Galileo Extended Slots Characterisation and relation with the Nominal Constellation

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On 2014 the two spacecraft of the 3rd launch of the Europe's Galileo satellite navigation system where injected by the upper stage into a faulty orbit out of the range that the satellites could recover for achieving the Galileo nominal Constellation. The design of a recovery mission was initiated right after taking into account the implications at satellite level of the wrong injection orbit, the operational constrains, and maximizing the programmatic return value of the spacecrafts contributing to the global constellation performance in case they could be introduced in the Galileo navigation service.

A manoeuvres campaign was conducted during winter 2014 to reach a resonant orbit with a repeat cycle twice the one of the nominal constellation and positioning both spacecrafts with a relative angular phase of 180 degrees at the apsides.
Thanks to further improvements in the Ground Segment processing and the expansion of the Navigation Message the introduction of these satellites into Galileo Service is under assessment. For this purpose, a tuned reference orbit has been provided to the European GNSS Service Centre.

Table 1. Galileo Extended Slots definition from the European GNSS Service Centre [1]

Satellite	Units	GSAT0201	GSAT0202
Reference Epoch	UTC	2016.08.01 00:00:00	
SV ID	-	18	14
Slot	-	Ext01	Ext02
Launch Date	-	22.08.2014	22.08.2014
Semi-Major Axis	km	27977.6	27977.6
Eccentricity	-	0.162	0.162
Inclination	deg	49.85	49.85
RAAN	deg	56.986	56.986
d(RAAN)/dt	deg/day	-0.03986760	-0.03986760
Arg. Perigee	deg	52.408	52.408
d(Arg. peri)/dt	deg/day	0.03383184	0.03383184
Mean Anomaly	deg	35.226	215.226
d(Mean Anomaly)/dt	deg/day	667.86467481	667.86467481

The reference extended slot for these two satellites follows the same format as the Galileo Nominal Constellation slots. This facilitates the addition of the satellites to existing software.

In this paper the creation of the reference orbit together with their limited departures is addressed, as well as the evolution of both spacecraft relative to the nominal Galileo constellation. Furthermore, the paper will show some of the benefit of using the extended slots for navigation purposes when combined with the current nominal constellation. In particular it is shown how the extended slots contribute to basic user performance parameters, maintaining as much as possible the repeatability of the constellation geometry from ground. Beyond the usage for navigation, these two eccentric satellites also provide interesting features for scientific application, e.g. characterisation of the gravitational red-shift.

References
[1] https://www.gsc-europa.eu/system-status/orbital-and-technical-parameters