Grant agreement no. 607379

SPA.2013.2.1-01 - Analysis of Mars Multi-Resolution Images using Auto-Coregistration, Data Mining and Crowd Source Techniques

- Collaborative project -

D8.1
User Requirements Workshop

WP 8 – Outreach

Due date of deliverable: Month 4 – April 2014

Actual submission date: 19/12/2014

Start date of project: January 1st 2014 Duration: 36 months

Lead beneficiary for this deliverable: DLR

Last editor: Klaus Gwinner

Contributors: DLR, FUB

Project co-funded by the European Commission within the Seventh Framework Programme (2007-2013)		
Dissemination Level		
PU	Public	x
PP	Restricted to other programme participants (including the Commission Services)	
RE	Restricted to a group specified by the consortium (including the Commission Services)	
CO	Confidential, only for members of the consortium (including the Commission Services)	

History table

Version	Date	Released by	Comments
V0.1	20.05.2014	K. Gwinner	First draft of workshop minutes and description
V0.2	23.05.2014	S. van Gasselt	Revised and amended workshop minutes
V0.3	27.10.2014	S. van Gasselt	Sections on description and evaluation of online survey added
V0.4	19.11.2014	K. Gwinner	Section on workshop added
V1.0	03.12.2014	K. Gwinner	Complete version
V1.1	17.12.2014	K. Gwinner	Revised version after internal review

Executive Summary

The iMars project is developing a user platform for Mars surface science, consisting of a collection of data products from Mars orbital imaging data sets, and specific tools for producing, exploring and analyzing these (WebGIS, Crowd Sourcing). The project also applies the data products and tools to studies on surface changes over time, which is a new and dynamic field of Mars science. The concept of iMars includes inquiries of user needs, interests and feed-back during the project. Deliverable D8.1 “User Requirements Workshop” is summarizing the concepts and implementation adopted for the 2014 User requirements workshop and user survey, reports on their execution, and on conclusions derived from the user’s responses. While the workshop was designed to provide information on the project’s aims and development plans, and to initiate links with potential users, a questionnaire based survey was opened for several month to obtain information on user requirements and research interests. The workshop was held on May 1, 2014, at the General Assembly of the European Geoscience Union (EGU). The survey was opened at the same event and closed on September 24, 2014, after the European Planetary Science Congress (EPSC). This deliverable concludes the activities of Task 8.1 (User requirements workshop).

Table of contents

Key word list

User requirements, User Workshop, User Survey, Dissemination

Definitions and acronyms

Acronyms	Definitions
COSPAR	Committee on Space Research
CTX	Context Camera
DLR	Deutsches Zentrum für Luft- und Raumfahrt
DTM	Digital Terrain Model
EGU	European Geophysical Union
EPSC	European Planetary Science Congress
ESA	European Space Agency
EU	European Union
FUB	Freie Universität Berlin
GIS	Geographic Information System
HiRISE	High Resolution Imaging Science Experiment
HRSC	High Resolution Stereo Camera
MEX	Mars Express
MGS	Mars Global Surveyor
MRO	Mars Reconnaissance Orbiter
MSSL	Mullard Space Science Laboratory
PSA	Planetary Science Archive
PDS	Planetary Data System
RSL	Recurring Slope Lineae
UCL	University College London
UNOTT	University of Nottingham
WebGIS	Server A software service providing access to GIS functionalities over the web using standard protocols and browsers.

1. Introduction

1.1 General context

The iMars project is developing a user platform for Mars surface science, consisting of a collection of data products from current Mars orbital imaging data sets back to image data sources from the 1970s, and specific tools for producing, exploring and analyzing these data products (WebGIS, Crowd Sourcing). The project also applies the data products and tools to studies on surface changes over time, which is a new and dynamic field of Mars science.

The overall aims of iMars are summarized in the Grant agreement as follows:

iMars proposes to add value by creating more complete and fused 3D models of the surface from combined stereo and laser altimetry and use these 3D models to create a set of coregistered imaging data through time, permitting a much more comprehensive interpretation of the Martian surface to be made. Emphasis will be placed on co-registration of multiple datasets from different space agencies and orbiting platforms around Mars and their synergistic use to discover what surface changes have occurred since NASA's Viking Orbiter spacecraft in the mid-1970's. […] The resultant time-stamped imagery will be interfaced to automated data mining analysis software based on techniques developed for Earth surveillance. We will also build on the huge momentum, developed in the Zoouniverse system by building a "MarsZoo" project for mass public participation in the feature mapping of Mars. Co-operation with US colleagues will be through the Technical Advisory board at annual project meetings and with European scientists through the workshops as well as the exploitation of the 3D datasets in visualisation engines such as Google Mars. The iMars datasets and tools will allow the creation of new communities of geoscientists. iMars will also allow much greater public participation in data analysis so stimulating a much greater interest in space-based data.

Planetary surface science has seen a dramatic increase in both quality and quantity of observations over the last 15 years, especially in 3D imaging of surface shape. This has led to large volumes of high-resolution data, the ability to overlay data from different epochs, and examine time-dependent changes (such as the recent discovery of boulder movement, tracking inter-year seasonal changes and looking for occurrences of fresh craters). Consequently, planetary science studies can be based on complex sets of multi-type observation data, and, conversely, new research themes have emerged and capable and rapidly evolving new science tools are in use.

The collection of Mars Science data available today, and relevant to the goals of the iMars project, comprises the following data sources:

- Viking images provided high-resolution as well as (some) stereoscopic views of the surface of Mars for the first time (Kirk et al., 1999).
- The Mars Global Surveyor spacecraft included the Mars Orbiter Laser Altimeter (MOLA), delivering data that have been used to derive an improved global geodetic reference system of Mars. In addition, the Mars Observer Camera (MOC) with its narrow angle device (Malin and Edgett, 2001) delivered meter-scale surface images

of the surface for the first time, including some suitable for stereo analysis, although at very limited spatial extent (Kirk et al., 2003).

- The Mars Express (MEX) mission of the European Space Agency (ESA) includes the High-Resolution Stereo Camera experiment (HRSC; Neukum et al., 2004; Jaumann et al., 2007), capable of providing high-resolution digital terrain models (DTMs) at up to ten times higher grid spacing than MOLA, as well as panchromatic and multi-spectral images (Gwinner et al., 2009, 2010). Mapping Mars by such data at the global scale is among the foremost goals of HRSC, but will not be achieved during the lifetime of the iMars project according to the progress of data acquisition.
- Mars Reconnaissance Orbiter (MRO) with its Context Camera (CTX; Malin et al., 2007) is currently acquiring high-resolution images at ground pixel size between 5 m and 12 m at a global scale. MRO also includes the High Resolution Imaging Science Experiment (HiRISE; McEwen et al., 2007; Kirk et al., 2008) which uniquely provides images at sub-meter ground pixel size, although for small parts of the surface of Mars. A fraction of the data of both imaging systems of MRO comprises stereoscopic images.

1.2 Deliverable objectives

The concept of iMars includes inquiries of user needs, interests and feed-back during the project. Tool development should thus be guided by requirements derived from user surveys and workshops, and links to potential user groups should be established.

To this end, a user workshop to take place in an early project phase and a formalized survey on user requirements and interests were planned and implemented in the first half of 2014. This is the first of three activities of this type planned for the lifetime of the project under WP8. While the future events (First and Final User Consultation Workshops, M20 and M32) will also address experiences and feed-back of users applying iMars tools and data, the first event and survey was largely designed to introduce and make known the project and its aims.

Deliverable D8.1 “User Requirements Workshop” is summarizing the concepts and implementation adopted for the 2014 user workshop and survey, reports on their execution, and the conclusions that were derived from the user’s responses. This deliverable concludes the activities of Task 8.1 (User requirements workshop). The purpose and central aim of T8.1 has been specified in the Description of work as follows:

In order to ensure that the outcomes of iMars are “fit-for-purpose”, it is important to capture user requirements near the commencement of the project. This will be done through a user requirements workshop held in conjunction with a major scientific conference, such as the EGU14.

2. Methods approach

User Requirements Workshop. The main purpose of the workshop was to introduce the project to potential users and interested scientists, introduce possible science topics for the science cases of the project, and request initial feed-back on requirements from the user community. Fig. 1 shows the agenda of the workshop. The contents of the talks were designed to both convey information on iMars aims and developments and to promote discussion with the participants. The user feed-back was to be recorded by taking minutes at the site (ANNEX 1). In addition, a questionnaire to fill in after the workshop was developed (ANNEX 3), considering the level of detail of the expected response, time available at the workshop, and previous experience on participant response.

Figure 1. *Agenda of the iMars User requirements workshop held at the EGU General Assembly 2014 in Vienna.*

User Survey. The main purpose of the survey was the identification of WebGIS user requirements and requirements related to scientific challenges that involve identification of surface features. The online questionnaire has been integrated into the main iMars website (www.i-mars.eu, see Figure III-1) that provided 13 questions or tasks split over 13 pages. These questions were intended to cover two main topics in WP 5 (GIS) and WP 6–7 (Feature Detection) in order to derive user needs and wishes.

- Two questions covering background information.

- Six questions covering GIS-related needs and experience of users. The purpose of these questions was to assess the level of GIS-experience of users. A generally low level would result in more intuitive webGIS designs and fewer selection dialogs. In contrast, generally experienced users are used to deal with more complicated dialogs. In addition it was important to assess which kind of functions (set of functions) are generally needed by users. Non-expert users can usually not answer that question and for that reason questions related to their everyday research habits have been implemented so that WP 5 can define appropriate tools.

- Five questions covering the importance of detecting variable features including the importance of particular feature types. The set of queries were targeted at identifying additional features users would like to have covered using feature extraction functionality and crowd-sourcing techniques. Priorities could be given so that implementation can focus on specific feature types.

Apart from gathering background information and information on habits and opinions (Q1, Q2, Q7, Q9, Q10, Q13) questions are predominantly ranking questions with ordinal scales (Q3, Q4, Q8, Q11, Q12), free-form text questions (Q6) and a mixture of both (Q5).

It should be stressed that although input for the survey was gathered cooperatively and iteratively across work packages, questions provided by each work package were aimed at answering specific work-package issues. Therefore, we did not aim at characterising users by cross-correlating sets of survey variables but rather aimed at receiving comments that can be distilled into user requirements. Each question can therefore be treated independently of other questions.

Below we discuss the contents of the questions in order to highlight their purpose and the anticipated value of returned answers. Questions and full dialogs are displayed in ANNEX 3.

1. Please, tell us something about your background. What is/are your main study area/s of scientific interest related to Mars?

We want to learn about user background and assume that researchers dealing with mapping and geodesy are probably experts in GIS usage while engineers might not have had any interaction whith such systems. We also assume that researchers who are willing to answer our questionnaire are probably a primary user group of GIS technology and the iMars webGIS. Answers are on a nominal scale, we provided five possible answers and the option to add other research fields. Users could enter more than one study area.

2. What are your most frequently used data sources for these studies? (please specify data product type or processing level, e.g. Viking EDR, Viking MDIM, ...)

The detail of answers allows us to assess the level of acquaintance of the user with specific datasets. It also allows us to learn about the currently most used dataset for Mars research. Researchers can rank up to three commonly used data sets but we did not provide a list of possible choices in order to test user knowledge.

3. WEBGIS: How often do you actively use GIS (desktop or web)?
We here want to learn about the user's experience in using GIS and provided 4 answers on a ranking scale (daily, weekly, monthly, never).

4. WEBGIS: What would you say is your level of GIS knowledge?
We want to learn about the user's experience in using GIS and provided 4 answers on a ranking scale (from expert to no experience). This question is a complement to question 3.

5. WEBGIS: Do you use web-based planetary GIS for your research? If so, which? Please sort according to frequency (1: most frequent, 3: least frequent).
If researchers use webGIS, we learn about their experience and choices. If researchers enter systems that are no GIS but, e.g. archiving platforms, we also learn about their basic understanding of GIS technology. If there is a trend in answers, we could adapt complexity of the system appropriately.

6. WEBGIS: When you compare web-based GIS and desktop GIS which functionalities are you missing most in either of these systems?
If researchers can answer this question they are probably experienced users. There is no doubt that webGIS technology is way behind desktop tools but we here want to know which feature researchers are missing most (free-form text answer).

7. WEBGIS: What is the main objective in using a desktop or web-based GIS? (multiple answers possible)?
We want to learn about the main purpose researchers are using GIS technology and provide possible answers based on our own experience. If there is a clear trend, we can derive requirements and adapt webGIS developments appropriately to answer these demands.

8. WEBGIS: How important are the following GIS features for your daily work? Please rank your choices from not important to most important.
The researcher is confronted with 10 general-purpose features and capabilities of GIS in order to extract what researcher may find most important. The purpose here is to define features that have priority during implementation if the return is statistically relevant.

9. FEATURES: This map (see figures) by the HiRISE team shows the distribution of change detections (SPRC=South Polar Residual Cap, RSL=Recurring slope lineae). What additional change features are of scientific interest?
Spacecraft observations of Mars have reached a level where temporal changes can be spotted and analysed. The HiRISE team provided a list of features that are being observed by the team for changes. We ask researchers to provide additional features the iMars group has not thought about so that they can be discussed for implementation.

10. FEATURES: What change methods do you believe that people better suited to than computers?
The following three questions are related to abilities of humans vs. computer with respect to detection and identification of features. While changes in image data can easily be detected, the type of change and the process leading to change are not necessarily identified easily.

11. FEATURES: Rank the change features that people are better suited than computers to perform.
For all 12 features listed in question 9 researchers should rank how humans are better suited than computers to detect changes.

12. FEATURES: Rank the change features that are most scientifically important to detect, identify or measure.
For all 12 features listed in question 9 researchers should rank which features are important to detect, identify and measure.

13. FEATURES: Are there any other change features which iMars should consider? If possible, say whether they are important for detection, identification, measurement.
Any other features we have not thought of can be added here.

Finally, researchers were given the possibility to leave their e-mail address in order to receive updates on the outcome and progress of work.

3. Summary of activities and results

User Requirements Workshop. The First iMars User Workshop took place on the EGU premises (room Y7) and was scheduled for 1st May 2014, 12:15 to 13:15. The EGU conference offered the earliest possible opportunity to organize the workshop at a scientific meeting with large attendance. The workshop was attended by 23 researchers including six iMars team members and one invited speaker.

The workshop was accompanied by a presentation of iMars in the scientific program of EGU, and similar presentations were given at other relevant meetings with strong involvement in planetary science, i.e. EPSC 2014 and COSPAR (2014) as well as at the June 2014 team meeting of the HRSC Co-Investigator team (presented by J.-P. Muller). At these occasions, attendants were also invited to respond to the online user requirements survey.

The workshop at EGU was chaired by K. Gwinner (DLR) who gave a short introduction on the purpose of the workshop, the agenda (Fig. 1) and the associated user requirements survey. The general presentation of the iMars project was given by J.-P. Muller (UCL) and was followed by a presentation of J. Morley (UNOTT) which specifically was addressing user interaction aspects of the project (WebGIS, crowd sourcing). These presentations are found in ANNEX 2 of this document. Finally, S. van

Gasselt (FUB) gave a brief introduction to the survey, discussing the main groups of survey questions.

The topic of change detection for Mars and related activities of the HiRISE team was introduced in an invited presentation given by Sarah Mattson (University of Arizona; Fig. 2). She addressed features and phenomena at the surface of Mars for which changes have been detected and the use of HiRISE and CTX data to observe such changes. Her talk was followed by a short discussion on expected detection limits for these data sources and the actual practice of multi-temporal data analysis by the instrument teams.

In the concluding discussion these aspects were taken up again, on the background of how iMars can effectively contribute to change detection. General agreement was found on the need of automated processes for data processing and detection to support the hitherto manual and mostly qualitative assessments.

Further discussion was centered on the questions of how results of data processing, feature extraction and crowd sourcing can be assessed by a user community, and authorship issues connected to such access types. The latter question arises when results of data analysis are provided online or in the form of a database. Discussion platforms and the use of team authorships were proposed as potentially useful instruments.

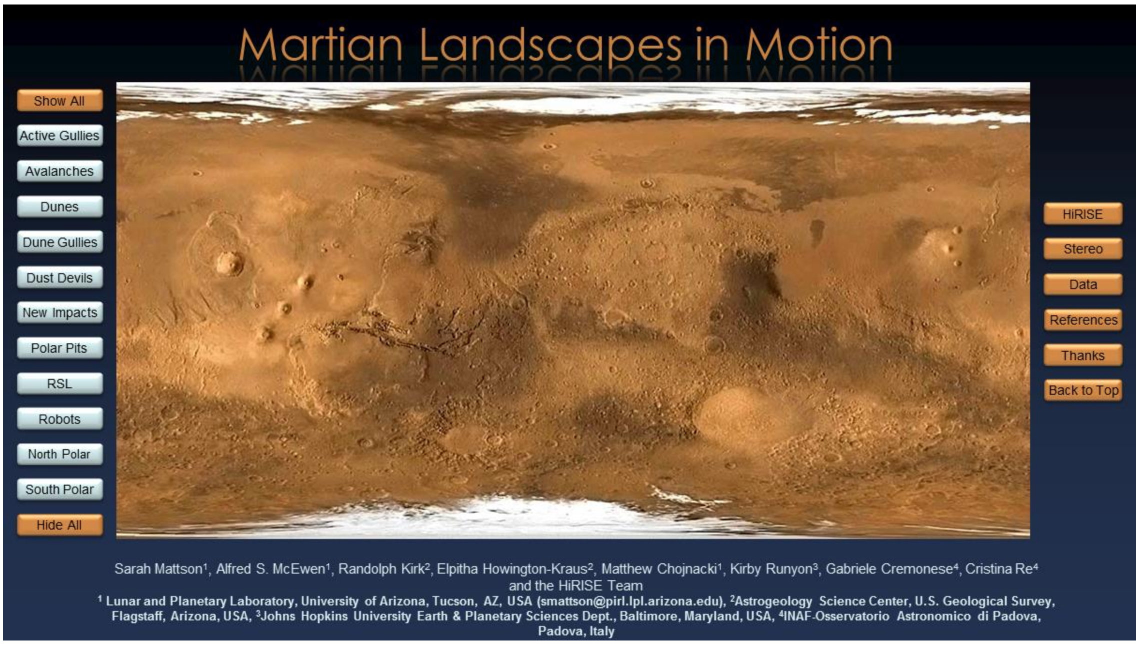


Figure 2. *Cover viewgraph of the invited presentation given by Sara Mattson (Arizona State University / HiRISE Team) at the iMars User requirements workshop.*

User Survey Implementation and Execution. Form-based webpages for the online survey were implemented using PHP 5.4.20 (http://php.net, released 19/09/13) and a MySQL 4 DBMS (http://dev.mysql.com, switched to MySQL 5 before EPSC) running on Apache 2.2 webserver (http://httpd.apache.org/) on dedicated web space. A PDF format, form-like document for print or e-mail was created in parallel and distributed at conferences and meetings or by mailing (see Figure III-2 to III-5).

Although a number of first responses were received after the General Assembly of European Geosciences Union (EGU) 2014, the consortium, in particular project management with WP 5-8, agreed to extend the survey until after the European Planetary Science Congress (EPSC) in September 2014 in order to enhance the statistical significance of the survey based on an increased number of data.

User Workshop and Survey Evaluation. The responses to the survey were combined in tables (ANNEX4) which were analysed in terms of absolute numbers, percentages and average values, as appropriate. Qualitative data such as comments were ordered and represented in text form. The user comments, questions, and discussion points from the user workshop at EGU were recorded in a minutes document (ANNEX 1).

All results were evaluated in anonymized form and a number of key requirements were extracted and discussed in the frame of work package meetings of WP 5 (webGIS system requirement specifications and design document, FUB) and in terms of specifications for WP 6 (Change detection from Data mining & validation, UCL) and WP 7 (Crowd-sourced features for change discovery and validation of data mining, UNOTT).

After presenting the survey at two large conferences and in different mailing campaigns, we received 76 returns of which 7 were provided in analog format. Of these 27 returns (36%) could be used for evaluation. Usability threshold was 20%, i.e. if a researcher answered at least 5 questions, results were used for evaluation.

Given the relatively small size of the community and the relative small number of researchers interested in methodology and technical design of GIS, the total number of returns is considered to meet the expectations. However, the return cannot be characterised as being representative of the entire potential user community, in particular taking into account the low number of complete (i.e. usable) returns. However, the survey provided a valid insight into requirements and expectations of the research community. More importantly, it provided specific requirements for current developments in WP 5-8.

The main outcomes of the survey can be summarized as follows:

1. Web-based feedback came from Austria, Canada, England, France, Germany, and Portugal, which reflects the consortium’s nationalities and the locations of major conferences (Austria, Portugal).

2. Most researchers work in the field of geomorphology (74%) and geology (63%) followed by geodesy sensu lato (33%) followed by research fields in materials and composition (26%), Only three researchers answered that they would be working in a field of engineering science (11%).

3. Among our responses, HRSC (70%) and CTX (67%) are the datasets that are being used most for analysis of Mars. They are followed by HiRISE (48%) and MOLA (30%). CRISM and THEMIS seem to be less commonly used with 19% and 11%, respectively.

4. 41% of all researchers who have answered this survey are experienced GIS users who use GIS software on a daily basis. 11% have never used GIS. 37% of the researchers say, that they know in GIS what to do but they do not feel that they are experts (only 22% say so). Consistently (see 3), only 11% do not know anything about GIS.

5. Most researchers seem to use JMars (19%) and Google Earth in their research when applying GIS-type functionalities (19%). Tools from the PDS and PSA archives or instrument teams are used by 15% of the users.

6. Answers to researcher's usage of GIS technology and the main statements with respect to web- and desktop-based GIS are highly diverse. The advantages of webGIS are that local hard disks are not cluttered but there seems to be a general consensus that reliable data analysis, map preparation and mapping can only be done in desktop GIS thus far (see appendix for all answers).

7. Most researchers use GIS for map production purposes (67%) followed by using GIS for checking data availability (48%) and analysis (48%). Only 11% use GIS for data processing purposes.

8. For most users, raster display and modifications are most important (8 votes). Data queries follow with no negative votes, map production with only two negative votes. Interactive mapping and raster processing were least important, confirming 7.

9. For tracking of variable features no significant preference can be seen. Dust devil tracks, dark streaks and CO2 geysers are in the range of 22% (dark streaks) – 30% (dust devil tracks). As an additional feature for detection, rock slides and slumps were indicated.

10. Half of the researchers suggested that humans are better in identifying variable features (48%). Only one fifth thinks, humans are better in detecting these features (22%). Over one third (37%) stated humans are better capable of measuring features.

11. Feature identification and detection could not be clearly separated by users in this survey. Only 5 researchers returned results for the next two questions

whereby 3 results clearly demonstrate that the way ranking had to be done was not understood (multiple identical ranks). These results have been left out.

4. Conclusions and future steps

With 23 participants, the User requirements workshop at EGU has met an acceptable though not vigorous interest. Concerning attendance to the workshop and responses to the survey, we can conclude that the main purpose of making potential users and interested scientists aware of iMars, and of requesting initial feed-back on requirements from the user community, was met. In that sense, the format of the workshop, in particular as far as it gave ample room for information on aims and development plans of the project, can be judged effective for such an early stage of the project. On the other hand, it must be stated that much of the feed-back was received through the online survey, which has been flanked also by other meeting presentations.

The discussions at the workshop allow deriving some high-level conclusions:

1. Responses to the project presentations demonstrate that the basic concept of the project is considered valid and potentially useful for current planetary surface science.

2. The research topic of surface changes meets high interest and the approach of iMars to this field is considered well suited in general. Responses also suggest the European community is broad in its interests in surface change phenomena and likely represents a potentially strong user group for tools related to surface change.

3. Making available research data products and tools such as planned in iMars opens up questions concerning authorship rights in scientific research that should be further addressed.

4. Workshop discussions were of a more general nature, according to the limited amount of technical detail that could be presented at this early stage of the project. It is suggested that presentations of actual project developments at about mid-term will allow for more detailed feed-back and can also attract additional attendants.

Although we have to acknowledge that the set of responses to the user requirements survey has to be considered not well-constrained in a statistical sense and the survey responses should therefore not be over-interpreted, a number of high-level conclusions became clearly apparent also from the survey:

5. For the development of tools, iMars should concentrate on geomorphology and geology rather than developing for engineering or spectral data analysis.

6. If developments can be aimed at certain datasets, HRSC and CTX would provide the currently well-established dataset and resolution. THEMIS is, contrary to personal communications behind with only 11%. This, however, can be caused by a bias with respect to distribution of the survey. Representation of e.g. team memberships, or main research interests among the responses would have to be assessed to answer this, which is beyond the capabilities of this survey.

7. Wen developing functionality for GIS the iMars consortium should be aware that users are likely to be experienced GIS users.

8. Some researchers seem to expect more elaborate functionality and interoperability with respect to mapping and data analysis, not just simple data viewer functionalities like panning and zooming in multiple datasets.

9. Map layouts and print/export functionality seem to be important features of webGIS while interactive mapping and higher-level processing are considered to be not important. The iMars webGIS implementation should therefore prioritise layout and map export/printing functions.

Although the survey cannot be considered to be representative of the actual world-wide use of planetary data, the results indicate that those (predominantly European) users already working with Mars Express data are more interested in access to more elaborate data products and GIS functionalities than in new platforms for simply accessing available archival data products.

For future user surveys, a focus should be put on obtaining statistically more reliable data. The experience of the iMars survey shows that attracting and motivating a large number of researchers to work through a set of questions can be a difficult task. However, regarding the future user consultation events, we expect that once the software functionality can be demonstrated, more users will be able and interested to provide substantiated feedback.

5. Publications resulting from the work described

Developments of the iMars project for a large part are related to setting up an effective user platform for current Mars Science. In this context, the user requirements workshop held at EGU 2014 in Vienna and the related survey were aimed at collecting information on actual research goals and requirements from active professionals involved in Mars science and exploration. While such information is considered very useful as guidance for the design and development of iMars tools, the resulting data are not necessarily representative and statistically significant. Thus, no immediate publications were planned on the outcomes of the workshop.

Conversely, the workshop and survey were also aimed at underpinning the presentation of the project to the community and promoting the establishment of a user community applying iMars tools and providing user feed-back also in the later stages of the project (planned user consultation workshops in 2015 and 2016). Therefore, the EGU workshop was flanked by a project presentation in the regular program of the conference and the related conference abstract (Muller et al., 2014), as well as similar presentations at COSPAR 2014 (Ivanov et al., 2014) and EPSC (van Gasselt et al., 2014):

> Muller, J.-P., Gwinner, K., van Gasselt, S., Ivanov, A., Morley, J., Houghton, R., Bamford, S., Yershov, V., Sidirpoulos, P., Kim, J., 2014. EU-FP7-iMars: Analysis of Mars Multi-Resolution Images using Auto-Coregistration, Data Mining and Crowd Source Techniques: an overview and a request for scientific inputs. EGU General Assembly 2014, 27.04.-02.05, Vienna, Austria.
>
> Ivanov, A., Oberst, J., Yershov, V., Muller, J.-P., Kim, J., Gwinner, K., van Gasselt, S., Morley, J., Houghton, R., Bamford, S., Sidiropoulos, P., 2014. EU-FP7-iMars: Analysis of Mars Multi-Resolution Images using Auto-Coregistration, Data Mining and Crowd Source Techniques. 40th COSPAR Scientific Assembly, 02.-10. August, Moscow, Russia, Abstract B0.8-8-14.
>
> S. van Gasselt, Morley, J., Houghton, R., Bamford, Ivanov, A., Muller, J.-P., Yershov, V., Sidiripoulos, P., Gwinner, K., Wählisch, M., Kim, J., 2014. The iMars WebGIS. EPSC Abstracts, Vol. 9, EPSC2014-693, European Planetary Science Congress, 2014.

6. Bibliographical references

Gwinner, K., Scholten, F., Spiegel, M., Schmidt, R., Giese, B., Oberst, J., Oberst, J., Jaumann, R., Heipke, C., Neukum, G., 2009. Derivation and validation of high-resolution digital terrain models from Mars Express HRSC-data. Photogramm. Eng. Rem. S. 75 (9), 1127–1142.

Gwinner, K., Scholten, F., Preusker, F., Elgner, S., Roatsch, T., Spiegel, M., Schmidt, R., Oberst, J., Jaumann, R., Heipke, C., 2010a. Topography of Mars from global mapping by HRSC high-resolution digital terrain models and orthoimages: Characteristics and performance. Earth Planet. Sc. Lett. 294, 506-519, doi:10.1016/j.epsl.2009.11.007.

Jaumann, R. and 25 co-authors, 2007. The High Resolution Stereo Camera (HRSC) experiment on Mars Express: instrument aspects and experiment conduct from interplanetary cruise through the nominal mission. Planet. Space Sci. 55 (7-8), 928–952, doi:10.1016/j.pss.2006.12.003.

Kirk, R.L., Howington-Kraus, E., Redding, B.R., Galuszka, D., Hare, T.M., Archinal, B.A., Soderblom, L.A.,Barrett, J.M., 2003. High resolution topomapping of candidate

MER landing sites with Mars Orbiter Camera narrow-angle images. *Journal of Geophysical Research* 108(E12), 8088. doi:10.1029/2003JE002131.

Kirk, R.L., J. Barrett, E. Howington-Kraus, 1999. A database of Viking Orbiter image coverage for cartographic and scientific use. 30th Lunar and Planetary Science Conference, #1857.

Kirk, R.L., Howington-Kraus, E., Rosiek, M.R., Anderson, J.A., Archinal, B.A., Becker, K.J., Cook, D.A., Galuszka, D.M., Geissler, P.E., Hare, T.M., Holmberg, I.M., Keszthelyi, L.P., Redding, B.L., Delamere, W.A., Gallagher, D., Chapel, J.D., Eliason, E.M., King, R., McEwen, A.S., HiRISE Team, 2008. Ultrahigh resolution topographic mapping of Mars with MRO HiRISE stereo Images: Meter-scale slopes of candidate Phoenix landing sites. *Journal of Geophysical Research* 113, E00A24. doi:10.1029/2007JE003000.

Malin, M.C., Edgett, K.S., 2001. Mars Global Surveyor Mars Orbiter Camera: Interplanetary cruise through primary mission. J. Geophys. Res. 106 (E10), 23429-23570, doi:10.1029/2000JE001455.

Malin, M.C., Bell, J.F., Cantor, B.A., Caplinger, M.A., Calvin, W.M., Clancy, R.T.,Edgett, K.S., Edwards, L., Haberle, R.M., James, P.B., Lee, S.W., Ravine, M.A., Thomas, P.C., Wolff, M.J., 2007. Context Camera investigation on board the Mars Reconnaissance Orbiter.*Journal of Geophysical Research* 112, E05S04. doi:10.1029/2006JE002808.

McEwen, A.S., Eliason, E.M., Bergstrom, J.W., Bridges, N.T., Hansen, C.J., Delamere, W.A., Grant, J.A., Gulick, V.C., Herkenhoff, K.E., Keszthelyi, L., Kirk, R.L., Mellon, M.T., Squyres, S.W., Thomas, N., Weitz, C.M., 2007. Mars Reconnaissance Orbiter's High Resolution Imaging Science Experiment (HiRISE*). Journal of Geophysical Research* 112, E05S02. doi:10.1029/2005JE002605.

Neukum, G., Jaumann, R., the HRSC Co-Investigator Team, 2004. HRSC: The High Resolution Stereo Camera of Mars Express, ESA SP-1240, 19 p.

ANNEX 1 – Minutes of User Requirements Workshop

Minutes of Meeting
iMars User Workshop at EGU 2014

The First iMars User Workshop took place on the EGU premises (room Y7) and was scheduled for 1st May 2014, 12:15 to 13:15. The main purpose of the workshop was to introduce the project to potential users and interested scientists, introduce possible science topics for the science cases of the project, and request initial feed-back on requirements from the user community. The workshop was attended by 23 persons (max, with some minor fluctuation) including six iMars team members and an invited speaker.

iMars Team Members:

Team speakers: Klaus Gwinner (KG, chair), Jan-Peter Muller (JPM), Jeremy Morley (JM), Stephan van Gasselt (SvG, Minutes)

Other iMars team attendees: Anton Ivanov, Jung-Rack Kim.

Guest Speaker: Sarah Mattson (SM, HiRISE instrument team)

12:15 Introduction by KG and handout of printed questionnaires.

12:18 Introduction to iMars aims and work packages by JPM. Including an overview of available multiple coverage for the Mars surface

12:28 SM reports on HiRISE findings of surface changes on Mars via an interactive presentation.

Currently more than 3000 HiRISE stereo pairs have been acquired, but less than 200 DTMs released to public. Illustrative examples for surface changes for presented for active gullies, avalanches, ripple movement, dune gullies, dust devils, new impacts, recurrent slope lineae, pitted terrain.

Questions:

1. KG: What are likeliness and estimates of detection of changes in HiRISE data?
   SM: Resolution limit is about 0.5-1 m, if data are well co-registered, automated methods will be helpful to detect changes.
2. SvG: How are these detections currently made? By chance? Is there a systematic survey?
   SM: Individuals search for changes in HiRISE stereo pairs – systematically and visually.

12:53 Talk about GIS and Crowd Sourcing by JM

Minutes of Meeting
iMars User Workshop at EGU 2014

i-Mars.eu

13:00 Short Introduction to Questionnaire by SvG

Both a printed version and online version are available. Main groups of questions where introduced.

13:05 Plenary Discussion

1. Attendant1: How to access results of data/feature extraction and crowd sourcing?

   Possible scenarios include access via reports/publications or through a database.

2. Attendant2: How to handle authorships in the case of publication of crowd-sourcing results/findings?

   JPM: Discussion fora play an important role when new findings are made as there are several active community members that can be identified.

   JM: Team lists are conceivable if publishers are willing to implement such list authors (… and the xyz team). Lists with dozens or even hundreds of authors are also possible as done by, e.g., Science.

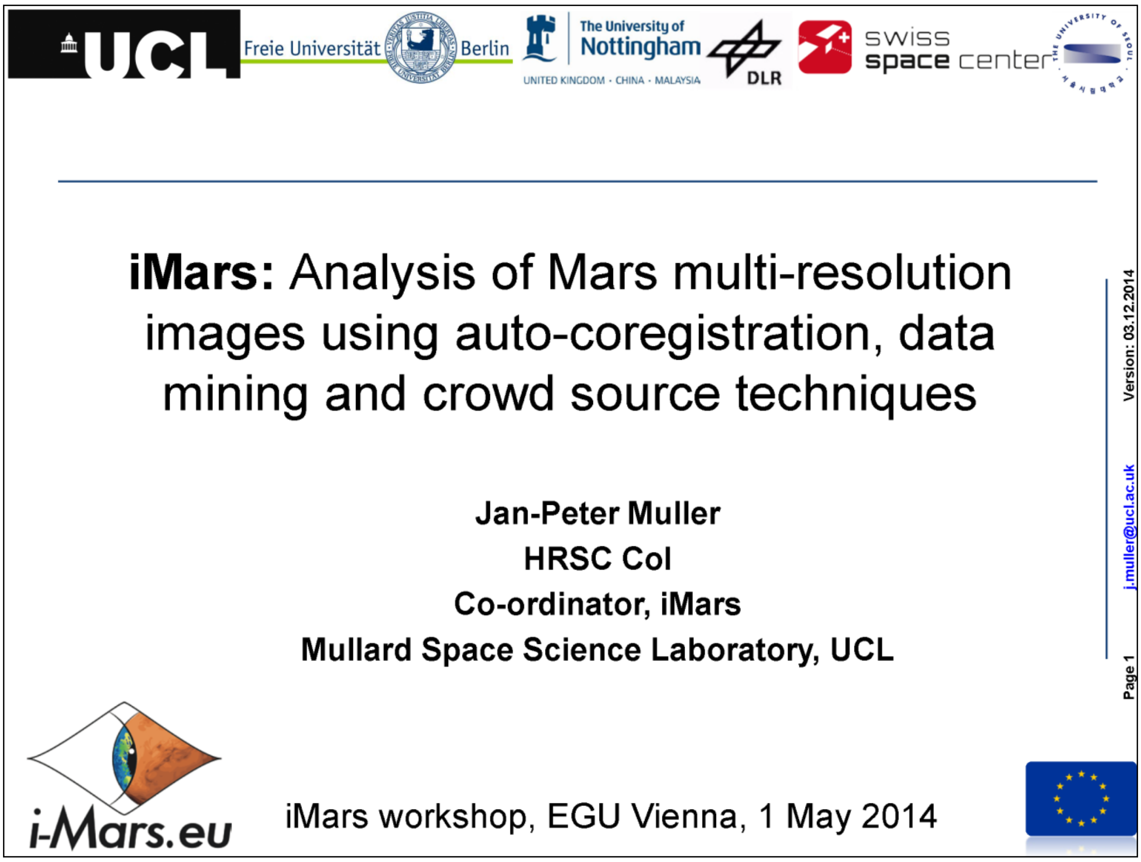
   Attendant3: Often community members will be anonymous and/or have no academic background.

   SvG: iMars is targeted at providing the means for detecting changes by establishing a platform. Experts discussing the nature and implications of findings are possibly outside the team.

3. JPM provides final statement including an encouragement to support the project by responding on the questionnaire, or by providing any other information or feed-back the participants may find useful.

13:15 END

ANNEX 2 – iMars Presentations at EGU User Workshop



UCL Freie Universität Berlin The University of Nottingham UNITED KINGDOM · CHINA · MALAYSIA DLR swiss space center

Project Statistics

- Consortium
  - UCL : Jan-Peter Muller (Co-ordinator) & Mary Carter (Project Manager)
  - DLR : Klaus Gwinner
  - FUB: Stephan van Gasselt
  - EPFL: Anton Ivanov
  - UNOTT: Jeremy Morley
  - UoS: Jungrak Kim
- Duration: 1.1.14-31.12.16
- Cost 2.55 M€

Page 2 j.muller@ucl.ac.uk Version: 03.12.2014

UCL Freie Universität Berlin The University of Nottingham UNITED KINGDOM · CHINA · MALAYSIA DLR swiss space center

iMars Objectives

- To explore changes in the martian surface since the start of robotic exploration <u>using</u> automated data mining techniques and crowd-sourcing <u>from</u>
- HRSC OrthoRectified Images (ORIs) and Digital Terrain Models (DTMs) as base images <u>and</u>
- Automated co-registration of NASA orbital imagery together with higher resolution DTMs from CTX and HiRISE
- After capturing scientific consensus (e.g. HRSC team members) on key features to detect

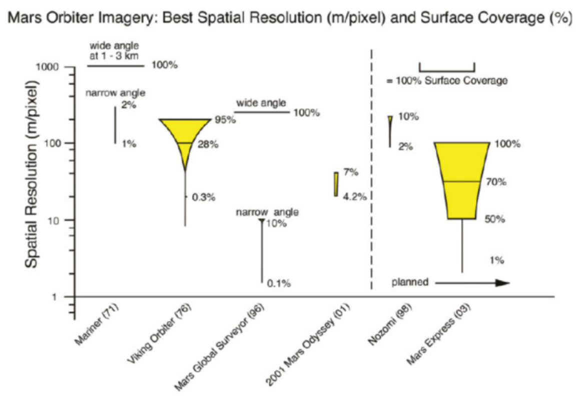
Page 3 j.muller@ucl.ac.uk Version: 03.12.2014

UCL | Freie Universität Berlin | The University of Nottingham (United Kingdom · China · Malaysia) | DLR | swiss space center

iMars: Background

- Focus on images with IFoV≤100m

Camera	%≤100m
HiRiSE red	1.39%
CTX	82.72%
HRSC *.nd2	98.11%
THEMIS-VIS	82%
MOC-NA	5.38%
VO	22.68%

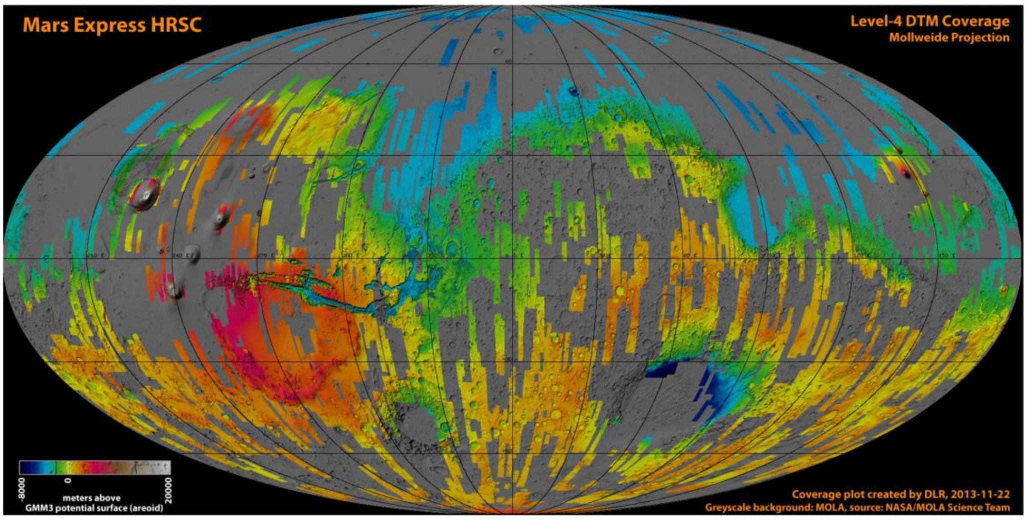


: 03.12.2014

Pa

UCL | Freie Universität Berlin | The University of Nottingham (United Kingdom · China · Malaysia) | DLR | swiss space center

iMars: Base reference DTM+ORI from HRSC



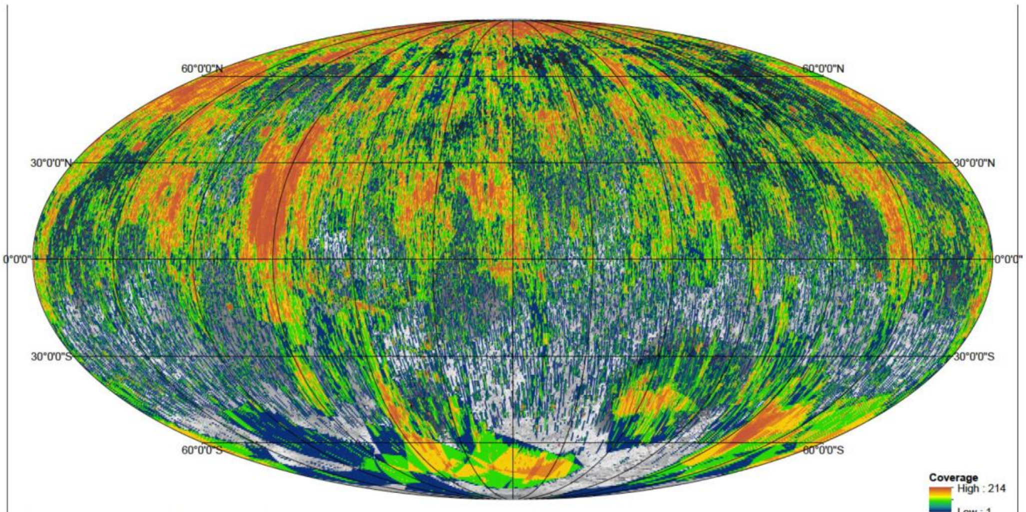
Version: 03.12.2014

j.muller@ucl.ac.uk

Page 5

i-Mars.eu

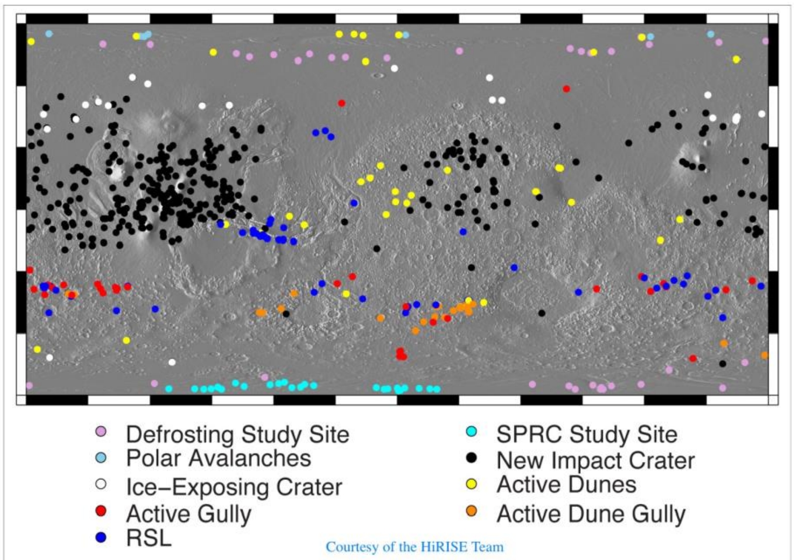
Seasonal image coverage: full time period



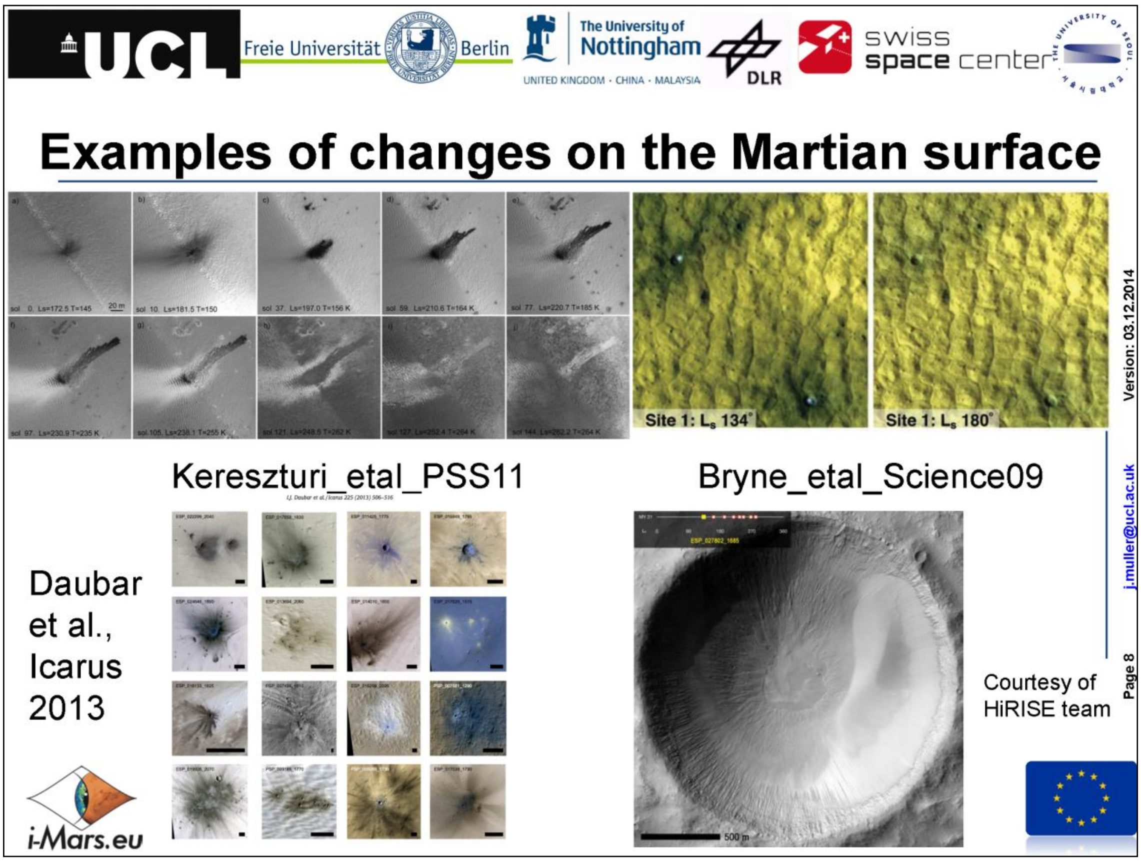
Martian Surface Coverage, Res.<20m, Spring (0<Ls<90), 1976-2013

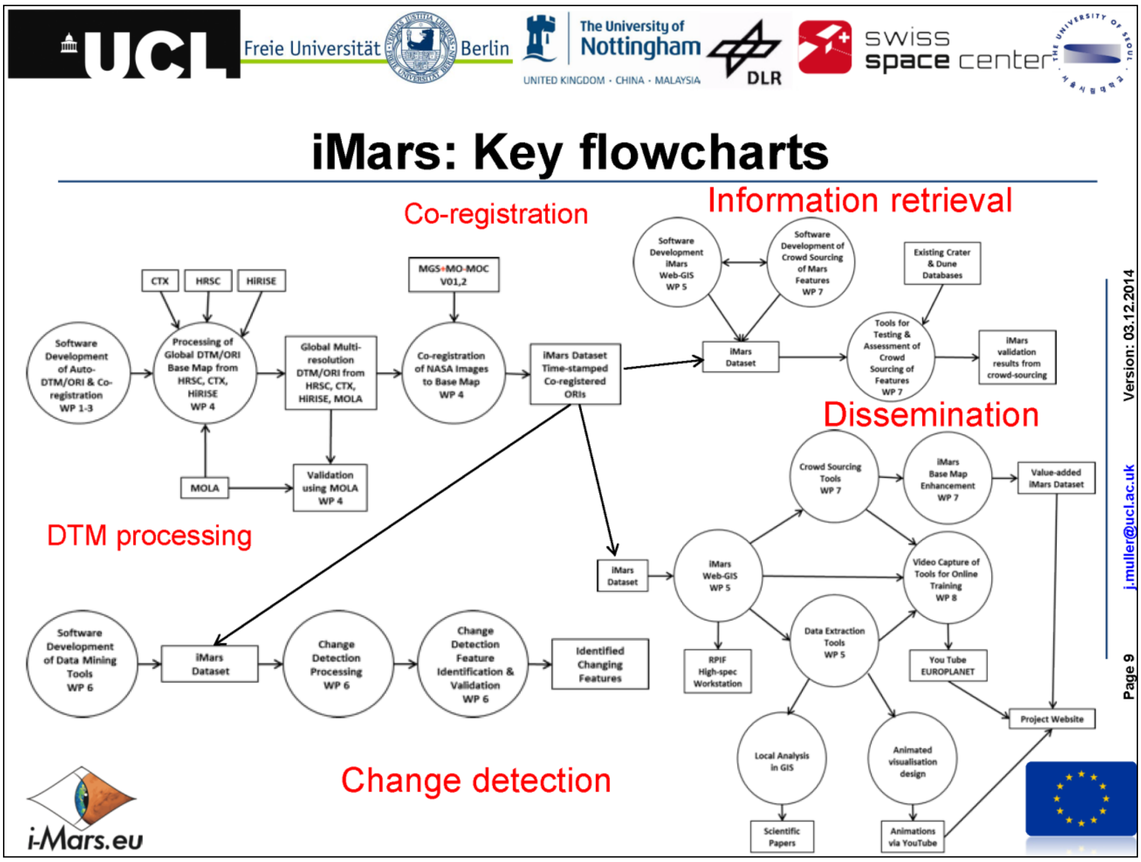
Version: 03.12.2014 j.muller@ucl.ac.uk Page 6

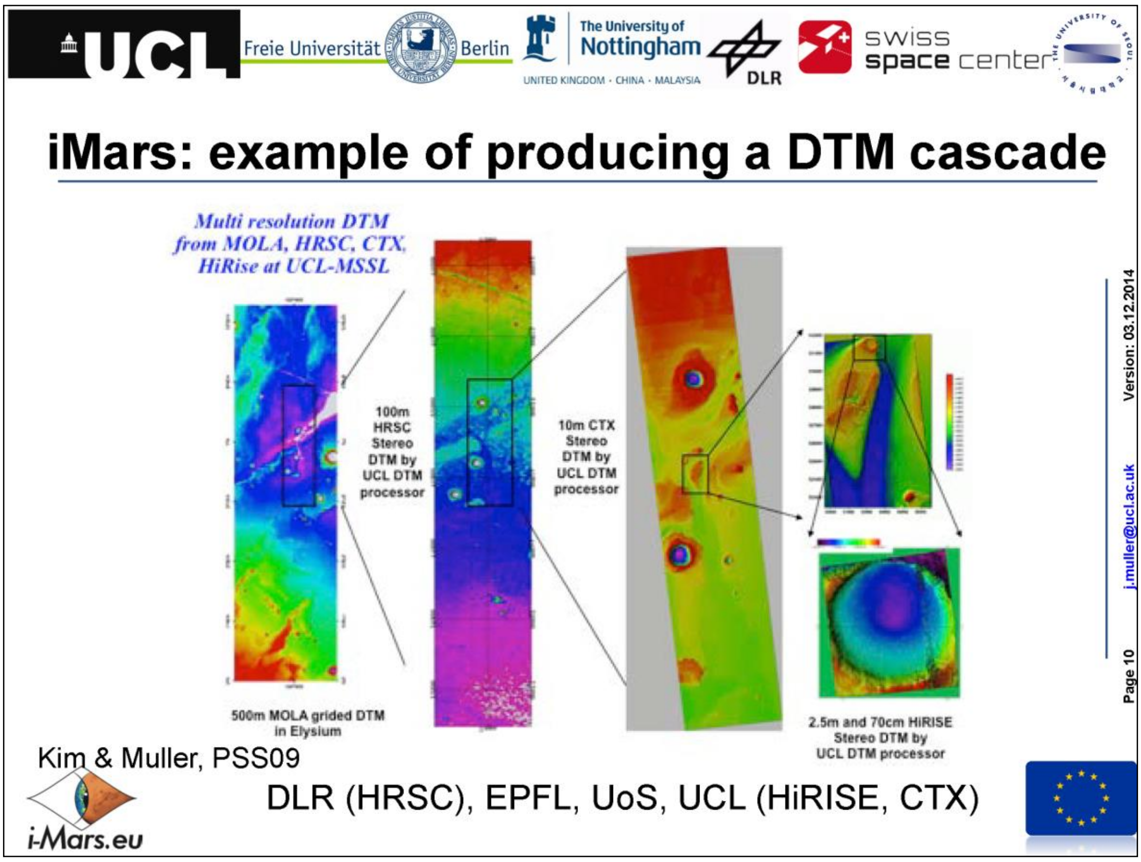
Change features discovered by HiRISE up to 2014

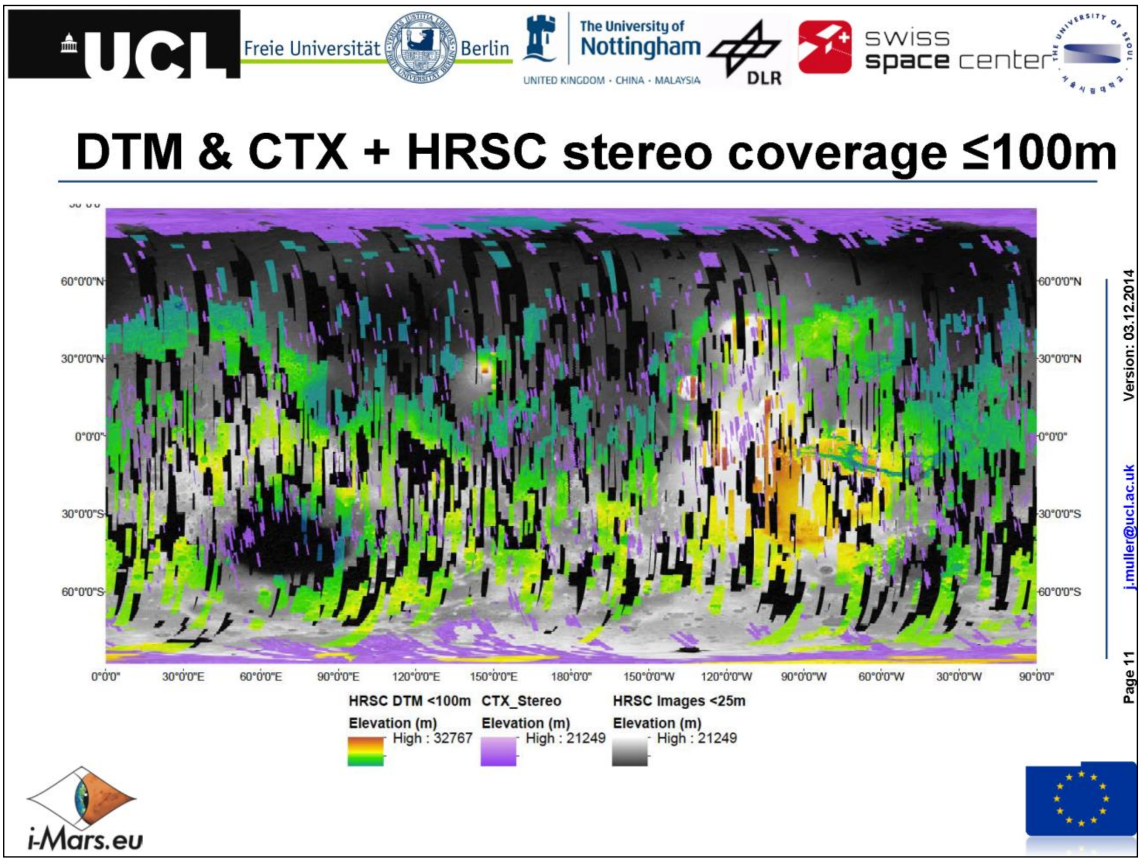


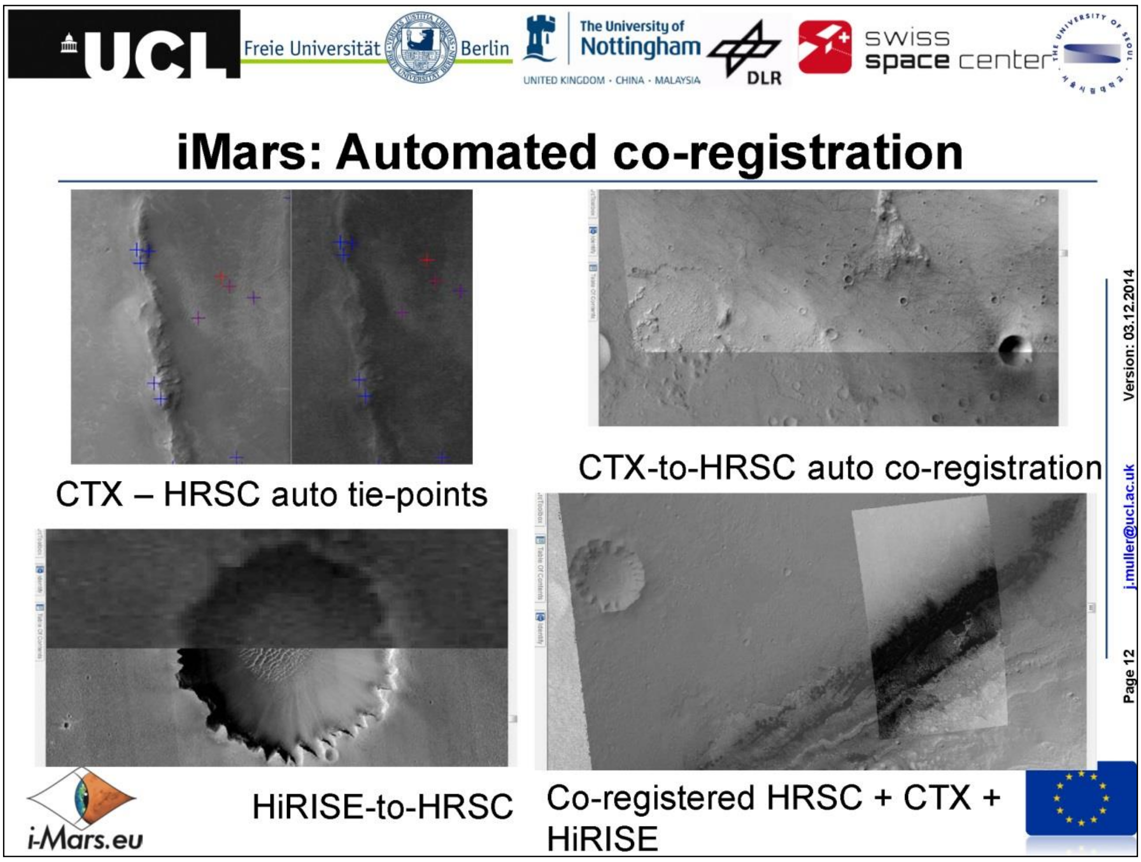
Version: 03.12.2014 j.muller@ucl.ac.uk Page 7

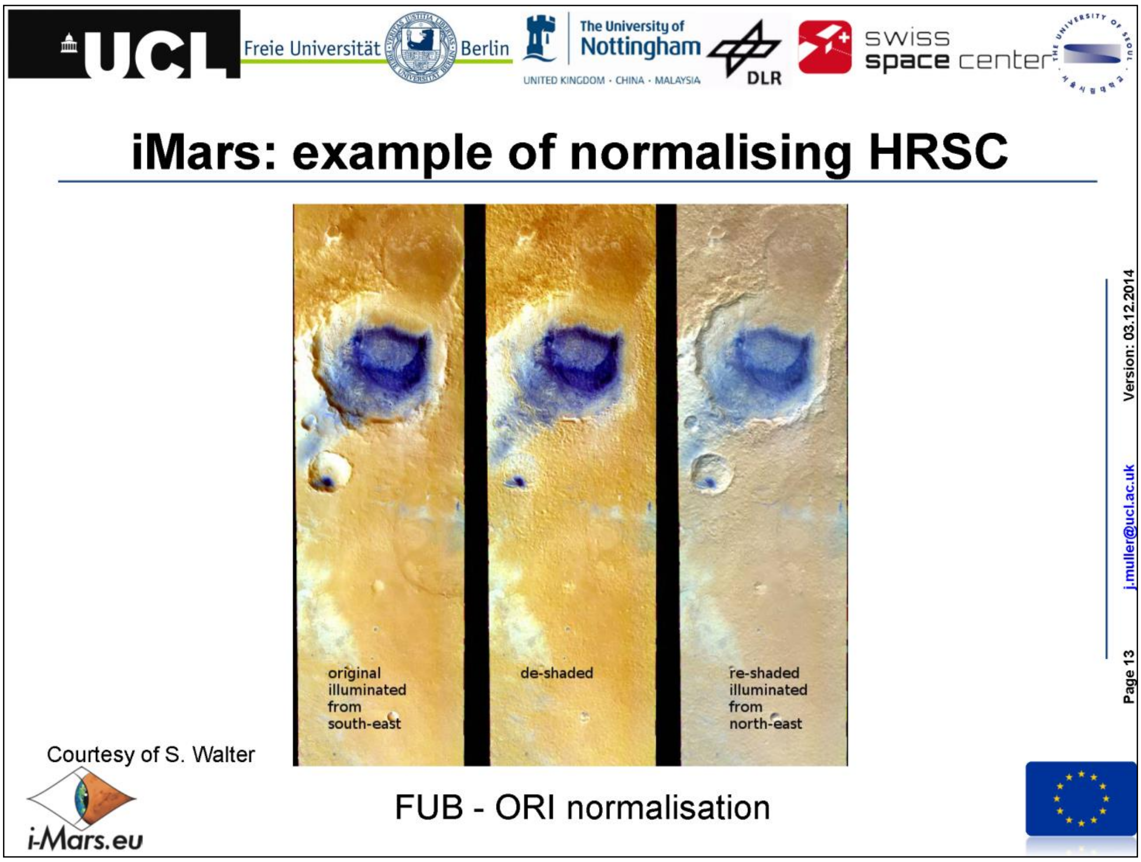

UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
Examples of changes on the Martian surface
Site 1: L_s 134°
Site 1: L_s 180°
Version: 03.12.2014
Kereszturi_etal_PSS11
Bryne_etal_Science09
Daubar et al., Icarus 2013
j.muller@ucl.ac.uk
Courtesy of HiRISE team
Page 8
500 m
i-Mars.eu

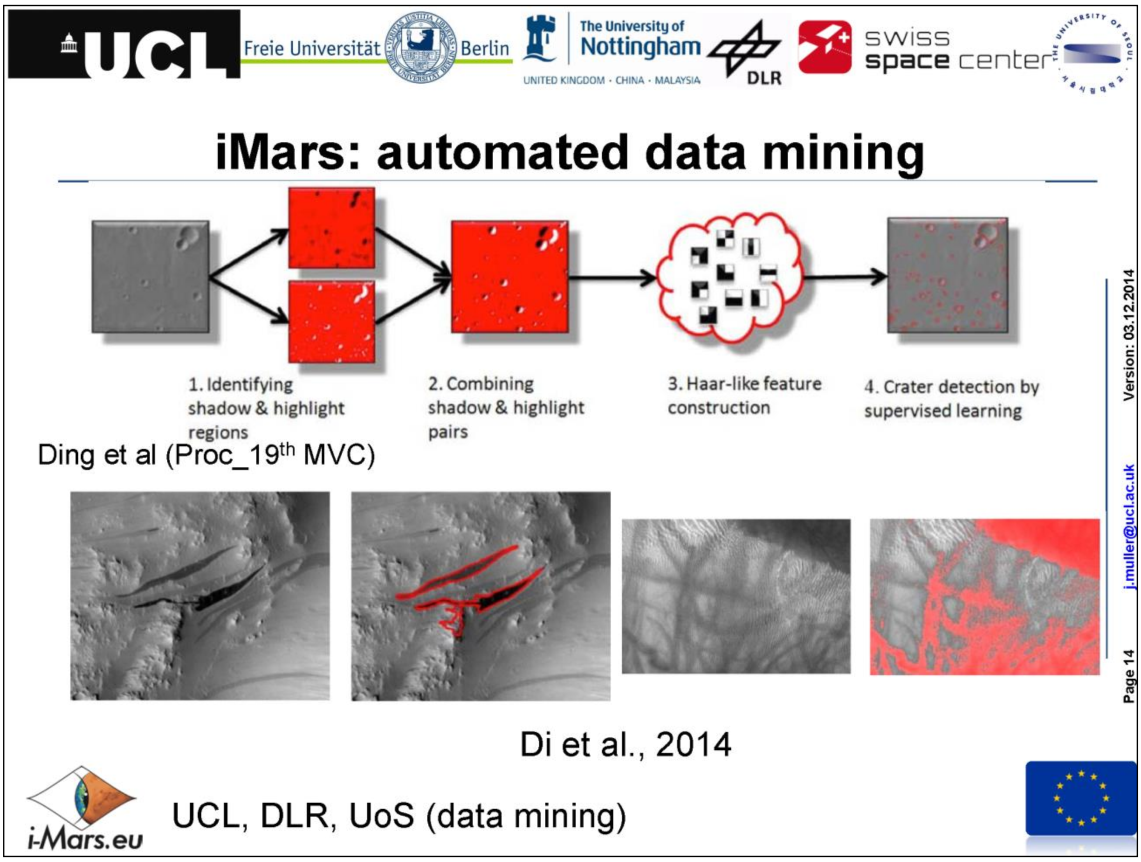

UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
iMars: Key flowcharts
Co-registration
Information retrieval
CTX
HRSC
HiRISE
MGS+MO-MOC V01,2
Software Development of Auto-DTM/ORI & Co-registration WP 1-3
Processing of Global DTM/ORI Base Map from HRSC, CTX, HiRISE WP 4
Global Multi-resolution DTM/ORI from HRSC, CTX, HiRISE, MOLA
Co-registration of NASA Images to Base Map WP 4
iMars Dataset Time-stamped Co-registered ORIs
MOLA
Validation using MOLA WP 4
DTM processing
Software Development iMars Web-GIS WP 5
Software Development of Crowd Sourcing of Mars Features WP 7
Existing Crater & Dune Databases
iMars Dataset
Tools for Testing & Assessment of Crowd Sourcing of Features WP 7
iMars validation results from crowd-sourcing
Dissemination
Crowd Sourcing Tools WP 7
iMars Base Map Enhancement WP 7
Value-added iMars Dataset
iMars Dataset
iMars Web-GIS WP 5
Video Capture of Tools for Online Training WP 8
Data Extraction Tools WP 5
RPIF High-spec Workstation
You Tube EUROPLANET
Project Website
Local Analysis in GIS
Animated visualisation design
Scientific Papers
Animations via YouTube
Software Development of Data Mining Tools WP 6
iMars Dataset
Change Detection Processing WP 6
Change Detection Feature Identification & Validation WP 6
Identified Changing Features
Change detection
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 9
i-Mars.eu


iMars: example of producing a DTM cascade
Multi resolution DTM from MOLA, HRSC, CTX, HiRise at UCL-MSSL
100m HRSC Stereo DTM by UCL DTM processor
10m CTX Stereo DTM by UCL DTM processor
500m MOLA grided DTM in Elysium
2.5m and 70cm HiRISE Stereo DTM by UCL DTM processor
Kim & Muller, PSS09
DLR (HRSC), EPFL, UoS, UCL (HiRISE, CTX)
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 10
i-Mars.eu

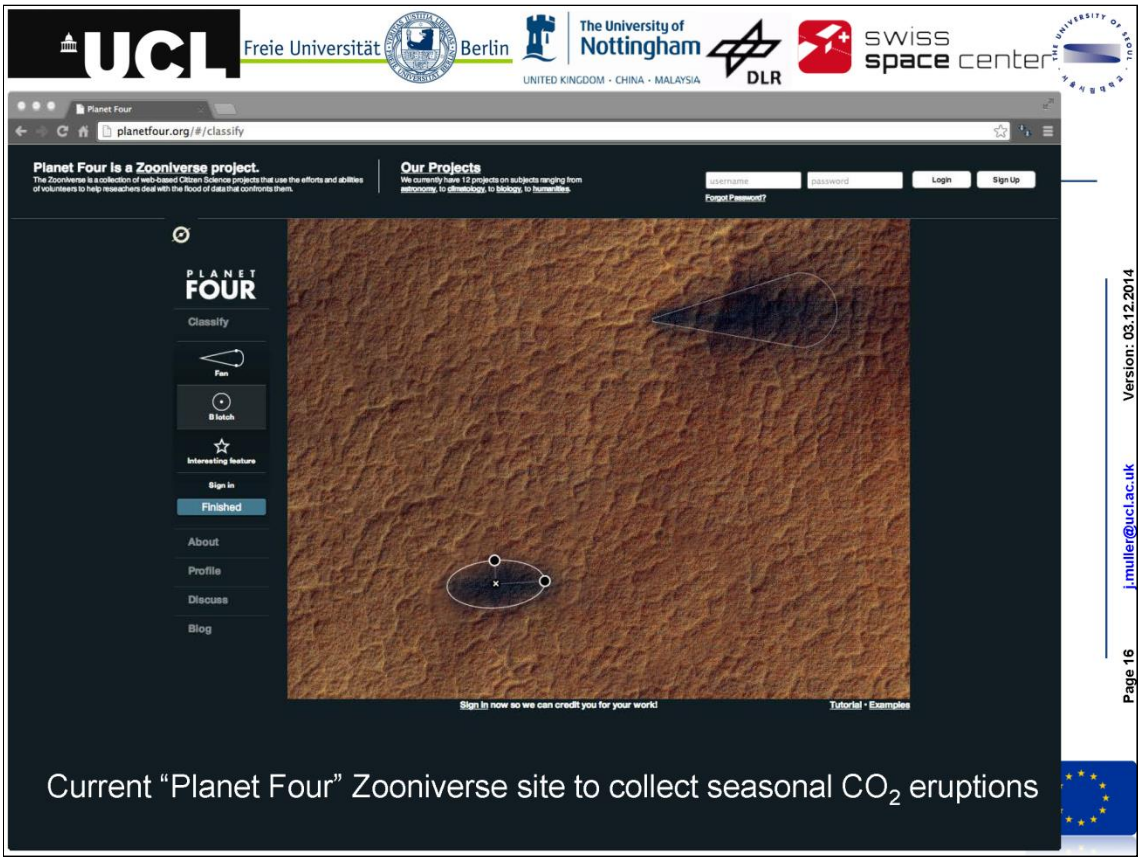

DTM & CTX + HRSC stereo coverage ≤100m
60°0'0"N
30°0'0"N
0°0'0"
30°0'0"S
60°0'0"S
0°0'0" 30°0'0"E 60°0'0"E 90°0'0"E 120°0'0"E 150°0'0"E 180°0'0" 150°0'0"W 120°0'0"W 90°0'0"W 60°0'0"W 30°0'0"W 90°0'0"
HRSC DTM <100m
Elevation (m)
High : 32767
CTX_Stereo
Elevation (m)
High : 21249
HRSC Images <25m
Elevation (m)
High : 21249
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 11
i-Mars.eu

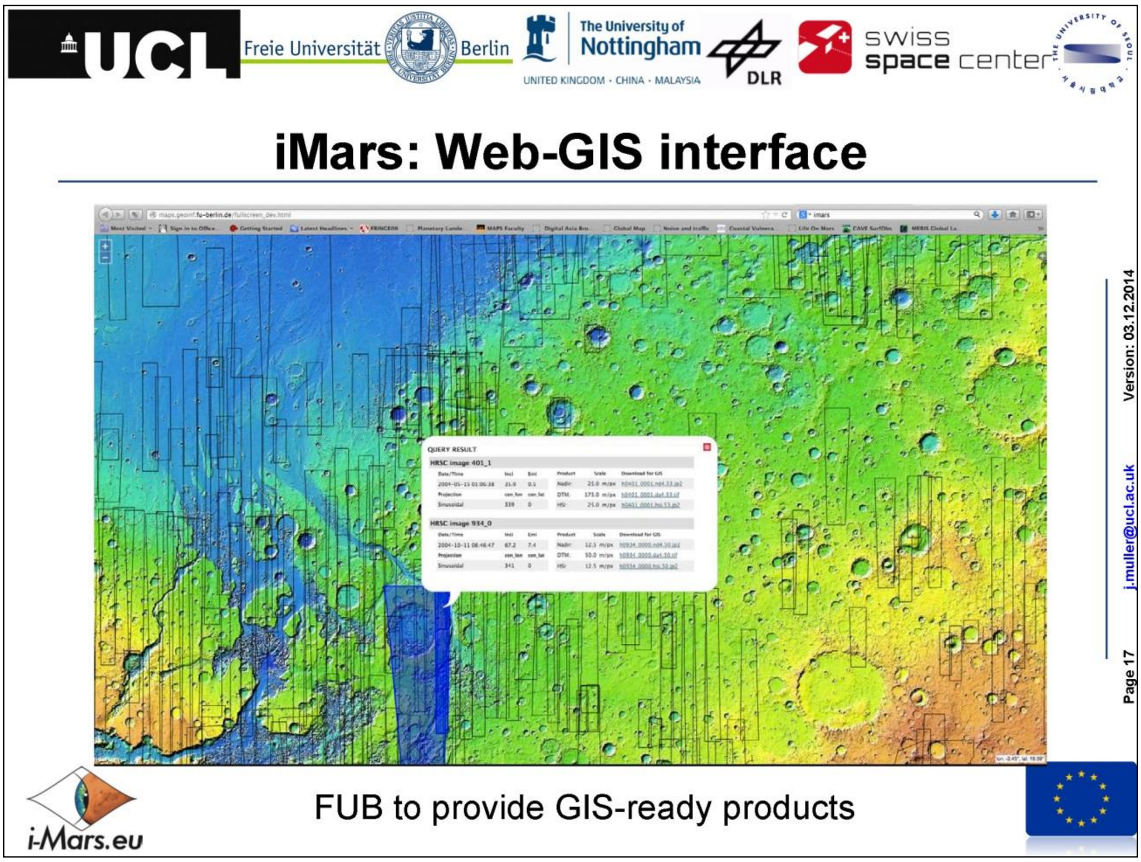

UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
iMars: Automated co-registration
CTX – HRSC auto tie-points
CTX-to-HRSC auto co-registration
HiRISE-to-HRSC
Co-registered HRSC + CTX + HiRISE
i-Mars.eu
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 12

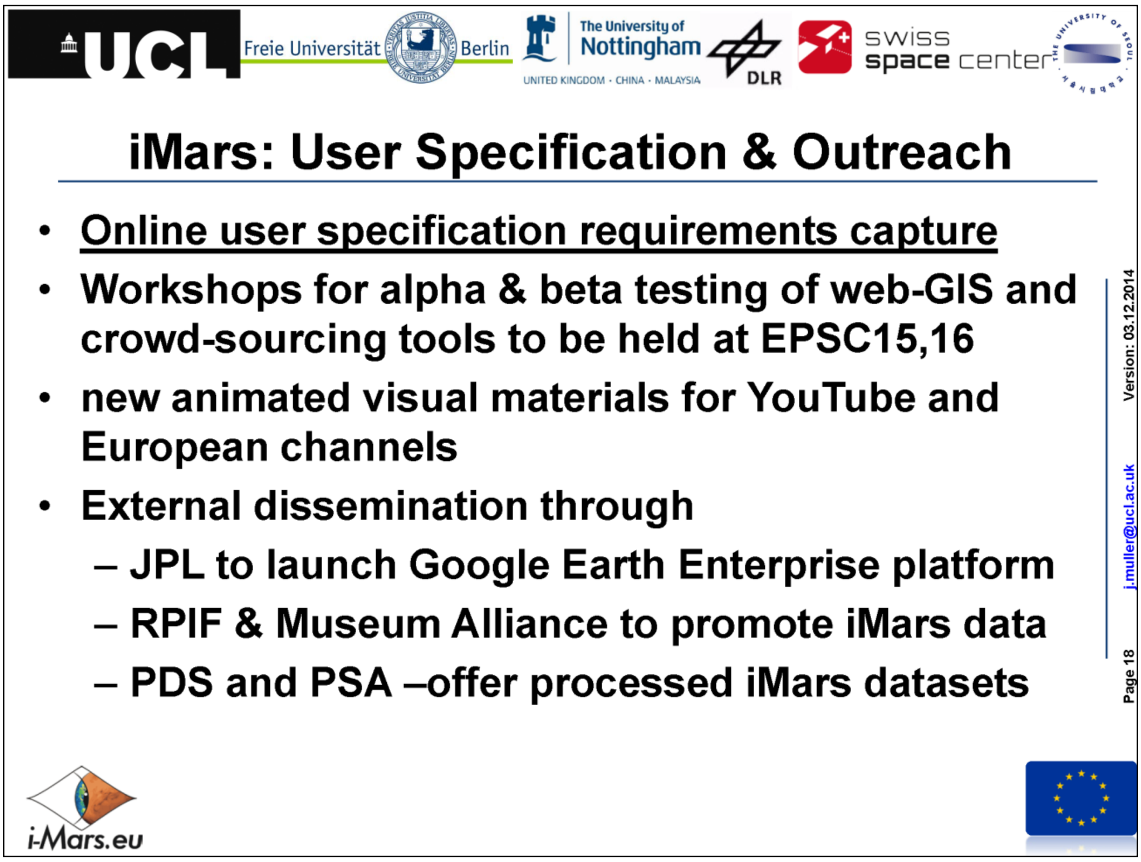

UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
iMars: example of normalising HRSC
original illuminated from south-east
de-shaded
re-shaded illuminated from north-east
Courtesy of S. Walter
FUB - ORI normalisation
i-Mars.eu
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 13

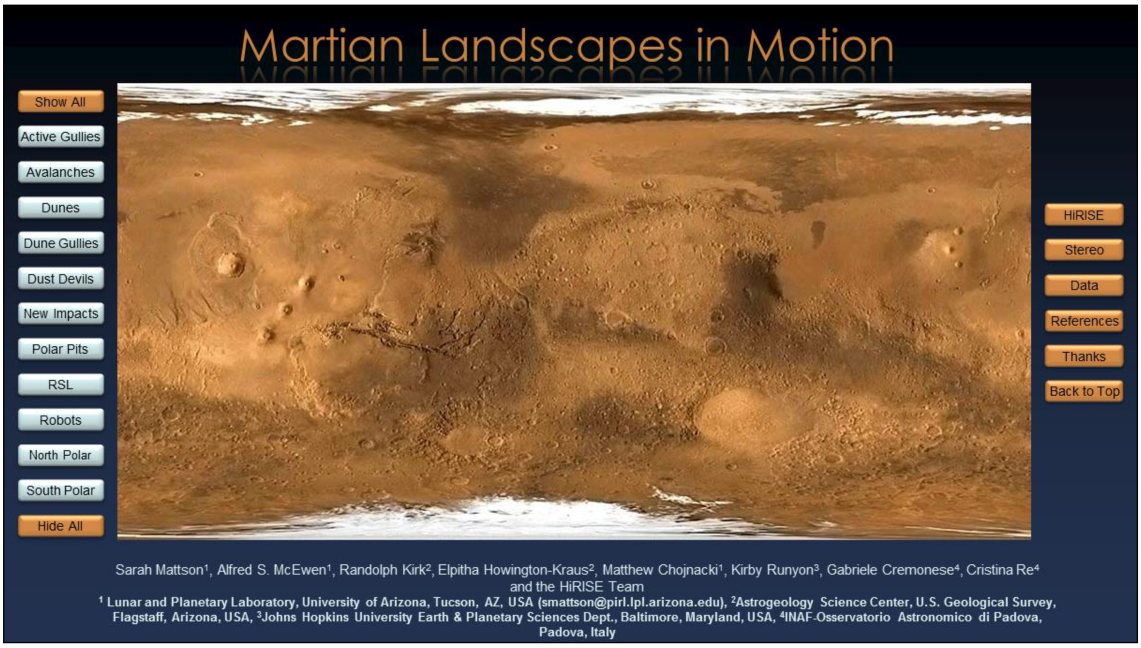

UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
iMars: automated data mining
1. Identifying shadow & highlight regions
2. Combining shadow & highlight pairs
3. Haar-like feature construction
4. Crater detection by supervised learning
Ding et al (Proc_19th MVC)
Di et al., 2014
UCL, DLR, UoS (data mining)
i-Mars.eu
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 14


UCL
Freie Universität Berlin
The University of Nottingham
DLR
swiss space center
https://www.zooniverse.org
ZOONIVERSE
REAL SCIENCE ONLINE
Take part in Science Projects
Experiment in Laboratory
cyclonecenter.org
Help classify over 30 years of tropical cyclone data.
View details
All Space Climate Humanities Nature Biology
Space
How do galaxies form?
Explore the surface of the Moon
Study explosions on the Sun
Find planets around stars
UNOTTS – crowd-sourcing using Zooniverse
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 15


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
planetfour.org/#/classify
Planet Four is a Zooniverse project.
Our Projects
PLANET FOUR
Classify
Fan
Blotch
Interesting feature
Sign in
Finished
About
Profile
Discuss
Blog
Sign in now so we can credit you for your work!
Tutorial · Examples
Current "Planet Four" Zooniverse site to collect seasonal CO2 eruptions
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 16


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
iMars: Web-GIS interface
FUB to provide GIS-ready products
i-Mars.eu
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 17


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
iMars: User Specification & Outreach
• Online user specification requirements capture
• Workshops for alpha & beta testing of web-GIS and crowd-sourcing tools to be held at EPSC15,16
• new animated visual materials for YouTube and European channels
• External dissemination through
– JPL to launch Google Earth Enterprise platform
– RPIF & Museum Alliance to promote iMars data
– PDS and PSA –offer processed iMars datasets
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 18
i-Mars.eu


Martian Landscapes in Motion
Show All
Active Gullies
Avalanches
Dunes
Dune Gullies
Dust Devils
New Impacts
Polar Pits
RSL
Robots
North Polar
South Polar
Hide All
HiRISE
Stereo
Data
References
Thanks
Back to Top
Sarah Mattson1, Alfred S. McEwen1, Randolph Kirk2, Elpitha Howington-Kraus2, Matthew Chojnacki1, Kirby Runyon3, Gabriele Cremonese4, Cristina Re4 and the HiRISE Team
1 Lunar and Planetary Laboratory, University of Arizona, Tucson, AZ, USA (smattson@pirl.lpl.arizona.edu), 2Astrogeology Science Center, U.S. Geological Survey, Flagstaff, Arizona, USA, 3Johns Hopkins University Earth & Planetary Sciences Dept., Baltimore, Maryland, USA, 4INAF-Osservatorio Astronomico di Padova, Padova, Italy

UCL | Freie Universität Berlin | The University of Nottingham UNITED KINGDOM · CHINA · MALAYSIA | DLR | swiss space center | The University of Seoul

iMars
WebGIS & Crowdsourding components

Jeremy Morley

Geospatial Science Theme Leader, Nottingham Geospatial Inst., Uni. Notitngham

Stephan van Gasselt, FUB, Jan-Peter Muller, UCL MSSL, iMars team

Page 1 Jeremy.morley@nottingham.a.uk Version: 03.12.2014

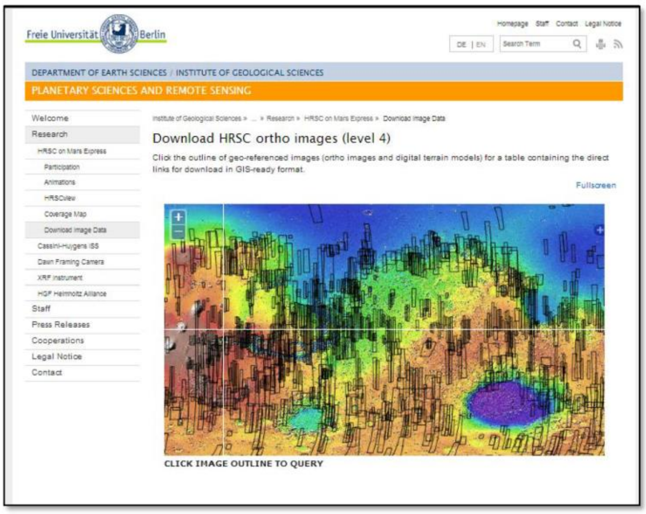
www.iMars.eu

SEVENTH FRAMEWORK PROGRAMME

UCL | Freie Universität Berlin | The University of Nottingham UNITED KINGDOM · CHINA · MALAYSIA | DLR | swiss space center | The University of Seoul

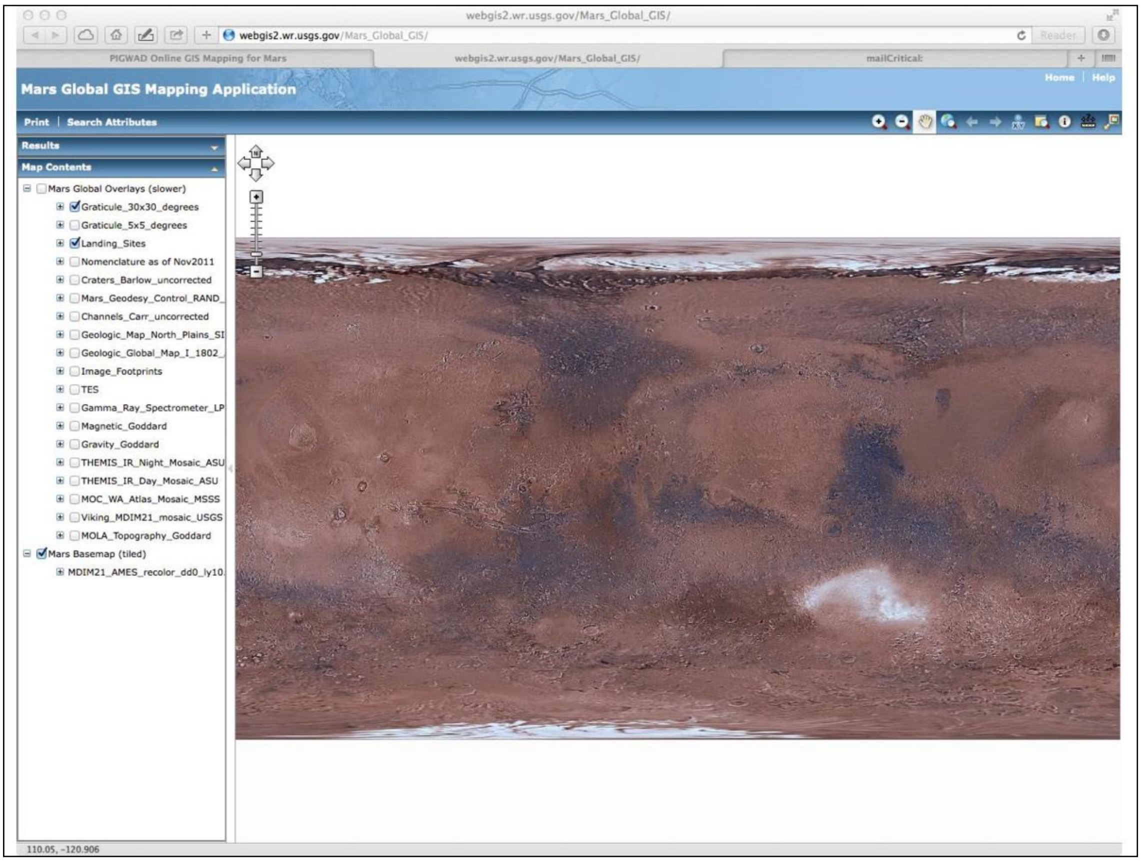
Many GIS-like features are on the open market (Jmars, PIGWAD+, ...)

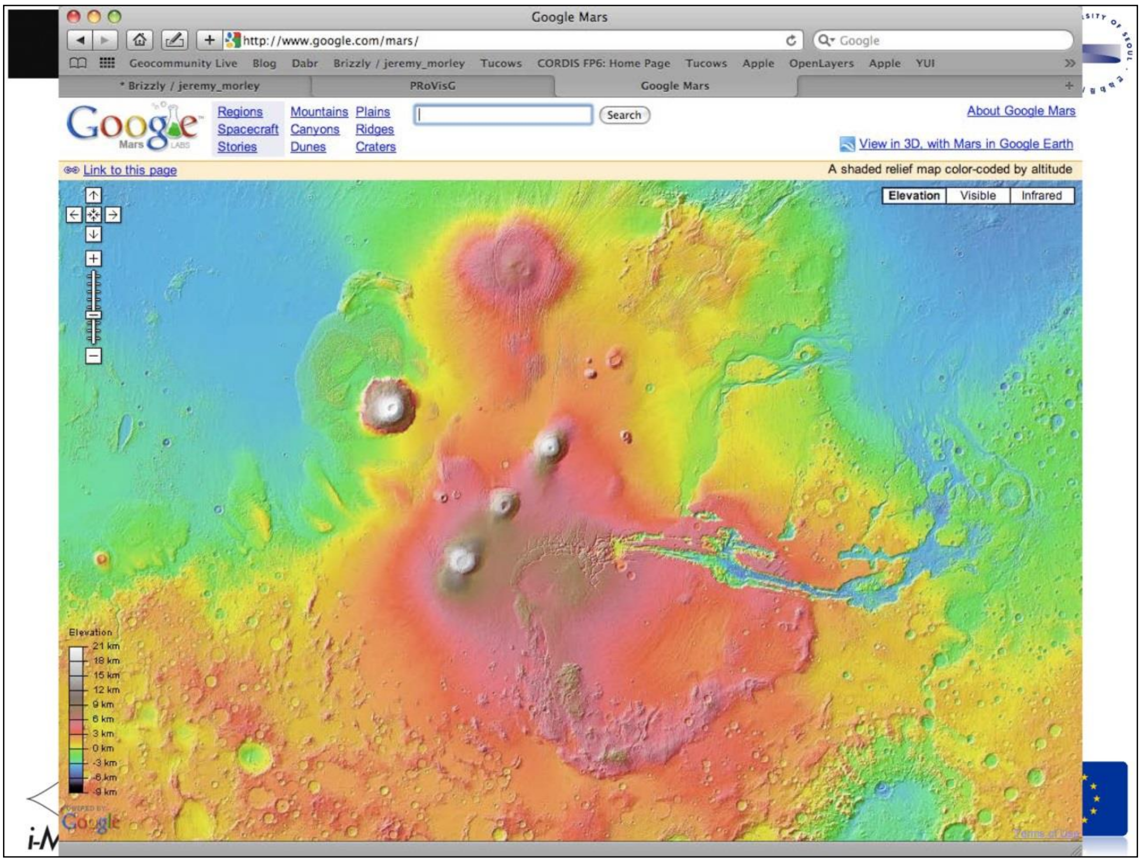
Some archives (PSA/PDS) offer GIS-like features or formats.

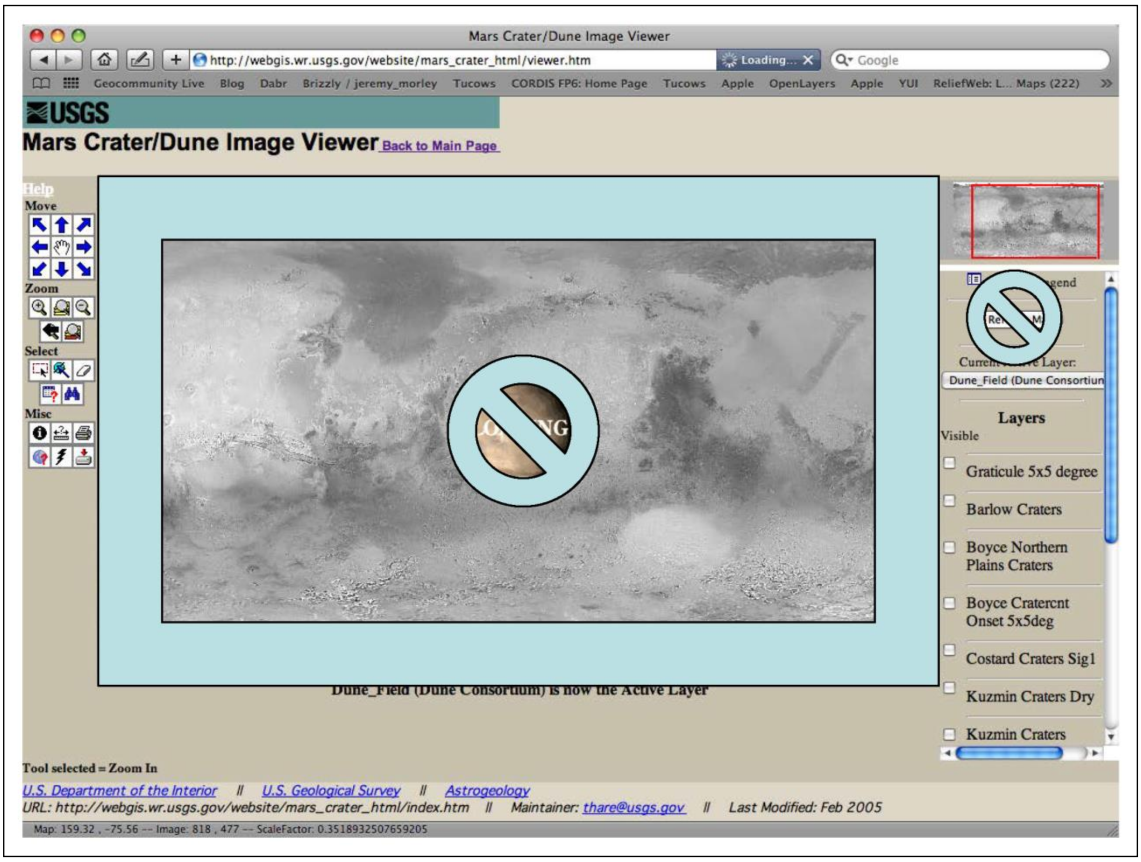


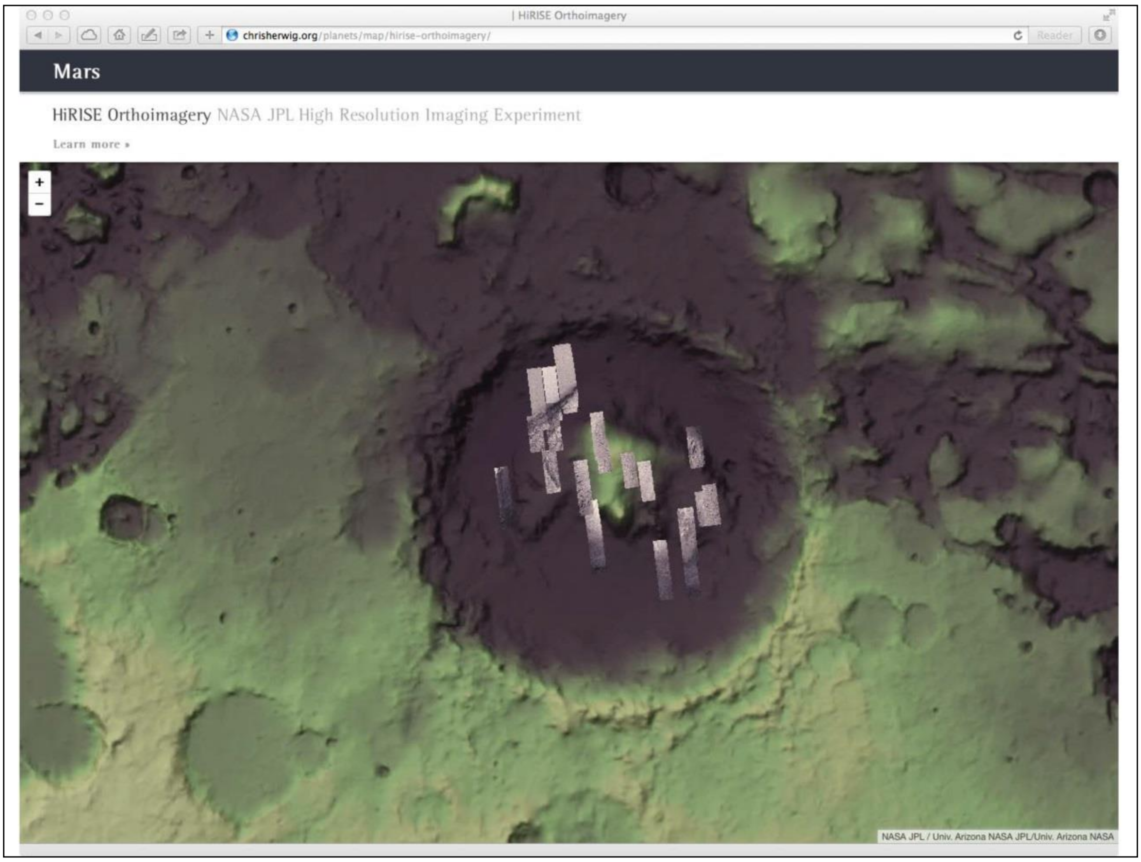
Simple open layers-based GIS for Searching Data Interactively
http://maps.planet.fu-berlin.de/

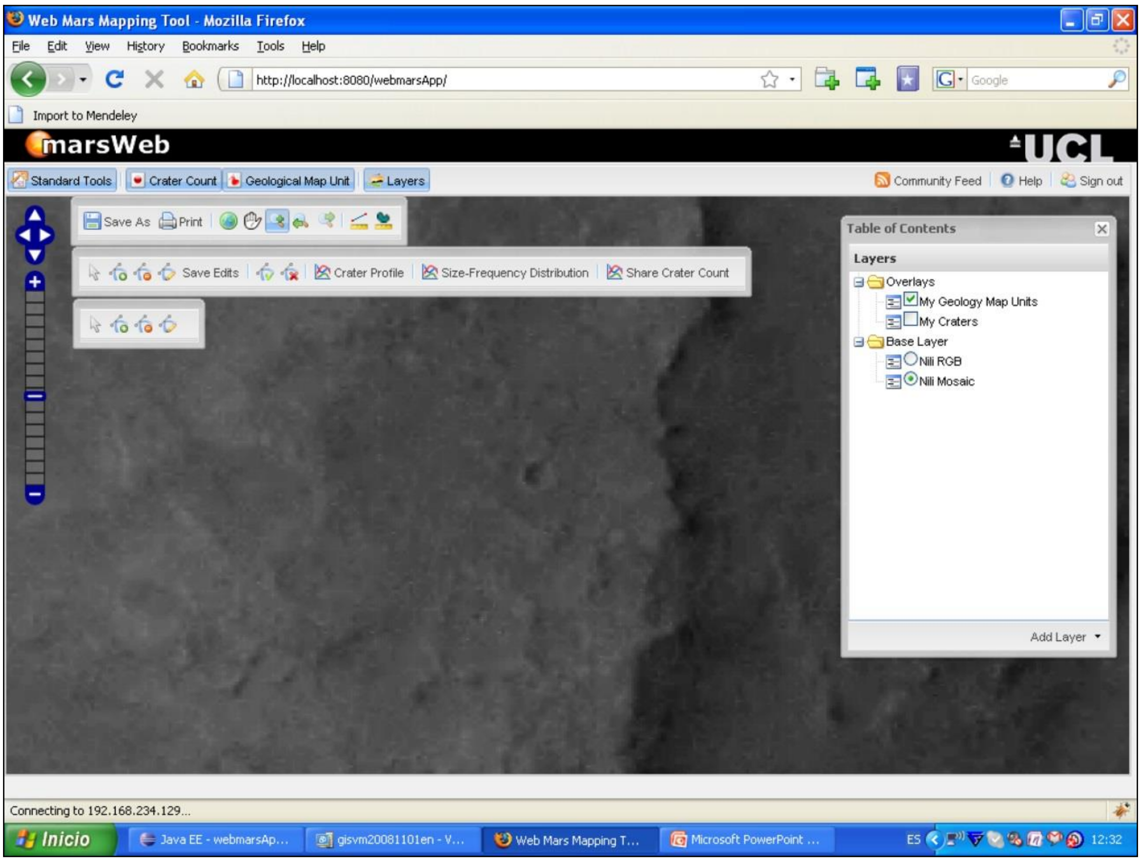
i-Mars.eu


webgis2.wr.usgs.gov/Mars_Global_GIS/
PIGWAD Online GIS Mapping for Mars
mailCritical:
Mars Global GIS Mapping Application
Home | Help
Print | Search Attributes
Results
Map Contents
Mars Global Overlays (slower)
Graticule_30x30_degrees
Graticule_5x5_degrees
Landing_Sites
Nomenclature as of Nov2011
Craters_Barlow_uncorrected
Mars_Geodesy_Control_RAND_
Channels_Carr_uncorrected
Geologic_Map_North_Plains_SI
Geologic_Global_Map_I_1802_
Image_Footprints
TES
Gamma_Ray_Spectrometer_LP
Magnetic_Goddard
Gravity_Goddard
THEMIS_IR_Night_Mosaic_ASU
THEMIS_IR_Day_Mosaic_ASU
MOC_WA_Atlas_Mosaic_MSSS
Viking_MDIM21_mosaic_USGS
MOLA_Topography_Goddard
Mars Basemap (tiled)
MDIM21_AMES_recolor_dd0_ly10
110.05, -120.906


Google Mars
http://www.google.com/mars/
Geocommunity Live Blog Dabr Brizzly / jeremy_morley Tucows CORDIS FP6: Home Page Tucows Apple OpenLayers Apple YUI
* Brizzly / jeremy_morley
PROVisG
Google Mars
Regions Mountains Plains
Spacecraft Canyons Ridges
Stories Dunes Craters
Search
About Google Mars
View in 3D, with Mars in Google Earth
Link to this page
A shaded relief map color-coded by altitude
Elevation Visible Infrared
Elevation
21 km
18 km
15 km
12 km
9 km
6 km
3 km
0 km
-3 km
-6 km
-9 km


Mars Crater/Dune Image Viewer
http://webgis.wr.usgs.gov/website/mars_crater_html/viewer.htm
Loading...
Google
Geocommunity Live Blog Dabr Brizzly / jeremy_morley Tucows CORDIS FP6: Home Page Tucows Apple OpenLayers Apple YUI ReliefWeb: L... Maps (222)
USGS
Mars Crater/Dune Image Viewer
Back to Main Page
Help
Move
Zoom
Select
Misc
Current Active Layer:
Dune_Field (Dune Consortium
Layers
Visible
Graticule 5x5 degree
Barlow Craters
Boyce Northern Plains Craters
Boyce Cratercnt Onset 5x5deg
Costard Craters Sig1
Kuzmin Craters Dry
Kuzmin Craters
Dune_Field (Dune Consortium) is now the Active Layer
Tool selected = Zoom In
U.S. Department of the Interior // U.S. Geological Survey // Astrogeology
URL: http://webgis.wr.usgs.gov/website/mars_crater_html/index.htm // Maintainer: thare@usgs.gov // Last Modified: Feb 2005
Map: 159.32 , -75.56 -- Image: 818 , 477 -- ScaleFactor: 0.3518932507659205


| HiRISE Orthoimagery
chrisherwig.org/planets/map/hirise-orthoimagery/
Reader
Mars
HiRISE Orthoimagery NASA JPL High Resolution Imaging Experiment
Learn more »
+
−
NASA JPL / Univ. Arizona NASA JPL/Univ. Arizona NASA



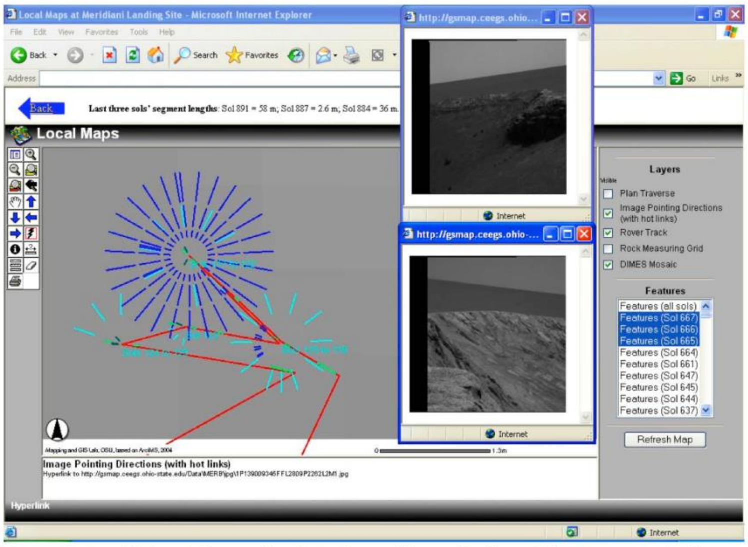
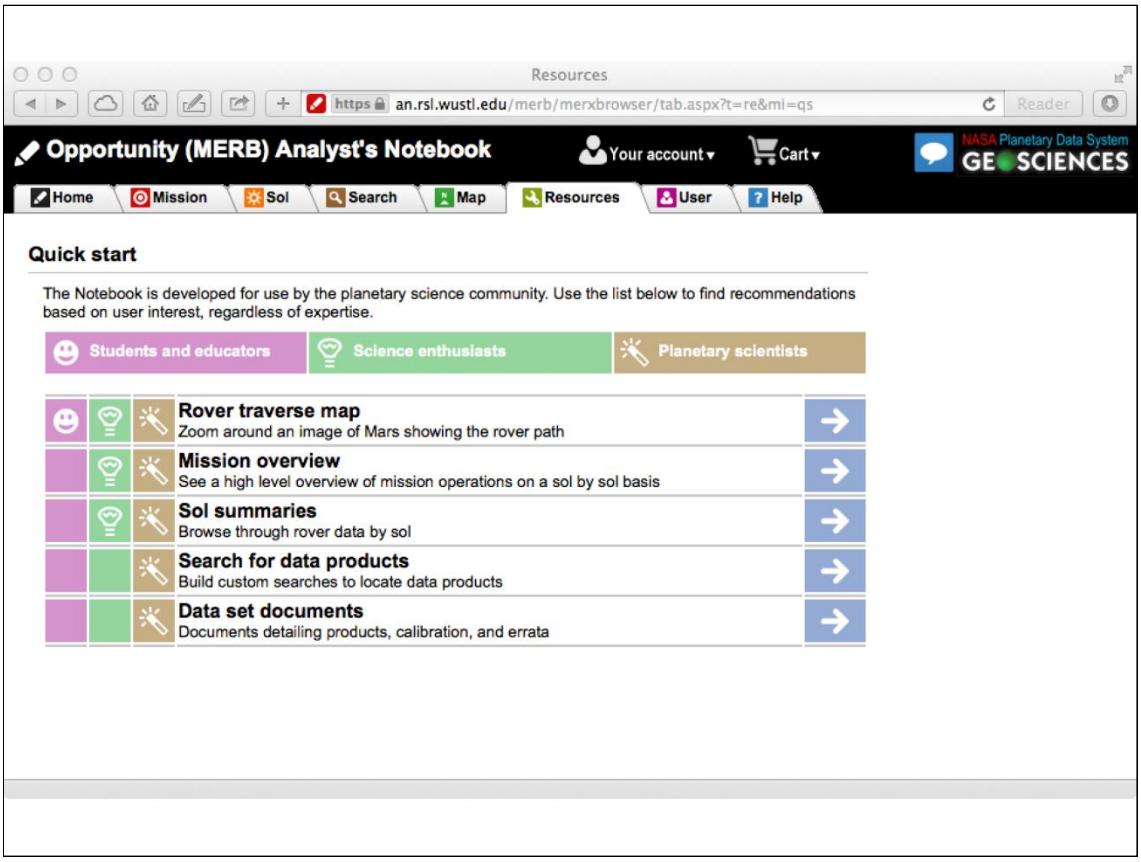
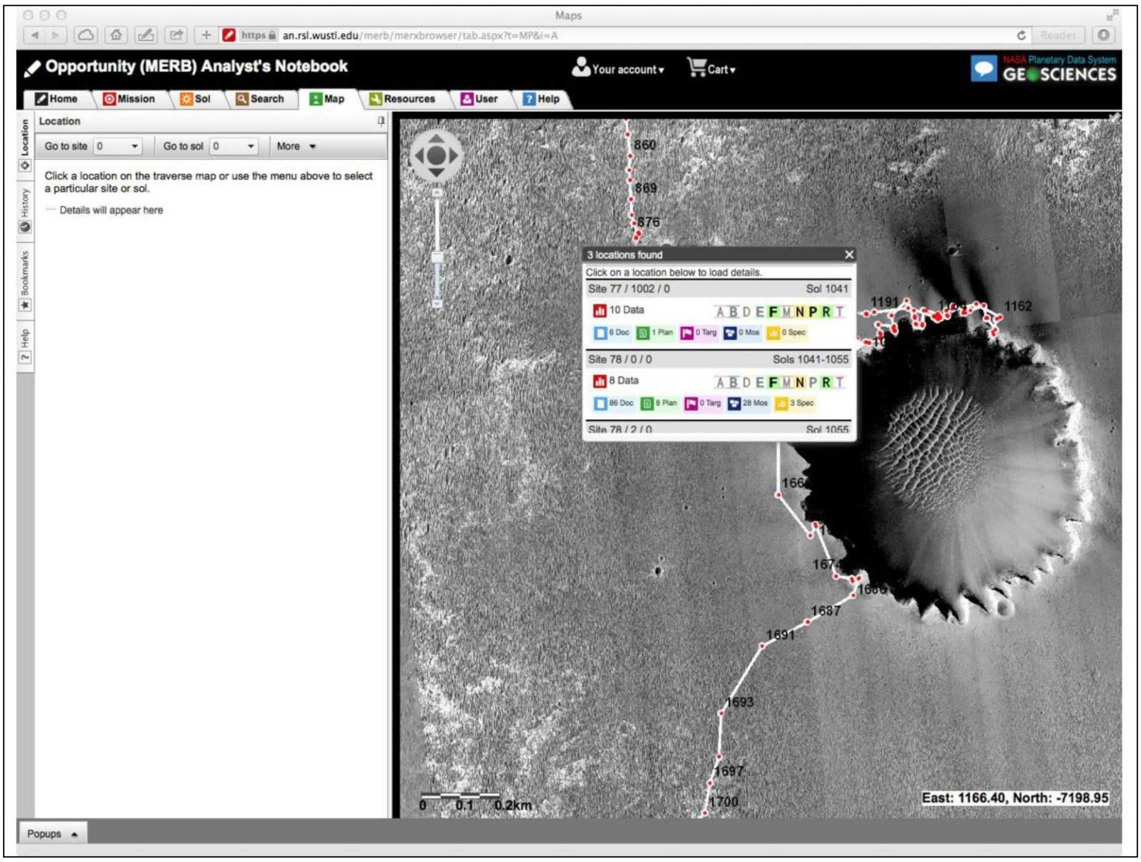
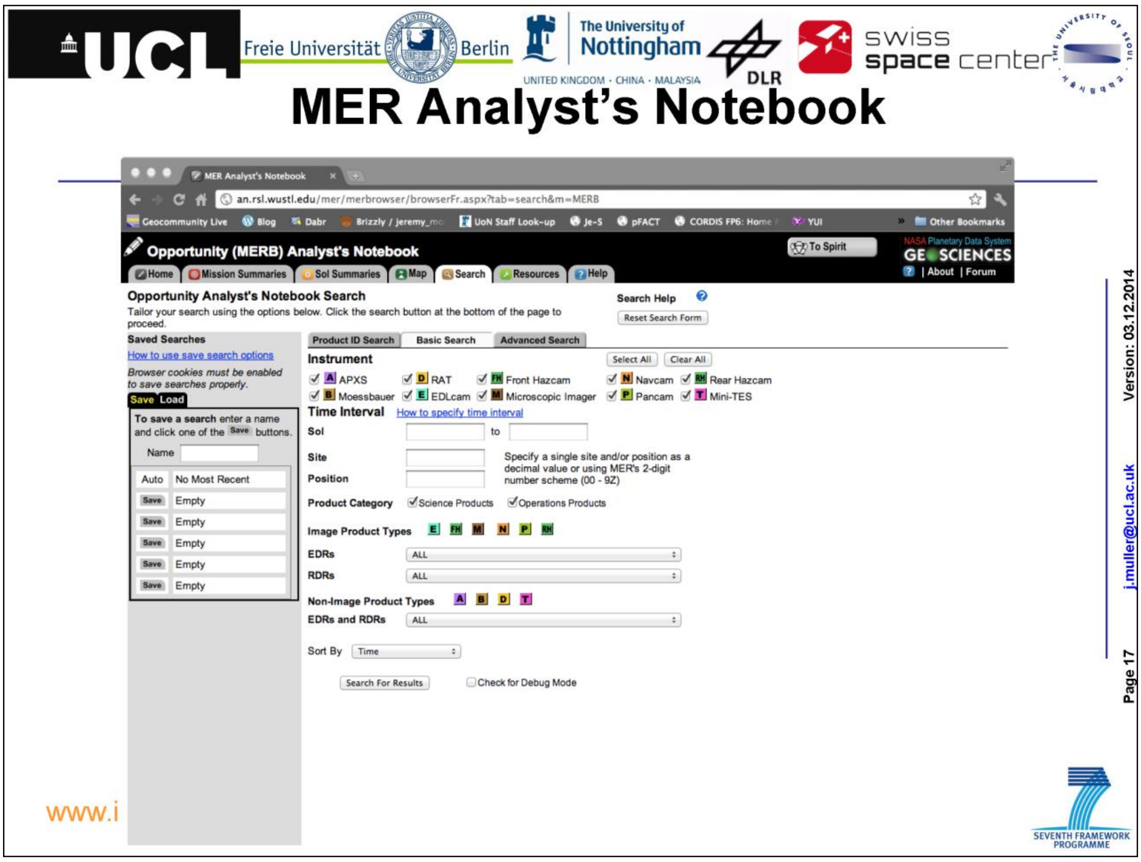


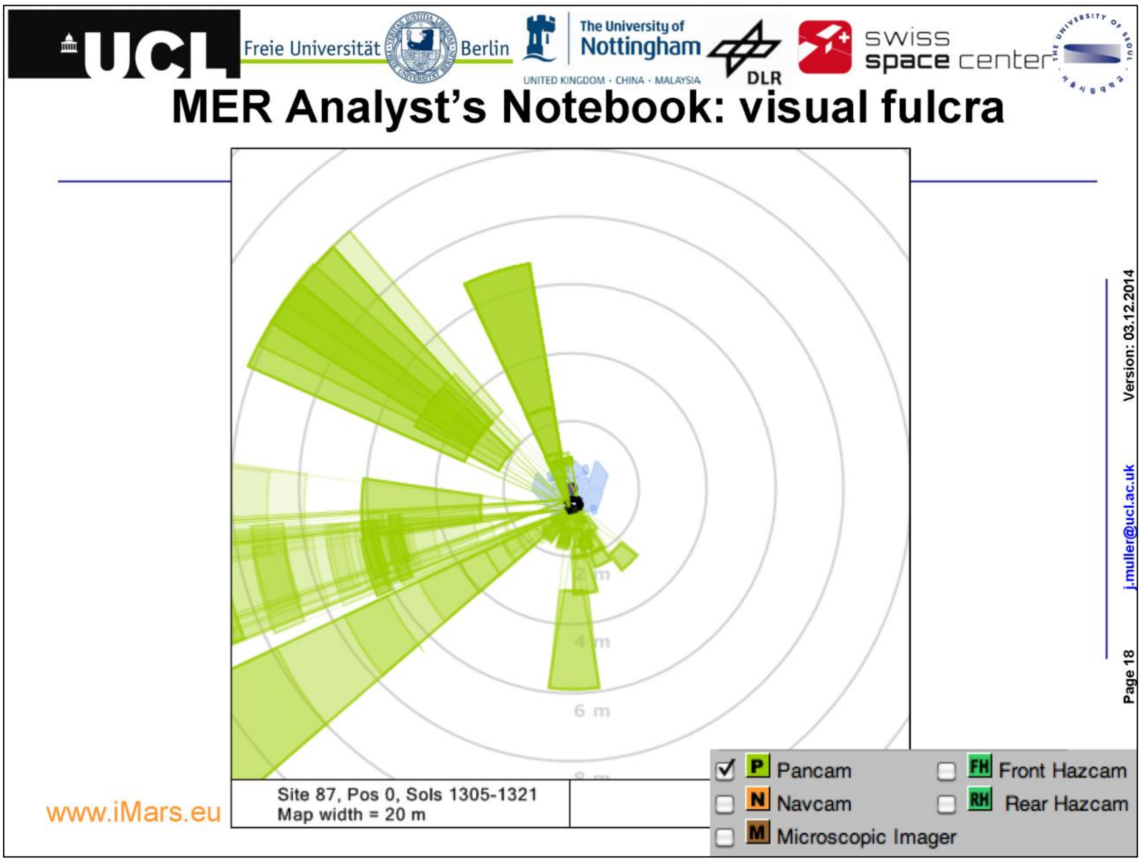
Figure 5. Local Map information interface allows display of the image pointing as lines of different colors (image types) and hotlink to the actual images in the windows

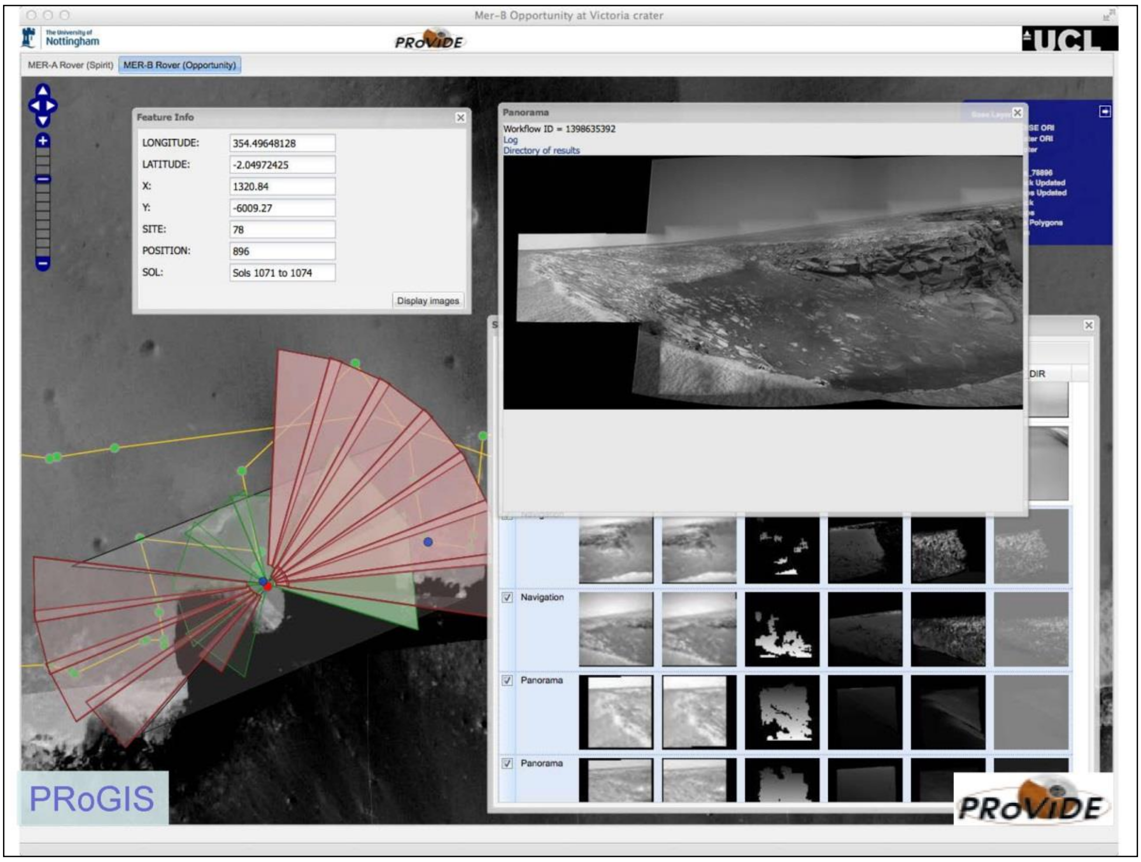
Source: Li et al., Photogrammetric Engineering & Remote Sensing, Vol. 73, No. 6, June 2007, pp. 671–680. / Requirements of the OSU Mars WebGIS for the MER 2003 Mission

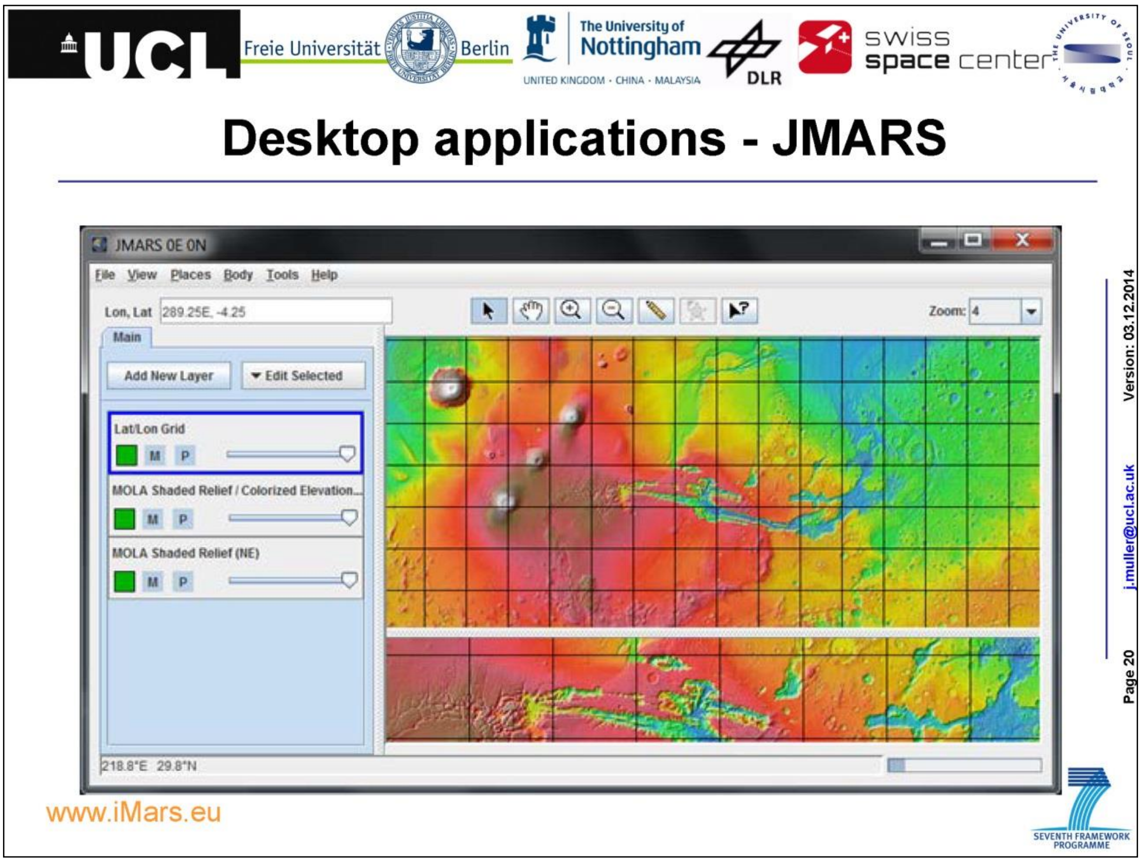

Resources
https an.rsl.wustl.edu/merb/merxbrowser/tab.aspx?t=re&mi=qs
Reader
Opportunity (MERB) Analyst's Notebook
Your account
Cart
NASA Planetary Data System
GEOSCIENCES
Home
Mission
Sol
Search
Map
Resources
User
Help
Quick start
The Notebook is developed for use by the planetary science community. Use the list below to find recommendations based on user interest, regardless of expertise.
Students and educators
Science enthusiasts
Planetary scientists
Rover traverse map
Zoom around an image of Mars showing the rover path
Mission overview
See a high level overview of mission operations on a sol by sol basis
Sol summaries
Browse through rover data by sol
Search for data products
Build custom searches to locate data products
Data set documents
Documents detailing products, calibration, and errata

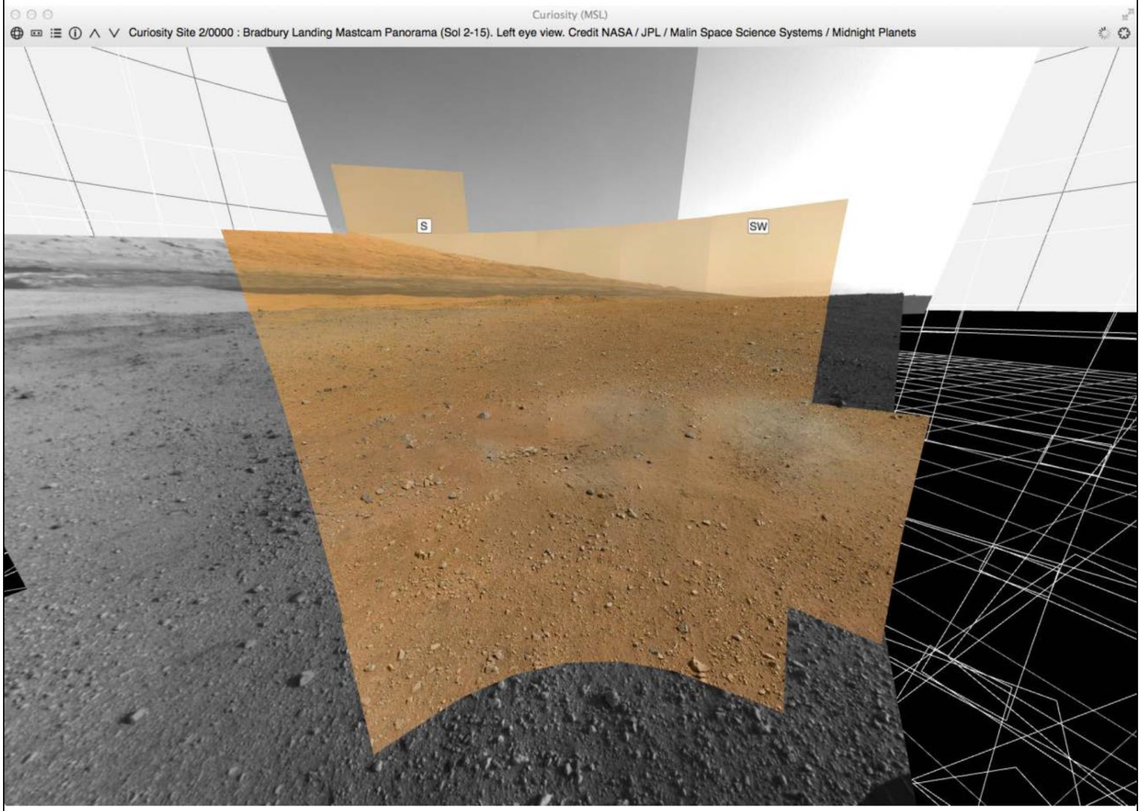

Maps
https an.rsl.wustl.edu/merb/merxbrowser/tab.aspx?t=MP&i=A
Opportunity (MERB) Analyst's Notebook
Your account
Cart
GEOSCIENCES
Home
Mission
Sol
Search
Map
Resources
User
Help
Location
Go to site
Go to sol
More
Click a location on the traverse map or use the menu above to select a particular site or sol.
Details will appear here
3 locations found
Click on a location below to load details.
Site 77 / 1002 / 0
Sol 1041
10 Data
Site 78 / 0 / 0
Sols 1041-1055
8 Data
Site 78 / 2 / 0
Sol 1055
860
869
876
1191
1162
1687
1691
1693
1697
1700
0
0.1
0.2km
East: 1166.40, North: -7198.95
Popups


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
MER Analyst's Notebook
Opportunity (MERB) Analyst's Notebook
Home
Mission Summaries
Sol Summaries
Map
Search
Resources
Help
Opportunity Analyst's Notebook Search
Tailor your search using the options below. Click the search button at the bottom of the page to proceed.
Search Help
Reset Search Form
Saved Searches
How to use save search options
Browser cookies must be enabled to save searches properly.
Save Load
To save a search enter a name and click one of the Save buttons.
Name
Auto No Most Recent
Empty
Product ID Search
Basic Search
Advanced Search
Instrument
Select All
Clear All
APXS
RAT
Front Hazcam
Navcam
Rear Hazcam
Moessbauer
EDLcam
Microscopic Imager
Pancam
Mini-TES
Time Interval
How to specify time interval
Sol
to
Site
Position
Specify a single site and/or position as a decimal value or using MER's 2-digit number scheme (00 - 9Z)
Product Category
Science Products
Operations Products
Image Product Types
EDRs
RDRs
ALL
Non-Image Product Types
EDRs and RDRs
Sort By
Time
Search For Results
Check for Debug Mode
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 17
www.i
SEVENTH FRAMEWORK PROGRAMME


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
MER Analyst's Notebook: visual fulcra
2 m
4 m
6 m
Site 87, Pos 0, Sols 1305-1321
Map width = 20 m
Pancam
Navcam
Microscopic Imager
Front Hazcam
Rear Hazcam
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 18
www.iMars.eu


Mer-B Opportunity at Victoria crater
PRoVIDE
UCL
MER-A Rover (Spirit)
MER-B Rover (Opportunity)
Feature Info
LONGITUDE: 354.49648128
LATITUDE: -2.04972425
X: 1320.84
Y: -6009.27
SITE: 78
POSITION: 896
SOL: Sols 1071 to 1074
Display images
Panorama
Workflow ID = 1398635392
Log
Directory of results
Navigation
Panorama
PRoGIS

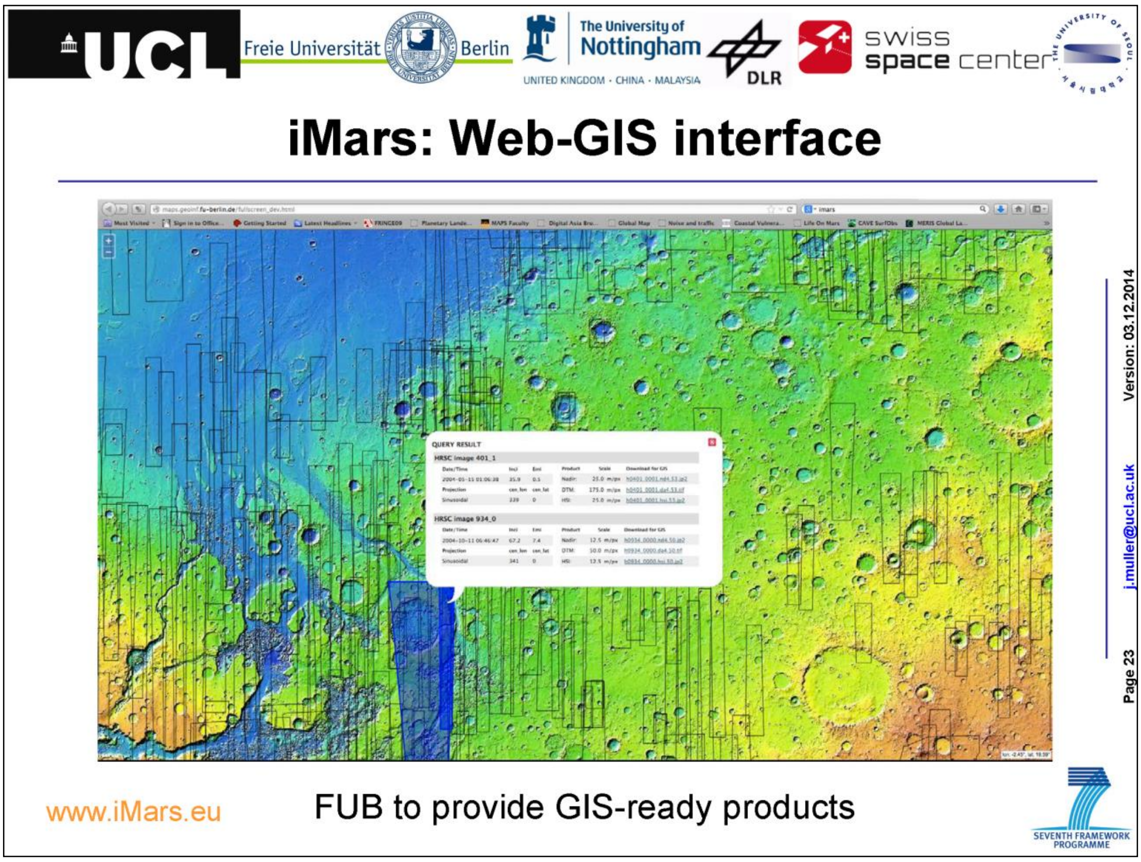

UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
Desktop applications - JMARS
JMARS 0E 0N
File View Places Body Tools Help
Lon, Lat 289.25E, -4.25
Zoom: 4
Main
Add New Layer
Edit Selected
Lat/Lon Grid
MOLA Shaded Relief / Colorized Elevation...
MOLA Shaded Relief (NE)
218.8°E 29.8°N
www.iMars.eu
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 20
SEVENTH FRAMEWORK PROGRAMME

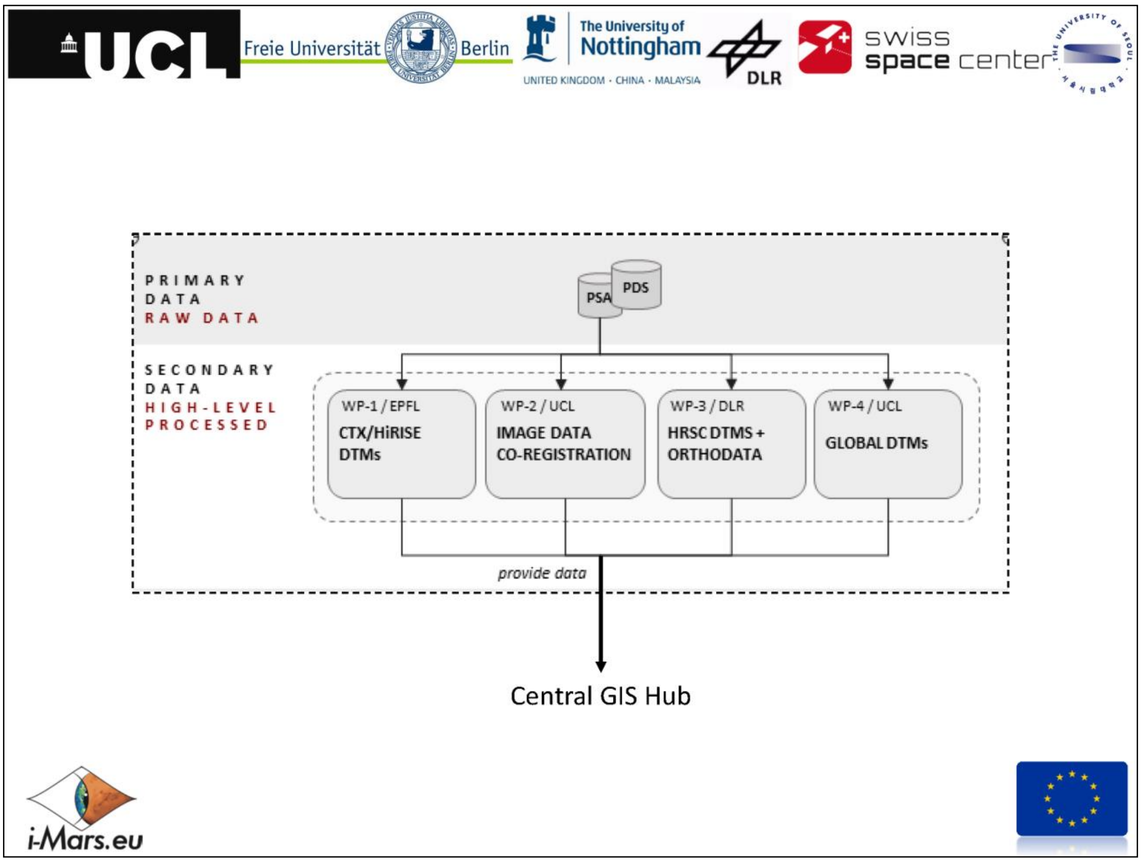


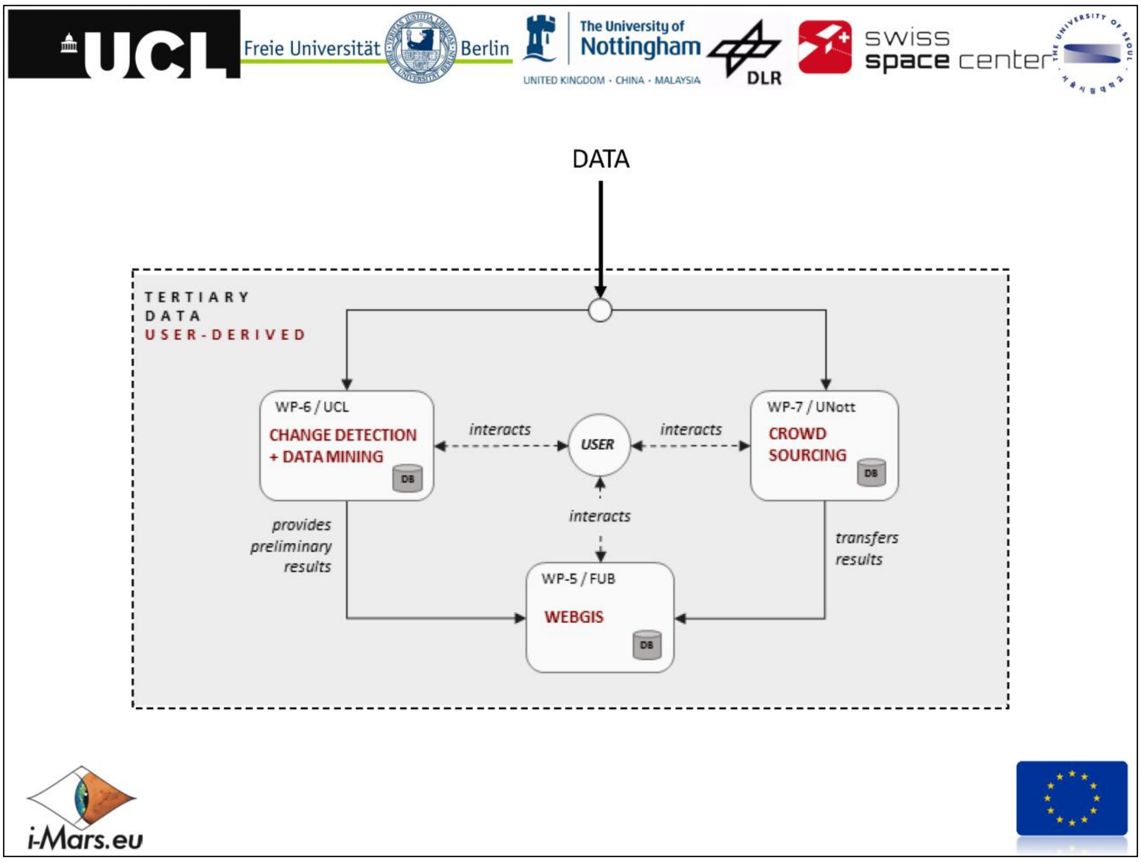
iMars webGIS (WP 5) forms the central interactive hub and receives data from

- archives,
- crowd-sourcing and
- higher level processing.

It is intended to provide functionality co-defined by the user community and to allow for interactive data manipulation.


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
iMars: Web-GIS interface
QUERY RESULT
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 23
www.iMars.eu
FUB to provide GIS-ready products
SEVENTH FRAMEWORK PROGRAMME


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
PRIMARY DATA
RAW DATA
PSA
PDS
SECONDARY DATA
HIGH-LEVEL PROCESSED
WP-1 / EPFL
CTX/HiRISE DTMs
WP-2 / UCL
IMAGE DATA CO-REGISTRATION
WP-3 / DLR
HRSC DTMS + ORTHODATA
WP-4 / UCL
GLOBAL DTMs
provide data
Central GIS Hub
i-Mars.eu


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
DATA
TERTIARY
DATA
USER-DERIVED
WP-6 / UCL
CHANGE DETECTION
+ DATA MINING
DB
interacts
USER
interacts
WP-7 / UNott
CROWD
SOURCING
DB
interacts
provides
preliminary
results
transfers
results
WP-5 / FUB
WEBGIS
DB
i-Mars.eu


OGC
Making location count.
http://opengeospatial.org
Home
Standards
Programs
Participate
OGC Blog
Events
About OGC
Member Login
Search
Geospatial and location standards for:
Aviation
Built Environment & 3D
Business Intelligence
Defense & Intelligence
Geosciences & Environment
Government &
Spatial Data Infrastructure
Mobile Internet &
Location Services
Emergency Response &
Disaster Management
Sensor Webs
University & Research
Earth Observation
Analysis
Proximity
Crowdsourcing
CAD
Spatial Policy
Open
Points of Interest
Place
Where
Interoperability
Geoweb
Share
Open Data
Geosemantics
Information Integration
Geosynchronization
Data Quality
Situational Awareness
Metadata
Alerts
Real Time
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 26

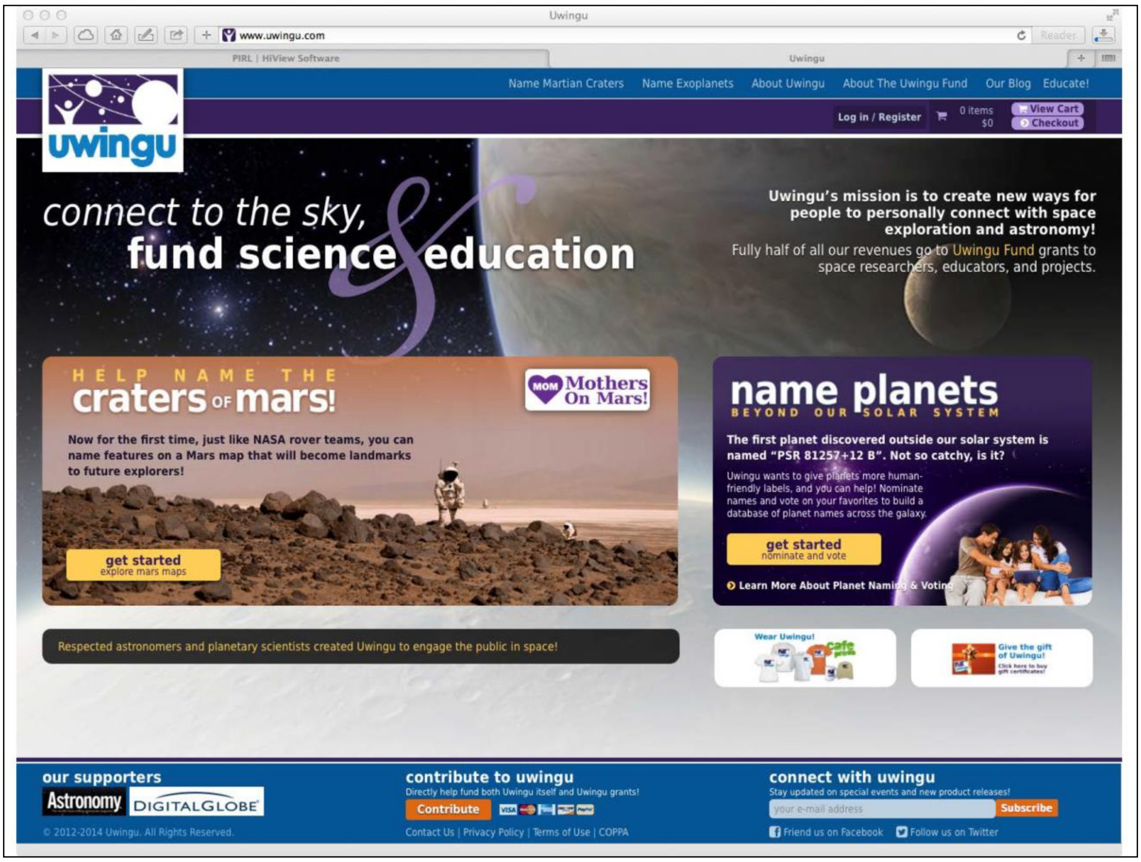
WP7:
Crowd-sourced features for change discovery and validation of data mining

Jeremy Morley, Rob Houghton, Steven Bamford
University of Nottingham

www.iMars.eu

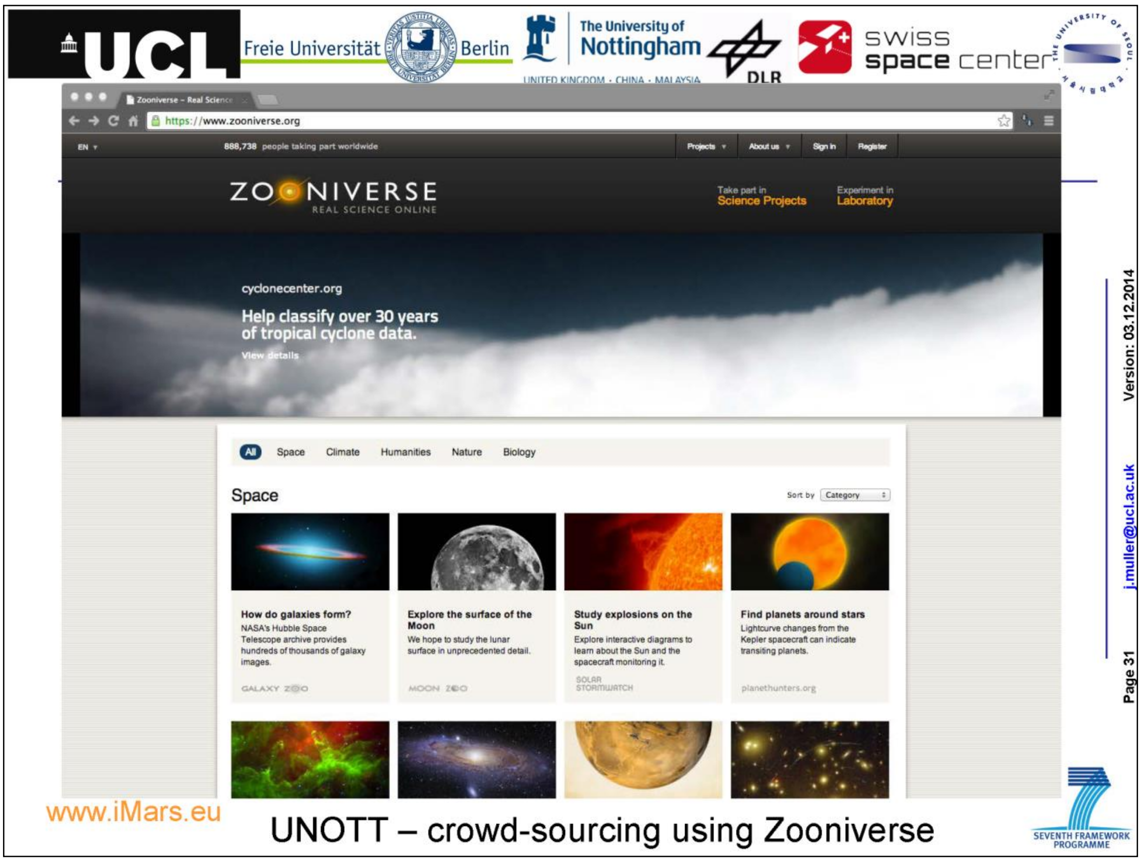
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 27

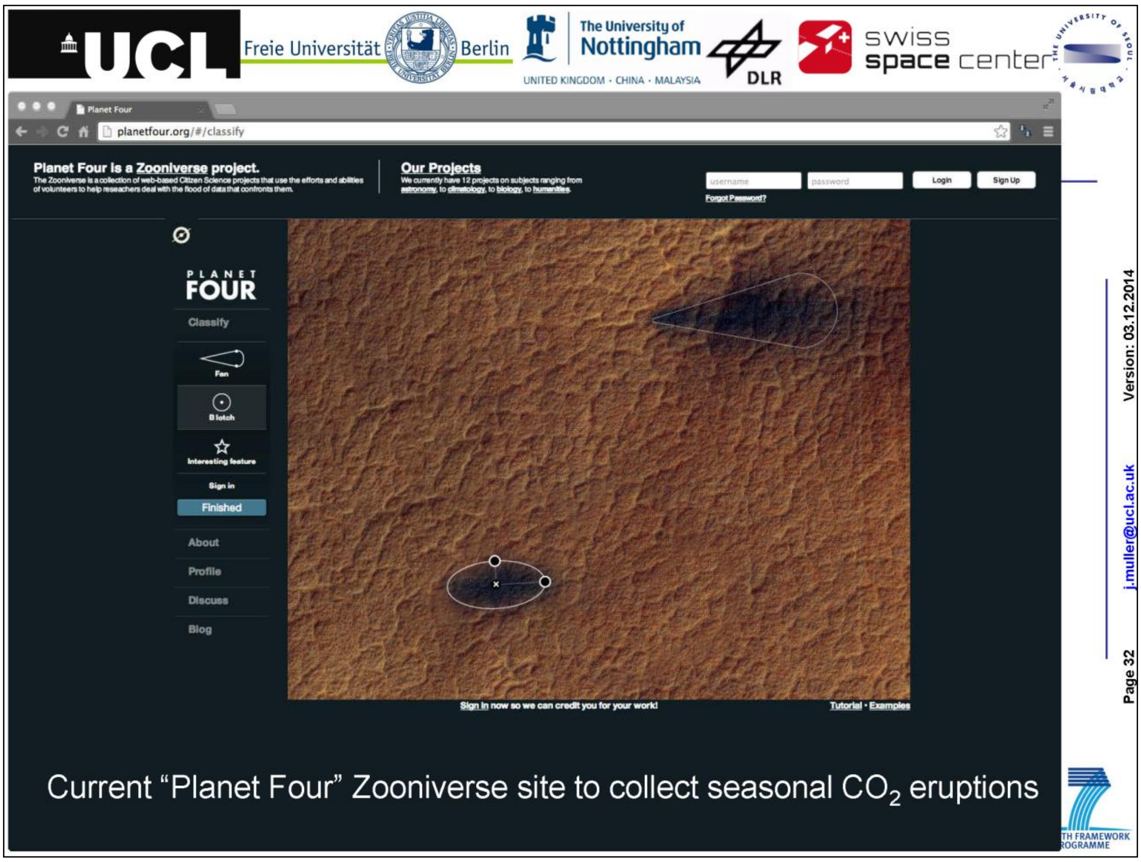
SEVENTH FRAMEWORK PROGRAMME




Name Martian Craters–and Make an Impact of Your Own! | Uwingu
www.uwingu.com/mars/
Home Page
Name Martian Craters
Name Exoplanets
About Uwingu
About The Uwingu Fund
Our Blog
Educate!
Log in / Register
View Cart
Checkout
uwingu
Name Martian Craters–and Make an Impact of Your Own!
Name Mars Just Like NASA Rover Teams Do
For years, space mission rover drivers have named craters on Mars and Apollo astronauts have named landing site landmarks on their Moon missions.
Now it's your turn to help create the first crowdsourced Mars map, with names for all of the approximately 500,000 largest, still unnamed craters on Mars! You can also help name the map grid rectangles of all the Districts and Provinces in our address system– the first ever address system for Mars.
Read More
See Also: Mars Crater Naming FAQ
Quick Option
If you don't want to select your crater yourself, just pick your price level and we'll have a Mars scientist choose a crater for you!
Choose My Crater For Me
Mothers On Mars!
Mars Surface Viewer
Instructions: Click and drag this map to move around Mars, or select another location from the Mars Global Map below.
Just mouse over and click on craters, districts, and provinces to name them!
About naming craters
About Districts and Provinces
View: All Craters Districts Provinces
Key: Named crater Available crater Reserved crater
District: 310, Province: 103
Monemonio
$25
Newest Named Crater: Monemonio Named By Monemonio


USGS Astrogeology: Map-a-Planet
www.mapaplanet.org
USGS
science for a changing world
Astrogeology Research Program
Home Help Search About Us
Map-a-Planet
PDS Imaging Node
Explore global imagery of the planets and satellites from a variety of missions in an easy to use web interface. Customize and download your own image maps of the Moon, Mars, Venus, and other planets and moons.
To get started:
1. Select a planet or moon from the buttons on the right.
2. Click on the image of the dataset you'd like to explore.
3. Start exploring!
4. Select resulting images for download.
5. ... and also 'Order' custom products .
What imagery will I find here?
FAQs
Help
Meet the Team
What's New? and Featured Data sets
LRO-LOLA Gridded Data Record Digital Elevation Model!
September 2012
» LOLA lunar elevation data are now available. From the "Moon" page, select the LRO-LOLA image or "LRO-LOLA DEM" text link.
Kaguya (SELENE) Laser Altimeter Topographic Map!
December 2011
» Lunar surface elevation data are now available. From the "Moon" page,
Planets & Earth's Moon
Mercury
Venus
Moon
Mars
Moons of Jupiter
Callisto
Europa
Ganymede
Io
Moons of Saturn
Rhea
Dione
Tethys


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
https://www.zooniverse.org
888,738 people taking part worldwide
Projects
About us
Sign in
Register
ZOONIVERSE
REAL SCIENCE ONLINE
Take part in Science Projects
Experiment in Laboratory
cyclonecenter.org
Help classify over 30 years of tropical cyclone data.
View details
All
Space
Climate
Humanities
Nature
Biology
Space
Sort by Category
How do galaxies form?
NASA's Hubble Space Telescope archive provides hundreds of thousands of galaxy images.
Explore the surface of the Moon
We hope to study the lunar surface in unprecedented detail.
Study explosions on the Sun
Explore interactive diagrams to learn about the Sun and the spacecraft monitoring it.
Find planets around stars
Lightcurve changes from the Kepler spacecraft can indicate transiting planets.
planethunters.org
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 31
www.iMars.eu
UNOTT – crowd-sourcing using Zooniverse
SEVENTH FRAMEWORK PROGRAMME


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
Planet Four
planetfour.org/#/classify
Planet Four is a Zooniverse project.
Our Projects
Login
Sign Up
Forgot Password?
PLANET FOUR
Classify
Fan
Blotch
Interesting feature
Sign in
Finished
About
Profile
Discuss
Blog
Sign in now so we can credit you for your work!
Tutorial · Examples
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 32
Current "Planet Four" Zooniverse site to collect seasonal CO_2 eruptions
TH FRAMEWORK PROGRAMME

Objectives

- Review human factors research on human computation & automation.
- Test HF theory in the domain of Martian geomorphological feature recognition.
- Build a MarsZoo project in Zooniverse to produce data on a range of features, taking into account the results of HF testing.
- Validate MarsZoo results with scientific users & against automated results.
- Communicate "best practice" results

www.iMars.eu

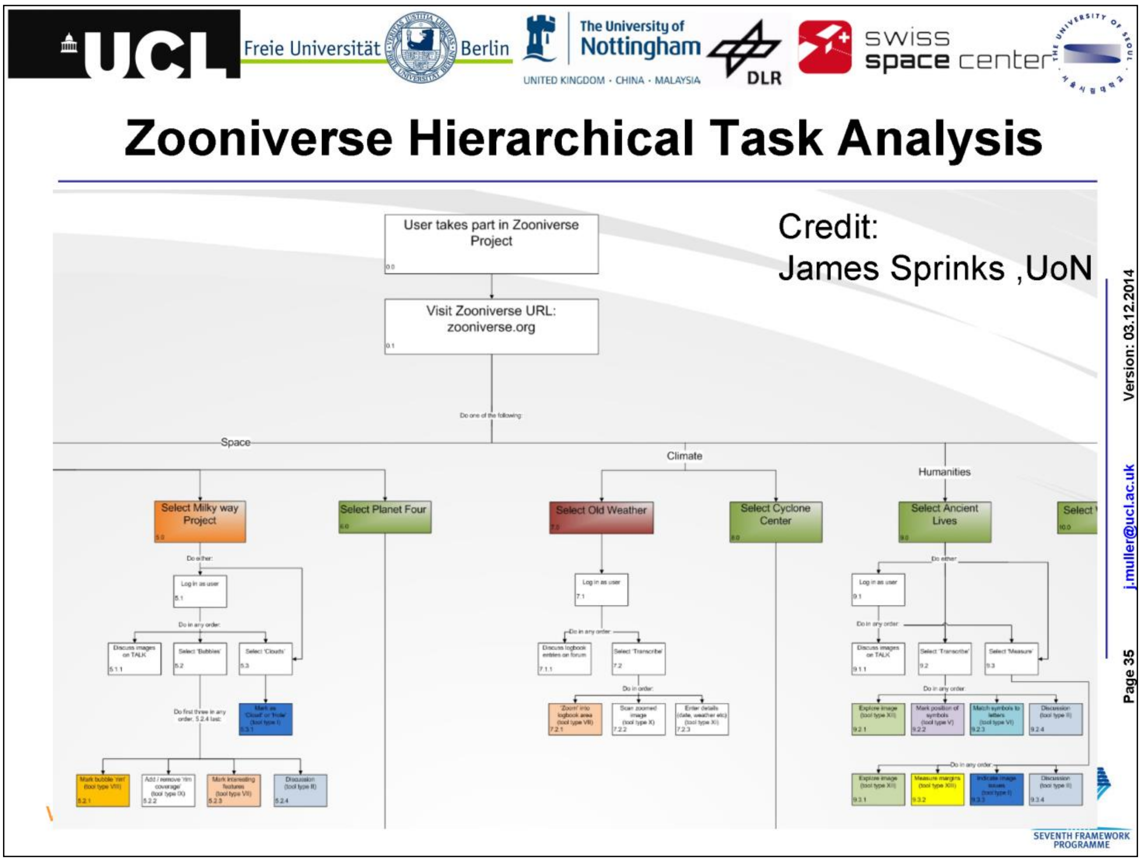
Page 33 j.muller@ucl.ac.uk Version: 03.12.2014

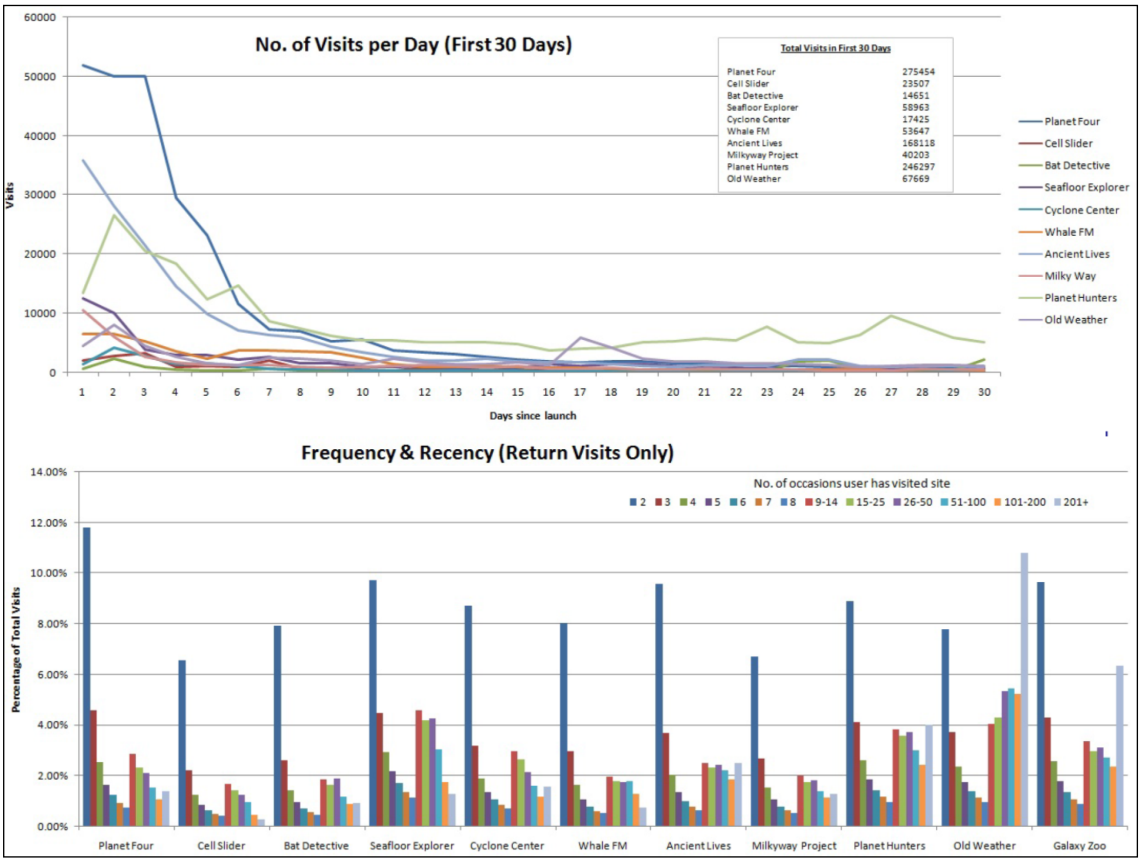
Human Factors Analysis & Crowd-Sourcing

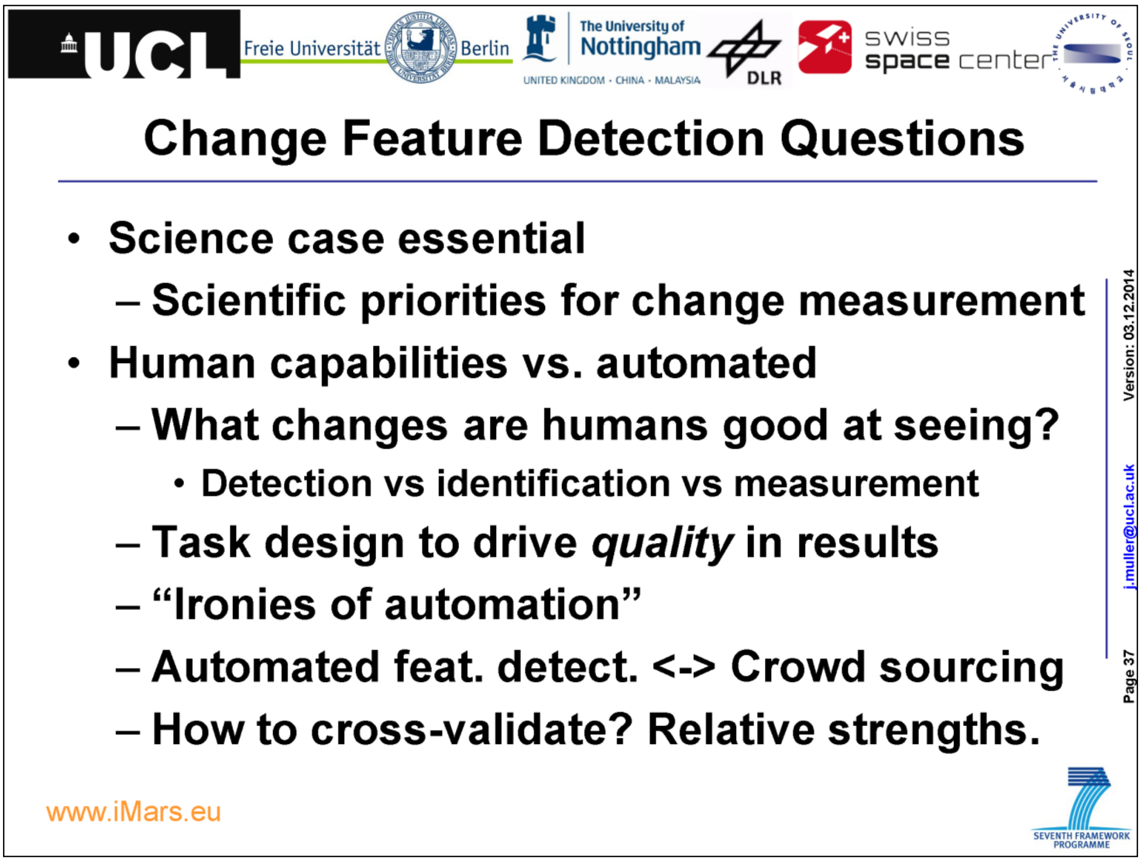
- Zooniverse developed relatively organically
- Studies of motivation & quality, no in-depth investigation of the interface factors that keep people motivated & concentrated -> good data
- Human factors examines the human-computer interface design, and human as part of the analysis system
- Example: hierarchical task analysis. Breaking down the different interface structures of Zooniverse projects to identify success factors

www.iMars.eu

Page 34 j.muller@ucl.ac.uk Version: 03.12.2014


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
Zooniverse Hierarchical Task Analysis
Credit:
James Sprinks ,UoN
User takes part in Zooniverse Project
Visit Zooniverse URL: zooniverse.org
Space
Climate
Humanities
Select Milky way Project
Select Planet Four
Select Old Weather
Select Cyclone Center
Select Ancient Lives
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 35
SEVENTH FRAMEWORK PROGRAMME


No. of Visits per Day (First 30 Days)
Visits
Days since launch
Total Visits in First 30 Days
Planet Four 275454
Cell Slider 23507
Bat Detective 14651
Seafloor Explorer 58963
Cyclone Center 17425
Whale FM 53647
Ancient Lives 168118
Milkyway Project 40203
Planet Hunters 246297
Old Weather 67669
Planet Four
Cell Slider
Bat Detective
Seafloor Explorer
Cyclone Center
Whale FM
Ancient Lives
Milky Way
Planet Hunters
Old Weather
Frequency & Recency (Return Visits Only)
No. of occasions user has visited site
2 3 4 5 6 7 8 9-14 15-25 26-50 51-100 101-200 201+
Percentage of Total Visits
Planet Four
Cell Slider
Bat Detective
Seafloor Explorer
Cyclone Center
Whale FM
Ancient Lives
Milkyway Project
Planet Hunters
Old Weather
Galaxy Zoo


UCL
Freie Universität Berlin
The University of Nottingham
UNITED KINGDOM · CHINA · MALAYSIA
DLR
swiss space center
Change Feature Detection Questions
• Science case essential
– Scientific priorities for change measurement
• Human capabilities vs. automated
– What changes are humans good at seeing?
• Detection vs identification vs measurement
– Task design to drive *quality* in results
– "Ironies of automation"
– Automated feat. detect. <-> Crowd sourcing
– How to cross-validate? Relative strengths.
Version: 03.12.2014
j.muller@ucl.ac.uk
Page 37
www.iMars.eu
SEVENTH FRAMEWORK PROGRAMME

ANNEX 3 – User requirements survey questionnaire

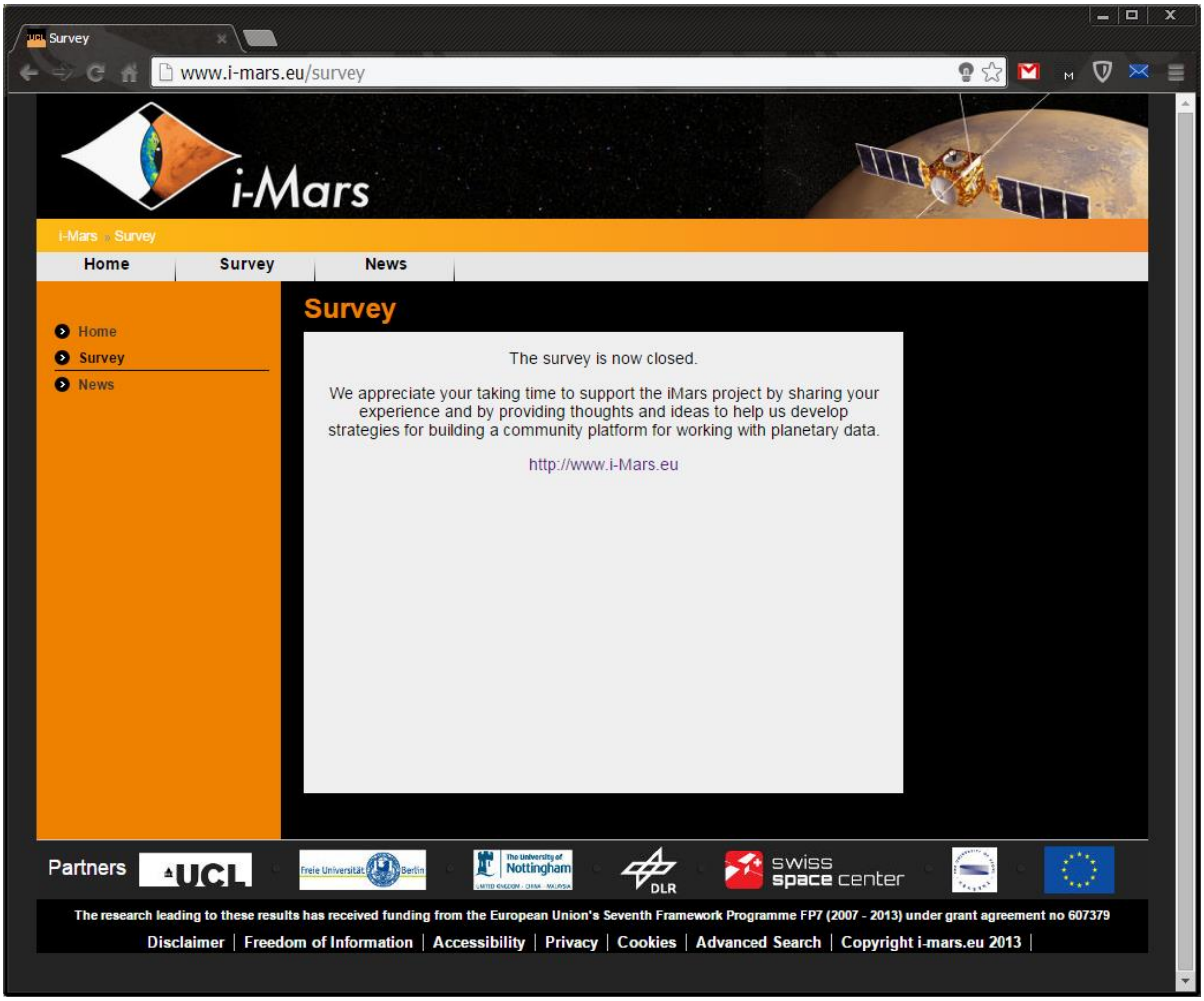


Figure III-1: Survey integrated into the main project website.

UCL | Freie Universität Berlin | The University of Nottingham UNITED KINGDOM · CHINA · MALAYSIA | DLR | swiss space center | The University of Tokyo

Questionnaire for the

iMars User Workshop at EGU 2014

We appreciate your taking time to support the iMars project by sharing your experience and by providing thoughts and ideas to help us develop strategies for building a community platform for working with planetary data.

This PDF form is sent to survey@i-mars.eu once you hit the *submit*-button at the end of the form. You can also save it and send it to us using the above e-mail address. In case you prefer to fill out the online questionnaire instead, please visit the project's website at http://www.i-Mars.eu

Thank you for your support.

If you wish to be included in project updates, please leave your e-mail address.

e-mail (optional) ____________________

1. What is/are your main study area/s of scientific interest related to Mars? Multiple answers are possible.

- ☐ Morphology
- ☐ Surface Composition
- ☐ Geodesy/Topographic Mapping
- ☐ Geologic Mapping
- ☐ Engineering
- ☐ other: ____________________

2. What are your most frequently used data sources for these studies Please also specify data product type or processing level.

____

____

____

http://www.i-Mars.eu/survey

i-Mars

Figure III-2: PDF Survey page 1/4.

3. How often do you use GIS (desktop or web)? Please provide one answer.

- Daily
- Weekly
- Monthly
- Never use GIS

4. What would you say is your level of GIS knowledge? Please provide one answer.

- Expert
- I know what to do
- Learner
- Do not use GIS

5. Do you use web-based planetary GIS and data archives for your research? If so, which? Please sort according to frequency (1: most frequent, 3: least frequent).

1. most frequent
2. less frequent
3. least frequent

6. When you compare web-based GIS and desktop GIS which functionalities are you missing most in either of these systems?

7. What is the main objective in using a desktop or web-based GIS? Multiple answers are possible.

- check data availability/coverage (i.e. image search)
- data processing support
- data analysis
- map production and visualisation
- other:

http://www.i-Mars.eu/survey

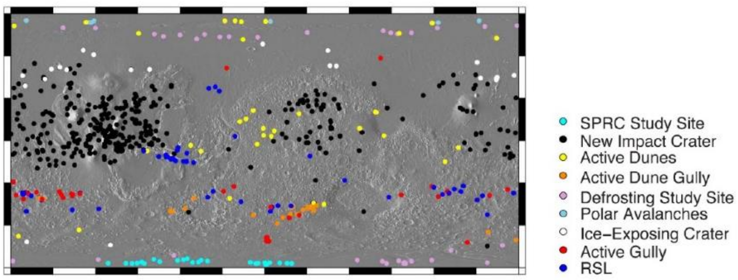
i-Mars

Figure III-3: PDF Survey page 2/4.

8. How important are the following GIS features for your work?
Please rank your choices from *not important* (---) to *most important* (+++).

	---	--	-	0	+	++	+++
vector-data import (shapefiles)							
modification of attributes							
attribute/spatial queries							
image data download							
map production features							
interactive mapping functionality							
complex analysis tools							
fast navigation in raster data							
sophisticated raster processing							
fast raster display and zoom/pan							

9. This map by the HiRISE team shows the distribution of change detections (SPRC= South Polar Residual Cap, RSL=Recurring slope lineae). What additional change features are of scientific interest?



- Dust devil tracks
- CO_2 geysers
- Dark streaks
- Others:

http://www.i-Mars.eu/survey

Figure III-4: PDF Survey page 3/4.

10. What change methods do you believe that people better suited to than computers?

○ detect ○ identify ○ measure

11. Rank the change features that…

	…people are *better suited* than computers to…			…are *most scientifically important* to…		
	detect	identify	measure	detect	identify	measure
Dust Devil Tracks						
CO2-Geysers						
Dark Streaks						
Polar Avalanches						
Ice-exposing Crater						
Active Gully						
Active Dune Gully						
Recurring Slope Lineae						
South Polar Residual Cap						
New Impact Crater						
Active Dunes						
Defrosting Features						

Please rank until you can't rank anymore (rank 1: least significant to rank 11: most significant).

13. Are there any other change features which iMars should consider?
If possible, say (check) whether they are important for

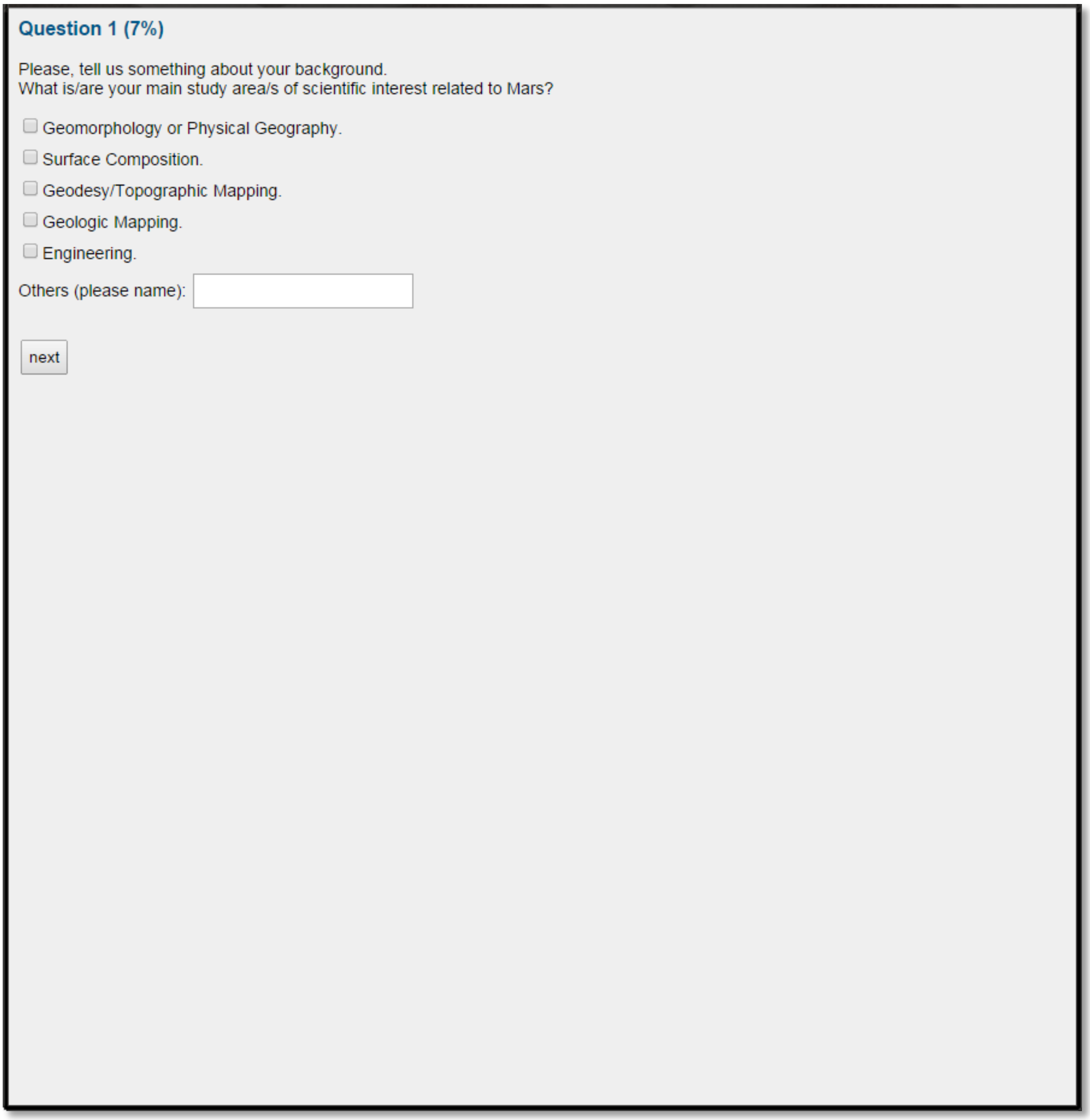
	☐ Detection	☐ Identification	☐ Measurement
	☐ Detection	☐ Identification	☐ Measurement
	☐ Detection	☐ Identification	☐ Measurement

http://www.i-Mars.eu/survey

i-Mars

Save and Send

Figure III-5: PDF Survey page 4/4.



Question 1 (7%)

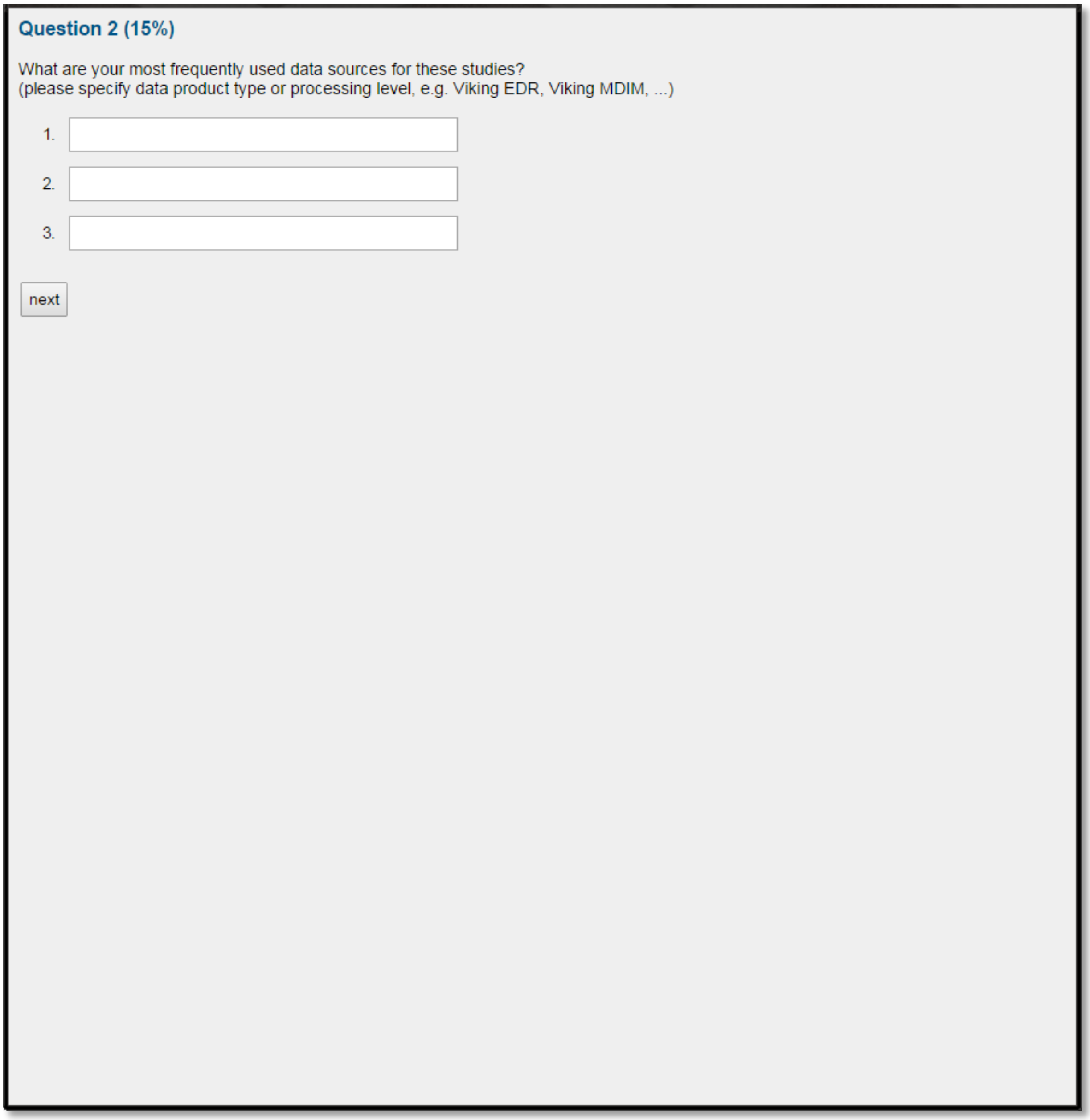
Please, tell us something about your background.
What is/are your main study area/s of scientific interest related to Mars?

- [ ] Geomorphology or Physical Geography.
- [ ] Surface Composition.
- [ ] Geodesy/Topographic Mapping.
- [ ] Geologic Mapping.
- [ ] Engineering.

Others (please name):

next

Figure III-6: Question 1 – User's research background (topic: background #1).



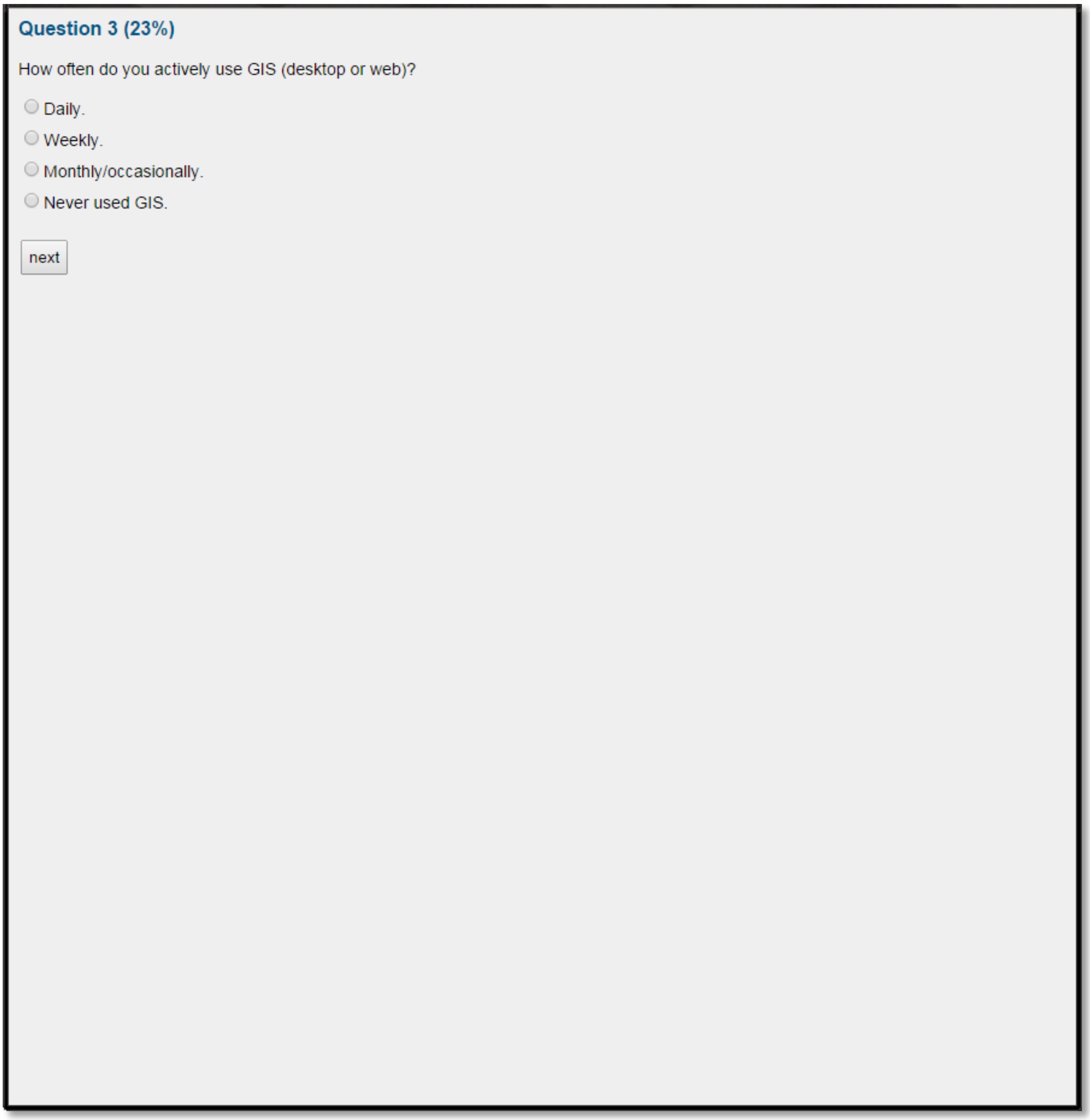
Question 2 (15%)

What are your most frequently used data sources for these studies?
(please specify data product type or processing level, e.g. Viking EDR, Viking MDIM, ...)

1.
2.
3.

next

Figure III-7: Question 2 – The three most important data products that are used for research work (topic: background).


Question 3 (23%)

How often do you actively use GIS (desktop or web)?

- Daily.
- Weekly.
- Monthly/occasionally.
- Never used GIS.

next

Figure III-8: Question 3 – Frequency of GIS usage (topic: GIS #1).

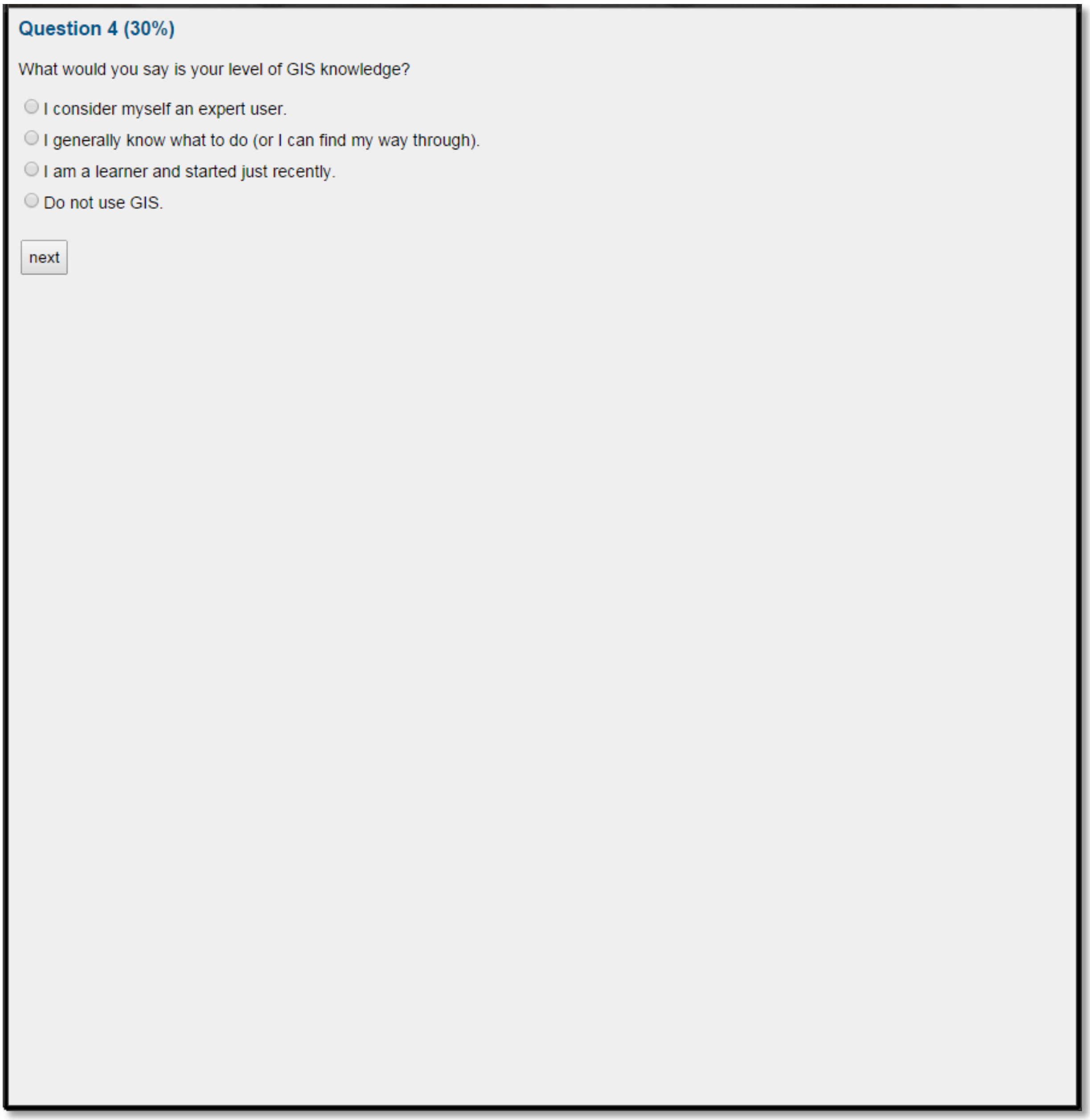
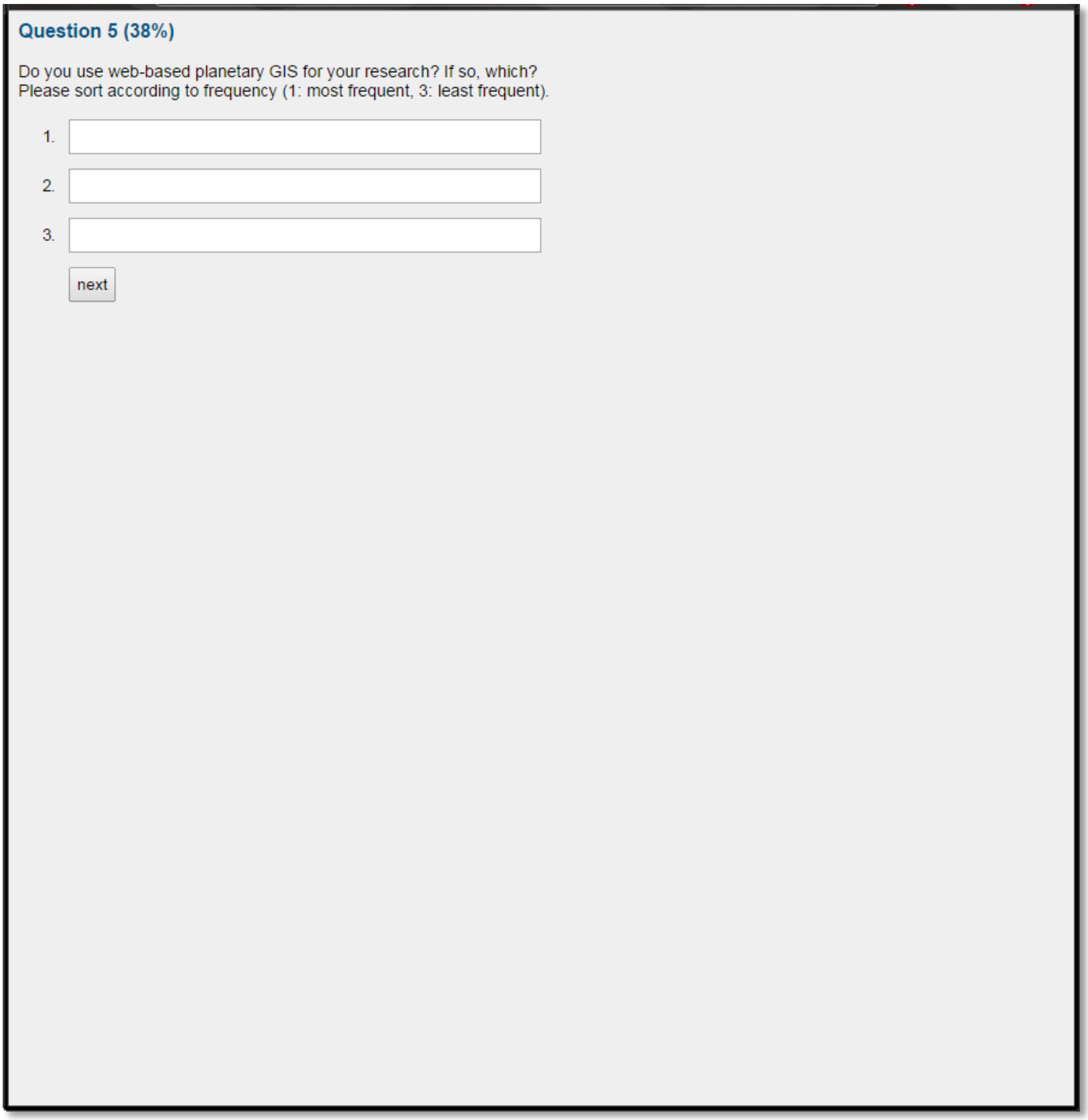


Figure III-9: Question 4 – Level of GIS knowledge (topic: GIS #2).


Question 5 (38%)

Do you use web-based planetary GIS for your research? If so, which?
Please sort according to frequency (1: most frequent, 3: least frequent).

1.
2.
3.

next

Figure III-10: Question 5 – Usage of web-based GIS (topic: GIS #3).

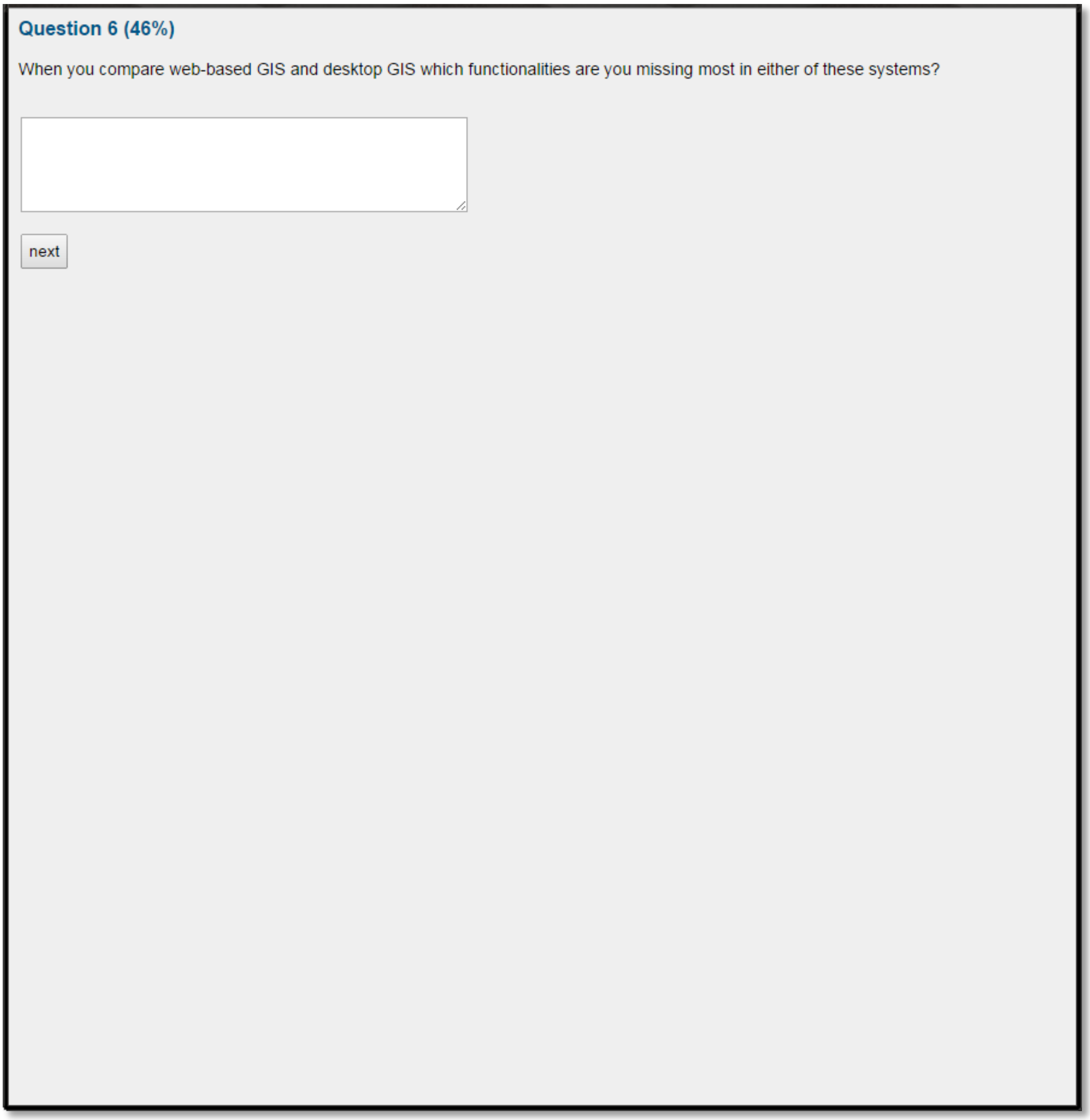
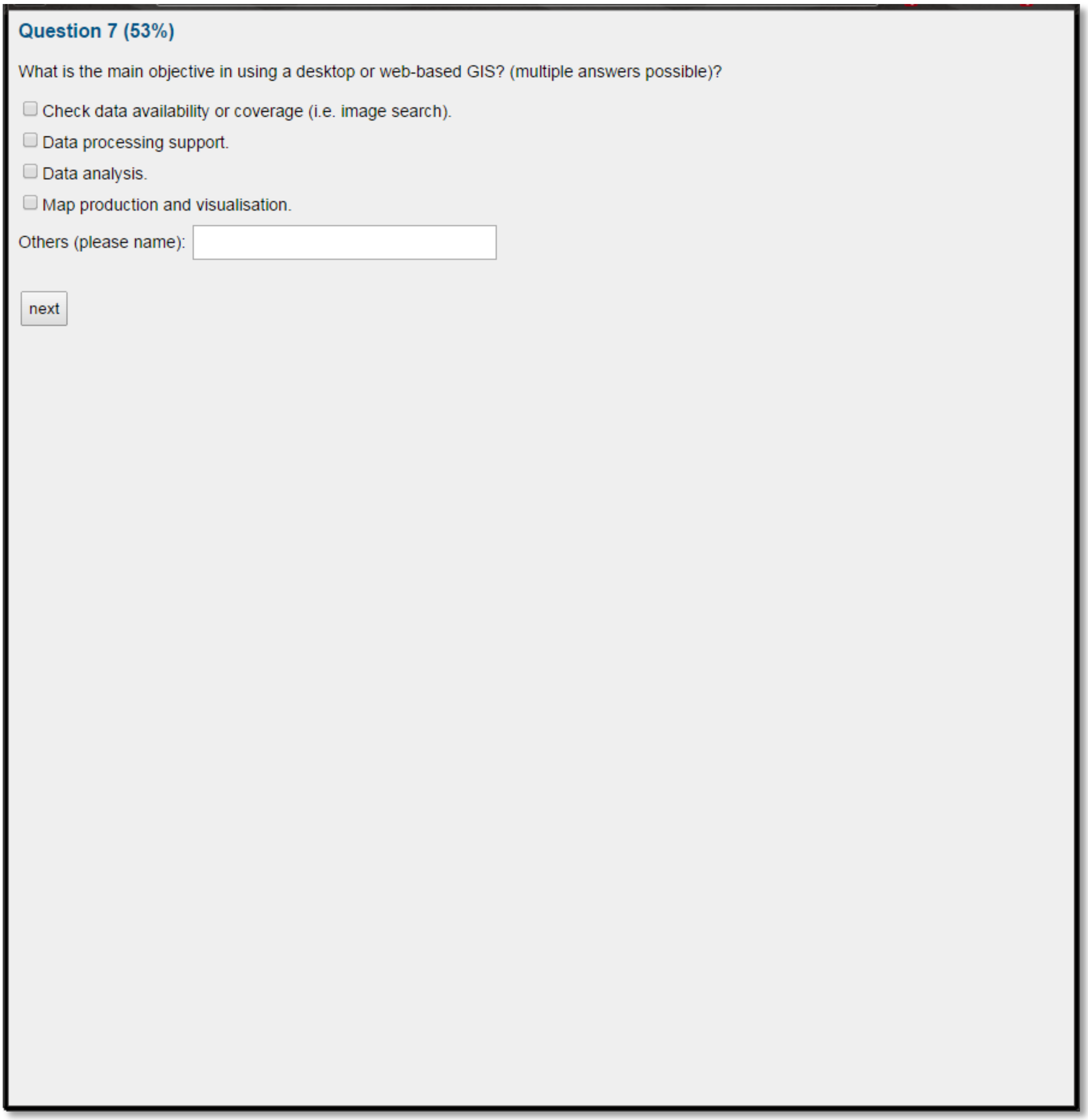


Figure III-11: Question 6 – Feature comparison between desktop and web-based GIS (topic: GIS #4).


Question 7 (53%)

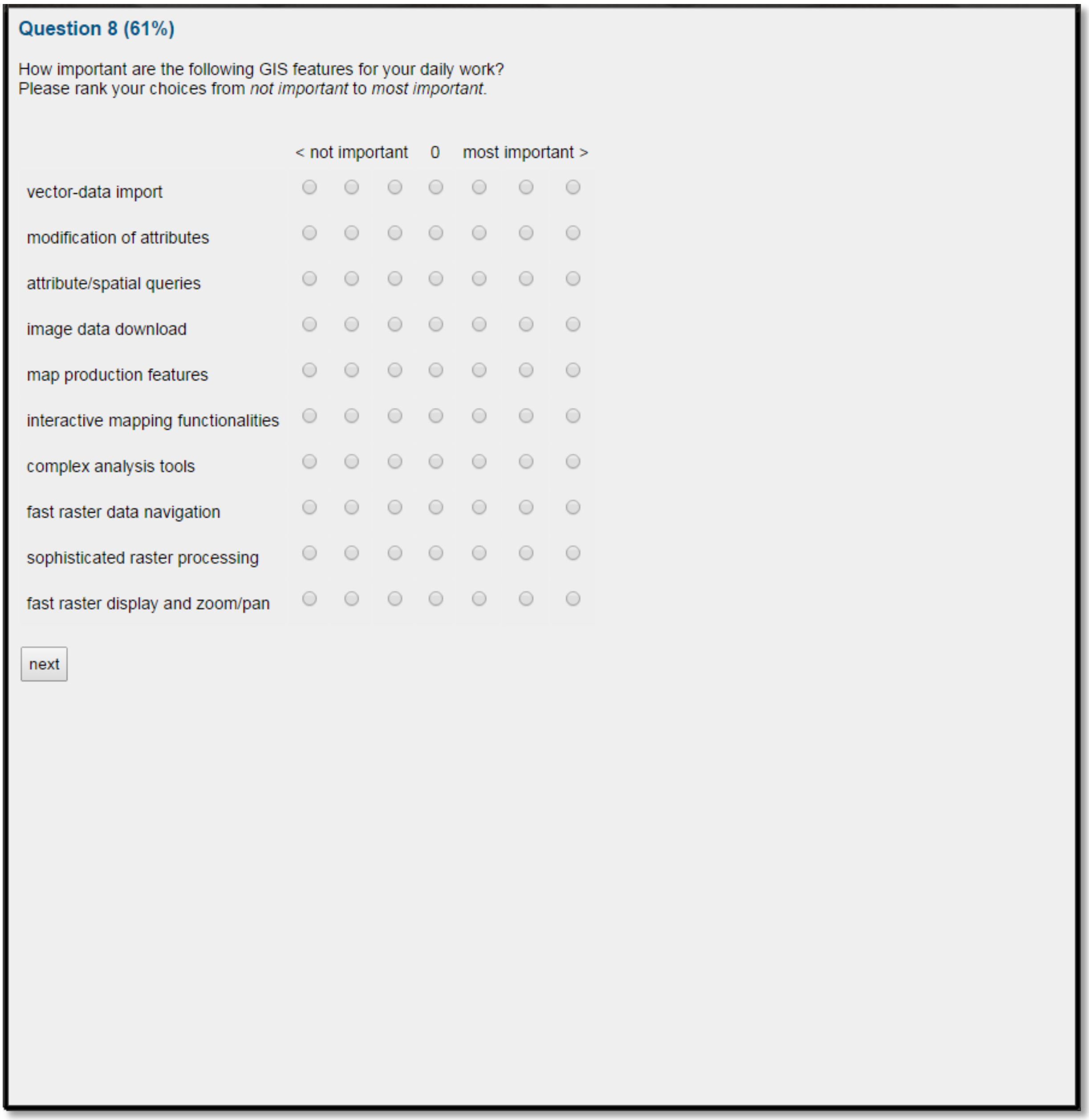
What is the main objective in using a desktop or web-based GIS? (multiple answers possible)?

- ☐ Check data availability or coverage (i.e. image search).
- ☐ Data processing support.
- ☐ Data analysis.
- ☐ Map production and visualisation.

Others (please name):

next

Figure III-12: Question 7 – Objectives in using GIS technology (topic: GIS #5).



Question 8 (61%)

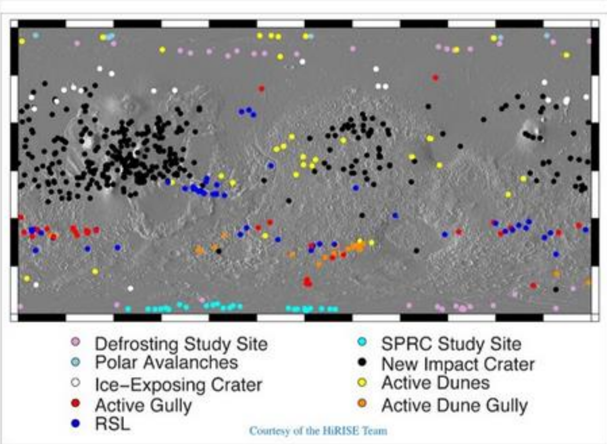
How important are the following GIS features for your daily work?
Please rank your choices from *not important* to *most important*.

	< not important			0			most important >
vector-data import	○	○	○	○	○	○	○
modification of attributes	○	○	○	○	○	○	○
attribute/spatial queries	○	○	○	○	○	○	○
image data download	○	○	○	○	○	○	○
map production features	○	○	○	○	○	○	○
interactive mapping functionalities	○	○	○	○	○	○	○
complex analysis tools	○	○	○	○	○	○	○
fast raster data navigation	○	○	○	○	○	○	○
sophisticated raster processing	○	○	○	○	○	○	○
fast raster display and zoom/pan	○	○	○	○	○	○	○

next

Figure III-13: Question 8 – Importance of GIS features (topic: GIS #6).

Question 9 (69%)



This map by the HiRISE team shows the distribution of change detections (SPRC=South Polar Residual Cap, RSL=Recurring slope lineae). What additional change features are of scientific interest?

- [ ] Dust-devil tracks.
- [ ] CO_2 geysers.
- [ ] Dark streaks.

Others (please name):

next

Figure III-14: Question 9 – Common variable surface morphologies as indicated by the HiRISE team that are potentially of interest for feature detection within iMars. Users may add additional features of interest (topic: variable features #1).

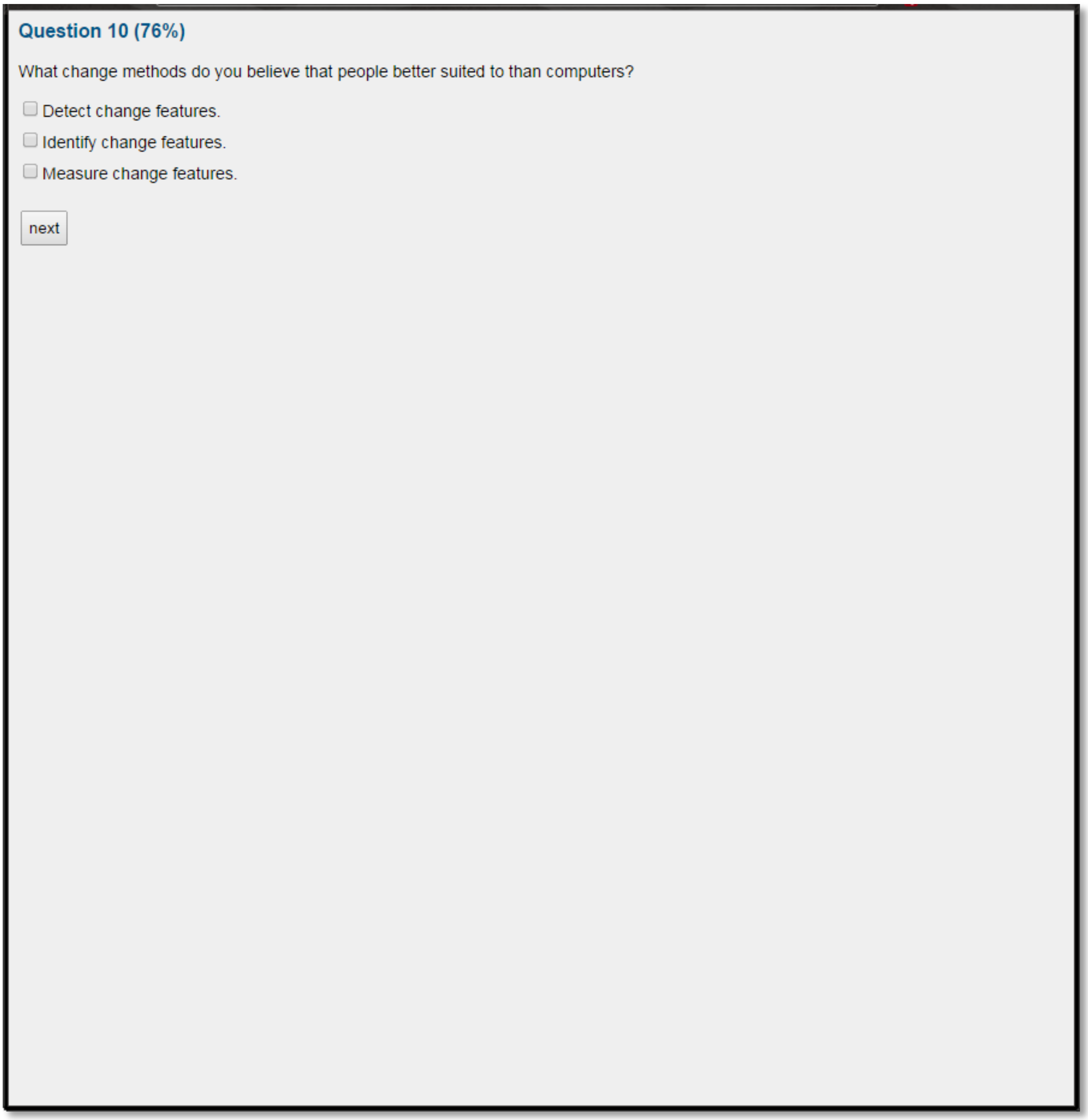
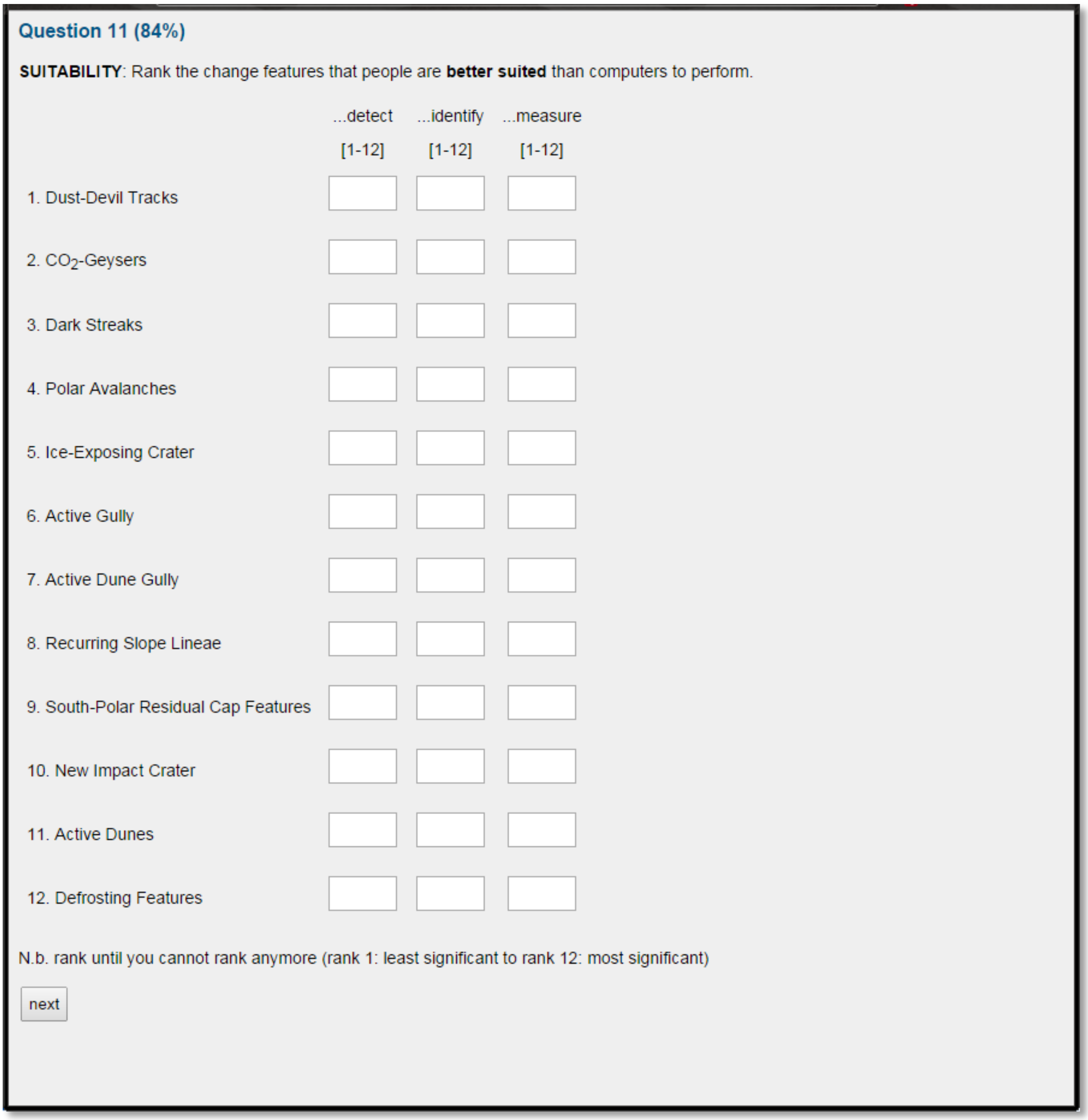


Figure III-15: Question 10 – Detection suitability #1 (topic: variable features #2).



Question 11 (84%)

SUITABILITY: Rank the change features that people are **better suited** than computers to perform.

	...detect [1-12]	...identify [1-12]	...measure [1-12]
1. Dust-Devil Tracks			
2. CO_2-Geysers			
3. Dark Streaks			
4. Polar Avalanches			
5. Ice-Exposing Crater			
6. Active Gully			
7. Active Dune Gully			
8. Recurring Slope Lineae			
9. South-Polar Residual Cap Features			
10. New Impact Crater			
11. Active Dunes			
12. Defrosting Features			

N.b. rank until you cannot rank anymore (rank 1: least significant to rank 12: most significant)

next

Figure III-16: Question 11 – Detection suitability #2 (topic: variable features #3).

Question 12 (92%)

SCIENTIFIC IMPORTANCE: Rank the change features that are most **scientifically important** to...

	...detect [1-12]	...identify [1-12]	...measure [1-12]
1. Dust-Devil Tracks			
2. CO_2-Geysers			
3. Dark Streaks			
4. Polar Avalanches			
5. Ice-Exposing Crater			
6. Active Gully			
7. Active Dune Gully			
8. Recurring Slope Lineae			
9. South-Polar Residual Cap Features			
10. New Impact Crater			
11. Active Dunes			
12. Defrosting Features			

N.b. rank until you cannot rank anymore (rank 1: least significant to rank 12: most significant)

next

Figure III-17: Question 12 – Detection suitability #3 (topic: variable features #4).

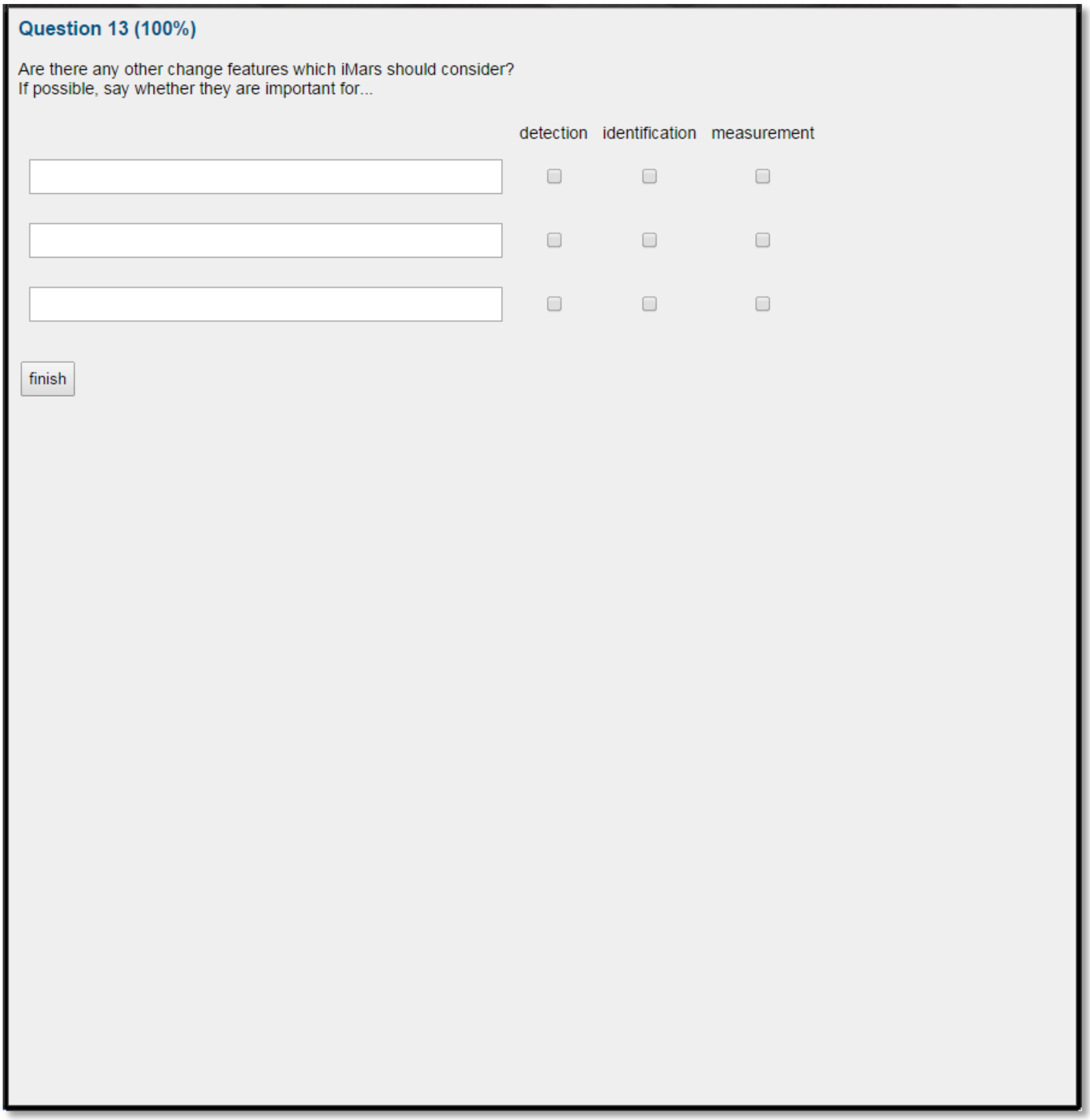


Figure III-18: Question 13 – Detection suitability #3 (topic: variable features #5).

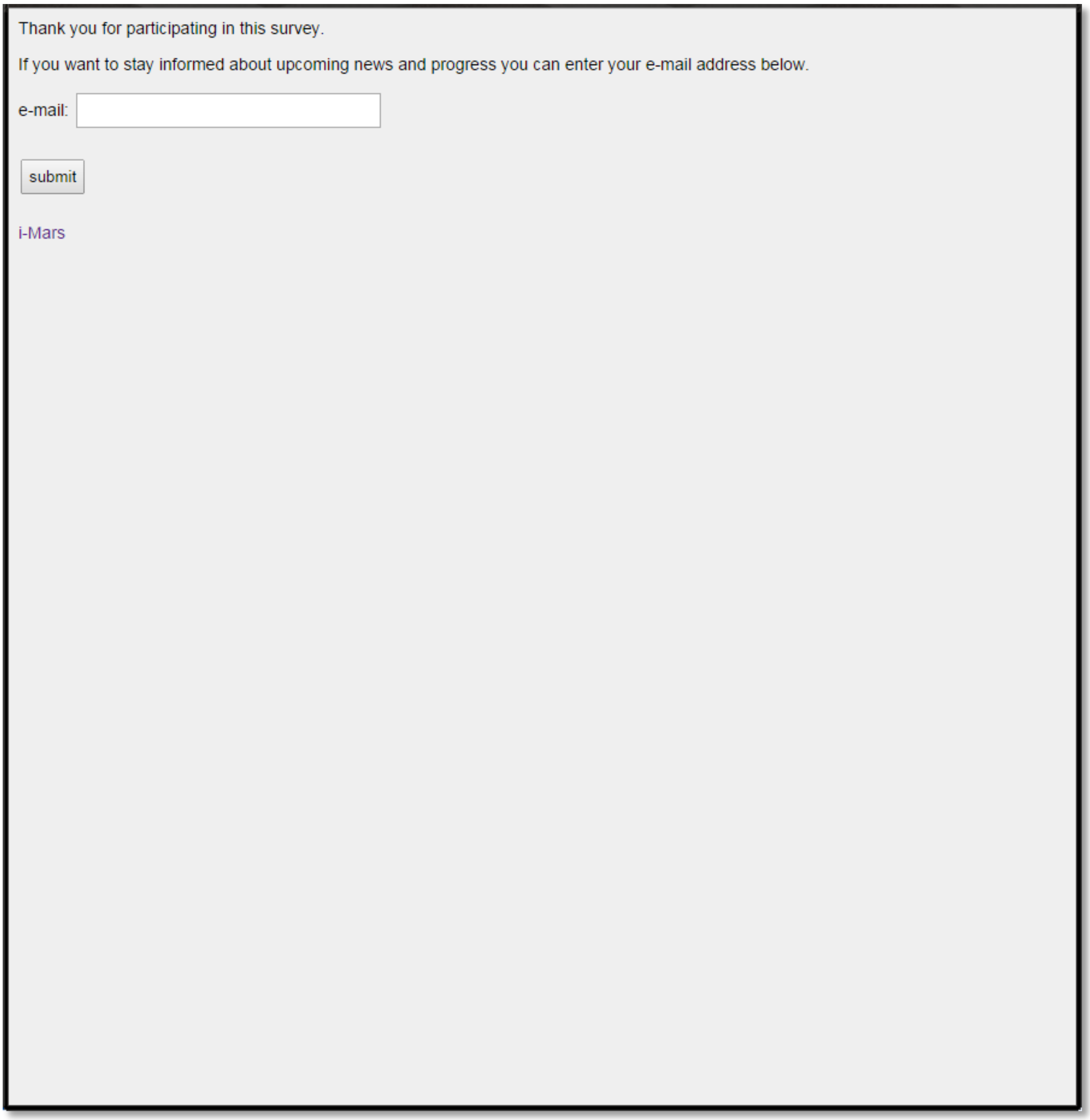


Figure III-19: Final dialog. Users may enter their e-mail address for regular updates.

ANNEX 4 – Table of survey results

Q1 Research Areas (RA)					
Morphology	**Composition**	**Geodesy and Topo**	**Geology**	**Engineering**	**Others**
1		1			
1				1	
1			1		
1	1		1		
1	1		1		
1			1		
1			1		
1			1		
1		1	1		
1			1		
1	1		1		
1		1			
1	1		1		
	1	1	1	1	
1			1		
1			1		
					fractal analysis on topography
1					
		1			
1		1	1		
		1		1	
		1			
		1			
1					
	1		1		
1			1		
1	1		1		
20	7	9	17	3	1
74%	26%	33%	63%	11%	4%

Figure IV-1: Survey results table for Question 1 (main scientific interest).

Q2 Dataset (DS)						
CTX	HiRISE	HRSC	THEMIS	CRISM	MOLA	Rover
1	1					
1	1		1			
1	1	1				
	1	1		1		
1		1		1		
1	1	1				
1		1			1	
1		1			1	
	1	1			1	
1	1				1	
1	1	1		1		
	1	1				
1	1			1		
1		1			1	
1		1			1	
1		1		1		
		1				
1						
		1				
1	1	1			1	
						1
1	1	1				
		1			1	
1		1				
1		1	1			
	1		1			
18	13	19	3	5	8	1
67%	48%	70%	11%	19%	30%	4%

Figure IV-2: Survey results table for Question 2 (most frequently used data sources).

Q3 GISUSE				Q4 GISEX			
daily	weekly	montly	never	expert	know-how	learner	none
	1			1			
1					1		
1				1			
1					1		
		1			1		
	1				1		
		1				1	
		1				1	
1				1			
1				1			
1					1		
		1					
1					1		
1				1			
		1				1	
1					1		
			1		1		1
		1					
		1				1	
	1						
			1				1
			1				1
1					1		
1					1		
	1			1			
11	4	7	3	6	10	4	3
41%	15%	26%	11%	22%	37%	15%	11%

Figure IV-3: Survey results table for Questions 3 and 4 (frequency and expertise of GIS usage).

Q5 PGIS
CTX i- hiriser mage finder;J Mars;google earth and
Google Earth;;
Google Mars;JMARS;web-based data search tools (ASU
JMARS;;
jmars;;
JMARS;HRSCview;
Google Mars; HRSCview
PDS
PDS; Analyst's Notebook; PSA
Mars Orbital Data Explorer; Google Mars

Figure IV-4: Survey results table for Question 5 (currently used GIS software/ platforms).

Q6 PUSE
It is not so easy to use web based gis with your onwn data Web - good visualization of data sets without having to fill a hard drive. Desktop - good points - calculations, data manipulation good vector file manipulation. statistics add in packages. pretty much any data from any planet can be used in them which is good for comparison work Availability without having to connect to the internet! Desktop - miss access to a wide variety of basemaps and on-demand viewing of large single-image files (HiRISE/CTX). Online - slow loading times for large images and reduced functionality - not as easy (or impossible) to make vector shapes, calculations, advanced raster functions. Web-based GIS allows to display data very quickly without having to process them but it cannot really be used for mapping and quantitative measurements. It takes some time to process the data and add them in a Desktop GIS. However, this is the only way to really extract some information from the data and to do mapping. I use only desktop GIS so far   1. Being able to process the data in your own way, rather than just use the maps available on the site. However, this clearly isn't really the point of online GIS at the moment. 2. Extracting data at certain points into a shapefile. Analysis and functionality not widely found in planetary web GIS. Customisability and programmability also. high-res. image export & layer management   Text and figure editing on Webbased GIS. real 3D   --- Fast display and small latencies when "processing" edits --- Check data availability; find regions by name

Figure IV-5: Survey results table for Question 6 (most relevant GIS functionalities).

Q7 GISPURP			
data availability	processing	analysis	map production
1	0	1	1
1	1	1	1
1	0	1	1
0	0	0	0
0	0	1	1
1			1
		1	1
		1	1
1		1	1
1		1	1
0		1	1
1			1
1	1	1	0
			1
1		1	1
		1	1
1			1
1			1
1			
1	1		1
		1	1
13	3	13	18
48%	11%	48%	67%

Figure IV-6: Survey results table for Question 7 (objectives of GIS use).

Q8
GIS FEATURES

Vectors	Attributes	Queries	Data Download	Map Production	Interactive Mapping	Complex Analysis	Fast Raster	Raster Processing	Raster Display
3	3	2	1	3	2	2	2	2	3
2	2	3	3	2	1	3	3	3	3
	2	1	-2	2	x	1	-3	-3	-1
-2	2	2	3	3	-2	x	3	1	3
3	3	2	2	3	2	2	1	2	3
2	2	2	2	2	-1	2	2	2	2
2	2	1	x	3	2	3	1	2	2
-2	0	1	3	3	2	3	1	0	3
-2	0	1	3	3	2	2	3	3	3
3	0	3	3	-2	-2	-2	3	-1	3
1	1	2	-3	1	1	2	-1	0	-2
1	1	1	1	2	1	1	1	1	1
0	1	1	1	2	1	0	1	1	1
-1	-3	0	1	2	1	-1	3	1	3
3	3	3	-3	-3	3	-3	3	-3	3
1	-3	3	3	0	-3	0	3	0	2
0,9	1,0	1,8	1,2	1,6	0,7	1,0	1,6	0,7	2,0

Figure IV-7: Survey results table for Question 8 (ranking of a list of GIS features).

Q9 CHFEAT			
Dust Devils Tracks	CO2 geysers	Dark Streaks	Rock Slides
1	1	1	
1	1	1	
1			
1		1	
1			
1		1	
	1	1	1
	1	1	
1			
	1	1	
1	1		
8	6	7	1
30%	22%	26%	4%

Figure IV-8: Survey results table for Question 9 (additional change features of interest).

Suitability					
detect		identify		measure	
	1				
		1			
			1		
			1		
			1		
	1		1		1
	1		1		1
	1	1		1	
			1		1
			1		1
	1		1		1
			1		1
					1
	1		1		1
			1		1
6		13		10	
22%		48%		37%	

Figure IV-9: Survey results table for Questions 10ff (suitability of computers to analyzing changes).