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Raman Laser Spectrometer (RLS) on-board data processing and compression

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Abstract

The Raman Laser Spectrometer (RLS) is one of the Pasteur Payload instruments, within the ESA's Aurora Exploration Programme, ExoMars mission. Particularly, the RLS scientific objectives are as follows: identify organic compound and search for life; identify the mineral products and indicators of biologic activities; characterize mineral phases produced by water-related processes; characterize igneous minerals and their alteration products; characterise water/geochemical environment as a function of depth in the shallow subsurface.

The straightforward approach of operating the instrument would result in a vast amount of spectrum images. A flexible on-board data processing concept has been designed to accommodate scientific return to the sample nature and data downlink bandwidth.

1. Introduction

The nature of the materials being analysed makes measurements differ one to the other. The acquisition of the spectra from different materials shall be, therefore, adaptive and dynamic. This, makes mandatory the development of means to perform on-board processing in order to:

1- Estimate the acquisition parameters
2- Merge and compress together images acquired within a stable environment
3- Prioritize the downlink of traces of interest found.

Currently, development of extended Phase B is on going and it is expected to hold a PDR end 2013. During this phase, the validation of algorithms is being done, and it's expected to share processing resources with the Rover.

RLS is being developed by an European Consortium composed by Spanish, French, German and UK partners. It will perform Raman spectroscopy on crushed powdered samples inside the Rover's Analytical Laboratory Drawer.

2. On-board processing cycle

During a Raman Measurement Cycle, two main tasks are performed: Optical Health Check Activity and Sample Measurement Activity. The former will verify the region of interest within the CCD illuminated area, while the latter will perform two acquisitions:

1- Reference spectrum: used to remove fluorescence, calculate time of exposure, number of shots and accumulations, and identify traces of interest within the spectrum.

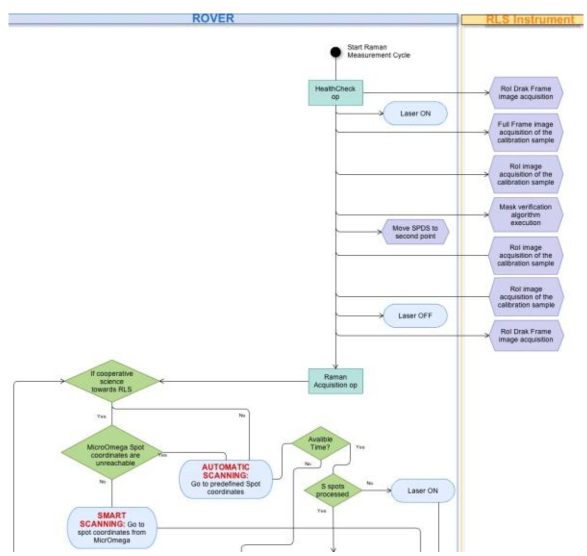

Figure 1: Measurement Cycle 1

2- Final spectrum: acquire the sample with the inferred parameters, prioritize downlink, merge images and compress.

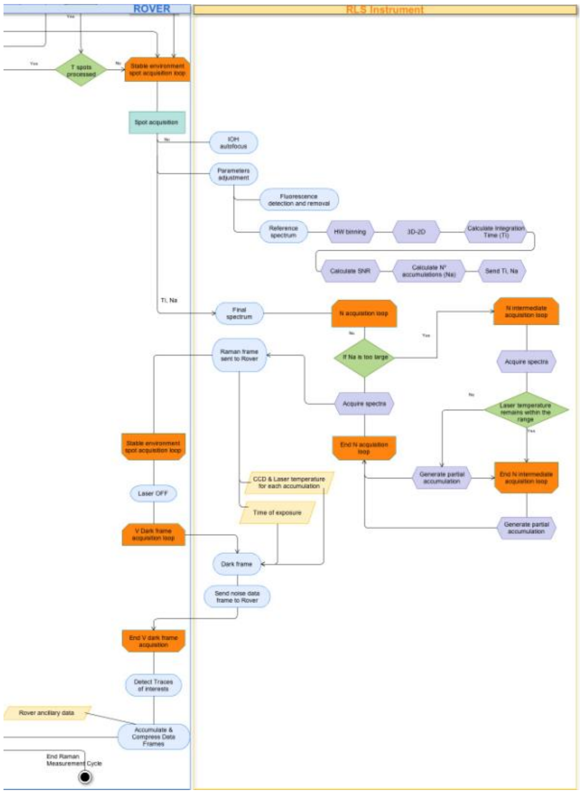

Figure 2: Measurement Cycle 2

2.1. Region of interest verification and acquisition parameters estimation.

RoI verification algorithm runs taking, as inputs, images from a calibration sample. It identifies the CCD area where the spectrum is projected, and the shape of the spectral distribution.

The acquisition parameters estimation is based on SNR maximization criteria, inferring: the time of exposure so that the CCD will not saturate, and the number of shots to be accumulated (averaged) in order to increase SNR and reduce operational time.

2.2. Traces of interest detection

This algorithm is intended at providing the RLS the ability to detect potential points of interest along the spectral line. This way the instrument will have the ability to prioritize the download of interesting points, and provide earth with valuable information for the next decision point. When interesting traces are found, scientific Telemetry will be prioritized accordingly and will be downloaded as critical scientific data.

The parameters, which make a Raman spectrum interesting or not, are related to the possibilities of finding a sample related to extant or past life, as well as with water related mineral activity. Hence, the importance of a spectrum is based on its spectral characteristics, i.e., having peaks at certain spectral regions, due to the fact that some determined molecular bonds will vibrate at a determined frequency.

2.4. Merge and compress

After a compression analysis, it has been decided to combine/merge several images in one, before compression. This provides better compression ratios than separately. Several combinations of images were tested at different levels: at pixel (Join pixels of 3 images, one by one), row (first row of the first image, under which goes first row of second image…) and image level (join images, one after the other).

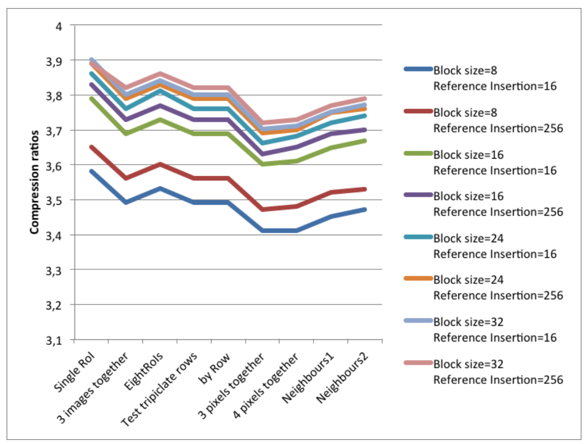

Figure 3: Impact of Rice algorithm parameters on different combinations of images.

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