AIRBUS DS' HCA: AN HIGH CAPABILITY ACTUATOR FOR SMALL SATELLITE MISSIONS

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ABSTRACT

This paper presents Airbus Space Products latest development in the area of Agile Actuators for small to medium-size spacecrafts. The result of several years of design and development, the High Capability Actuator (HCA) is a smart reaction wheel that provides the satellite with an unmatched effective torque/consumption ratio. At GNC system level, it brings high-speed manoeuvres and enhanced pointing control by combining ease of use and cost efficiency.

After introducing the range of products that HCA extends, the paper discusses the motivations for developing such a product. The HCA internal architecture and key performances are then presented, followed by the current product maturity. The product main components are finally detailed, together with their interfaces.

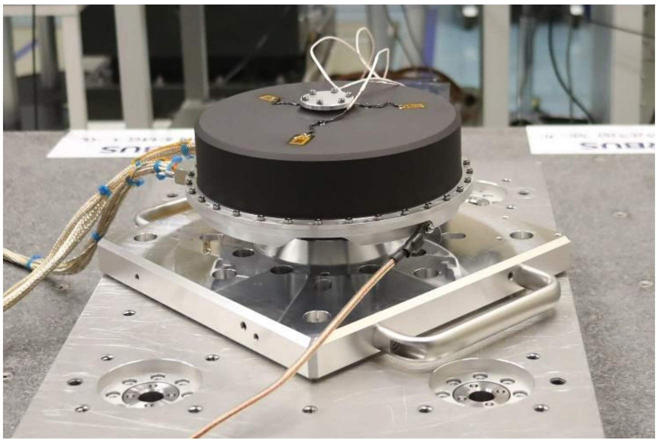


Figure 1 - HCA mechanism flight model during acceptance test

1. AIRBUS DS HERITAGE ON ACTUATORS

1.1. A reference competence for actuators development and production

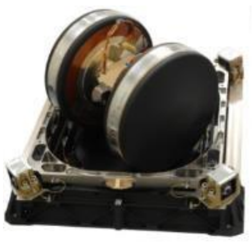
Airbus DS has gained in the past years a unique experience in actuators development, industrialization and production. From the first 1997 Control Moment Gyros (CMG) design, through the development of CMG 15-45 then CMG 75-75 and 40-60, the production of CMG flight models, a particular emphasis has been put at Airbus DS on the systematic optimization of the actuators overall architecture (size reduction, components and technology simplification) to anticipate industrialization.

1.2. An extended actuator family

Airbus DS have an extensive portfolio of high torque actuators. The CMG 15-45 S is oriented to 1-ton class satellite, a radiation hardened version of CMG 15-45 S (CMG 15-45 R) for missions with severe radiation environment, and two larger models CMG 40-60 and CMG 75-75 for respectively 2 and 3-tons class satellites. HCA targets 200 to 500 kg satellites.

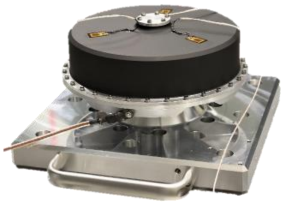
The CMG 15-45 has been developed with CNES and ESA support during the early 2000's. At the date of writing, ten clusters of Flight Models (FM) are in orbit, representing forty actuators.

The larger CMG 75-75 has been developed and qualified in 2015. Flight models of this product have been delivered, and most of them are running in orbit.



Addressing the 2-ton class satellites, the CMG 40-60 is currently under development and qualification.

Sharing the benefit of CMG heritage in term of internal know-how and subset supply chain, Airbus DS started the development of the high capability Reaction Wheel HCA in 2015. Geared towards the small satellite market (200-500 kg), its 4 Nms momentum and 0.98 Nm is torque brings high-speed manoeuvres and enhanced pointing control to this segment by combining ease of use and cost efficiency. 4 FM HCA are already delivered and 12 further FM are under production and tests.



2. HCA – A CUTTING-EDGE EQUIPMENT

HCA reaction wheels are unique actuators on the market. They are the result of more than 15 years of development closely aligned with the needs of high-resolution Earth observation missions. They feature several technological breakthroughs:

- Recovery of mechanical energy: Through a Bank of Supercapacitors, the equipment can recover the mechanical energy from the rotor during the braking phases and re-inject it during the acceleration phases. Only internal losses must be compensated by the energy taken from the satellite bus. This makes it possible to achieve unrivalled torque capability without affecting the power budget of the system.
- Angular measurement: the equipment is instrumented with an angular measurement for precise speed estimation over the entire operational range. The local speed loop efficiently rejects internal disruptions of the equipment (oil drops, zero crossing) significantly improving the performance, while simplifying the Attitude and Orbit Control System (AOCS). The equipment also provides an angular increment measurement which, by hybridization with other platform sensors, can provide information on the satellite's attitude.

These innovations allow unmatched performances for customers:

- Almost 1.0 Nm torque capacity for a limited power consumption. The HCA torque/power ratio is higher than any reaction wheel on the market, comparable with CMG, as depicted in figure 5.
- HCA cluster ease of use:
- No need for any complex algorithm to be commanded, in contrast to CMG.
- Embedded speed loop rejects internal disturbances which have not to be dealt at AOCS level anymore.
- Fully digital interface for TeleMetry (TM) and TeleCommand (TC)
- Each actuator is composed of 3 independent elements, facilitating its integration in the spacecraft.
- High precision angular momentum realization compatible with highly stable missions

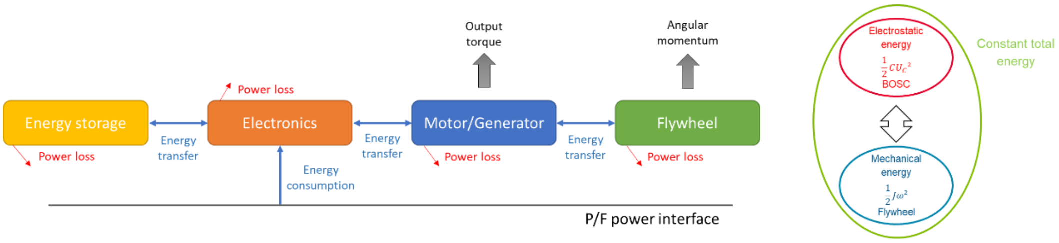


Figure 2 - Law of conservation of energy

The equipment's operation is based on a reversible conversion of the kinetic energy of the rotor. The energy taken from the satellite bus only compensates for the internal losses of the equipment.

3. HCA FUNCTIONAL ARCHITECTURE

The HCA assembly is composed of three different units:

- A mechanism which is the wheel mechanical assembly and is referred as HCA-M (High Capability Actuator Mechanism),

- A driving electronics, which commands the HCA-M and is referred as HCA-E (High Capability Actuator Electronics),
- A Bank of SuperCapacitors, which stores energy and is referred as BOSC.

3.1. Functional architecture

The complete HCA functional architecture (HCA-M, HCA-E and BOSC) is illustrated on figure 3, and detailed in the following sections.

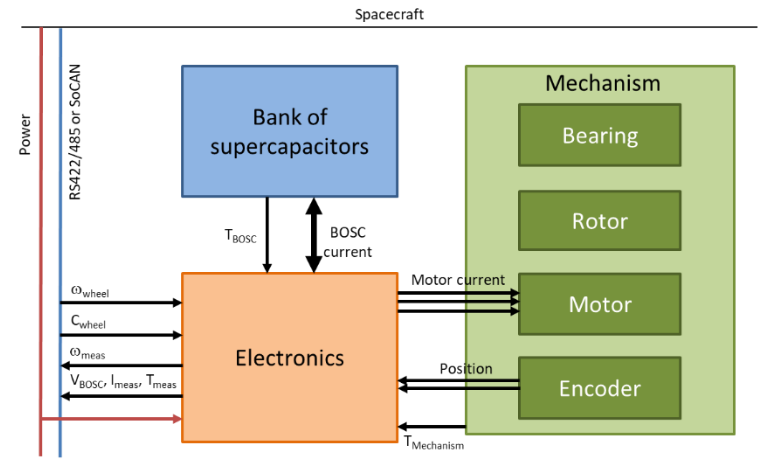


Figure 3 - HCA functional architecture

HCA assembly is connected to the spacecraft OBC through a redundant RS422/RS485 or SoCAN. HCA-E drives the mechanisms to the set point.

Thermal control for HCA units shall be done at satellite level. Temperature measurements of BOSC, mechanism bearing and motor, electronics are available on digital data link. The current HCA configuration does not embed any heaters.

Each HCA assembly is plugged on the main non regulated power bar with dedicated LCLs which shall be implemented outside of the HCA assembly.

4. CONNECTION SCHEME

Typical HCA cluster is composed of four HCA-M and two HCA-E (2 x 2 independent channels) and four BOSC.

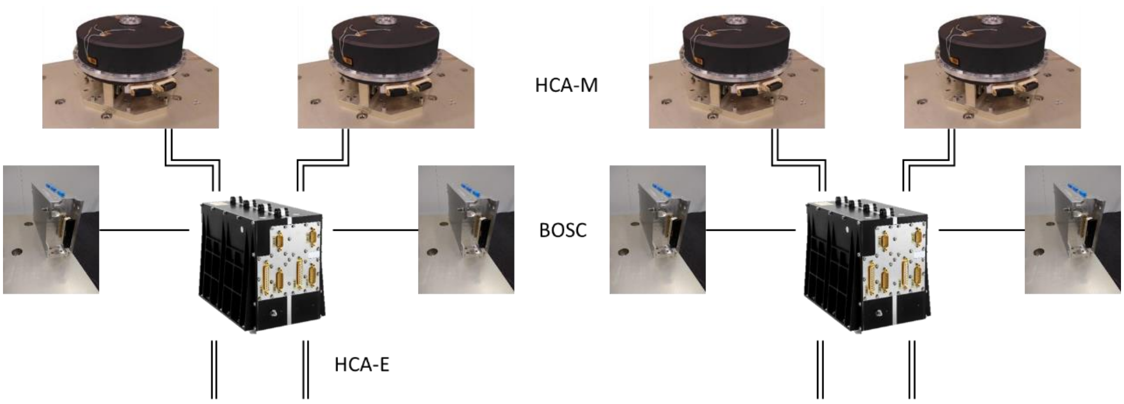


Figure 4 - HCA cluster implementation

HCA-M, HCA-E and BOSC are interconnected through dedicated interface cables.

5. OPERATION MODES

The result of a comprehensive reflection at the satellite system level, HCA wheels offer several operating and control modes to adapt to the needs of the different phases of the missions.

There are two modes used to manage the trade-offs between performance, consumption and lifespan. The manoeuvre mode (MAN) is the nominal operating mode enabling high torque capabilities. The quasi-static mode (QS) may be used outside of the critical mission phases. In this mode, the torque range is reduced in order to limit losses and optimise the lifespan.

The equipment also offers three speed or torque control modes:

- Speed mode: a coherent torque/speed pair telecommand is sent by the AOCS. The equipment uses the torque in open loop and for interpolating the speed setpoint, as depicted in figure 6.
- Closed loop torque mode: in this mode, only a torque command is required. The speed loop is activated in order to reject the internal perturbations and ensure that the requested reaction torque is produced.
- Open loop torque mode: in this mode, only a torque command is required. The speed loop is deactivated, and the controlled torque corresponds to the motor torque without compensation of the perturbations. This corresponds to the conventional wheel control mode and is compatible with an angular measurement malfunction.

All of these operating and control modes make it possible to adapt to the AOCS requirements in the best way possible, while respecting the constraints associated with the equipment.

6. HCA PERFORMANCES

6.1. Torque capacity

With almost 1 Nm for 48 W, HCA stands out from the competition with an excellent maximum torque to consumption ratio. This characteristic makes integration on small platforms possible and paves the way for wheel hyper-agility.

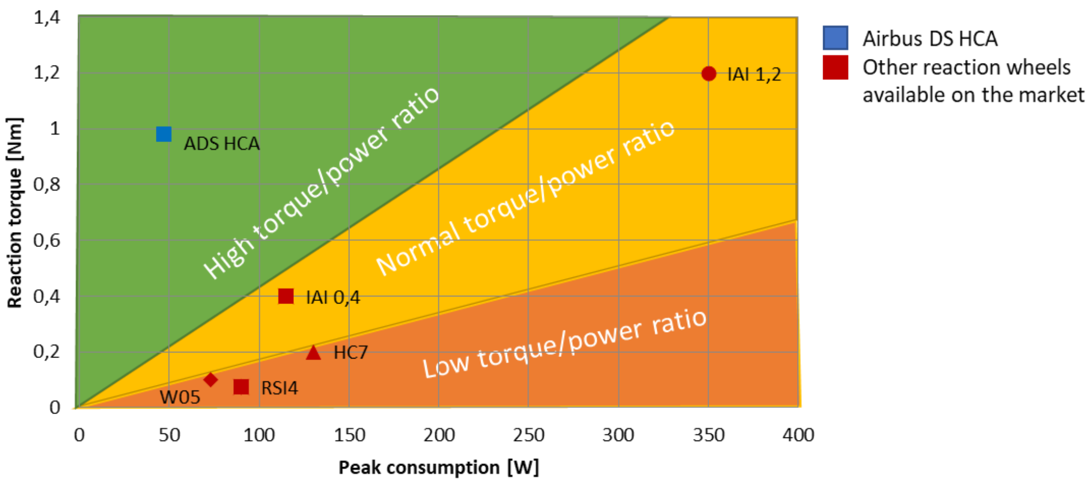


Figure 5 - HCA's positioning in the reaction wheel market

Energy recovery during braking limits its consumption for an unmatched effective torque on the market.

6.2. Angular momentum accuracy

HCA-M is equipped with an optical encoder derived from the CMG product line, delivering fine incremental position measurement. HCA-E compensates already known encoder discrepancies and processes a highly accurate speed estimation. It is thus used inside a speed loop to reject efficiently disturbance torques such as the torque friction, the zeros-crossing, and power driver imperfections.

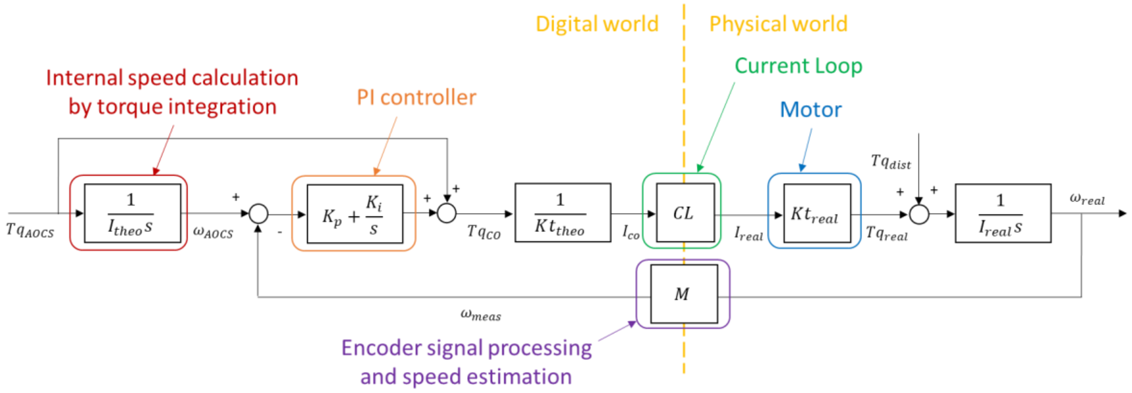


Figure 6 - Internal speed control loop architecture

The speed loop bandwidth is tuned to maximize disturbance rejection without interacting with isolator modes. A precise synchronisation of the torque feedforward action and the internal speed calculation ensures accurate speed command tracking even after torque discontinuities.

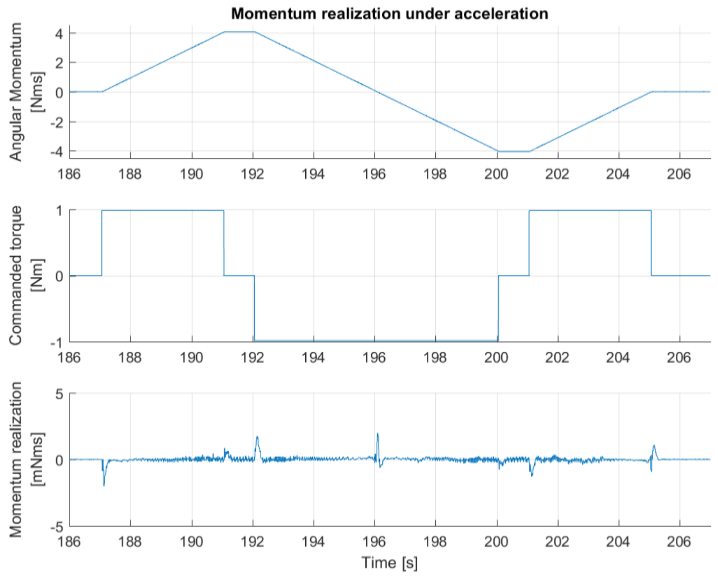


Figure 7 - Speed realization during maneuver – Test result on FM

7. HCA MATURITY

7.1. From blank page to qualified status

The first initial concept studies started in 2006 leading to the development of two prototypes mechanisms (3 and 9 Nms) as well as one driving electronics in the early 2010. The formal flight model development for the 1 Nm/4 Nms operating point was decided in 2015 in order to give agility to middle size earth observation satellites around 2020.

The developments of the mechanism, the power electronics and the BOSC have been conducted in parallel.

7.2. Mechanism

In the early phase of the final development, the focus has been made on the lifetime validation of the ball bearing on a representative utilization profile.

Figure 8 - HCA Ball Bearing Unit

At the end of 2015, 6 models entered lifetime test. By the end of 2018, the compliance with a typical 10-year mission Earth Observation mission satellite had been proven (see figure 10 on the left hand side). A life test has been extended on 4 of those Ball Bearing Units to prove the conformity with the new mission profile (see figure 10 on the right hand side). More the 16 million zeros-crossings have been successfully tested during this campaign.

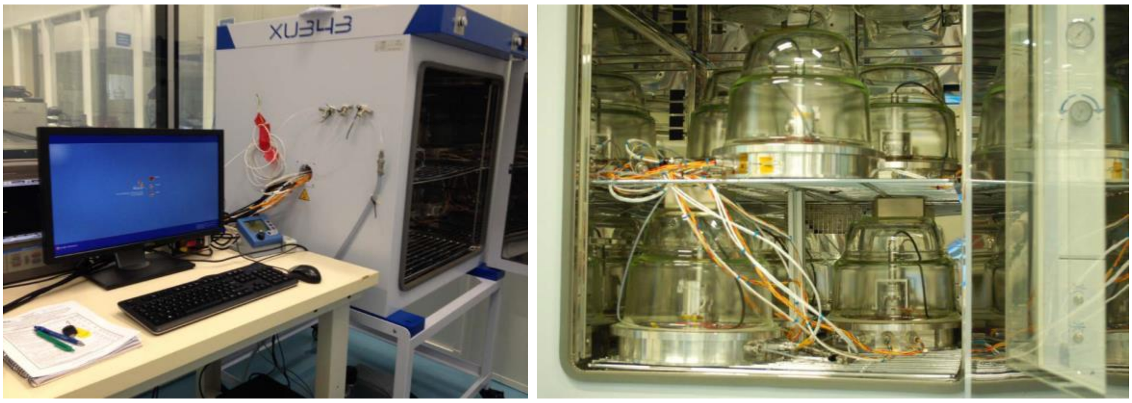


Figure 9 - Ball bearing lifetime test bench

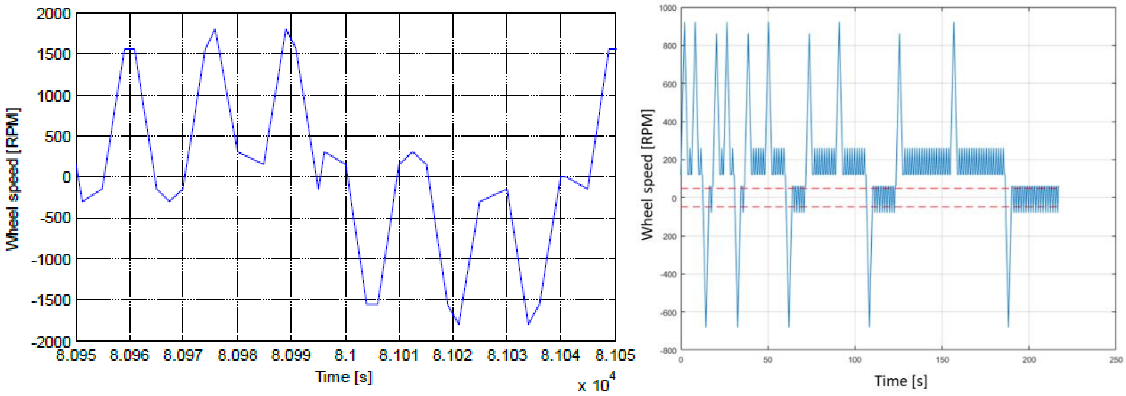


Figure 10 - Ball Bearing Unit (BBU) life test speed profiles

At the end:

- 4 BBU have successfully endured two life tests, for a total test duration of 4 years and 18 million zero-crossings.
- 2 BBU achieved one life test, 2 year test duration, 2 million zero crossing. They were kept at this stage to be reference for the first life test campaign.
- One EQM mechanism underwent a 4 month life test on the first mission profile, proving its behavior similarity with test at BBU level.

Provided by the same Small-to-Medium Entreprise (SME) as for CMG, the motor and the encoder followed a standard development process. EM models were produced to test the functional requirements and an EQM endured environmental tests before being integrated in the EQM mechanism.

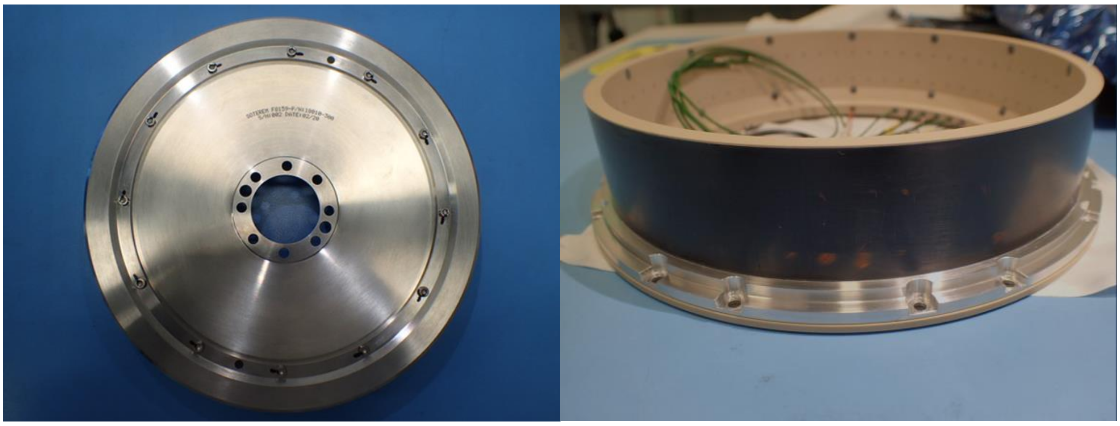


Figure 11 - HCA motor, rotor (on the left) and stator (on the right)

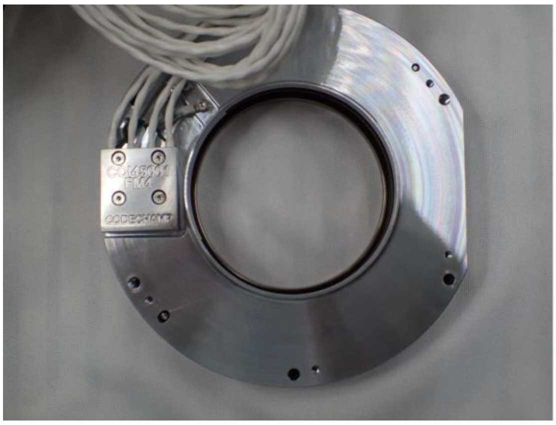


Figure 12 - HCA encoder

The mechanism was qualified in 2018.

7.3. Electronics

HCA-E development started in 2015 to reach qualified status (TRL 8) in 2021 (see HCA-Electronic).

7.4. BOSC

The development of the BOSC was supported by ESA from 2015 to 2019 as part of General Support Technology Programme. The BOSC was qualified in 2021 (TRL8), extra life tests were conducted until 2022.

8. QUALIFICATION AND ACCEPTANCE TEST SEQUENCE

HCA-M, HCA-E and BOSC all endured a complete qualification sequence composed of functional, environmental and EMC tests. The following charts details the HCA qualification and acceptance test sequence.

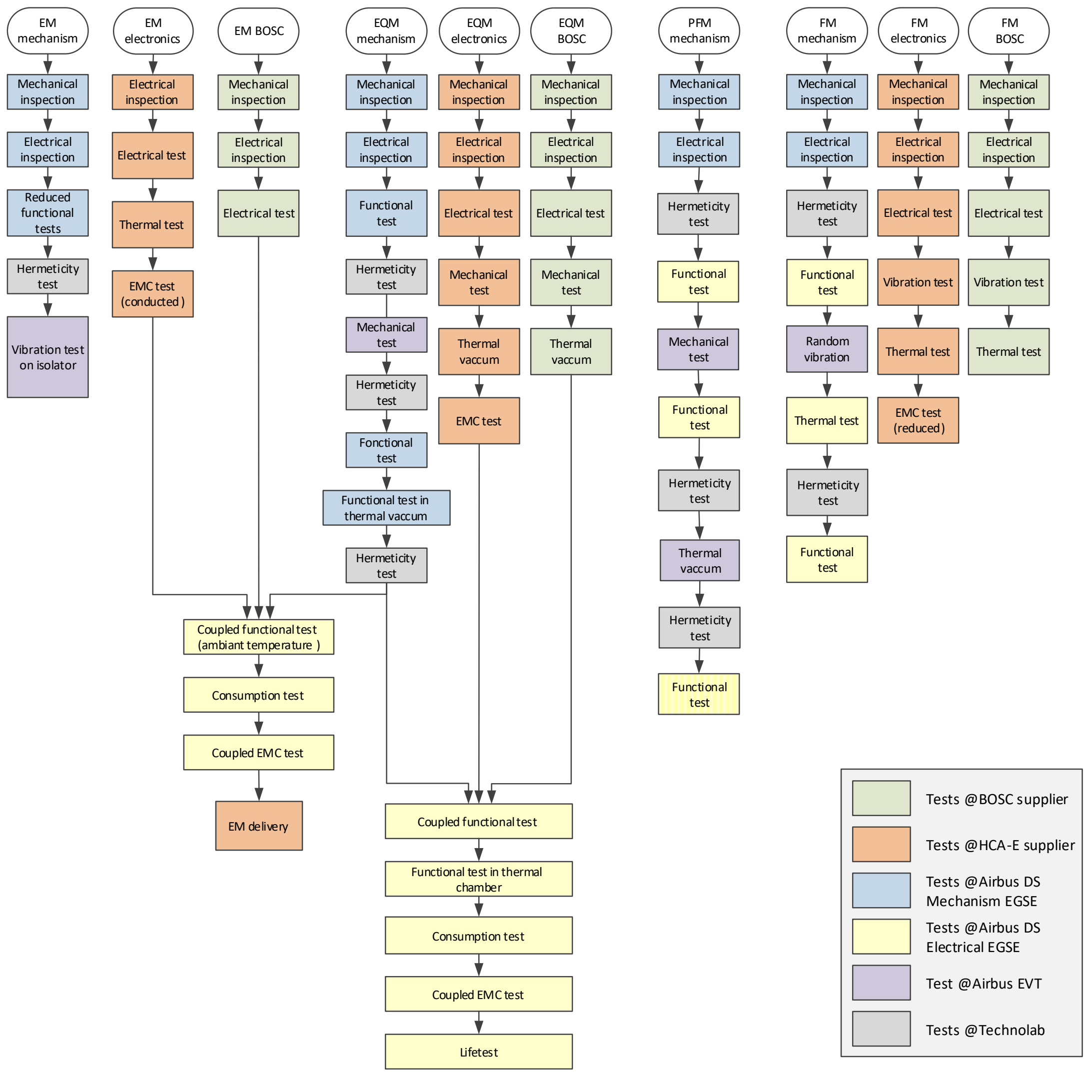


Figure 13 – Qualification test sequence overview

In 2018, HCA was selected to fly on an Earth observation mission made of 4 satellites. The first flight set integration is ongoing in the satellite platform, 3 more flight set deliveries are expected in the first semester 2023.

9. HCA INTERFACES

9.1. HCA data interface

The HCA assembly is connected from the HCA-E to the satellite with a redundant RS 422/RS 485 or SoCAN data bus. It is commanded by a cyclical command, typically at 8 Hz, on the data bus coming from the AOCS. In return, the HCA-E sends telemetries giving the different parameters needed for the spacecraft control loop and also a health status which informs at each step the proper functioning of the units.

9.2. HCA power interface

The two HCA-E channels are powered directly to the power bus. A current protection shall be installed as follow:

- Two LCL 4 A for each HCA-E.

There are no ON/OFF powering commands on the HCA. Each HCA-E channel is separately powered by connecting it to the power bus. The HCA-E channels start as soon as they are powered. Therefore, an ON/OFF switch on each power line shall be implemented on satellite side in order to command the powering of the HCA assembly.

10. HCA-MECHANISM

10.1. HCA-M description

The HCA-M is basically a reaction wheel, equipped with an optical encoder. It allows really accurate momentum realization for highly demanding missions.

10.2. HCA-M technical features

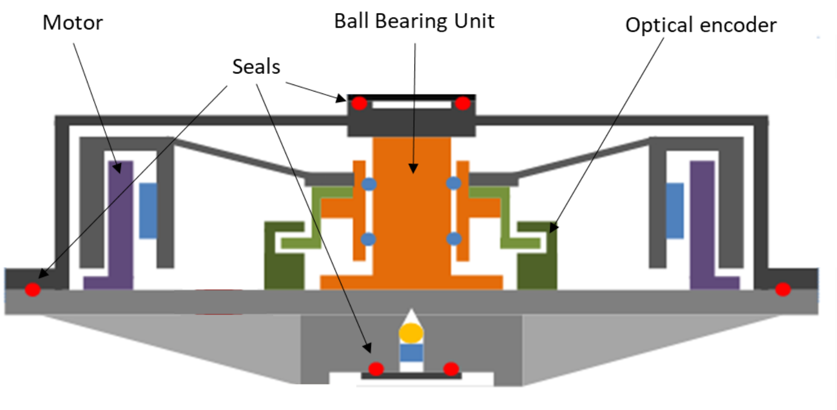


Figure 14 - HCA-M subassemblies

The HCA Mechanism is composed of

- A brushless torque motor to create the motor and reaction torques,
- A ball bearing unit for the guidance of the rotating inertia,
- A highly accurate optical encoder to measure the wheel speed,
- An hermetic casing to ensure determined physical and chemical environment corresponding to life test conditions

10.3. HCA-M mechanical qualification

HCA-M withstands the following qualification level.

Three axis	
Frequency (Hz)	Acceleration (g)
5 Hz – 23 Hz	11 mm
23 – 100 Hz	24g
100 – 200 Hz	10g

Table 1 - HCA-M qualification vibrations level (sine)

Lateral (in plane)		Axial (out of plane)	
Frequency (Hz)	Acceleration (g)	Frequency (Hz)	Acceleration (g)
20	0.01 g²/Hz	20	0.01 g²/Hz
100 – 150	1 g²/Hz	90 - 140	0.4 g²/Hz
250 - 386	0.1 g²/Hz	200 - 362	0.1 g²/Hz
433	0.01 g²/Hz	450 - 495	0.003 g²/Hz
520 - 560	0.006 g²/Hz	504 - 635	0.1 g²/Hz
610	0.01 g²/Hz	690 – 810	0.019 g²/Hz
655	0.042 g²/Hz	840	0.039 g²/Hz
1000	0.01 g²/Hz	1000	0.01 g²/Hz
2000	0.0001 g²/Hz	1020 - 1050	0.006 g²/Hz
		2000	0.0001 g²/Hz
Total	11.76 gRMS	Total	9.24 gRMS

Table 2 - HCA-M qualification vibrations level (randoms)

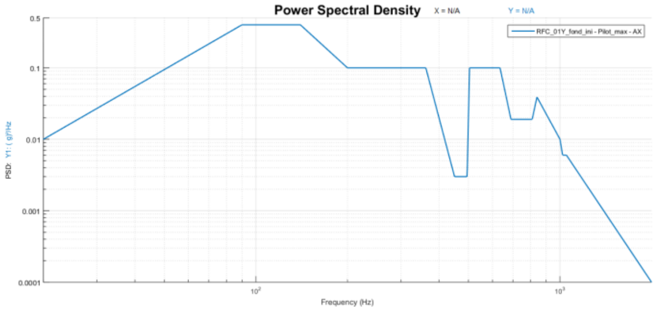


Figure 15 - HCA-M random vibrations along Y axis – Qualification level

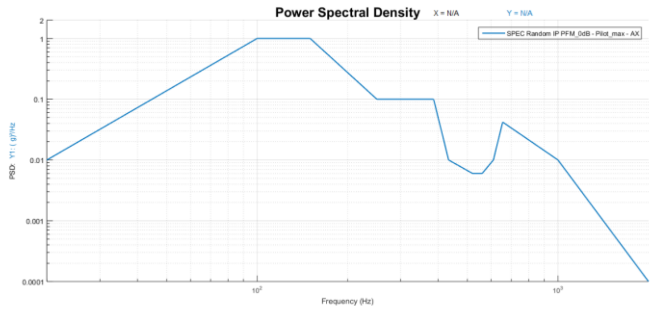


Figure 16 - HCA-M random vibrations along X and Z axis – Qualification level

Lateral (in plane)		Axial (out of plane)	
Frequency (Hz)	Acceleration (g)	Frequency (Hz)	Acceleration (g)
10	10 g	100	10 g
600	110 g	600	125 g
10 000	110 g	10 000	125 g

Table 3 - HCA-M shock qualification status

If necessary, the mechanism can be mounted on isolator.

10.4. HCA-M thermal qualification

The HCA-M thermal design is such that the mechanism is coupled only radiatively to the environment. To reduce the internal gradients and thus to homogenize HCA-M temperature, the radiative coupling is optimised. Therefore the maximum number of parts is covered by a surface treatment with emissivity greater than 0.8 (black paint).

HCA-M qualification environment is the following:

Non-operational max	+70 °C
Operational max	+60 °C
Operational min	+0 °C
Start-up	-15 °C
Non-operational min	-20 °C

Table 4 - HCA-M qualification temperatures

Startup is defined as the minimal temperature the mechanism can be switched ON. Thermistor acquisition, encoder power supply and H-bridge can be activated. It brings dissipation inside the mechanism and help the temperature to increase. However, no rotation of the rotating part is allowed below 0 °C at the BBU.

The environment temperature is defined at TRP located as following:

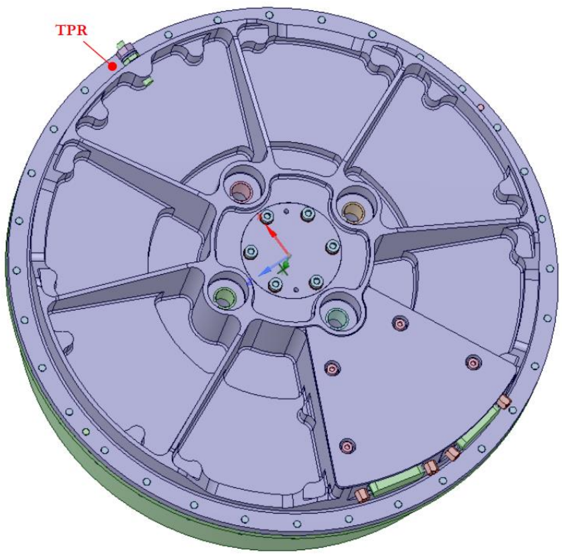


Figure 17 - TRP location

HCA-M is equipped with three thermistors, two inside stator windings and one inside BBU. The temperature measurement is done by the power electronics and available via TM on data bus.

HCA-M dissipation are described in the following table:

HCA-M dissipation			
Angular momentum [Nms]	Reaction torque [Nm]	Nominal case [W]	Worst Case [W]
Stand by	Stand by	0	0
0,5	0	1,1	1,7
0,5	0,98	10,3	14,1
4,0	0	12,3	21,4
4,0	0,98	22,4	35,7

Table 5 - HCA-M dissipation

The nominal values are based on test results while worst case consumptions are derived from worst case analysis.

10.5. HCA-M mechanical interfaces

HCA-M dimensions are described on the following figure. HCA-M interface is designed to be mounted on Airbus DS WEMS (damper), the total height is optimized by inserting WEMS branches inside wheel baseplate slots.

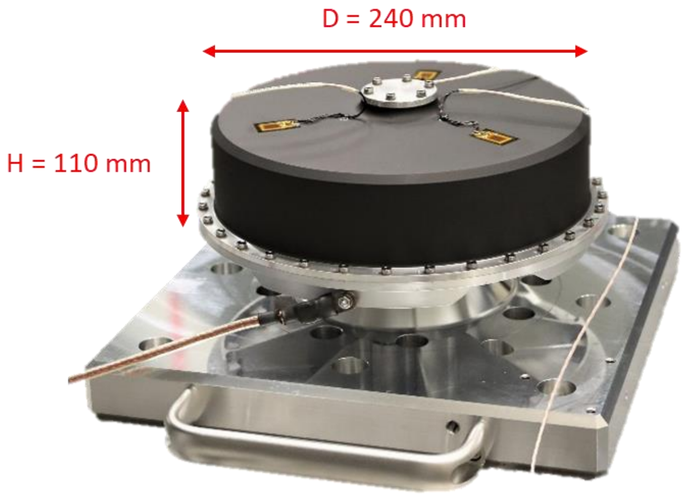


Figure 18 - HCA-M dimensions

The mass of one HCA-M is lower than 6.2 kg.

11. HCA-ELECTRONIC

11.1. HCA-E description

The following figure shows the global architecture: the HCA-E is the interface between the HCA-M, the BOSC and the satellite.

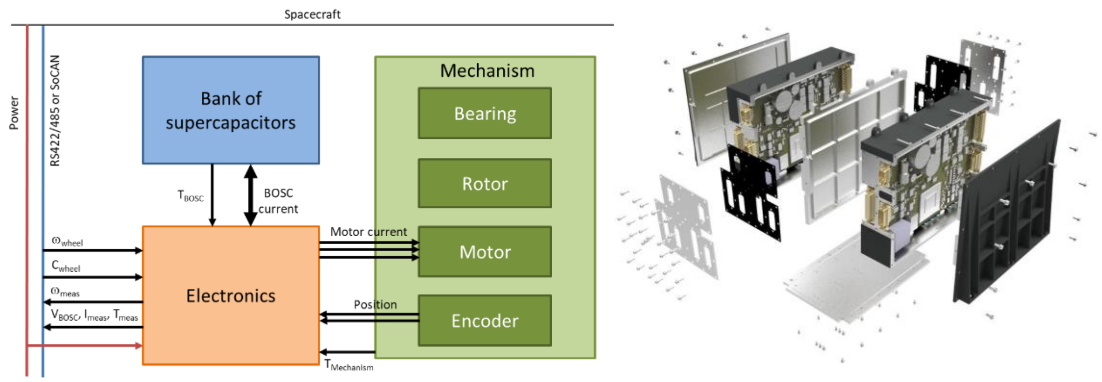


Figure 19 – HCA-E overview

11.2. HCA-E general architecture

HCA-E is an assembly of two identical modules, each of them composed by two boards. It drives independently two mechanisms and two BOSC.

11.3. Interface with the mechanism

- Interface with the encoder: the electronics receives analogue signals for the encoder from it derives an accurate speed estimation. This estimation is used inside wheel control loop as defined in Angular momentum accuracy.
- Interface with the motor: hall sensors included in motor stator deliver position information used to drive motor. Current loop deliver current inside motor phase which produces torque.

- Thermal interfaces: the mechanism is equipped with 3 thermistors (2 in the motor, 1 in the BBU) acquired by the electronics. The 3 temperatures are available on RS 422/485 or SoCAN datalink.

11.4. Interface with the system

- The primary bus of power from the satellite will be connected to the HCA-E.
- RS422/485 or SoCAN datalink is connected to HCA-E

11.5. Interface with the test facilities

In order to perform tests on HCA, the electronics has an interface with the test facilities. The HCA-E provides a copy of digital signals and analogue signals.

11.6. HCA-E power budget

The following table presents HCA total consumption (HCA-E + HCA-M + BOSC):

HCA power consomption			
Angular momentum [Nms]	Reaction torque [Nm]	Nominal case [W]	Worst Case [W]
Stand by	Stand by	5,0	6,0
0,5	0	9,3	11,3
0,5	0,98	35,2	42,8
4,0	0	21,6	35,2
4,0	0,98	47,5	70,2

Table 6 - HCA consumption (for one channel)

The different values in this table represent the power consumption for one HCA (one mechanism, one electronics channel and one BOSC)

The nominal values are based on test results while worst case consumptions are derived from worst case analysis.

11.7. HCA-E mechanical interface

HCA-E dimensions are described on the following figure.

Figure 20 - HCA-E dimensions

The mass of one HCA-E with two channels is lower than 5.7 kg.

11.8. HCA-E mechanical qualification

HCA-E withstands the following qualification level.

Three axis		
Frequency (Hz)	Acceleration (g)	Sweep rate
5 Hz – 20 Hz	15 mm	2 Oct/min
20 Hz – 100 Hz	24 g	

Table 7 - HCA-E qualification vibrations level (sine)

Lateral (in plane)		Axial (out of plane)	
Frequency (Hz)	Acceleration (g)	Frequency (Hz)	Acceleration (g)
20 Hz – 80 Hz	+4 dB/Oct	20 Hz – 80 Hz	+3 dB/Oct
80 Hz – 1000 Hz	0.1 g²/Hz	80 Hz – 400 Hz	0.5 g²/Hz
1000 Hz – 2000 Hz	-3 dB/Oct	400 Hz – 2000 Hz	-6 dB/Oct
Total	12.8 gRMS	Total	18.4 gRMS
Duration	120s	Duration	120s

Table 8 - HCA-E qualification vibrations level (randoms)

Three axis	
Frequency (Hz)	Acceleration (g)
100 Hz	20 g
2 000 Hz	2 000 g
10 000 Hz	2 000 g

Table 9 - HCA-E shock qualification status

11.9. HCA-E thermal qualification

HCA-E can withstand the following thermal environments:

Non-operational max	+70 °C
Operational max	+60 °C
Operational min	-30 °C
Start-up	-30 °C
Non-operational min	-40 °C

Table 10 - HCA-E qualification temperatures

HCA-E dissipation is described in the following table:

HCA-E dissipation			
Angular momentum [Nms]	Reaction torque [Nm]	Nominal case [W]	Worst Case [W]
Stand by	Stand by	5,0	6,0
1,0	0	7,7	9,1
1,0	0,98	22,0	25,5
4,0	0	8,9	13,3
4,0	0,98	19,7	26,4

Table 11 - HCA-E dissipation (for one channel)

The nominal values are based on test results while worst case consumptions are derived from worst case analysis.

12. BOSC

12.1. BOSC description

The BOSC unit is composed of supercapacitors placed in series and parallel in order to achieve the requested capacitance and voltage ranges. A passive balancing system is implemented in order to make sure the cells voltages remains in safe areas. All individual cells voltages are available through test connectors in order to check the correct functioning of this balancing function.

Three thermistors are implemented for the thermal monitoring.

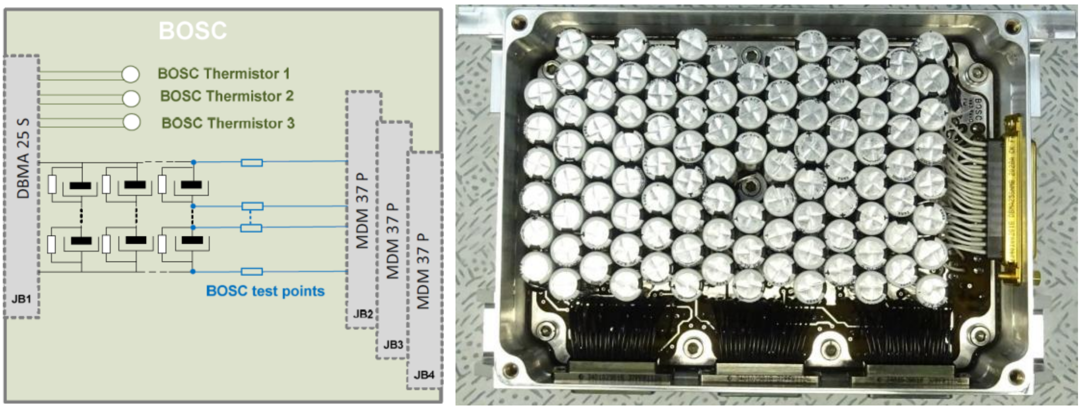


Figure 21 - Bank of supercapacitor overview

12.2. BOSC mechanical interface

BOSC dimensions are described on the following figure.

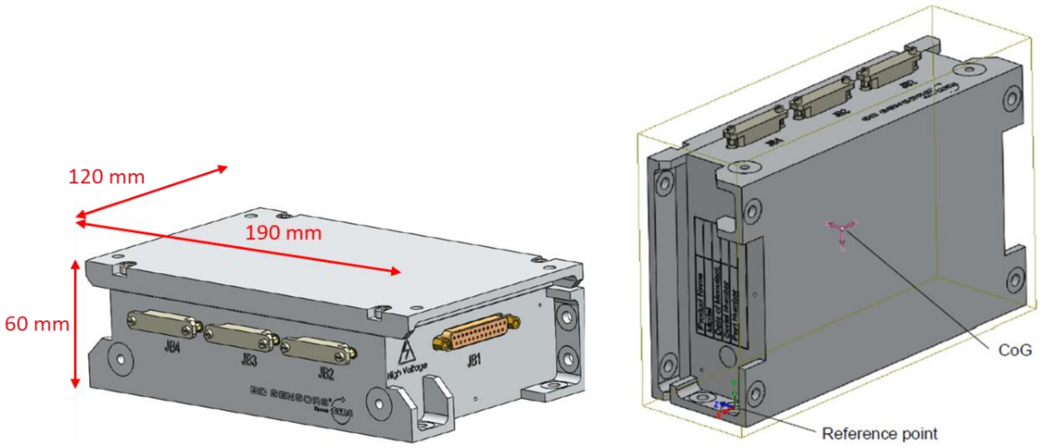


Figure 22 - BOSC dimensions and potential configurations

BOSC is designed to be fastened to satellite on two potential surfaces (as presented above) facilitating its integration in the spacecraft.

The mass of the BOSC is lower 1.27 kg

12.3. BOSC mechanical qualification

The BOSC can withstand the following mechanical environments:

Three axis		
Frequency (Hz)	Acceleration (g)	Sweep rate
5 Hz – 20 Hz	15 mm	2 Oct/min
20 Hz – 100 Hz	24 g	

Table 12 - BOSC qualification vibrations level (sine)

Lateral (in plane)		Axial (out of plane)	
Frequency (Hz)	Acceleration (g)	Frequency (Hz)	Acceleration (g)
20 Hz – 80 Hz	+4 dB/Oct	20 Hz – 100 Hz	+12 dB/Oct
80 Hz – 1000 Hz	0.1 g²/Hz	100 Hz – 300 Hz	1.5 g²/Hz
1000 Hz – 2000 Hz	-3 dB/Oct	300 Hz – 2000 Hz	-8 dB/Oct
Total	12.8 gRMS	Total	24.3 gRMS
Duration	120s	Duration	120s

Table 13 - BOSC qualification vibrations level (randoms)

Three axis	
Frequency (Hz)	Acceleration (g)
100 Hz	20 g
2 000 Hz	2 000 g
10 000 Hz	2 000 g

Table 14 - BOSC shock qualification status

12.4. BOSC thermal qualification

The BOSC can withstand the following thermal environments:

Non-operational max	+55 °C
Operational max	+55 °C
Operational min	-10 °C
Start-up	-30 °C
Non-operational min	-40 °C

Table 15 - BOSC qualification temperatures

The BOSC dissipation is described in the following table:

BOSC dissipation			
Angular momentum [Nms]	Reaction torque [Nm]	Nominal case [W]	Worst Case [W]
Stand by	Stand by	0	0
1,0	0	0,5	0,5
1,0	0,98	0,6	0,6
4,0	0	0,4	0,4
4,0	0,98	2,2	4,3

Table 16 - BOSC dissipation

The nominal values are based on test results while worst case consumptions are derived from worst case analysis.

13. CONCLUSIONS

This paper demonstrates the high maturity of the Airbus' HCA design and the superior performances it delivers for any GNC designer looking for fast manoeuvres enablers.

While delivering the HCA FMs for its first customer, Airbus continues developing and improving the product line:

- Larger versions of HCA are studied to address 400 to 600kg satellites. 3.5-Nm torque at 7-Nms momentum are today the targeted operating point.
- Space station application is also under study for an angular momentum of 4000Nms and a reaction torque of 20Nm.

While Earth observation missions are clearly the main use case for agile spacecrafts, interest can also come from science missions. Trying to monitor astronomical events (e.g. gamma-ray bursts, supernovae), some science missions can truly benefit from fast reorientations towards transient phenomena (NASA's SWIFT mission or ESA's LOFT mission concept are two examples). In this case, the faster the reorientation, the more science data can be acquired during the early stages of the event. The excellent performances in term of momentum realization are compatible with high stability missions and very long imaging phases.

14. BIBLIOGRAPHY

Conference papers:

- P.Faucheux and A.Pepoz, Airbus Defence and Space, Control Momentum Gyro, New CMG for agile satellite, AAS GNC Conference, 2019
- J.Chaix, A.Pepoz, T.Pareaud, A.Dupuis, S.Armand, D.Fruchard, Newton CMG Package, Making spacecraft agility accessible & cost effective four you satellite mission, AAS GNC Conference, 2022
- Airbus Space Products Agile Actuators portfolio:
- https://www.airbus.com/en/products-services/space/equipment/avionics

The HCA equipment is protected by the following patents:

- Dispositif d'actionneur pour varier l'attitude d'un engin spatial (FR 2 927 312 A1 – 11/02/2018).
- Procédé de commande d'un système de contrôle d'attitude et système de contrôle d'attitude d'un véhicule spatial (FR 2 957 895 B1 – 27/09/2017).
- Dispositif et procédé de détermination d'attitude d'un satellite et satellite embarquant un tel dispositif (FR 2 975 180 A1 – 09/05/2011).

15. PRODUCT DATASHEET

Performances		Airbus DS HCA
Maximum output torque		0.98 Nm
Maximum angular momentum		4.0 Nms
Nominal Mass	Mechanism	5.90 kg
	Electronics	5.60 Kg (for two channels in the same box driving one mechanism each)
	BOSC	1.21 kg
Volume	Mechanism	Ø240 mm, H 110 mm
	Electronics	L 240 mm, l 190 mm, H 150 mm (two channels)
	BOSC	L 190 mm, l 120 mm, H 60 mm
Consumption at null torque		9.3 W @ 0,5Nms
		21.6 W @ 4Nms
Consumption at maximum torque		35.2 W @ 0,5Nms
		47.5 W @ 4Nms
Stiffness		> 140 Hz
Life duration in flight		10 years
Communication interface		RSR422/485 or SoCAN
Reliability		415 FIT in FIDES, 797 FIT in MIL-HDBK
Maturity		Qualified in 2022

Table 17 - Airbus DS HCA Datasheet