THE MARS ATMOSPHERIC TRACE MOLECULE OCCULATION SPECTROMETER (MATMOS): AN OVERVIEW. S. A. Conway[1], K. Strong[1], K. A. Walker[1], K. S. Olsen[1], P. O. Wennberg[2], V. J. Hipkin[3], J. R. Drummond[4], G. C. Toon[5], P. B. Berube[6], J. J. Veilleux[6] and the MATMOS team, [1]Department of Physics, University of Toronto, 60 St George St, Toronto ON M5S 1A7 Canada, sconway@atmosp.physics.utoronto.ca, [2]Division of Engineering and Applied Science and Division of Geological and Planetary Sciences, California Institute of Technology, Pasadena CA 91125 USA, [3]Canadian Space Agency, John H. Chapman Space Centre, 6767 Route de l'Aéroport, Saint-Hubert QC J3Y 8Y9 Canada, [4]Department of Physics & Atmospheric Science, Dalhousie University, Sir James Dunn Building, Halifax NS B3H 3J5 Canada, [5]Jet Propulsion Laboratory, California Institute of Technology, 4800 Oak Grove Drive, Pasadena CA 91109 USA, [6]ABB Inc., 585 Boulevard Charest Est, Suite 300, Quebec QC G1K 9H4 Canada.

Introduction: The Mars Atmospheric Trace Molecule Occultation Spectrometer (MATMOS) is an infrared Fourier transform spectrometer (FTS) designed to detect trace gases in the Martian atmosphere with very high sensitivity. MATMOS was intended to fly on the ESA/NASA Exomars Trace gas Orbiter (EMTGO) in 2016, but was withdrawn in early 2012. Its initial selection for EMTGO provided opportunity for development, allowing algorithms and technology to be advanced in readiness to follow up future results from EMTGO, MAVEN, and the Mars Science Laboratory. Based on ACE-FTS (the Atmospheric Chemistry Experiment Fourier Transform Spectrometer) on board SCISAT-1, MATMOS is an occultation instrument measuring the solar spectrum between 850 and 4300 cm^{-1} at a spectral resolution of 0.02 cm^{-1} with a target signal-to-noise ratio greater than 200. Such high quality spectra can enable measurements of a large suite of atmospheric compounds with projected detection limits on the order of parts per trillion. In this work, we will give an overview of the design and projected capabilities of the spectrometer and discuss the instrument's present status and some test results.

Instrument Design: The MATMOS instrument follows a line of successful Fourier transform spectrometers designed to study the composition of the atmosphere from space. Notable instruments include ATMOS (Atmospheric Trace MOlecule Spectrometer) which flew on the Space Shuttle four times, the MkIV Fourier Transform Infrared Interferometer which has completed 21 balloon flights and ACE-FTS which has been providing measurements of over 30 species in the stratosphere and upper troposphere since early 2004. The interferometer design is derived from the ACE-FTS, and builds on the expertise acquired in Canada from the Canadian Space Agency's SCISAT-1 mission [1].

MATMOS is designed to obtain infrared transmittance spectra of the Martian atmosphere using the Sun as its source. Measurements are made twice per orbit (at sunset and sunrise) at tangent heights ranging between 0 and 200 km with ~3 km vertical resolution. The transmittance spectra, from which the concentration of various species can be retrieved, are determined using the ratio of these measurements with the solar spectrum acquired above the atmosphere [2].

One of the main advantages of the design of the MATMOS instrument is its simplicity as shown in Fig. 1. The spacecraft points the instrument to the center of the Sun and a small telescope gathers the sunlight and directs it to the interferometer. The sunlight is then modulated and directed to two detectors, an HgCdTe detector covering 800-1900 cm^{-1} and an InSb detector 1850-4320 cm^{-1}. Data processing will be performed on board due to data telemetry limitations. Corrections are applied to the raw interferograms before being converted to spectra, averaged, compressed and finally transmitted to Earth, thus greatly reducing the data volume [3].

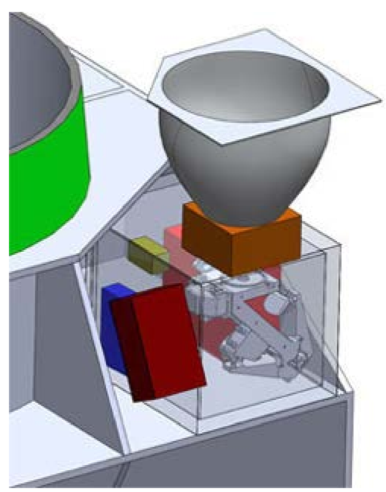

Figure 1 *Schematic view of the MATMOS instrument mounted on science deck of the ExoMars spacecraft [3].*

The MATMOS interferometer design is based on ACE-FTS. It is a Michelson interferometer with two corner cubes mounted on a V-shape rotary arm [4]. The beam of light, as shown in Fig. 2, is reflected back by a mirror in one arm of the interferometer and by reflective coatings on sections of the beamsplitter [4] to achieve the +/- 25 cm optical path difference (OPD).

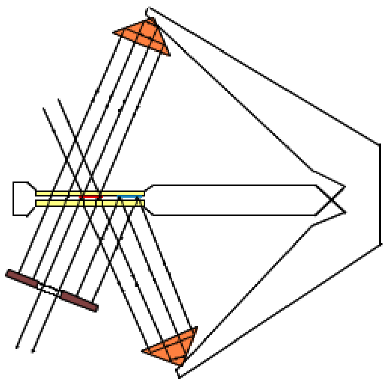

Figure 2 *Schematic of the MATMOS beam path [4].*

The planned features of the MATMOS instrument are summarized in Table 1.

Table 1 *MATMOS FTS Parameters [4]*

Parameter	Value
IR spectral range	850-4300 cm^{-1}
Spectral resolution	0.02 cm^{-1}
Maximum OPD	+/- 25 cm
Telescope diameter	80 mm
External field of view	1.56 mrad (~ 3 km vertical resolution for ExoMars TGO orbit)
Detectors	HgCdTe; InSb
Signal-to-noise ratio	> 200
Rate of acquisition	6 speeds: 2-6 s /spectrum (beta angle dependent)

Instrument Capabilities: High accuracy retrievals of multiple atmospheric species are possible due to MATMOS' high signal-to-noise ratio, high spectral resolution and broad spectral range. The projected limits of detection of the MATMOS instrument range between 1 and 100 parts per trillion [3]. The expected performance for several of the gases of interest is shown in Fig. 3 for 100 averaged profiles under high (dashed line) and low (solid line) dust conditions (τ = optical depth). In addition, retrieval of the isotopic composition of major and minor gases is possible. The projected precision for CO_2, CO and H_2O isotopologues in the Martian atmosphere for 100 averaged occultations, are shown in Fig. 4.

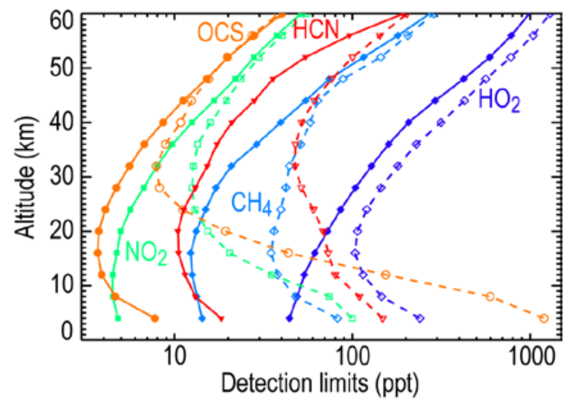

Figure 3 *Projected detection limits of the MATMOS instrument for 100 averaged occulations for high (τ = 0.6, dashed line) and low (τ = 0.1, solid line) dust opacities [3].*

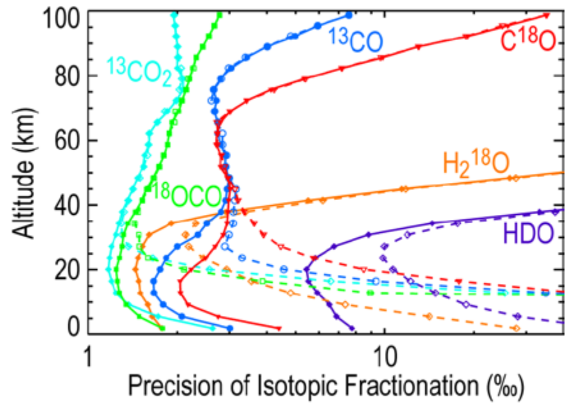

Figure 4 *Projected precision of isotopic abundances of CO_2, CO and H_2O for a 100 occultation average under high (τ = 0.6, dashed line) and low (τ = 0.1, dashed line) dust opacity [3].*

MATMOS EDU Testing: An Engineering Demonstration Unit (EDU) of the MATMOS interferometer subsystem was constructed by ABB Inc. The EDU has been used for testing and characterization with a focus on gaining a better understanding of interferometer performance, primarily the modulation efficiency of the interferometer, under simulated measurement conditions. In addition to acquiring solar spectra, instrument line shape measurements have been made using gas cells and stability tests have been performed. Results from the EDU testing will be presented.

References: [1] P.F. Bernath et al. (2005) *Geophys. Res. Lett., 32*, L15S01. [2] C. Boone et al. (2005) *Appl. Optics, 44 (33)*, 7218-7231. [3] Wennberg, P. O. et al. (2011) *Fourth international workshop on the Mars atmosphere: Modelling and observations*, Abstract. [4] L. Moreau et al. (2011) *OSA FTS Meeting*, Abstract #FTuA3.