Proba-3 Mission

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Proba-3 History

- Proba-3 is the ESA project dedicated to the in flight demonstration of precise formation flying.

- During the last years Proba-3 has evolved from the initial CDF studies at ESA, through the phase A studies, to the phase B1 and B2 reaching PDR in Autumn 2012.

- Proba-3 Phase CD/E1 proposal is currently in preparation and will start in Autumn 2013.

- Proba-3 is developed by a large consortium with a Core Team of companies lead by SENER and completed with QinetiQ Space nv, EADS CASA Espacio, GMV Space and Defence and Spacebel.
Mission Objectives

PROBA-3 mission objectives are: precise Formation Flying demonstration, Science and Experiments.
Challenges

- Achieve formation with **millimetre level accuracy**.
- Maintain millimetre level **accuracy while manoeuvring**.
- Demonstrate formation **station keeping** from **25m to 250m**.
- Maintain formation flying **over several hours**.
- **Autonomously manage the formation** and take mission critical decision with no ground supervision.
- **Validate** the formation flying metrology **sensor suite** capable of acquiring the formation and providing relative position determination **with micrometric precision**.
- **Calibrating** the system to compensate the **thermoelastic deformations**.

- The formation flying verification on ground is complicated by the impossibility to test the two satellite system in the formation range and representative environment.
Proba-3 Spacecraft

Proba-3 spacecraft are named according to the part of the Coronagraph System they are hosting.

**Coronoagraph Spacecrafts (CSC) hosts the coronagraph instrument.**

<table>
<thead>
<tr>
<th>Metrologies:</th>
<th>GNC Sensors:</th>
<th>GNC Actuators</th>
</tr>
</thead>
<tbody>
<tr>
<td>HAM sensor</td>
<td>3x STR</td>
<td>4xRW</td>
</tr>
<tr>
<td>CLS sensor</td>
<td>6x SAS</td>
<td>2x8 N thrusters</td>
</tr>
<tr>
<td>ISL</td>
<td>2x Gyros</td>
<td></td>
</tr>
<tr>
<td>MIRES</td>
<td>2x GPS</td>
<td></td>
</tr>
</tbody>
</table>

**Occulter Spacecraft (OSC) hosts the occulting disk.**

<table>
<thead>
<tr>
<th>Metrologies:</th>
<th>GNC Sensors:</th>
<th>GNC Actuators</th>
</tr>
</thead>
<tbody>
<tr>
<td>VBS</td>
<td>3x STR</td>
<td>4xRW</td>
</tr>
<tr>
<td>Corner cubes</td>
<td>6x SAS</td>
<td>2x8 mN thrusters</td>
</tr>
<tr>
<td>ISL</td>
<td>2x Gyros</td>
<td></td>
</tr>
<tr>
<td></td>
<td>2x GPS</td>
<td></td>
</tr>
</tbody>
</table>
## Formation Flying Metrology Chain

<table>
<thead>
<tr>
<th>Metrology Element</th>
<th>Operational Range</th>
<th>Accuracy (1s)</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPS</td>
<td>At perigee</td>
<td>7.5 cm (at perigee), &lt;10 m when propagated up to at apogee entry.</td>
</tr>
<tr>
<td>CLS</td>
<td>+/-13m @ 150m (lateral) 25-250 (longitudinal)</td>
<td>1 mm @150m (lateral)</td>
</tr>
<tr>
<td>FLLS</td>
<td>±20.5mm (lateral) 25-250 (longitudinal)</td>
<td>21 um (lateral) 30 um (longitudinal)</td>
</tr>
</tbody>
</table>

CLS from Centre Spatial de Liége  
FLLS from QinetiQ Ltd.
System Modes

Formation management requires definition of System Modes.

PROBA-3 mission is organised into four System Modes:

- STACK
- MANUAL
- OPERATIONAL
- PARKING
PROBA-3 Operational Mode

In OPERATIONAL Mode OSC is taking the lead of the formation and is commanding the CSC to execute the operational routine. Operational routine consists on 4 phases:
Proba-3 GNC Modes for the Operational Routine

The Operational routine is implemented with two levels of GNC modes: SC and FF.

SC-GNC modes are:
- Inertial Attitude Mode (IAM)
- Target Pointing Mode (TPM)
- Orbit Control Mode (OCM)

FF-GNC modes are:
- Apogee Preparation Mode (APM)
- Formation Coarse Mode (FCM)
- Formation Fine Mode (FFM)
- Formation Reconfiguration Mode (FRM).
- Perigee Preparation Mode (PPM)
- Navigation Mode (PNM)
Distributed System Autonomy

The FDIR main principle is that lowest-level isolation and recovery is attempted first. This approach minimizes the impact in the system operation.

Five recovery levels:

• **L0**: Action None (Unit Level Local recovery)
• **L1**: Unit/Function Recovery (Recovery by FDIR)
• **L2**: Unit/Function Reconfiguration (Unit substitution by FDIR)
• **L3**: OBC / System Recovery (Safe orbit entered & System Mode to MANUAL)
• **L4**: CAM (Drifting orbit entered & System Mode to MANUAL)
PDR Results

Formation Precision In Station Keeping (1σ):

- **0.66 mm for ISD < 40m**
- **1.73 mm for ISD < 160m**
- **2.58 mm for ISD < 250 m**

Formation Precision During Motion (1σ):

- **3.26 mm over 25-250m range**
Conclusions

• The PROBA-3 FF technology demonstration mission has successfully completed the phase B.

• PDR results indicate that millimetre level formation control is achievable.

• These promising results highlight the feasibility of this very challenging technology.

• PROBA-3 Phase CDE will start soon.
Thank you for your attention

Any questions?