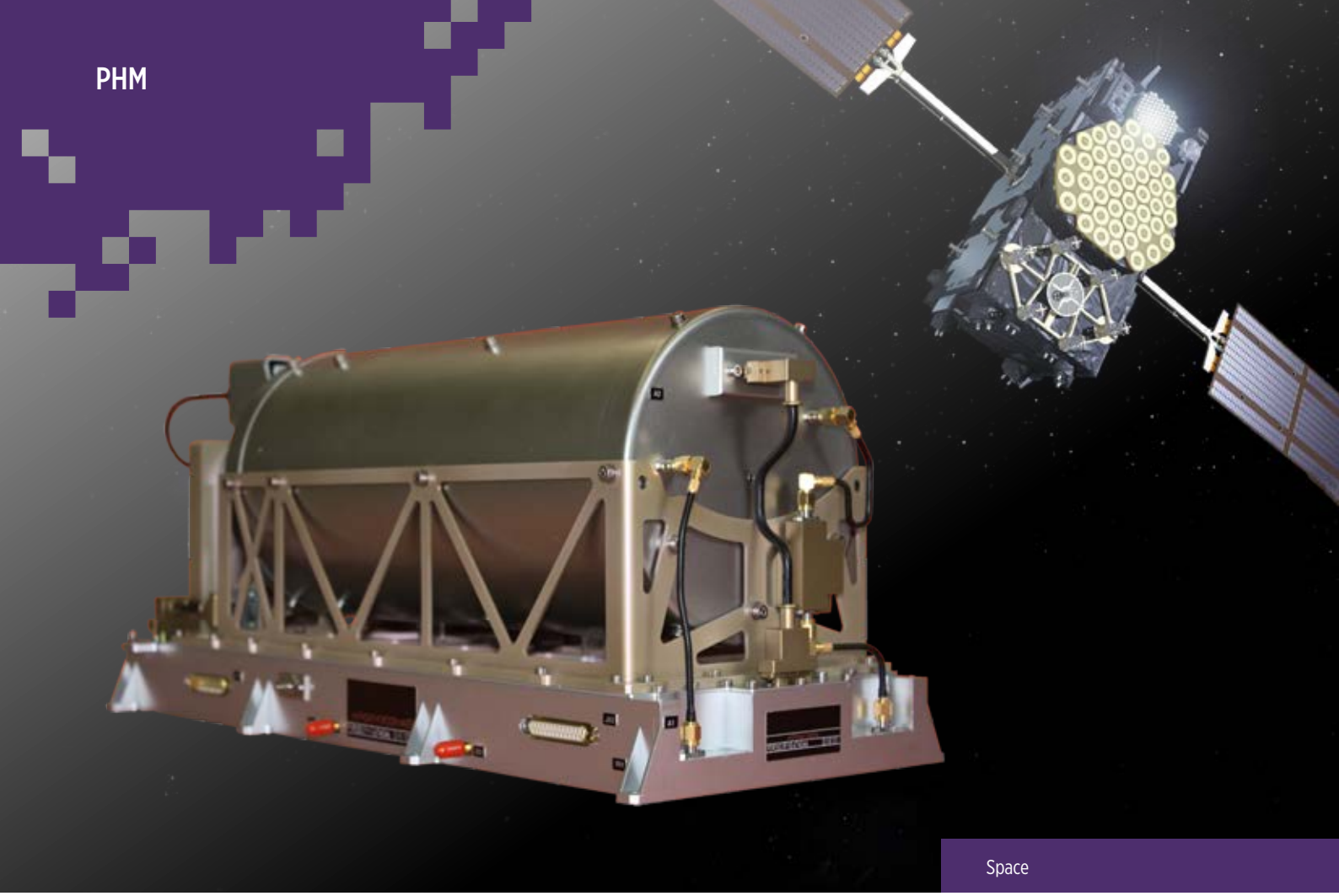

Space

PASSIVE HYDROGEN MASER

PHM is an atomic clock used for precise positioning, timekeeping and other onboard applications. Designed to operate in space for more than 12 years, it offers an outstanding stability for averaging times from 1 to 100,000 seconds. The company is also developing a mini PHM, which offers the same frequency stability as the PHM in a smaller package.

The PHM clock consists of two modules, named Electronic Package and Physics Package respectively. Its operating principle is based on the stimulated microwave emission at the frequency of 1420.4057517 MHz, generated by the decay of the hydrogen atoms inside the microwave cavity of the Physics Package.

The ultra-stable microwave signal emitted by the atoms is used to lock an Ultrastable Oscillator, providing the 10MHz standard reference frequency. The PHM is the most precise spaceborne atomic clock ever developed for an operational programme. In addition, it has been designed and qualified to comply with all space requirements, including radiation.

The PHM is the master clock of the Galileo Navigation Satellite System, developed in the frame of the joint ESA/EU programme for satellite navigation.

Following its successful experimental flight onboard GIOVE-B (Galileo In-Orbit Validation Element) in 2008, the company completed production of the PHM for the four In-Orbit Validation (IOV) satellites, subsequently launched in October 2011 and 2012. As of March 2013, it was possible to calculate a true Galileo-derived position on the ground by using the IOV satellites for the first time.

We have been working on the production of the PHM for the complete Galileo satellite constellation, with 15 PHM flight units already delivered to the Payload Prime Contractor, SSTL.

We lead the development of the PHM and its Electronics Package, with Orolia Switzerland Inc. as subcontractor for the supply of the Physics Package and Ultrastable Oscillator.

PHM

MPHM

Mini Passive Hydrogen Maser
With the contribution of Orolia Switzerland under an ESA contract financed by ASI, the company has been developing, since 2010, a mini PHM for the GALILEO Next-Generation Phase. The aim of the mini PHM project is to provide an instrument with the same frequency stability as the PHM, but with reduced volume and mass, less operational constraint, lower power consumption and environmental sensitivity.

The first development phase, completed in 2010 with an Elegant Breadboard Model, demonstrated that the stability performance of the PHM can be achieved with a smaller and lighter Physics Package. In the frame of the current phase, the Electronic Package has been redesigned, providing great improvements in term of mass and electrical performance.

The mini PHM design is based on the same technology and operating mode of the well consolidated PHM, leading to an instrument with improved characteristics and reliability, thanks to a consolidated expertise.

TECHNICAL SPECIFICATION

	PHM	Mini PHM
Output Frequency	10.00285741MHz (fH/142)	10.00285741MHz (fH/142)
Output Level	+ 7dBm (main and auxiliary outputs)	+ 7dBm (main and auxiliary outputs)
Frequency Drift (/Day)	$\leq 1x10^{-14}$ after 1 week $< 1x10^{-15}$ after 30 days	$\leq 1x10^{-14}$ after 1 week $< 1x10^{-15}$ after 30 days
Allan deviation ($1s<t<10^4s$)	$< 1x10^{-12} \times t^{-1/2}$ max. $< 7x10^{-13} \times t^{-1/2}$ typical	$< 1x10^{-12} \times t^{-1/2}$ max. $< 7x10^{-13} \times t^{-1/2}$ typical
Freq. sensitivity to temperature	$< 2x10^{-14}$/°C	$< 1 x10^{-15}$/°C
Freq. sensitivity to Main Bus Voltage	$\leq 3x10^{-15}$/V	$\leq 3x10^{-15}$/V
Dimensions	210 x 500 x 250mm	210 x 485 x 218mm
Mass	18.2Kg	12Kg
Main Bus Voltage	50V ± 1V	50V ± 1V
Power consumption (W)	≤ 70W at -5°C baseplate ≤ 60W at +10°C baseplate	≤ 54W at -5°C baseplate ≤ 47W at +10°C baseplate
Qualification Temperature Range	- 15°C to +20°C	- 15°C to +20°C
Lifetime (MEO Orbit)	>12 years	>12 years
ADEV (Secs)		
1	$1.8x10^{-12}$	$6.5x10^{-13}$
10	$3.2x10^{-13}$	$1.4x10^{-13}$
100	$7x10^{-14}$	$6.3x10^{-14}$
1000	$2.2x10^{-14}$	$2.2x10^{-14}$
10,000	$7x10^{-15}$	$7x10^{-15}$
50,000	$< 1x10^{-14}$	$< 1x10^{-14}$

LEONARDO
AIRBORNE & SPACE SYSTEMS

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