Cliffbot CRV tests

Mars2013 simulation

Main results

The CRV and an operator in the Aouda spacesuit

Summary

1 Objectives

The Cliff Reconnaissance Vehicle (CRV or "cliffbot") is intended to send cameras and/or scientific instruments downhill on slopes which are not safely accessible by men mostly when they are operating in space suits. The CRV 3-4 used for the 2013 Morocco simulation and as provided by Planète Mars association is only equipped with a camera.

Till now, and it was also the case in the 2012 Dachstein experimentation, **main objective** has been to demonstrate the vehicle mobility capabilities on slopes with more or less obstacles, different slope angles (even including more than 90° i.e. overhanging) which can be summarized as "terrain trafficability demonstration". One understandable objective is to be able to retrieve and bring back uphill the vehicle. One particular objective for the Morocco simulation may be, according to available photos of the area, to test the vehicle on very high cliffs. Most tests till now have been conducted on less than 18 m high cliffs. Higher cliffs will increase the elastic behavior of the rope.

The **second objective** is to assess what are the operating difficulties when the vehicle is operated by an operator in space suit. A derived objective is to test the operations only with the gloves.

The **third objective**, for an operator either in a spacesuit or without a spacesuit is to assess and see how to improve the vehicle situation awareness. The situation awareness is obtained through the forces feeling by the operator on the suspension rope, through visual observation of the vehicle and through the information transmitted uphill by the on board video camera. The visual observation may come from the operator himself but the direct visual link is often quickly lost when the vehicle is in the slope. Then the operator may stop the operations, tie the suspension rope to the anchoring point and have a look from another point to see the vehicle. Or someone else may observe the vehicle from a different point and send information to the operator.

The **fourth objective**, linked to the present type of instrument on board (i.e. a camera) is to assess geological interpretation capabilities. This activity is conducted in house outside the experiment field. Other instruments may be fitted on the vehicle if wished by other participants. The main limitation is the weight. The payload plate is a multiperforated plate which allows for different types of fixations (bolts, T raps,…)

2 Tests general information

Test n°	Date	Localisation (+ indication on a map separately)	Vertical Heigth m	Rope length m	Comments (spacesuit ops or not, difficulties, duration)	Data acquired (sciencecam, hazcam visual/photos/recording, outside photos or videos)
90	9/12/12	Outside wall Innsbruck Red Cross building	1,5	1,5	Operations in Aouda spacesuit	Sciencecam recorded (6 mn), hazcam on
91	9/12/12	Outside wall Innsbruck Red Cross building	1,5	1,5	Operations in Aouda spacesuit, vehicle in inverted position, 2 runs	Sciencecam recorded (5mn and 2 mn), hazcam on
92	3/2/13	North Camp Erfoud; close to WP1; west from WP1	5	6	Ops by D. Schildhammer in Aouda S; vehicle prepared by A. Souchier (anti roll rods and equipments on); 3 runs; 4m vertical then 35° slope	Hazcam and sciencecam operational; hazcam picture on the monitor; monitor photos; tests 92 to 95 filmed by Austrian TV Servus
93	"	"	8	16	Ops by A. Souchier; blockage at the lowest point: a rock protrudes between the right wheel spokes (see photos); manual deblockage; return up by a different way (length 21 m)	Hazcam and sciencecam operational; hazcam picture on the monitor
94	"	"	6	7	Ops by D. Schildhammer in Aouda S; vehicle prepared by A. Souchier (anti roll rods and equipments on); 4 runs on more than 4 m; 2 runs on 2 m; 1 run on 6 m; 1 run on 4 m; 1 run on 6 m; tests conducted between 15h35 and 16h00	Hazcam and sciencecam operational; hazcam picture on the monitor
95	"	"	7	10	Ops by A. Souchier	Sciencecam off; hazcam operational; objective was video by the TV crew of the hazcam monitor
96	5/2/13	¼ th of the big cliff North of Black Hill	19	19	Blockage on the way up 2 m under the starting point: the anti yaw main rod is stuck and slightly bent between two rocks (photos available); deblockage from under by a 3 m pole from a rocky (photos available); strong help from the polish TV team which was following the test	Sciencecam off; hazcam on and picture on the monitor (excepted when the vehicle is at maximum distance)

97	6/2/13	Above WP 1 at the crest top; 31N22.532 and 4W3.348	8	10	Operations by G. Groemer in Aouda S including all preparatory operations (anti roll rods and equipments on); 8 m vertical; overhang; the vehicle comes back rotated 180°; momentary blockage of the rope in a cliff crack; freed by pulling harder; pole to hold the receiver away from the cliff would be interesting	Hazcam and sciencecam operational; hazcam picture on the monitor
98	"	East of preceding point; 31N22.535 and 4W3.330	20	36 (max rope)	Operations by G. Groemer in Aouda S; 5m vertical then 35° debris slope	"
99	"	East of preceding point; 31N22.532 and 4W3.337	20	36	Operations by G. Groemer in Aouda S; same profile	"
100	"	Very close to first point; 31N22.532 and 4W3.348	20	36	Operations by G. Groemer in Aouda S; same profile; the vehicle rotates 180° in the overhang and roll on the debris slope with hazcam looking in front; comes back still rotated 180°	" Sciencecam videos from tests 92 to 100 provided to the TV teams; also loaded in the base camp computers.
101	18/2/13	31N22,551 et 4W03,280		46	Operations without spacesuit from the top of one of the fossil mud volcanoes. Red laser weak	TBC
102	"	Same location	Around 5	5	From the same location, exploration of a cave with a sky opening. The vehicle is used without the anti roll rods.	TBC
103	"	31N22,902, 4W2,986 Northern end of Kess Kess chain	32	32	Operations without spacesuit; quasi vertical cliff	TBC
104	"	Sphynx point	8	8	Operations without spacesuit; quasi vertical cliff; vehicle stopped before reaching the bottom of the cliff on an horizontal area	TBC

105	19/2/13	31N22,880, 4W 04,442	23	23	Operations without spacesuit; quasi vertical cliff	TBC
106	"	250 m west of previous test	15	15	Operations without spacesuit; quasi vertical cliff	TBC
107	"	31N22,880, 4W04,442; Western tip of the Kess Kess cliffs	35	35	Operations without spacesuit; quasi vertical cliff	TBC
108	"	31N22,864, 4W4,236	17	20	Operations without spacesuit; 60° slope cliff	TBC
109	"	31°N22,822, 4W4,070	18	18	Operations without spacesuit; vertical cliff	TBC

3 Results

Objective 1

During the 18 tests conducted in Morocco two "trafficability" problems occurred. In test 93 where the vehicle, after a 4 m vertical cliff, was operating in a debris slope, the operator was unable to pull it back because a 40 cm boulder was protruding between the right wheel spokes. Releasing the rope and pulling back, changing the operator position on the cliff was inefficient to solve the problem. The vehicle was moved by an observer on the slope and then brought back by the operator. As an excuse the debris slope is not exactly the type of slope for which the vehicle is designed. A solution however would be to have plain wheels. The present vehicle, which is only a demonstrator, was designed with the requirement of being able to fit in a suitcase for transportation which precludes the use of plain wheels.

During test 96 the vehicle was blocked on its way up a cliff. The rod linking the rope to the vehicle (also called anti yaw rod) engaged in a crack between two rocks which gave it a slight S shape. Releasing the rope was unable to let the vehicle go down under its own weight. The problem occurred 2 m from the top of a 18 m cliff. Fortunately a small plateau under the vehicle provided an access path from which the vehicle was pushed up by a 3 m rod. It is not known if pulling strongly the rope would have solved the problem.

These two tests were conducted by an operator without spacesuit.

During test 97 conducted by an operator in a spacesuit a momentary blockage occurred. The rope was inserted in a roughly vertical crack in the cliff. The vehicle was freed by pulling harder on the rope. The operator suggested that a "tool" pole which could be used to push more or less horizontally the rope away from the cliff would be interesting to solve this type of problem. It could have also been a solution for the blocking during test 96.

No other trafficability difficulties were reported during tests 101 to 109 when the PI was no more on the field in Erfoud.

Vehicle blockage at the end of test 96: the anti yaw rod is engaged (and slightly bent) between two blocks. Under the vehicle (left photo) the black pole which will be used to push it upwards is visible.

Considering the objective of extending the length on which the vehicle was tested, the objective was fulfilled. One test was conducted with a total rope length of 46 m. The rope container holds 36 m of rope and reaching 46 m implied to connect the end of the rope to another one in a second container. Three tests were conducted also till the 36 m of the first container rope length.

Objective 2

No special difficulties seemed to have been encountered linked to the vehicle operations in the Aouda spacesuits.

Objective 3

To improve the vehicle situation awareness by the operator the Hazcam which send real time pictures to the operator, was equipped with a rear facing mirror. For the Morocco campaign the Hazcam was oriented downwards. The orientation can be modified before a test. The rear facing mirror was thus looking upwards, trying to provide a view towards the upper part of the cliff. The mirror takes one fourth of the camera field of view. Probably it is not enough to have a clear view of the vehicle surroundings. Initially the idea was to equip the vehicle with two Hazcam looking up and down, but a two channels TV emitter was not found in time for the vehicle delivery to Innsbruck in December 2012. A solution where the two camera signals could be alternatively received uphill with only one video channel could be also interesting. The mirror was lost during tests 97 to 100. It was reported by the operator, during tests 97 to 100, that the picture seen uphill from the downward looking Hazcam was giving indications on the vehicle rotation under an overhanging while the vehicle was not visible from above, thus also, by the way, indicating that it was proceding under such an overhanging.

Picture from the Hazcam showing the debris slope with an observer in the upper left corner and the rear (upwards) facing mirror in the upper right corner

The CRV is now equipped with a new HD camera (in the Siencecam position) and the pictures may be received in real time on a smartphone which could improve the situation awareness. This capability was not used in Morocco.

It is interesting to note that the blockage during test 96 was not understandable from the Hazcam picture and also (later on during the analysis) from the Sciencecam picture. Understanding the blockage would have needed a lateral viewing camera looking at the right wheel. During the test 97, the blockage was understood by direct viewing and not by the Hazcam picture. Finally two 170° field of view cameras would be at minimum necessary. One solution tested in 2006 during the MDRS 43 simulation in Utah, was to install the Hazcam in a small pod roughly one meter above the vehicle on the rope and looking towards the vehicle. But the pod itself may be a blocking cause. In Utah it was only experimented on a smooth slope.

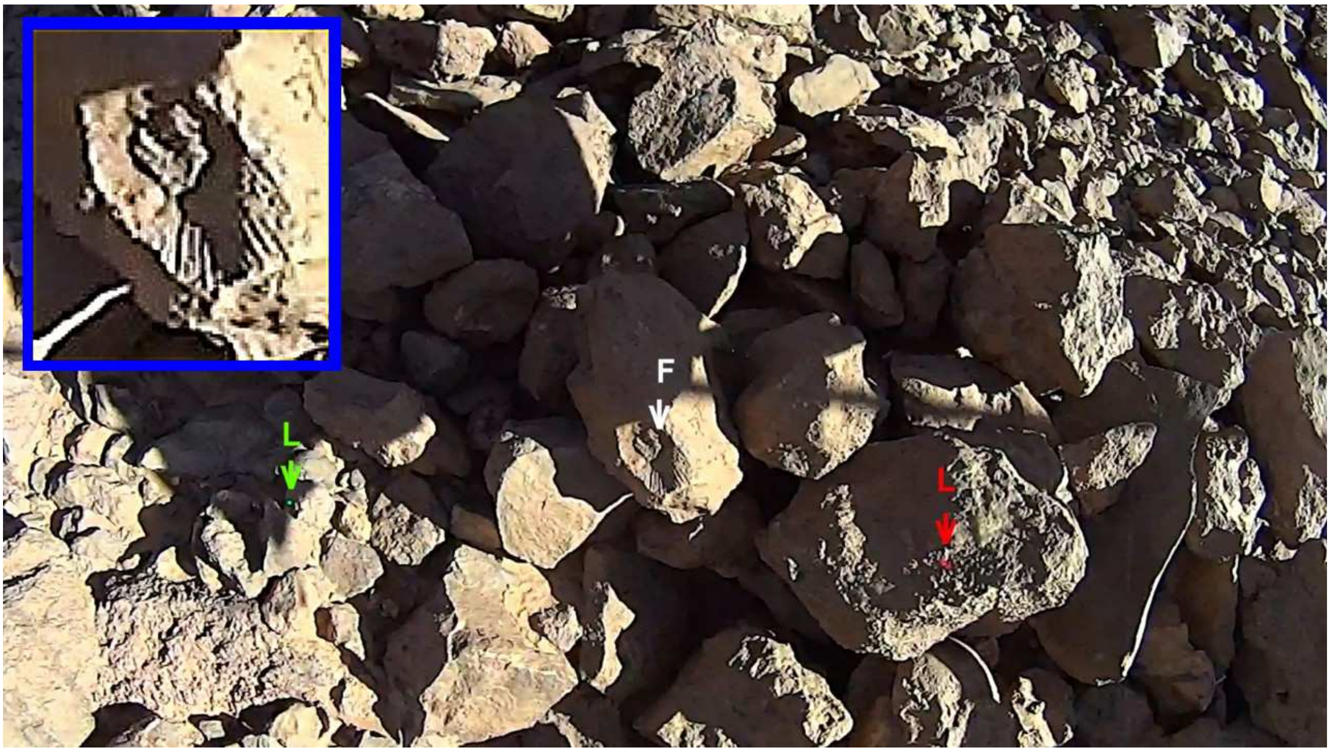
Objective 4

Interesting results were obtained in geological and terrain analysis in Morocco. Ten years ago, with the previous version of the vehicle, some tests were conducted on clay slopes on the Normandy sea side, in an area called the “Black Cows cliffs” where a lot of fossils from the tertiary era are embedded in the ground. Numerous fossils are visible on the ground by an observer. But in the camera field of view which covered only a width of around 20 cm, not so many fossils were visible.

In Utah there were not many fossils visible in the cliffs so the geological analysis was limited to cliff vertical cartography by stitching photos extracted from the videos.

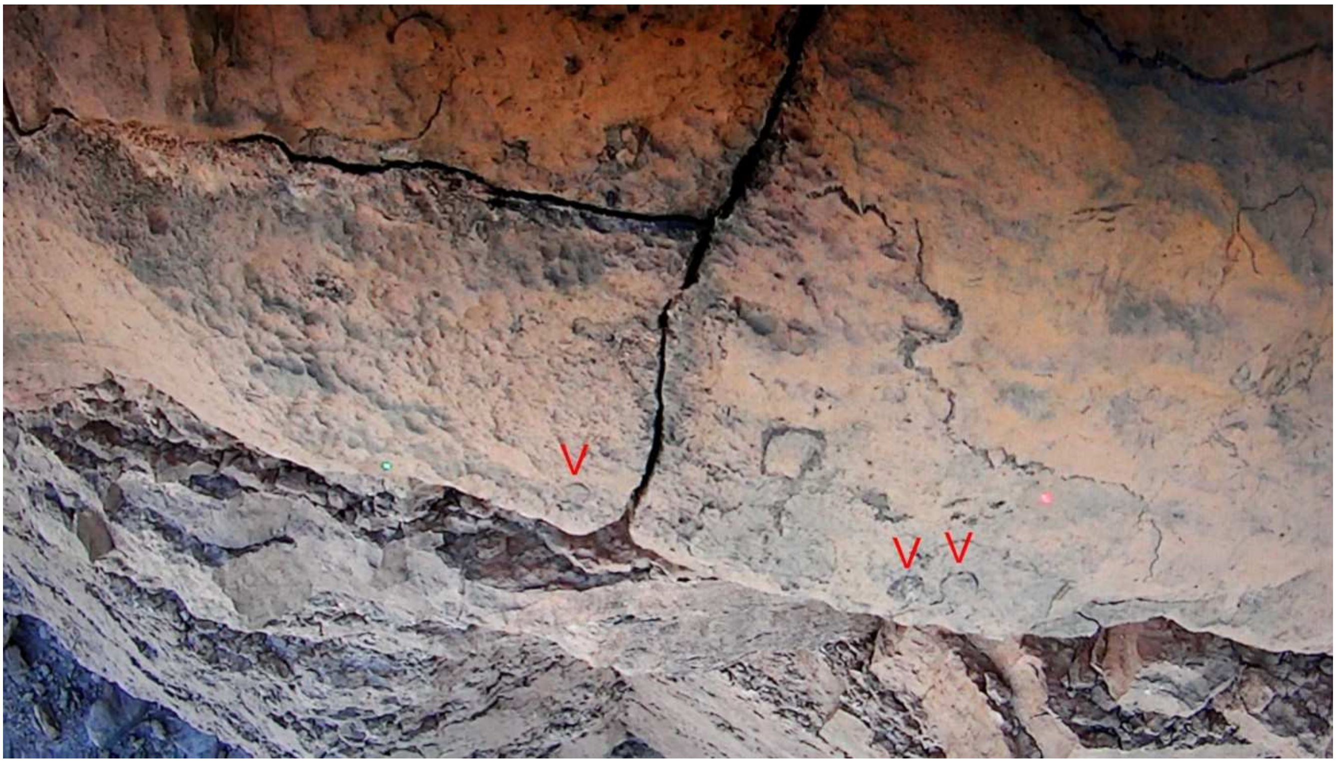
During the Morocco campaign, the new HD camera had a 120° field of view (a 170° field of view can also be selected). Numerous fossils were detected on the videos taken during tests 92 to 100. For the following tests the Sciencecam videos are not yet available.

The following photos give examples of the fossils detected in Morocco operations. Also the vehicle was useful to find intriguing blue stones at the bottom of a cliff, which were not visible from above.



Test 93 time 6.41 : The two lasers spots give a dimension reference of 22.5 cm. The fossil size in the middle may thus be deducted at 18 mm.

Test 94 time 24.42: two imbricated shell fossils.



Test 97 time 3.16: possible indication of fossils (circular shapes); the two laser spots, green on the left and red on the right are visible. Their distance is 22,5 cm, thus the circular shapes are 1.2 cm in diameter.

Test 97 time 9.33: possible fossils on the rocks in the debris slope.

Test 98 time 2.48: blue rocks and a fossil in the upper right.

Test 98 time 5.01: cylindrical rock which may be a fossil. Many were found on the field.

Test 98 time 5.11: striated rock.

Test 98 time 7.58: nice fossil of a shell.

Test 100 time 0.36: grey blue area in the cliff.

Other results

The 18 th of February, the operating team discovered a cave with a sky opening in one of the Kess Kess mud volcanoes and sent the CRV exploring this cave. The anti roll rods were not fitted to the vehicle to decrease the vehicle width. The video taken on board is not yet available to determine if any interesting features were found.

One of the Kess Kess mud volcanoes with a cave featuring a sky opening (doc. OeWF/Katja zanella-Kux).

During test 102 the vehicle is sent in a cave (most probably the one visible in the previous photo; tbc). This is a nice demonstration of accessibility by the vehicle of an area which cannot be reached in a spacesuit.(Doc. OeWF).

Concerning operations, a problem occurred the 6th of February during the batteries loading operations. The vehicle had to be ready at 11 am. The two 6V batteries charging is done in two steps: a long one under 6 V and a short one under 7.5 V. The battery n°1 was left under 7.5 V charging during breakfast and left too long (30 mn) leading to overheating. Fortunately a spare battery was available for this type of problems or others, and, at 9.41 am, the vehicle was ready with the new battery in place fully charged.

Overheated 6V battery one.

4 Conclusions

During the Morocco ÖWF Mars 2013 Mars exploration simulation campaign, the Cliff Reconnaissance Vehicle (or “Cliffbot”) test objectives were fulfilled.

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(docs APM/A. Souchier excepted if indicated otherwise)