DLR SPACEBOT CUP - GERMANY'S SPACE ROBOTICS COMPETITION

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ABSTRACT

In 2010 Germanys Ministry of Economics and Technology formulated the goals for a competitive and sustainable space strategy[1]. Robotics is a major column within this strategy and therefore, numerous activities in space robotics were initiated. One of those activities, the DLR SpaceBot Cup, is presented in this paper.

Key words: Planetary Robotics, Field Testing, Robotics Competition.

1. INTRODUCTION

Following the National Robotics Conferences in 2009 and 2012, the German Aerospace Center (DLR) developed and announced the DLR SpaceBot Cup as a national space robotics competition. The goal of this activity is on the one hand a better understanding of Germanys state of the art in academia and industry, relevant for space robotics. In its role as space administration, DLR has to know where strength, weaknesses, and technological gaps lie. On the other hand, DLR SpaceBot Cup is supposed to kick-start efforts to fuse singular technologies into working designs, ready to be benchmarked. With its focus on performance benchmarking it shares objectives with earlier efforts such as the ESA Lunar Robotics Challenge[2].

In its premiere in November 2013, stakes were high. Ten teams took the challenge to design and implement a robotic surface exploration system in not more than nine months. Ground control, mobility, perception, and manipulation were only some of the tasks to be accomplished. In the end, only partial tasks could be accomplished, although all systems were capable from a technological viewpoint (see [3]).

Two years later, the stage will be set again. Following the analysis of the lessons learned in DLR SpaceBot Cup 2013, DLR announced the second round mid-2014. Ten teams have been selected for participation and are working on their solutions to a demanding mission in November 2015. Their robotic systems will be deployed onto a sparsely known planetary surface and conduct exploration of the environment, take a soil sample, find and collect two artificial objects, and mount them to a third object. Communication between ground control station and planetary surface will be limited and impaired by delay, making autonomous functionality crucial for the success of the mission.

Figure 1. Rover manipulating the artificial objects, Source: DLR (CC-BY 3.0)

2. DLR SPACEBOT CUP

The DLR Space Administration envisioned the SpaceBot Cup to be a valid test for system capability. Since a major part of the desired capabilities for planetary exploration lies in the field of land robotics, the calls for participation were intentionally addressed at land robotics and not exclusively the space robotics community. This served two purposes: firstly, we wanted to find the best possible approach for a robotic system to solve the task. Secondly, make the land robotics community aware of their potential in space robotics. Potential that might prove to be of value for the German space program. In both the 2013 and the 2015 competition there are entrants without prior experience in space robotics.

In order to achieve validity, a series of requirements have to be fulfilled by both the competition environment and the teams. The core demands are listed in table 1. The teams have 60 minutes to complete a run. During the run, two objects have to be found, collected, and brought to a third object. Here, minor assembly is required (see 1).

Table 1. *Requirements of DLR SpaceBot Cup*

Mission Design
Area has to be explored Demanding terrain Infrastructure tasks Scientific taks Impair communication No GPS
Robotic System Design
Mapping, Localization, Navigation Perception Manipulation up to 800 g Deal with communication delay of 2 s Weight limit of 100 kg Autonomous operations
Benchmarking
Comprehensible scoring system and rule set Incentives to perform mission oriented

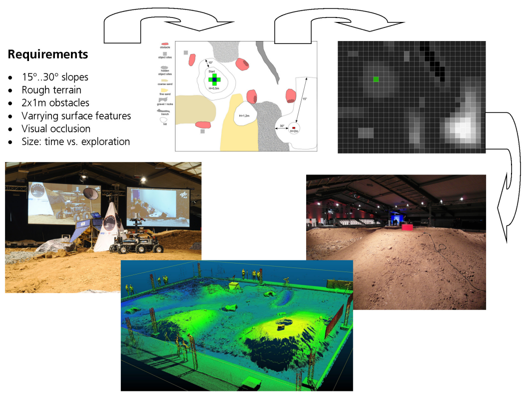

Figure 2. Building a Planet: The terrain of SpaceBot Cup 2013, Source: [Photos]DLR (CC-BY 3.0), [3D Scans] RWTH Aachen MMI

The yellow battery mock-up represents the infrastructure part: build a working scientific experiment. The blue cup represents the science part: collect/carry a sample to the on site laboratory. The red base object represents landed scientific instrumentation. Besides task completion, the system tested has to be capable of dealing with the SpaceBot Cup Model Planet as it is laid out on competition day. This encompasses lighting conditions, surface features, delayed and temporarily unavailable network traffic, disturbances through being indoors, and many more.

The central design task, besides the rulebook, is the the terrain. Focus here are possible future exploration targets like moons and planets like Mars. Requirements to be satisfied are therefore roughness and a general demanding environment for the system's mobility, the necessity to explore, and a perceivable texture of the surface (see 2 and 3). Nevertheless a competition like the SpaceBot Cup is constantly evolving in visible features like terrain and public events as well as behind the scenes.

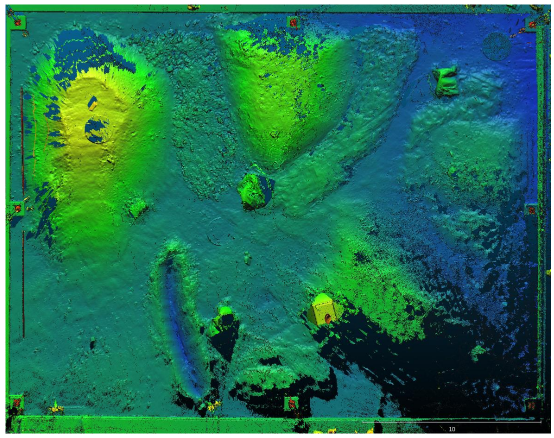

Figure 3. Elevation map of SpaceBot Cup 2013 Terrain, Source: RWTH Aachen MMI

Figure 4. A ground control station setup, Source: DLR (CC-BY 3.0)

2.1. Lessons Learned

The teams of 2013 were essentially capable of fulfilling their requirements. The systems' mechanical and electrical designs were mostly performing well in the SpaceBot Cup environment. However, during the runs many teams had to deal with unexpected failures that prevented fluent operation. Subsequently, the jury decided not to specify a ranking.

Following the event in November 2013, we collected and discussed lessons learned from the various stakeholder points of view: teams, organizers, jury members, and external observer. It showed that the paths leading to suboptimal performance were varying. A few prominent types of error were:

- compatibility problems with the managed communication infrastructure (e.g. high traffic demand, low time outs)
- perception in on site conditions (e.g. object detection false positives)
- code management (e.g. wrong version of s/w module)

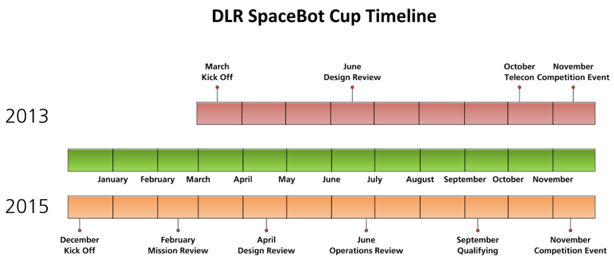

Figure 5. Timeline of the DLR SpaceBot Cups 2013 and 2015

The aggregated responses however also showed that a few factors are identified to have a large effect on the magnitude the system's shortcomings.

- Time - In 9 month most of the work goes into engineering and building a capable system. Quality management and testing however become secondary objectives.
- Testing - Rigorous testing for performance and compatibility eliminates most preventable sources of error.
- Communication - To have a clear understanding of the mission and foreseeable demands is key to mission success.
- Qualification - A "pre-flight test" a reasonable amount of time before the competition shall give a clear picture on requirement compliance.

With regard to time and communication, we as organizers introduced an updated timeline and review schedule (see 5). Time for development is now a full year. The review structure for 2015 includes three reviews of which two are on site. This is intended to help teams keep on track with their development goals and identify problems in the systems' design early on. Introducing a qualifying two month before the competition serves mainly the purpose of giving the teams a strong incentive to have a working basic system ready on time.

3. THE NEXT STEP: DLR SPACEBOT CUP 2015

In mid-2014 DLR Space Administration announced the second round of the SpaceBot Cup. Out of the pool of applicants ten teams qualified for participation (see 2 and 6). The scenario inherits strongly from DLR SpaceBot Cup 2013[3], yet we expect improvements. The main updates are the schedule described above with a rigorous qualification test, the chance to perform soil sampling as opposed to carrying a cup of water, and moving towards a crater like scenario.

4. CONCLUSION AND OUTLOOK

In 2013 the DLR SpaceBot Cup proved to be a versatile tool. It sparked development and educational opportu-

Table 2. The ten selected teams of DLR SpaceBot Cup 2015

Team	Organisation
AGAS	Uni Koblenz-Landau
ARTEMIS	DFKI Bremen
Attempto	Uni Tübingen
Carpe Noctem	Uni Kassel
Chemnitz University Robotics Team	TU Chemnitz
LAUROPE	FZI Karlsruhe
NimbRo Explorer	Uni Bonn
RMexplores!	DLR RM Oberpfaffenhofen
SEAR	TU Berlin
spacebot 21	hochschule 21 Buxtehude

Figure 6. Participants of SpaceBot Cup 2015, Source: `http://d-maps.com/carte.php?num_car=4692&lang=de`

nities in space robotics, brought the subject to a broad audience, and generated valuable insights for Germany's Space Administration. Nothing less is expected of DLR SpaceBot Cup 2015.
In September 2015 the qualifying will be a test for the teams as well as for the updated organisational approach. The competition event in November will then show which team may claim the SpaceBot Cup.

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