COLLISION RISK DURING LAUNCH PHASE

A. MACAIRE

SPACE CAPACITY ALLOCATION FOR A SUSTAINABILITY OF SPACE ACTIVITIES WORKSHOP – June 6-8th 2023

INTRODUCTION

Context

- **The need to assess accurately the collision risk at launch (LCOLA) is a specific necessity for launch operators**
- **Arianespace has developed methods to compute the collision risk probability, for a given list of objects, characterized by their TLEs**
- **A first collaboration with HELIX® solution from ArianeGroup as Space Surveillance Service Provider for the JUICE Launch**

Goal

- **Computing as precisely as possible the minimum distances between the launcher and any objects in orbit during the flight**
- **Enhance the communication between actors (satellites owners, launch service providers, Space surveillance Service providers)**
- **To use a standard for assessing the risk of collision, in terms of probability of having a contact between the launcher and an object orbiting the Earth during the launch phase**

INTRODUCTION

The risk assessment is performed for each flight

- **Validations of distance computations have been performed with several sources of computation**
- **The risk of collision concerns a limited period of time : 25 min for a direct injection to about 3 to 5 hours for longer missions such as MEO or direct GEO for which the launcher will perform one or several ballistic flight phases**
- **The riskiest cases are the LEO ones, especially when performing a multi payloads type of mission, including transfers from one orbit to another, which implies long missions in the vicinity of high density of objects**
- **The effort is now oriented towards a better accuracy and exhaustivity of the list of objects that is taken into account for the risk assessment**
- **In order to have a more accurate assessment of the orbits of the objects, Arianespace has several contacts with different entities who are able to measure the orbits of objects**
- **The computation of the risk probability takes into account as realistically as possible the dispersions and uncertainties (concerning the launcher and the object)**

I. INPUTS FOR THE CALCULATION

Mission data :

- **Launcher trajectory for the specific mission & relevant uncertainties**
- **Dates and lift-off time or window**

Objects in orbit :

- **Space-Track.org catalog given in TLE format**
- **Other sources of data (orbital data TDM, TLE ephemerid) is used (HELIX®)**

→ Arianespace welcomes any TLE providers

The computation is performed at the latest time as possible before the flight, using the most up-to-date & elaborated list of objects

Probability computation :

A filtering of the TLEs is performed, in the event that one object or satellite is declared dangerous, a dedicated probability calculation is made, based on Monte-Carlo analysis

II. COLLISION PROBABILITY ASSESSMENT

TLE INPUTS

The used TLEs are giving the nominal orbit of the object

Estimates of the uncertainties are used to perform the computation, assuming mainly an along-track dispersion

→ Ideally, the TLEs should be provided with an associated uncertainty

LAUNCHER INPUTS

The nominal trajectory of the launcher is used to determine the relative distances, as a reference case.

The trajectory dispersions are well known, using the experience of the previous flights

The main difference between forecast and real flight concerns the time of passage of the launcher on the nominal trajectory

II. COLLISION PROBABILITY ASSESSMENT

COOPERATION WITH HELIX®

Last Ariane 5 flight (VA260 - Juice mission)

The determination of a list of « dangerous » objects was performed with the help of the NORAD database (even if a warning is given not to use the TLE data for conjunction assessment).

HELIX® (ArianeGroup) gave some usable & elaborated inputs to confirm the TLE data for some objects on the predetermined list.

HELIX® uses optical means, so it requires an optimal position of the sensors for tracking any object on the launch trajectory on short notice. A minimum of days is needed before the flight to optimize the sensors' scheduling for tracking the objects.

III. OUTCOMES OF THE CALCULATION

VA260 Ariane 5 « Juice » mission

Results for the Ariane 5 flight performed on April 14th

Computation performed with forecast data			Computation with flight data		
Norad number	Min distance (km)	Time / H0 (s) Information	Distance min (km)	Time / H0 (s)	Delta flight-forecast (km)
xxx	52.0	1289.9	75.9	1292.4	**23.9**
yyy	61.2	1380.5	58.9	1383.6	-2.3
zzz	80.2	1334.4	55.9	1336.9	**-24.3**
uuu	118.8	1395.8	139.4	1401.3	**20.6**
vvv	147.2	1321.1	>150		

The computation made with the forecast trajectory gave some results that change when considering the actual flight trajectory ; the minimum distance may be reduced by about -25 km

Based on the calculation using the forecast trajectory, what should be the warning limit ?

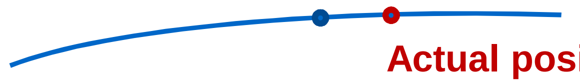
arianespace
arianeGROUP

IV. MODIFICATION OF THE ANALYSIS PROCESS

LAUNCHER DISPERSIONS

The main contributor to the dispersion of the launcher's real location in flight versus the forecast may be seen as a delayed or in advance position (mainly due to delta on mass budget or propulsion)

<u>During the boosted phase, for a given time of flight :</u>

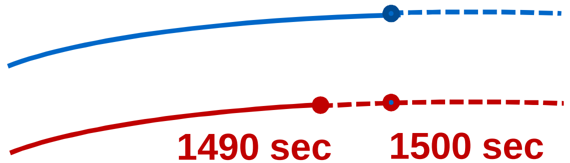


The way to simulate correctly the launcher dispersion is to run the collision assessment taking into account a dispersion on time of flight (increases the time of simulation)

→ The potential conjunctions are different when taking into account a delay on the trajectory

<u>After the shut-off of the upper stage :</u>

The injection orbit seen in flight is close to the forecast at the same time wrt the lift-off reference time



V. CONCLUSION & WAY FORWARD

The LCOLA risks computation is becoming an important aspect of the missions performed by Arianespace

An enhancement of the process is being put in place, taking into account the delay/advance of the launcher on its nominal track (main drawback : the time of computation could be long)

It is recommanded to make some progress in the following fields :

- **Have a better communication between actors (the ones who have the means to determine the TLEs of objects orbiting the Earth / the satellite operators / the launch service providers) ; a first step has been made with HELIX®**

- **Have a better estimation of the accuracy of a TLE**

- **Setting some rules (probability threshold / minimum relative distance threshold / etc) to declare that there is a risk of collision (this should depend on the quality of the TLE determination)**