DISC, the Dust Impact Sensor and Counter, on board Comet Interceptor ESA space mission, for in situ dust environment characterization of a dynamically new comet.

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Introduction: The Comet Interceptor space mission [1] was selected by ESA in June 2019 as the first Fast-class mission. Comet Interceptor will have the capability of characterizing a dynamically new comet, or an interstellar object, if it will be found on a suitable trajectory. These bodies can only be discovered when entering the inner Solar System, so Comet Interceptor will be probably launched before its exact target is known. A unique, multi-point 'snapshot' measurement of the comet-solar wind interaction region is to be obtained, complementing single spacecraft observations previously made at other comets.

The instrument suite Dust-Field-Plasma (DFP) will measure: the charged gases, energetic neutral atoms, magnetic fields, and dust surrounding the comet. DFP includes the Dust Impact Sensor and Counter (DISC) to characterize in situ the cometary dust environment.

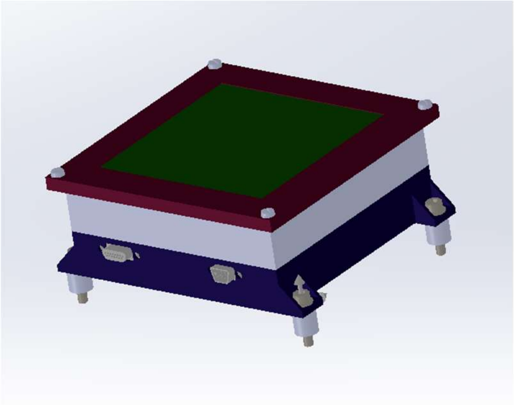

Figure 1 DISC instrument box 3D Cad model

DISC design: DISC consists of a single parallelepiped-shaped aluminum box (121 x 115,5 x 46 mm^3) containing the electronics and the sensing plate. At the bottom of the mechanical box two electronic boards are housed: one dedicated to the digital processing and communication with DAPU functions, the other dedicated to the sensor's analog signal conditioning. Above the electronic boards there is a "dust shield", which has the purpose of protecting the electronic boards from possible hypervelocity dust particles crossing the sensing plate, located at the top of the box and exposed to the dust environment. To save mass the dust shield, in the current design, is made of aerogel blocks installed within a lightweight aluminum container connected to the box. The design of the sensing device will be similar to the GIADA-IS (Grain Impact Analyser and Dust Accumulator-Impact Sensor) flown successfully on-board the Rosetta/ESA space mission [2]. The sensing plate is equipped with 3 zirconate piezoelectric sensors (PZTs) glued at the corners of a 0.5 mm thick aluminum plate, resulting in a 100 x 100 mm^2 sensitive area. The PZTs detect the acoustic bending Lamb waves, generated by the dust impact, propagating across the plate and convert the elastic deformation of the plate into an electrical signal whose amplitude is linked to the momentum of the impacting particle. A calibrator PZT transducer is also glued under the fourth corner of the aluminum plate. This internal calibrator produces a repeatable excitation signal monitoring DISC responsivity during in-flight operations.

DISC working principle: DISC aims to determine: dust mass distribution; dust particle count; dust impact duration; dust density/structure; dust coma features. DISC is a monitoring instrument: when the dust impact is above the DISC sensitivity the acquisition is enabled and the data is recorded.

Preliminary simulations show the compatibility of the GIADA Impact Sensor configuration with the performances expected for DISC. Preliminary simulations of Hyper Velocity Impacts (HVI) were carried out to check the Lamb waves induced in a sensing plate with the mechanical characteristics of the GIADA impact Sensor. HVI simulated signal is reported in *Figure 3* (upper panel) and compared with real signal produced by a PZT of the GIADA Impact Sensor (lower panel) after a low-speed particle impact (< 40 m/s). Simulation results confirm for HVI, far from the impact point, a similar elastic behavior of the sensing plate as for low-speed impacts.

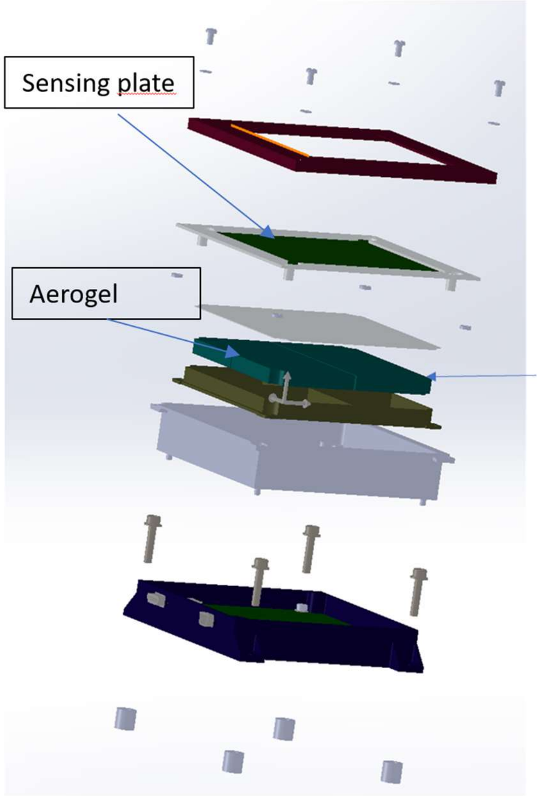

Figure 2 Exploded view of DISC highlighting the sensing element and the internal aerogel dust shield protecting the electronic boards.

DISC performances: In Table 1 are reported the momentum values expected to be measured by DISC, i.e. for dust particles with sizes 1 – 200 micron, dust densities previously constrained by in situ measurements [4] and velocities of the lower and upper limit of the possible speeds of the S/C flyby. From the measured dust particle momentum, combined with the dust speed, i.e. the S/C speed, individual particle mass will be retrieved. DISC will determine: a) the dust mass distribution for particles with masses in the range 10^{-15}–10^{-8} kg; b) particle count for masses $>10^{-8}$ kg.

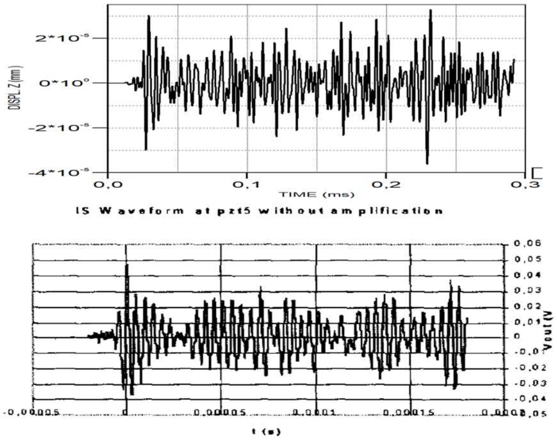

Figure 3 Comparison between simulated hyper velocity DISC impact sensing plate lamb wave (upper panel) and real low speed lamb wave measured by GIADA Impact sensor (bottom panel).

In addition, DISC will characterize: 1) dust impacts in terms of duration to retrieve information on particles density/structure; 2) possible sensing plate surface damages due to dust impacts, by means of the PZT calibrator;

Table 1. The dust particle momentum p for different flyby speed V.

Size [micron]	p [kg m/s] (V= (flyby speed 7 km/s)	p [kg m/s] (V=flyby speed 70 km/s)
1	2,35E-11	2,35E-10
2	1,88E-10	1,88E-09
5	2,93E-09	2,93E-08
10	2,35E-08	2,35E-07
20	1,88E-07	1,88E-06
50	2,93E-06	2,93E-05
100	2,35E-05	2,35E-04
200	1,88E-04	1,88E-03

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