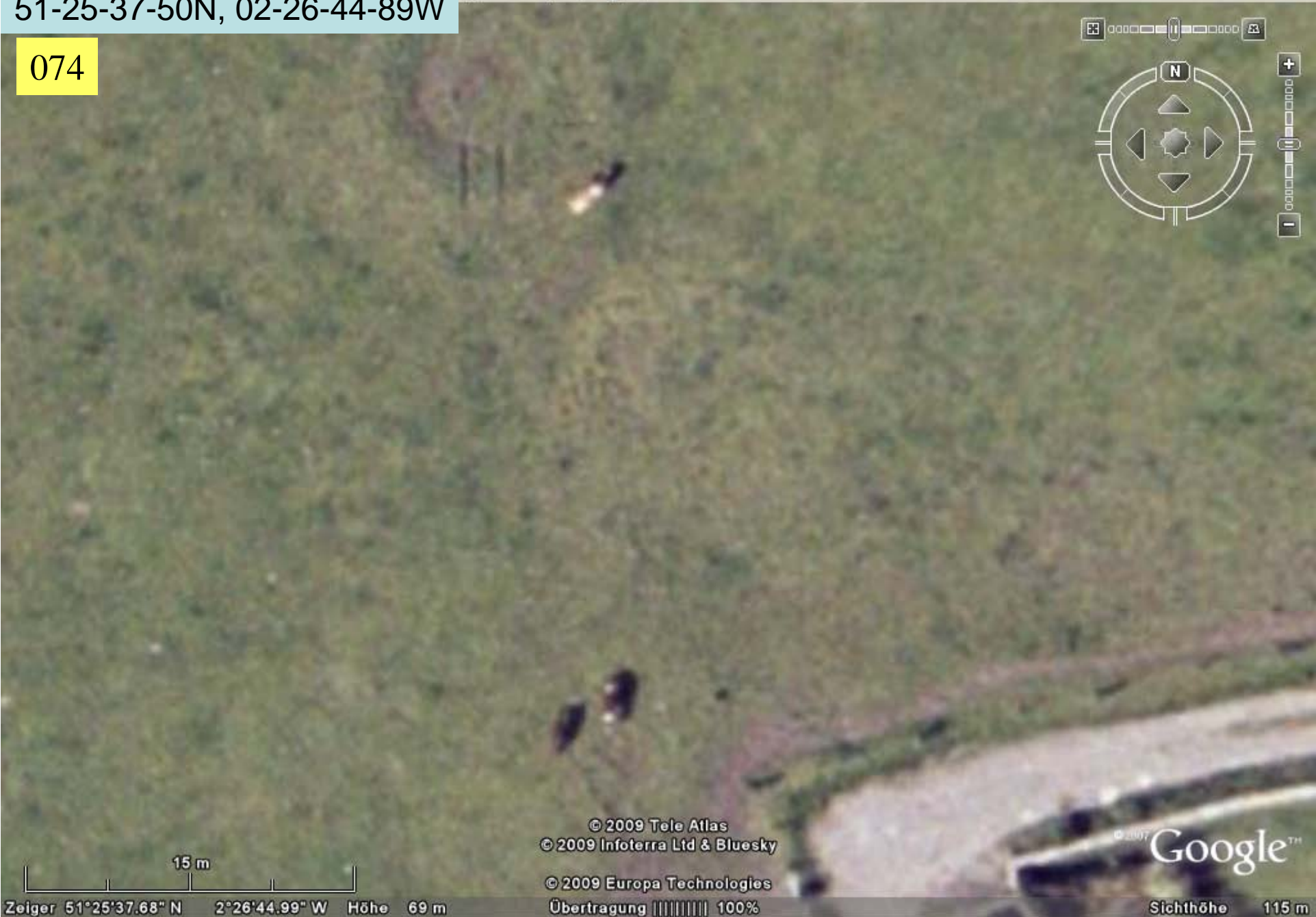
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18 m  
Zeiger 51°27'04.28" N 2°27'10.47" W Höhe 78 m

Sichthöhe 137 m

51-25-37-50N, 02-26-44-89W

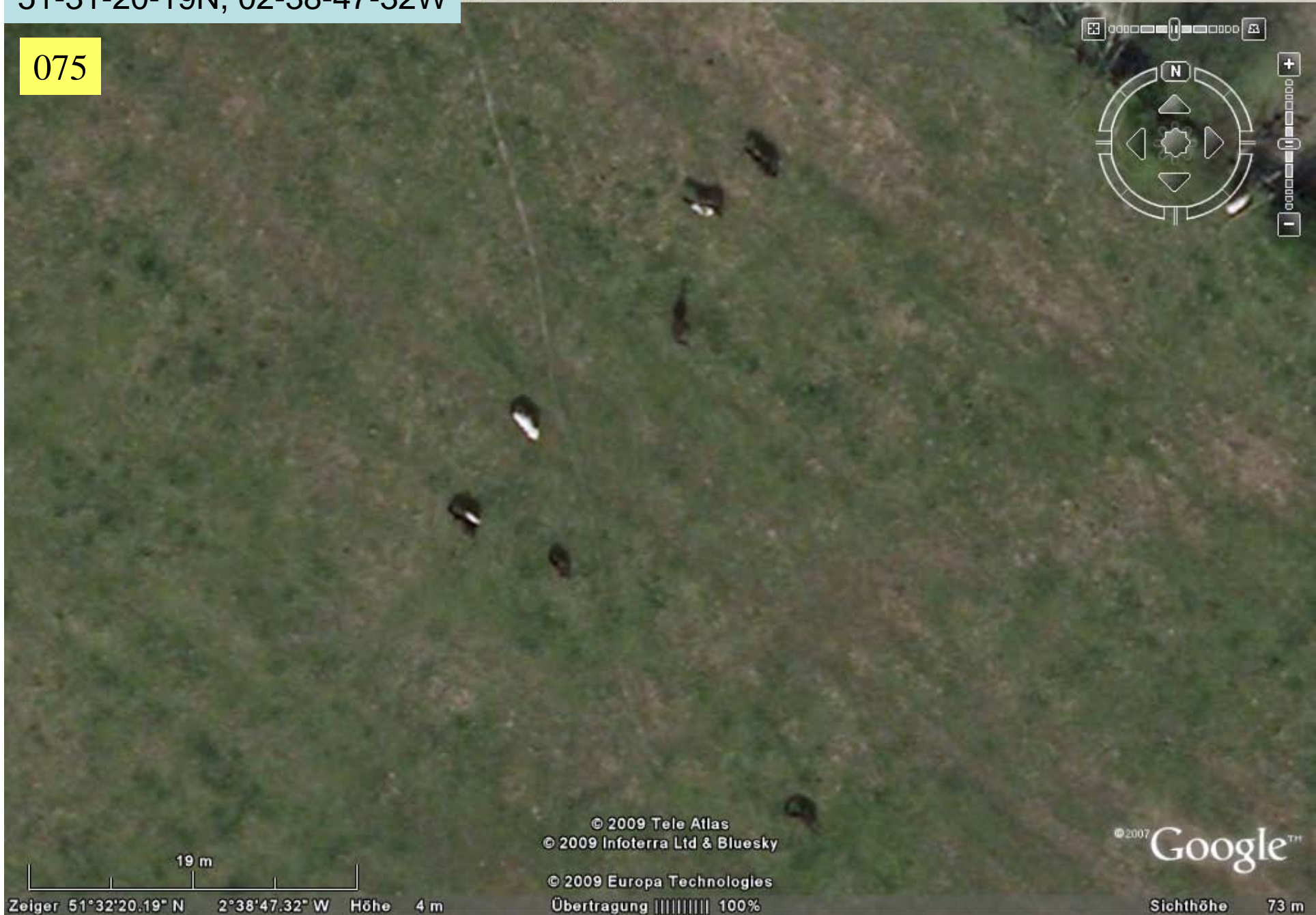
074





51-31-20-19N, 02-38-47-32W

075



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Zeiger 51°32'20.19" N 2°38'47.32" W Höhe 4 m

Sichthöhe 73 m