# Spoilt for choice – five candidate landing sites on Comet 67P/Churyumov-Gerasimenko

*25 August 2014*

Never before did a mission team have to select a landing site on a comet – the Philae lander will be the first spacecraft ever to land on a comet and conduct in situ measurements. The ESA Rosetta spacecraft and the Philae lander began their journey to their final destination – comet 67P/Churyumov-Gerasimenko – 10 years ago. As the spacecraft approach their target, the task of the lander team, which is led by the German Aerospace Center (Deutsches Zentrum für Luft- und Raumfahrt; DLR), has not been easy – the comet's surface is not just made up of flat areas, but features numerous crevasses, slopes, craters and boulders. "Based on the particular shape and the global topography of Comet 67P/ Churyumov-Gerasimenko, it is probably no surprise that many locations had to be ruled out," says DLR researcher Stephan Ulamec, Project Manager for the Philae lander. On 24 August, five possible landing sites were decided upon. "The candidate sites that we want to follow up for further analysis are thought to be technically feasible on the basis of a preliminary analysis of flight dynamics and other key issues – for example they all provide at least six hours of daylight per comet rotation and offer some flat terrain."

**Weighing up the criteria**

During the selection process, the scientists from the DLR Lander Control Center in Cologne, the Science, Operations and Navigation Centre (SONC) of the French space agency, CNES, together with the scientists who are operating instruments on board Philae, took into account various criteria – for example, plenty of solar illumination is required to charge Philae's batteries after the first 64-hour scientific phase, so that it operates for a long period of time and is able to conduct additional science investigations. If the lander does not receive sufficient energy, there will be consequences for the planned 'long term science phase', the phase in which all instruments will be studying the evolution of the comet on its path towards the Sun. Permanent sunlight would, in contrast, cause the lander to overheat, thus limiting the operational life of Philae and its instruments. The time that passes between the separation of the lander from the mother craft to the actual landing will have an impact on the science – the longer it takes to land, the lower the amount of energy that will be available for the first science phase on the comet's surface.

**A complex landing**

The landing could be risky if the terrain is too rugged and there are, for example, depressions and boulders the size of the lander or steep slopes in the area. Since the position of the Rosetta orbiter when it releases Philae toward the comet cannot be determined precisely, scientists can define a landing ellipse with a diameter of about one kilometre. If the lander misses the targeted area, it could touch down in the adjoining region, perhaps encountering a rather unfriendly environment. The selected landing site must also allow regular communications between the Rosetta orbiter and the lander, to send the acquired data back to Earth. Only then will the wishes of the scientists be taken into account; they would prefer to select a possibly active, off-gassing, but also primordial region, in which the cometary material has barely changed since the formation of the Solar System 4.5 billion years ago.

**Search for the best compromise**

However, the ideal landing site – one with a flat surface, plenty of hours of sunlight, good accessibility and ensuring optimal scientific conditions – has not been discovered on Comet 67P/Churyumov-Gerasimenko by the lander team. During the selection process, they had to weigh the pros and cons and swallow several bitter pills. "It is clear that we have to compromise," says Ulamec. The first data regarding temperatures, outgassing and terrain has been produced by instruments on the orbiter. From the first 10 possible landing sites, A to H, the lander team finally chose five candidates on the comet, which consists of a smaller lobe, a larger lobe and a narrow, very active 'neck' connecting them together. Three of the possible landing sites (B, I and J) are located on the lower section of the comet and the remaining two (A and C) are found on the larger part of the cometary body.

**Landing site A** is located in an interesting region on the larger comet lobe, which allows a view of the smaller comet lobe. The narrow area between these two parts is probably already active as the comet begins its journey closer to the Sun. Images with increasing resolution will now allow more detailed investigations to assess the risks posed by small depressions and slopes on this landing site. The illumination conditions also need to be analysed in more detail.

**Landing site B**, inside a crater-like structure on the smaller lobe of the comet, has a relatively flat terrain and could likely prove safe for landing. However, the illumination conditions here are less than the ideal – this could lead to a problem with the longer-term scientific planning. Before landing on the comet's surface, the dangers posed by the boulders in the crater interior must be investigated further. The boulders also indicate that the region has been altered and therefore the material is not as pristine as that found at other places on the comet.

**Landing site C** lies on the larger lobe of the comet. Here, scientists have found a range of different landforms such as depressions, cliffs, hills and flat areas – and also material that appears brighter than usual on the acquired images and is thus particularly interesting. But it is precisely these surface structures that must now be looked at in more detail to assess the risks they could pose for a safe landing. The illumination conditions are good, which will be of benefit to the later phases of scientific investigation.

**Landing site I** is in a relatively flat area and could comprise newer material. Using new images, the surface will be analysed in detail over the coming weeks to determine the extent of existing rough structures more accurately. The illumination of the landing site should allow for long-term science planning.

The **fifth candidate site, J,** is very similar to I – the landing site also sits on the smaller comet lobe, has interesting surface features and good lighting. This landing site is the most favourable for the CONSERT experiment, which will probe the comet's interior by studying radio waves that are reflected and scattered by the nucleus. This landing site is more favourable than landing site I. However, since there are some boulders and terracing features, higher-resolution camera images will be necessary to study the terrain in detail.

**Landing sites with lots of potential**

"Every site has the potential for unique scientific discoveries," says Ulamec. The DLR Institute of Planetary Research has a leading role in four scientific instruments on the mission and is involved in three other experiments. The ROLIS (Rosetta Lander Imaging System), located on the bottom of the lander will, during the descent, already begin to acquire its first images of the comet. Then, it will examine the surface structure of the comet. The thermal probe MUPUS (Multi-Purpose Sensors for Monitoring Experiment) will penetrate up to 40 centimetres into the comet to measure the temperature and thermal conductivity. The SESAME experiment is mounted in the soles of the lander feet and transmits and receives acoustic and electric signals.

These tools will only be able to be used if Philae lands safely. Until 14 September 2014, the lander team will therefore take a closer look at the five possible candidate sites and choose two finalists. In October, after more detailed analyses, the final landing site will be determined. The much anticipated moment is scheduled to occur on 11 November 2014 – the first ever landing on a comet and the first scientific investigations conducted on a comet's surface.

---

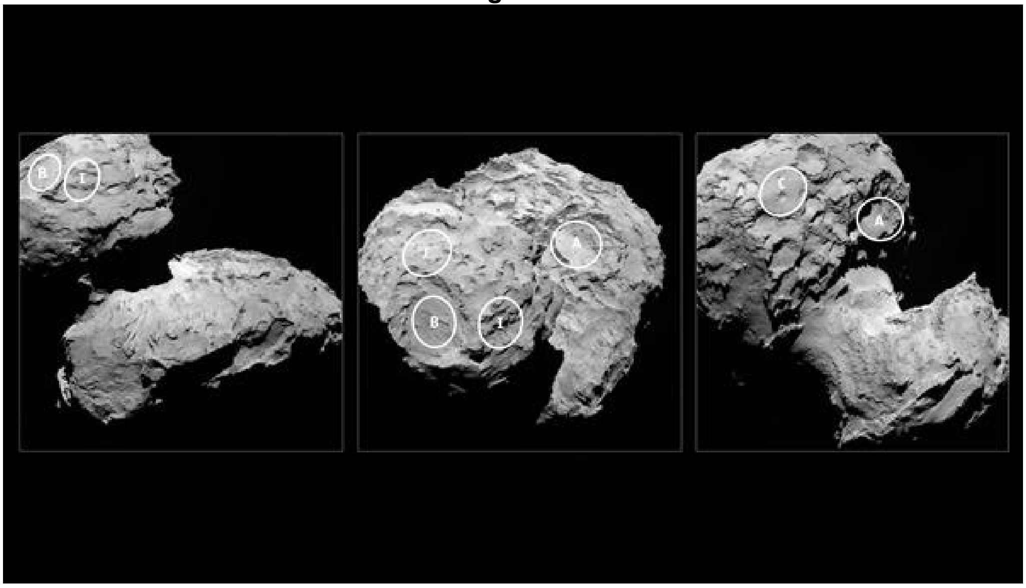
## Contacts

*Manuela Braun*
*German Aerospace Center (DLR)*
*Media Relations, Space Research*
*Tel.: +49 2203 601-3882*
*Fax: +49 2203 601-3249*
*Manuela.Braun@dlr.de*

*Dr Stephan Ulamec*
*German Aerospace Center (DLR)*
*Microgravity User Support Center (MUSC), Space Operations and Astronaut Training*
*Tel.: +49 2203 601-4567*
*Stephan.Ulamec@dlr.de*

---

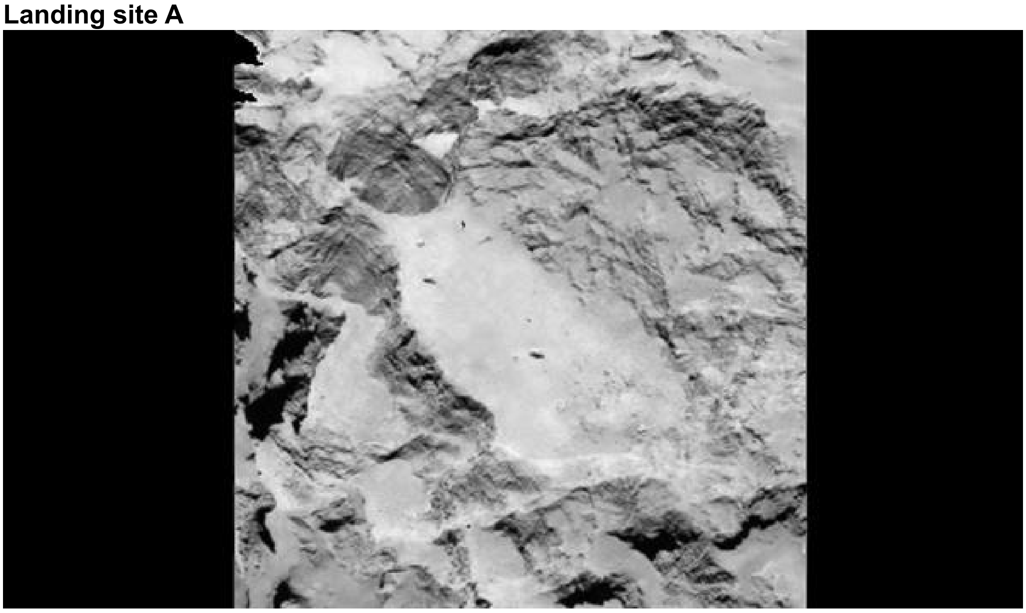
**Five candidate sites for Philae's landing**



From the first 10 possible landing sites, A to H, the lander team finally chose five candidates on the comet, which consists of a smaller lobe, a larger lobe and a narrow, outgassing 'neck' connecting them together. Three of the possible landing sites (B, I and J) are located on the lower section of the comet and the remaining two (A and C) are found on the larger part of the cometary body.

Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA.

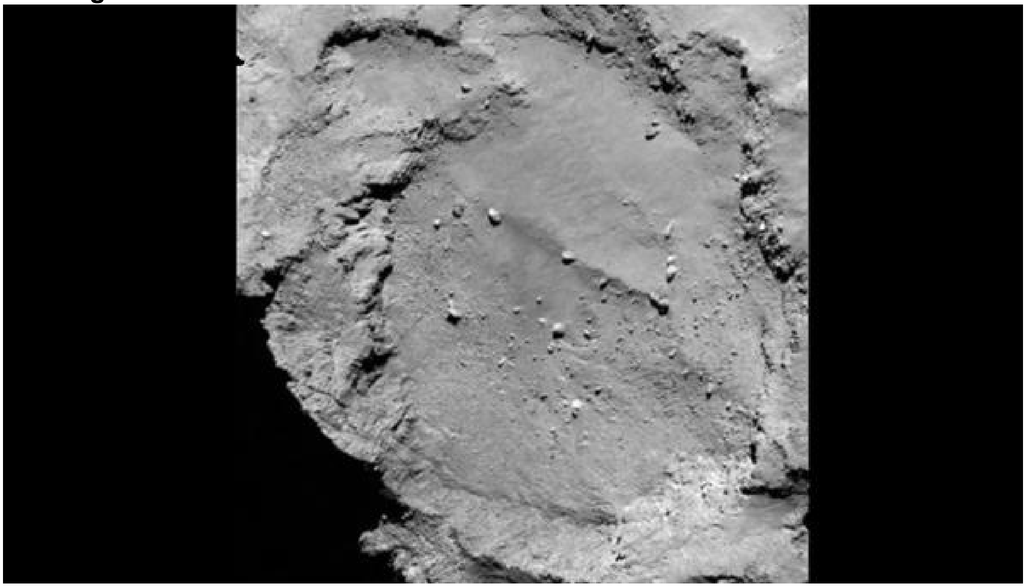
**Landing site A**



Landing site A is located in an interesting region on the larger comet lobe, which allows a view of the smaller comet lobe. The narrow area between these two parts is probably already active as the comet begins its journey closer to the Sun. Images with increasing resolution will now allow more detailed investigations to assess the risks posed by small depressions and slopes on this landing site. The illumination conditions also need to be analysed in more detail. This image was acquired by the OSIRIS camera on Rosetta from a distance of 100 kilometres on 16 August 2014. The resolution is approximately 1.85 metres per pixel.

Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA.

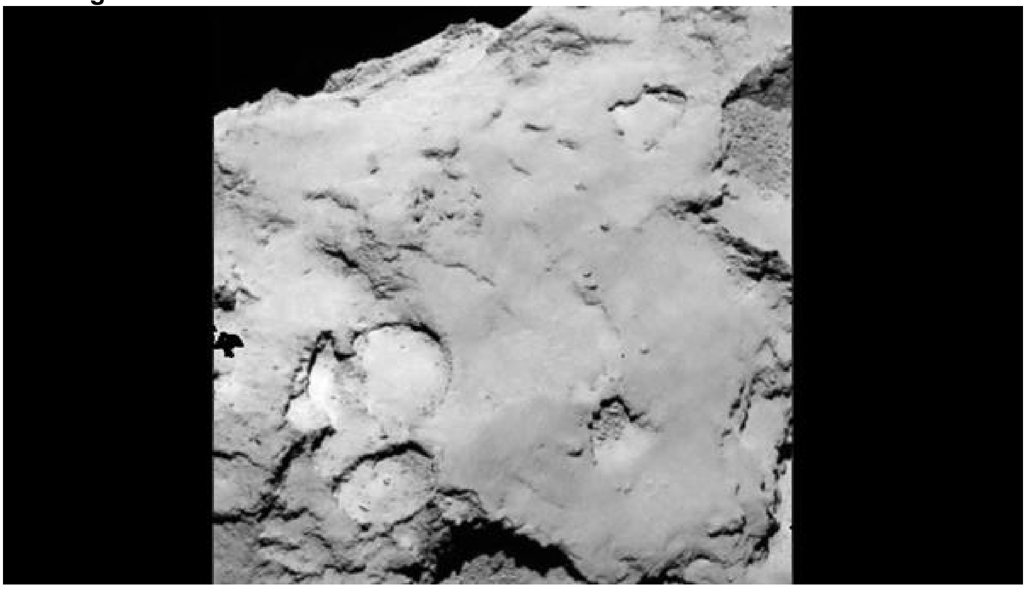
**Landing site B**



Landing site B, inside a crater-like structure on the smaller lobe of the comet, has a relatively flat terrain and could likely prove safe for landing. However, the illumination conditions here are less than the ideal – this could lead to a problem with the longer-term scientific planning. Before landing on the comet’s surface, the dangers posed by the boulders in the crater interior must be investigated further. The boulders also indicate that the region has been altered and therefore the material is not as pristine as that found at other places on the comet. This image was acquired by the OSIRIS camera on Rosetta from a distance of 100 kilometres on 16 August 2014. The resolution is approximately 1.85 metres per pixel.

Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA.

**Landing site C**



Landing site C lies on the larger lobe of the comet. Here, scientists have found a range of different landforms such as depressions, cliffs, hills and flat areas – and also material that appears brighter than usual on the acquired images and is thus particularly interesting. But it is precisely these surface structures that must now be looked at in more detail to assess the risks they could pose for a safe landing. The illumination conditions are good, which will be of benefit to the later phases of scientific investigation. This image was acquired by the OSIRIS camera on Rosetta from a distance of 100 kilometres on 16 August 2014. The resolution is approximately 1.85 metres per pixel.

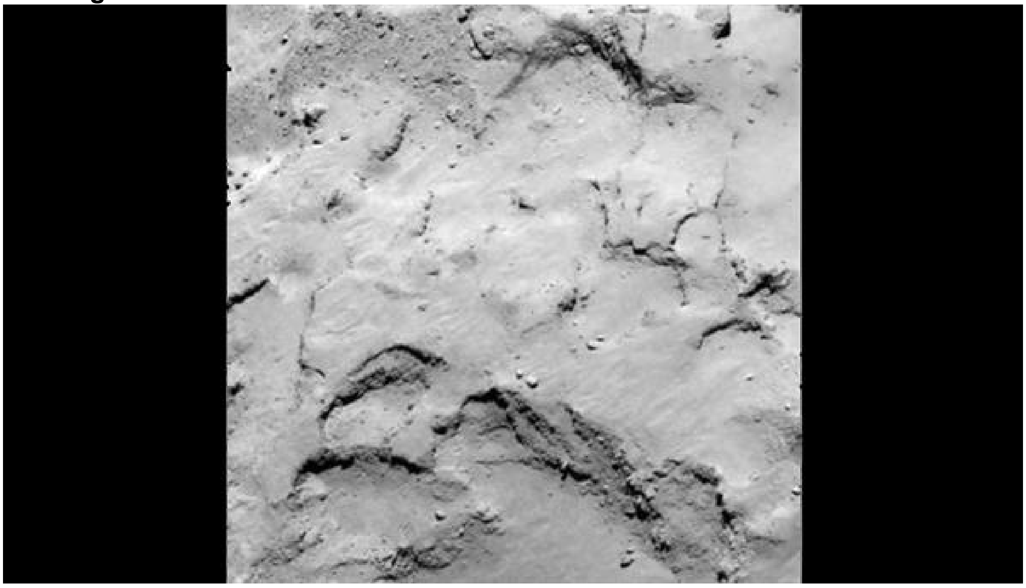
Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA.

**Landing site I**

Landing site I is in a relatively flat area and could comprise newer material. Using new images, the surface will be analysed in detail over the coming weeks to determine the extent of existing rough structures more accurately. The illumination of the landing site should allow for long-term science planning. This image was acquired by the OSIRIS camera on Rosetta from a distance of 100 kilometres on 16 August 2014. The resolution is approximately 1.85 metres per pixel.

Credit: ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA.

**Landing site J**



Landing site J is very similar to site I – this landing site also sits on the smaller comet lobe, has interesting surface features and good lighting. This landing site is the most favourable for the CONSERT experiment, which will probe the comet's interior by studying radio waves that are reflected and scattered by the nucleus. This landing site is more favourable than landing site I. However, since there are some boulders and terracing features, higher-resolution camera images will be necessary to study the terrain in detail. This image was acquired by the OSIRIS camera on Rosetta from a distance of 100 kilometres on 16 August 2014. The resolution is approximately 1.85 metres per pixel.

Credit: : ESA/Rosetta/MPS for OSIRIS Team MPS/UPD/LAM/IAA/SSO/INTA/UPM/DASP/IDA.

---