EPSC Abstracts
Vol. 8, EPSC2013-1001, 2013
European Planetary Science Congress 2013

On the Applicability of Geographic Information Systems for Landing-Site Assessments

S. van Gasselt (1), A. Nass (2,3)
(1) Institute of Geological Sciences, Freie Universitaet Berlin, D-12249 Berlin, Germany (Stephan.vanGasselt@fu-berlin.de),
(2) Institute of Planetary Research, German Aerospace Center (DLR), D-12489 Berlin, Germany, (3) Institute for Geography, University of Potsdam, D-14476 Potsdam, Germany.

1. Motivation and Background

As of 2013, a total number of 45 autonomous lander, sample-return or rover missions have been launched to the Moon, Venus, Mars, and Titan since 1960. Slightly less than 50% of these attempts were successful (see [4] and compilation in figure 1). Reports of the National Research Council (NRC) or recent surveys and roadmaps of space agencies clearly state the importance of autonomous units operating on the surface of other planets as precursors to in-depth robotic analyses and human exploration [1, 2, 3].

The selection of landing sites for autonomously operating planetary probes is a complex task, mainly because of partial gaps in the determinability of surface properties based on remote-sensing data, but also because scientific as well as engineering aspects need to be co-evaluated to provide a basis for a successful and effective mission-operation with measurable scientific output. Science criteria are always related to a set of (planet-specific) surface investigations conducted at a distinct location. Engineering constraints pick up science criteria and form an additional set of requirements within a geospatial context. This context makes it attractive to make use of established tools to geospatially analyse, define and rate locations in terms of a feasibility and safety assessment for lander or rover operations. For terrestrial applications, integration, analysis and evaluation of data from a geospatial domain are today usually conducted using highly modifiable but generic geographic information system (GIS) technology (GIST).

GIS allow us to define workflow models related to geospatially defined data and to extract information from such investigations. We here want to discuss how standard demands as put forward by recent mission-planning scenarios can be evaluated using standard GIST, i.e. we want to define adaptable workflows for solving characteristic problems. As a second aim, such

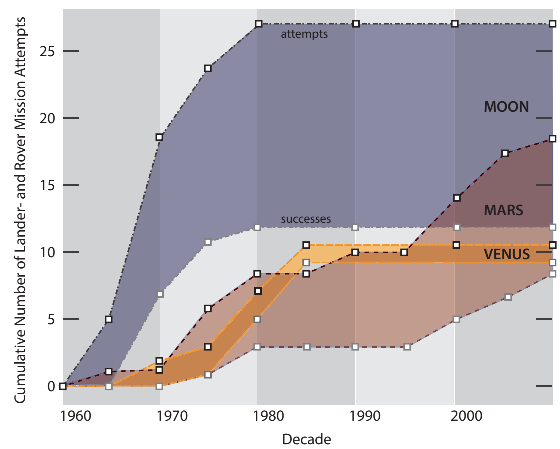

Figure 1: Cumulative overview plots of planetary landers, sample-return and rover mission designed for the Moon, Venus and Mars. Upper boundary curves mark cumulative number of planned mission, lower boundaries represent actual successes within 5-year binning intervals (source [4].

a procedure should provide a basis for discussion on how such systems can potentially provide not only (direct) data-management and evaluation support but also support for extraction of information, and, finally, decision support and evaluation of results.

2. Work Concept

Planetary lander and rover missions are cost-intensive and require intensive dedicated planning for various mission phases including entry, descent, and landing (EDL) in order to facilitate surface operations and science-data return. Planning involves different methods for extraction of information and evaluation of results in order to arrive at a decision. Software systems designed for decision support (DS) involve capabilities to adjust to changing boundary conditions

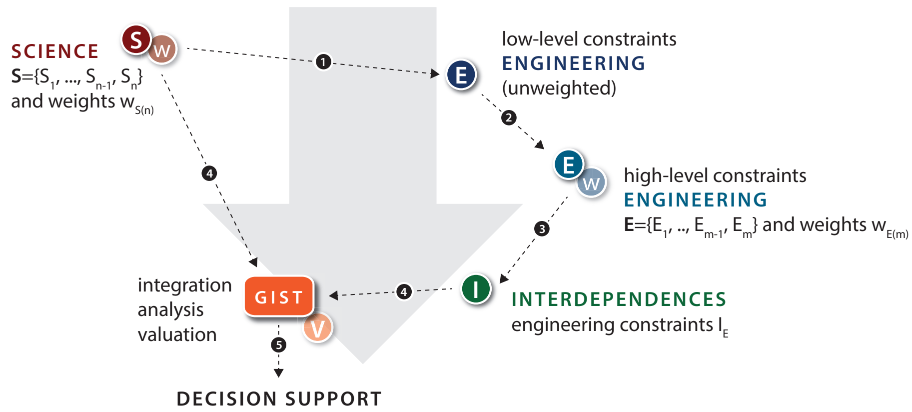

Figure 2: Different levels of requirements for landing-site selection and integration for evaluation.

(parameters) in a flexible way, i.e. they must respond adequately to a set of *input requirements*. Such systems must also allow to easily define and refine evaluation standards and as these standards are operation-dependent, they are prone to change and form *evaluation requirements*.

Both capabilities, adjustment to input requirements and definition of scales (for evaluation), are provided high-level in off-the-shelf GIS and are part of the GIS analysis subsystem. Consequently, it should be possible to define an overarching framework for landing-site assessments and decision support, with an adjustable parametrization in terms of input requirements and evaluation. Such a framework should then return results based on pre-defined standards and return sets of potential landings-site zones. Such a process is based upon input parametrization and includes (see figure 2):
(a) *input: science impact*: definition of impact and scientific constraints, i.e. importance of science arguments vs. engineering constraints (fig. 2, S),
(b) *input: engineering requirements*: definition of low- and high-level weighted physical/engineering constraints (fig. 2, E),
(c) *interdependences*: definition of interdependences between constraints sets (fig. 2, I),
(d) *evaluation requirements*: definition of well-defined scales defining the exact impact of constraints (fig. 2, V).

While scientific constraints are relevant for mission definition, engineering constraints can cause termination of a mission. Consequently, constraints come in to flavours: either non-weighted or with a weighted set of criteria that have to be evaluated in parallel. Additionally, parameters can be highly dependent on others: if, for example, an average number of rocks of a given size per unit area separates a good landing site from a less favourable one, no information on the distribution of rocks can be derived and a homogeneous distribution is suggested. Interdependences I built upon different engineering requirements E_i must therefore be modelled adequately: The set of I consists of functional terms involving E_i and defining necessary and sufficient criteria.

A conceptual valuation tool based on these basic components and modal-logic approaches has been built within a commercial off-the-shelf GIS and its potential (and validity) will be discussed during the presentation.

Acknowledgements: Author A.N. acknowledges support by the European Planetary Network.

References

[1] NASA (2006): Solar System Exploration – Roadmap for NASA's Science Mission Directorate, vi+144 pp., NASA JPL, CL#06-1867-A.

[2] National Research Council Space Studies Board (2011): Vision and Voyages for Planetary Science in the Decade 2013-2022, 410 pp., The National Academies Press (Washington).

[3] ESA (2005): Cosmic Vision – Space Science for Europe 2015-2025, 111 pp., BR-247.

[4] National Space Science Data Center (NSSDC) Master Catalog, Goddard Space Flight Center, Internet: http://nssdc.gsfc.nasa.gov. (accessed May 2013).