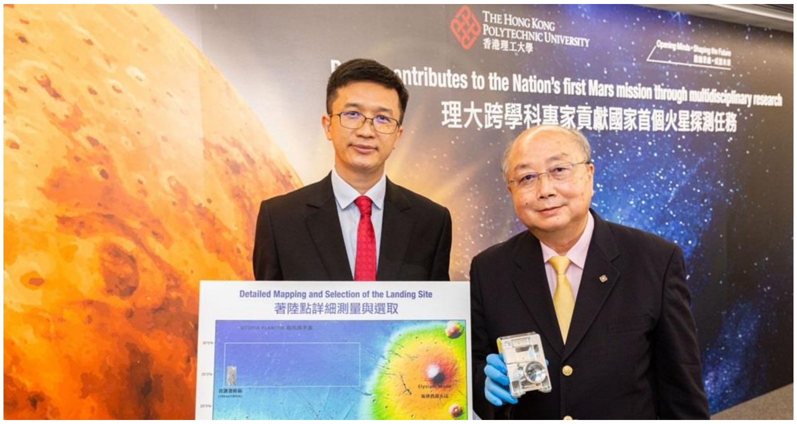
LSGI Scholar provides Mars landing site mapping and evaluation



(L: Prof. WU Bo; R: YUNG Kai-leung)

Two research teams at The Hong Kong Polytechnic University (PolyU) contributed to the Nation's first Mars exploration project Tianwen-1. By harnessing their extensive experience in the field of aerospace science and technology, as well as their commitment to research excellence, PolyU researchers played a vital role in the Tianwen-1 mission, in collaboration with the China Academy of Space Technology (CAST). Professor WU Bo helped identify possible landing regions with advanced topographic mapping and geomorphological analysis technologies. Professor YUNG Kai-leung developed a sophisticated space instrument, the "Mars Landing Surveillance Camera (Mars Camera)", for capturing images of the surroundings of the Red Planet and monitoring the status of the Zhurong Mars rover.

The spacecraft for the Tianwen-1 probe comprises an orbiter, a lander and the Zhurong rover, aiming to complete orbiting, landing and roving in one single mission, which is the first such attempt in global aerospace history. The mission aims to obtain scientific exploration data on the Red Planet, and currently, Tianwen-1 has completed orbiting Mars and has successfully landed on a pre-selected landing region on the Utopia Planitia of Mars. The Mars rover Zhurong is also due to begin Martian exploration.

Landing on Mars is a challenging endeavour due to several reasons, such as the complicated Martian surface, the very thin atmosphere as well as possible dust storms. There is also a 5-20 minutes time delay between Mars and Earth communications. It is therefore of paramount importance to select a landing site that is safe and of scientific significance.

From 2017-2020, upon invitation by CAST, **Professor WU Bo from PolyU's Department of Land Surveying and Geo-Informatics** led a team to carry out global-scale analysis and evaluation to help shortlist three candidate landing regions, namely the Amazonis Planitia, Chryse Planitia, and Utopia Planitia, that are all located within a latitude ranging from 5° - 30°N on Mars.

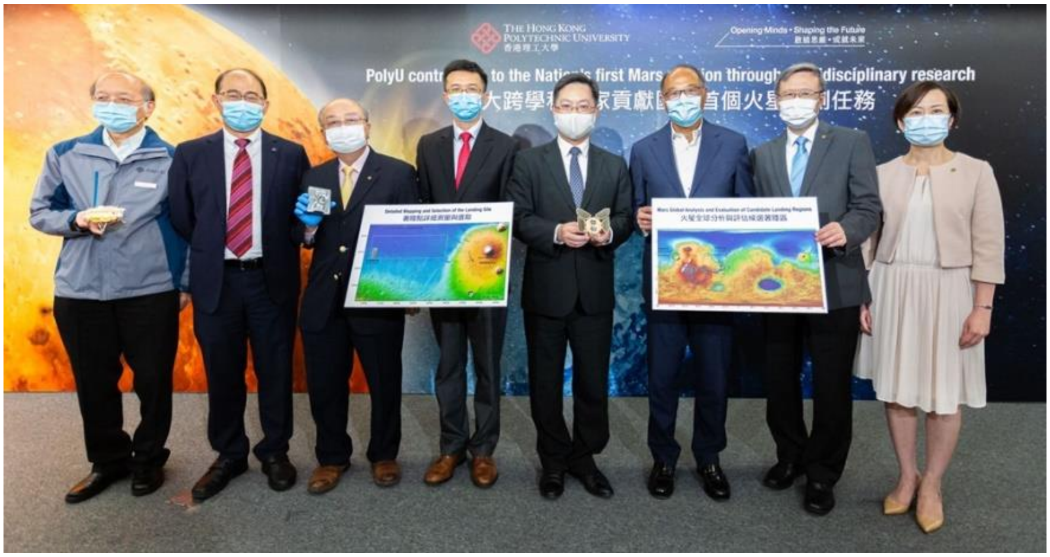
These regions have adequate solar illumination for optimised power generation and moderate temperature, lower elevation for longer deceleration time, and a flat terrain surface for safe landing.

The team further conducted detailed topographic and geomorphological mapping and analysis of the candidate landing regions, including their elevations, slopes, rock abundances, crater densities, and geological contexts. As a result of the evaluation, a region in the southern Utopia Planitia, the largest recognised impact basin in the northern hemisphere of Mars, was selected as the target landing region. Some features in the Utopia Basin like extensive sedimentary materials on the surface have been interpreted as morphological indicators of potential water-ice underneath, which are of great scientific interest since they may offer new insights into the existence of life on Mars and the evolutionary history of the Red Planet.

Since entering the orbit of Mars on 10 February 2021, the Tianwen-1 probe has collected and sent back a large quantity of sub-meter-resolution images of the target landing region covering an area of about 70km × 180km, which is about 11 times larger than the size of Hong Kong's territory. Using the high-resolution images from Tianwen-1, Professor Wu and his team generated high-resolution and high-precision 3D digital topographic models of the target landing region using the self-developed integrated 3D mapping model, to analyse the detailed topography and identify large slopes hazardous for landing.

To facilitate safe landing and roving on Mars, Professor Wu's team also developed AI-based techniques for more automated and robust analysis of geomorphological features like craters and rocks from the high-resolution images in a short period of time. Professor Wu said, "With the aid of the AI-based techniques, we analysed over 670,000 craters, over two million rocks, and hundreds of volcanic cones distributed over the target landing region in 1.5 months. We achieved much higher efficiency in the automatic extraction of rocks and craters with about 85% correctness." From the topographic and geomorphological mapping results, the team successfully identified several landing ellipses for the mission management team to finalise the landing site.

Professor Wu felt very honoured to be able to participate in and contribute to the Nation's Mars exploration project. He said, "The Tianwen-1 mission is a mega project, and we are only a small part of an effort of thousands of people, to support the accomplishments of the mission. All of my team members were fully dedicated to the undertaking over the past months. I am thankful to them for working around the clock to get the task completed on time, yet without comprising accuracy and details."



火星著陸區測量和評估

香港理工大學(理大)兩支跨學科研究團隊為國家近日首個火星探測項目「天問一號」作出貢獻。理大的科研人員憑藉多年來在航太科研領域所累積的豐富經驗，及卓越的研發成果，與中國空間技術研究院合作，在「天問一號」任務中發揮重要作用。當中吳波教授團隊研發創新的地形測量及地貌分析方法，協助選取火星著陸點。容啟亮教授的團隊則研發出精密的太空儀器「落火狀態監視相機」（「火星相機」），拍攝火星的周遭環境及火星車的狀況。

「天問一號」探測器由環繞器、著陸器和巡視器 (又名「祝融」火星車) 組成，目標是一次過完成「繞、落、巡」(即「環繞」、「著陸」和「巡視」)三大工作，是世界航天史上的首次嘗試；這次任務旨在獲取有關火星的科學勘探數據。目前，「天問一號」已完成火星軌道環繞及著陸預選著陸區烏托邦平原，「祝融」火星車正侍機展開巡視及勘探工作。

登陸火星是一項極具挑戰性的任務。火星表面的地形複雜，大氣層稀薄，而火星表面隨時可能出現的沙塵暴，加上火星與地球通訊有約 5 至 20 分鐘的延遲，凡此種種增加了登陸火星的難度。因此，選擇一個安全而具有科學價值的著陸點至關重要。

2017 至 2020 年期間，**理大土地測量及地理資訊學系吳波教授**應中國空間技術研究院的邀請，率領團隊進行火星全球的分析和評估，篩選出三個候選著陸區，分別位於亞馬遜平原、克里斯平原和烏托邦平原。這些候選著陸區均處於火星緯度 5°- 30°N 範圍，太陽日照充足，有助太陽能電池板供電，溫度適中；且位處低海拔，可以延長探測器降落時減速的時間；地形平坦，有利探測器安全著陸。

理大團隊進一步對候選著陸區進行了詳細的地形及地貌特徵分析，包括其海拔、坡度、岩石密度、撞擊坑密度，以及該區域的地質歷史。綜合研究結果，火星北半球最大的撞擊盆地烏托邦平原南部區域獲選為「天問一號」的目標著陸區。烏托邦平原的某些特徵，如其表面上廣泛存在的沉積物，顯示這個區域地下可能存在水冰，因此其科學意義重大，有助找出火星是否曾有生命的線索，了解火星的演化歷史。

「天問一號」自 2021 年 2 月 10 日進入環火軌道後，已收集並傳回大量覆蓋目標著陸區的亞米級高解像度圖像回地球。是次任務的目標著陸區面積達 70 公里 x 180 公里，即比整個香港的面積大 11 倍。吳波教授及其團隊利用自行研發的「三維集成測量模型」，將「天問一號」傳回的高解像度圖像，製成高精確度、高解像度的三維數碼地形模型，以詳細分析地形特徵，識別可能影響著陸安全的大型斜坡。

為了幫助「天問一號」在火星上安全著陸和巡視，吳波教授及其團隊亦研發出「基於人工智能的撞擊坑、石塊提取方法」，在短時間內從高解像度的圖像上自動提取撞擊坑和石塊等地貌特徵，以作更精確的分析。吳教授說：「我們利用這項人工智能技術，在一個半月內分析了分佈在目標著陸區內的 67 萬個隕石坑、逾 200 多萬塊岩石，和數百個火山錐，效率超卓，準確率達到了85%。」團隊根據地形和地貌的詳細測量結果，成功搜索出數個可能的著陸點，供「天問一號」任務的管理團隊作最終抉擇。

吳教授十分榮幸能夠參與國家的火星探測任務，並貢獻力量。他說：「『天問一號』火星探測任務是一個龐大的工程，是成千上萬人的努力成果，我們只是當中的一顆『螺絲釘』。

過去幾個月，我的每一位團隊成員為這個項目全力以赴，日以繼夜工作，精益求精，沒有因為時間緊迫而對準確度和工作中的細節讓步，最終我們在限時內完成任務。」

Full version of university press release:

https://www.polyu.edu.hk/media/media-releases/2021/0521_polyu-contributes-to-the-nations-first-mars-mission-with-multidisciplinary-research/ (Eng)

https://www.polyu.edu.hk/tc/media/media-releases/2021/0521_polyu-contributes-to-the-nations-first-mars-mission-with-multidisciplinary-research/ (Chi)

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<港人港地>【短片】【航天科技突破】中國成為第二個成功登陸火星的國家、香港也有出一分力 理大團隊協助「天問一號」監察火星、理大學者容啓亮：火星低溫是最大挑戰！

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