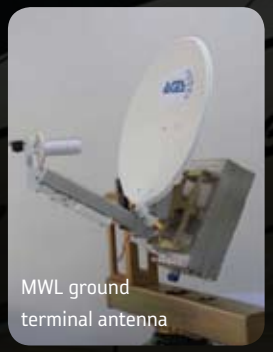
The ACES Operations



MWL ground terminal antenna

ACES will be operated from the ACES User Support Operations Centre at the CADMOS facility in CNES Toulouse. Operations make full use of the existing European ISS infrastructure and ground networks including the Columbus Control Centre and a special network of microwave terminals which are linked to the most stable and accurate ground clocks available.

The Science Community

The ACES Science community is composed of two groups:

- The Investigator Working Group (IWG) co-chaired by the ESA project scientist supported by 22 scientists from 6 countries.
- The International Users Committee (IUC) is composed of a further 60 scientists from 10 countries.

Scientific Objectives and Applications

The scientific objectives of the ACES mission include:

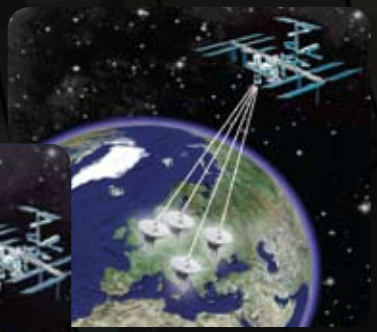
- To demonstrate the performances of a new generation of space clocks;
- To achieve time and frequency transfer with stability better than 10^{-16};
- To perform fundamental physics tests.

The results of these comparisons will provide new tests of fundamental laws of physics such as an improved measurement of Einstein's gravitational red-shift, a search for anisotropies of the speed of light, and a search for space-time variations of fundamental physical constants.

A new method for mapping the Earth's gravitational potential based on a measurement of the differential red-shift experienced by two clocks at two different locations will be demonstrated by ACES.

ACES will connect TAI laboratories and compare the best primary standards, contributing to the generation of atomic time scales.

Global clock comparison



Common view clock comparison

The ELT in combination with the ACES MWL will allow studies of atmospheric propagation delays.

A GNSS receiver directly connected to the ACES clock signal will provide accurate orbit determination and support GNSS remote sensing applications (radio-occultation and coherent reflectometry).

For more information please contact:
rosario.nasca@esa.int

Or consult the ACES web-page:
www.esa.int/ACES

Front page: The ACES payload (without thermal insulation) is shown mounted on the Columbus external payload facility

September 2011

→ ATOMIC CLOCK ENSEMBLE IN SPACE (ACES)

European Space Agency

Atomic Clock Ensemble in Space (ACES)

The Atomic Clock Ensemble in Space (ACES) is a fascinating new experiment that will expand the range of research on the International Space Station (ISS).

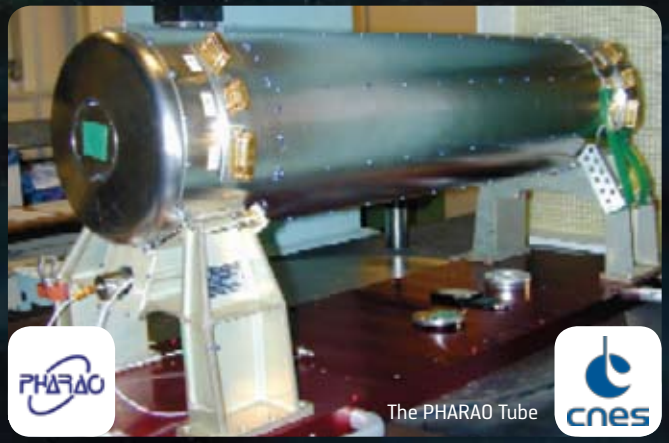
Time flies on the ISS

The most precise measurement of time yet – in space – will be used to probe our knowledge of the fundamental laws of physics governing the Universe. ACES will test Einstein's general relativity and alternative theories of gravitation. Taking full advantage of the microgravity environment provided by the ISS, ACES will establish a stable and accurate onboard timescale which will be used to perform space-to-ground and ground-to-ground comparisons of the best available atomic clocks.

The ACES Payload

The ACES payload is designed for launch in the unpressurised cargo bay of the Japanese H-II Transfer Vehicle (HTV). Once in orbit, ACES will be attached to the Columbus Laboratory Earth-facing external payload platform using the Space Station Robotic systems.

The key instruments are the two atomic clocks:



The PHARAO Tube

- PHARAO (Projet d'Horloge Atomique par Refroidissement d'Atomes en Orbite) is a primary frequency standard based on samples of laser cooled cesium atoms. PHARAO is funded and developed by the French National Space Agency (CNES).

- SHM (Space H-Maser) is an active hydrogen maser for space applications developed in Switzerland by Spectratime under ESA contract with funding provided by the Swiss Space Office (SSO).

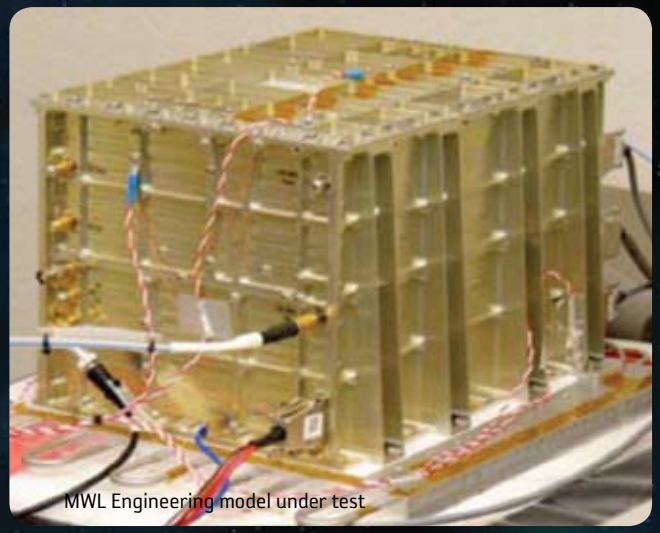

SHM bulb assembly

The performances of the two clocks are combined to generate an onboard timescale using the excellent short-term stability of SHM and the long-term stability and accuracy of PHARAO.


FCDP Engineering model

The comparison of PHARAO and SHM and the distribution of the ACES clock signal will be accomplished using the Frequency Comparison and Distribution Package (FCDP).

Telecommand and data handling processes will be controlled by the eXternal PayLoad Computer (XPLC). A GNSS receiver connected to the onboard timescale will provide precise orbit determination of the ACES clocks. It will support radio occultation and radio reflectometery experiments.


MWL Engineering model under test

The clock signal will be transferred to ground by a specially designed dual frequency bi-directional, 4 channel microwave link (MWL).

The European Laser Timing (ELT) link will allow clock comparisons, time transfer, and ranging experiments in the optical domain. The combination of ELT and MWL will also permit detailed studies of atmospheric propagation delays.

The ACES Mission

The planned mission duration is 18 months with a possible extension to 3-yrs. After optimisation performances in the 10^{-16} range for both frequency instability and inaccuracy are expected.

This corresponds to a time error of about 1 second over 300 million years.

Eventually worldwide comparisons with the best available ground clocks using different atoms or molecules will be performed with 10^{-17} frequency resolution. The results being used to test fundamental laws of physics and to challenge our knowledge of the Universe.