FFI FACTS

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September 2018 - Design /production: FFI

The RIMFAX radar is developed at the Norwegian Defence Research Establishment (FFI) and selected by NASA to be one of the science instruments on board the NASA rover to Mars in 2020.

The radar has the ability to penetrate to more than 10 meters depth depending on ground conditions.

Ground Penetrating Radar - GPR

The Radar Imager for Mars' Subsurface Experiment – RIMFAX – is a ground penetrating radar that will add a new dimension to the rover's toolset by providing the capability to image the shallow subsurface beneath the rover in unprecedented detail. RIMFAX will aid the Mars 2020 Rover's mission to explore the ancient habitability of its field area, and select a set of samples that will eventually be returned to Earth.

GPR is a geophysical method that is widely used on Earth to study subsurface bedrock, soils, groundwater and ice. It has also been used successfully by the Chinese lunar rover Yuto to study the structure of the lunar crust. GPR instruments send radio frequency electromagnetic waves into the ground and then detect the reflected signals as a function of time to reveal the subsurface structure.

RIMFAX will provide a detailed view of the subsurface structure in the Mars 2020 rover's field area that will complement large-scale measurements from the orbital radars MARSIS and SHARAD.

RIMFAX History

RIMFAX is based on a number of GPR instruments developed over the past 25 years. These instruments have been deployed successfully to study a range of terrestrial environments, including temperate glaciers on Svalbard, ice shelf studies in Antarctica, snow

accumulation on glaciers, and on the US-Norwegian Antarctic Traverse.

RIMFAX was selected in July, 2014 by NASA to be one of seven instruments on the Mars 2020 rover.

Scientific Objectives of RIMFAX

Radar is an outstanding remote sensing technique for Mars because it can easily penetrate the ubiquitous surface dust and regolith layers. Both Earth-based radar imaging and spacecraft radars have revealed buried terrains such as lava flows, buried channels, and polar ice cap stratigraphy.

A significant challenge in Mars rover missions has been the lack of access to vertical stratigraphy. The principal goals of the RIMFAX investigation are to image subsurface structure, and to provide information regarding subsurface composition. RIMFAX has the potential to provide a view of the stratigraphic section and a window into the geological history and associated environmental history.

Due to planetary protection requirements, the Mars 2020 rover will not be targeted to a site where near-surface ground ice or liquid water are likely to be present within the first few meters of the surface. However, the existence of deeply buried layers of ice, liquid water, or brines that are not in equilibrium with present climatic conditions cannot be excluded by presently available observations. RIMFAX's potential to provide new information regarding this possibility is substantial.

Depending on materials, RIMFAX will image the subsurface stratigraphy to more than 10 meter depth, with vertical resolutions better than 30 cm, and a horizontal sampling distance of 10 cm along the rover track. The data provided by RIMFAX will aid the Mars 2020 rover in its mission to explore the ancient habitability of its field area, and select a set of promising samples for caching and eventual sample return.

RIMFAX is planned to be operating while the rover is moving. RIMFAX will measure the surface reflection and use that for a first estimate of the surface permittivity and thereby the radar propagation velocity in the near surface. The radar wave is attenuated as it propagates down into the subsuface of Mars. The RIMFAX radar is therefore designed to have a high System Dynamic Range so as to be able to look deep into the martian subsurface. This is done by gating the radar and collecting two soundings every 10 cm with different radar parameter settings: One sounding collected for shallow near surface structures and one sounding for deeper structures.

Field tests

Mars is a cold and arid planet with no liquid water at the surface. A RIMFAX prototype instrument has been tested during several field seasons on Svalbard sounding into snow, ice and permafrost rock. The radar was mounted on a sled pulled by a snowmobile.

In April 2018 the RIMFAX instrument was tested in different type of Mars like geology in Utah, USA. The instrument was mounted on an electric vehicle and the figure shows a sounding profile from Coral Pink Sand Dunes in Utah.

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RIMFAX
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MARS 2020

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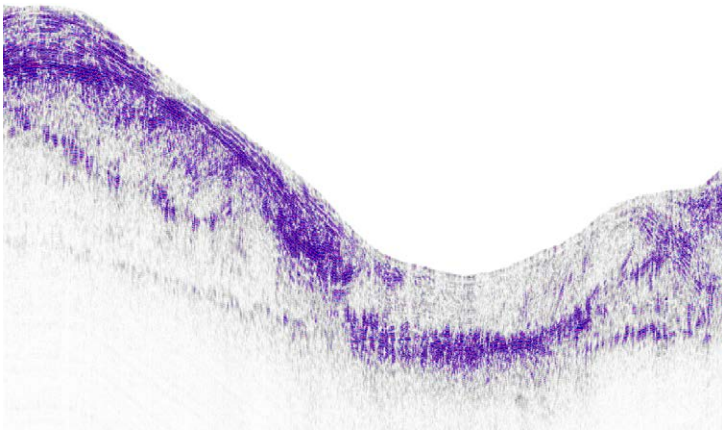
The radar system

The RIMFAX radar is a gated Frequency Modulated Continuous Wave (FMCW) radar operating over the frequency band 150 – 1200 MHz. The radar is made up of an electronics box and an ultra wideband slot antenna. The electronics is mounted inside the Mars 2020 rover while the antenna is mounted on the rear of the rover looking down.



RIMFAX Instrument mounted on an electric vehicle simulating the Mars rover in Utah in 2018. The image above: RIMFAX sounding from Coral Pink Sand Dunes in Utah showing subsurface sedimentary layers.