PRELIMINARY TRANSFER ORBIT MISSION ANALYSIS OF COMS

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ABSTRACT ... In this paper, the preliminary transfer orbit analysis results for the COMS mission were presented. As the first step of transfer orbit analysis, the preliminary analyses of LAE burn strategy, geometrical visibility, and launch window were performed. For the analysis process, all launcher nominates were divided into three groups according to the declination of LAE thrust angle. So, the three launch cases were assigned as the representative launcher of each group, respectively. They are Ariane-5, Atlas summer and winter launch cases. And all analyses were performed at the representative launcher of each group. One nominal and three back-up plans were considered for the establishment of LAE burn strategy. And for geometrical visibility analysis, four TT&C ground stations were considered. Finally, the preliminary launch window analysis was performed about the duration of one year from the first day of September 2008. The analysis results show that the all launch cases comply with the transfer orbit operation requirements.

KEY WORDS: COMS, Mission Analysis, Transfer Orbit, Launch Window

1. INTODUCTION

The COMS, first Korean geostationary meteorological satellite, is scheduled to launch at the end of 2008. For the development of launch and early operation plan in GTO, the transfer mission analysis should be performed. During the second half of the year 2005 and the first half of the 2006, the first preliminary transfer mission analysis was performed for the COMS mission. This paper will present the brief summary of the analyses.

The COMS contract to develop the COMS satellite and to provide support for system activities has been awarded by KARI to ASTRIUM France. The COMS joint project group is composed of KARI and ASTRIUM engineers.

2. TRANSFER ORBIT ANALYSIS PROCESS

2.1 Transfer Orbit Operation Planning

For a transfer mission analysis, the information about sensor and actuator, propulsion subsystem, telemetry and command antenna pattern, mission profile and constraints are required.

Three main sequences on the transfer orbits are defined here below:

Injection phase: This phase goes from the separation to the end of the SC initialisation. The attitude is considered as undefined until the AOCS initialisation. The cruise mode is initialised when there is a ground station visibility.

Initial Gyro Calibration: this calibration is performed around the first apogee.

Apogee boost sequence: this attitude sequence is performed around each AEF. These attitude manoeuvres are necessary to go from cruise attitude to boost attitude and to go back to cruise attitude after the burn.

Typically, the transfer mission analysis is performed following next sequence. For the COMS mission, from step 1 to step 4 and step 10 were performed for three launch cases at the PDR phase. For the launch window analysis, some detail data of Eurostar-3000 mission were applied.

Step 1, mission constraints identifications and analysis
Step 2, impulsive burn planning
Step 3, burn plan simulation and tuning
Step 4, visibility analysis
Step 5, orbit determination accuracy analysis
Step 6, sun eclipses analysis in GTO
Step 7, dispersions analysis
Step 8, drift orbit analysis
Step 9, sun sensor setting and AOCS tuning
Step 10, launch window analysis

2.2 Transfer Orbit maneuver Planning

2.2.1 Transfer Orbit Maneuvers: The transfer orbit maneuvers are composed of series of LAE firings and 10N thrusters' firings to reach the IOT position in the geostationary orbit. The IOT position was assumed to 127° east in PDR mission analysis. Through the transfer analysis some maneuver parameters are defined, which are the starting time of the LAE firing and the duration, the right ascension and the declination of the thrust axis. These parameters should be optimized considering the mission operation constraints. Besides, all the impulse plans were established ensure the longitude rendezvous in order to maintain the contact with ground TT&C stations.

It is possible to correct the errors of performance of one thrust by computing the subsequent thrust. Also, it is possible to achieve the longitude phasing after the choice of the number of burns. It is necessary to determine the firings apogees for nominal and back-up strategies and to define the magnitude of each LAE firing.

Between each LAE firings, enough satellite visibility by ground stations is required in order to realize operations planning and to perform accurate orbit determination.

2.2.2 LAE Burn Strategy: A three LAE burns strategy is applied to perform the orbit circularization. For the three burns strategy, the following objectives should be reached as far as possible.

The ratio between the second burn and the third burn shall not be too large in order to limit the necessary change of the third burn attitude caused by a attitude correction to adjust a possible attitude error during the second burn. The AEF attitude is determined with respect to the sun position in the sun sensor's FOV used during the thrust firing. The attitude errors on right ascension and declination of the thrust axis during AEF depends on the sun position in the sun sensor's FOV. Thus a large difference between the second burn and the third burn attitudes may induce large dispersions on the third burn attitude. It may even induce the sun to be out of the sensor's FOV.

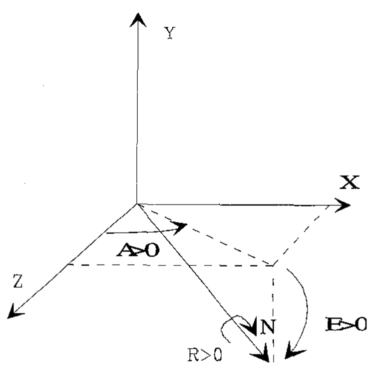

Figure 1. Thrust vector geometry.

2.3 Geometric Visibility Analysis

Ground control of the satellite during LEOP will use the S-Band. This PDR mission analysis checks the geometrical visibilities only.

Table 1. Ground TT&C Stations List

Station name	Longitude (deg East)	Latitude (deg)	Altitude (m)
Perth (PTH)	115.88	-31.80	27
Fucino (FUC)	13.60	42.16	679
Santiago (AGO)	289.35	-33.15	735
Southpoint (SPT)	204.34	19.01	245

The above ground stations network is considered: Southpoint, Santiago, Fucino and Perth. The information about these stations are described in Table 1. It is assumed that the geometric visibility is ensured for an elevation angle greater than 10 degrees. The co-ordinates of each ground station is expressed in the WGS84 reference frame.

2.4 Constraints for Launch Window Analysis

A launch window is the daily limited period during which the spacecraft injection into the required orbit is achievable. It is defined with respect to the UT of GTO injection.

The launch window is driven by four categories of constraint:

- Operational constraints
- AOCS constraints
- Thermal constraints
- PSS constraints

2.4.1 Operational Constraints: The operational constraints are related to the TM/TC visibilities of the satellite from the ground station network for all the operations requiring telemetry or telecommand. At least, a single ground station's visibility is required continuously during gyro calibration phases, LAE burn, solar array complete deployment as well as the preparation of the final earth acquisition. Only the geometric visibility is analysed for PDR.

2.4.2 AOCS Constraints: The AOCS constraints are related to the position of the eclipse occurrences, the AEF attitude control performances, and the visibility of the sun of sun sensors as well as the minimum operating altitude of the earth sensors.

Sun eclipses by the earth or the moon must be avoided at the time periods where the sun sensors are used gyro calibrations, boost axis orientation and AEF. Sun eclipses by the moon will be studied in the frame of the final mission analysis.

The major AOCS constraint is the visibility of the sun by the LiASS during the events sequences of the LEOP.

2.4.3 Thermal Constraints: The launch window thermal constraints are related to the solar aspect angle during some specific sequences as well as to the duration of the eclipses during each orbital revolution.

In order to guarantee the thermal control of the satellite, the solar aspect angle relative to the satellite's thrust axis must be limited before the LAE ignition and after the end of the firing.

The maximum eclipse duration allowed during each orbital revolution are defined according to both the thermal and PSS constraints.

The maximum sun by earth eclipse duration is set to 6 % of the orbital period. This value is bigger than the maximum sun eclipse by the earth on the geostationary orbit and is not reached during the transfer.

The sun eclipses by the moon (duration, lightning, position on the orbit) shall be analysed in the frame of a final mission analysis. Their cumulated effect with sun eclipses by the earth shall be analysed.

2.4.4 PSS Constraints: The launch window PSS constraints are related to the solar aspect angle during the LAE burns as well as to the duration of the eclipses during each revolution.

To cope with the maximum battery discharge, the satellite must be in cruise mode for an enough time before each AEF preparation sequences. The PSS eclipse constraints were defined in accordance to the thermal constraints. Thus, the same sun eclipses by the earth and by the moon eclipse constraints are applied.

3. PRELIMINARY TRANSFER ANALYSIS OF COMS MISSION

3.1 Initial Orbit Parameters

With respect to the thrust vector's elevation, all of the launcher's standard GTO elements can be categorized in to three launch cases. The initial GTO parameters are shown in the Table 2.

Table 2. Initial GTO parameters

Launch Case	Ariane-5	Atlas Summer	Atlas Winter
SMA (km)	24487.2	27646.2	27646.2
Eccentricity	0.73	0.53	0.53
Inclination (deg)	7.0	22.5	22.5
RAAN (deg)	182.1	161.0	162.0
ARP (deg)	178.3	0.0	180.0
Mean (deg)	0.0	0.0	0.0
Perigee Alt (km)	250	6719	6719
Apogee Alt (km)	35786	35786	35786

3.2 Simulation Results of Ariane-5 Launch Case

This section shows the feasibility of the COMS spacecraft mission from a mission analysis point of view for Ariane-5 ECA. The launch window is open all the days of the launch year. The duration of the launch window is always more than 1 hour. The COMS spacecraft launch is compliant with the Ariane-5 ECA launcher in the frame of a GTO launch.

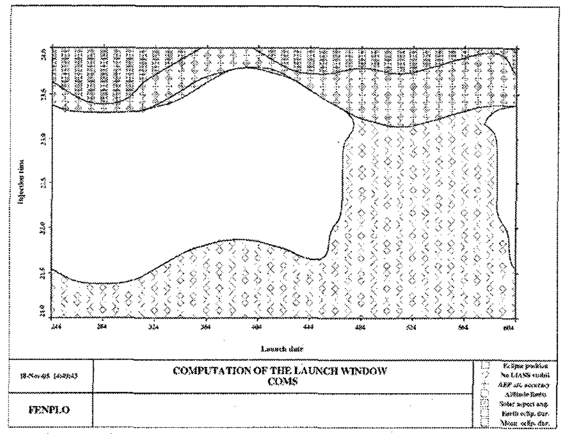

Figure 2a. COMS Launch Window by Ariane-5 in LiASS winter setting.

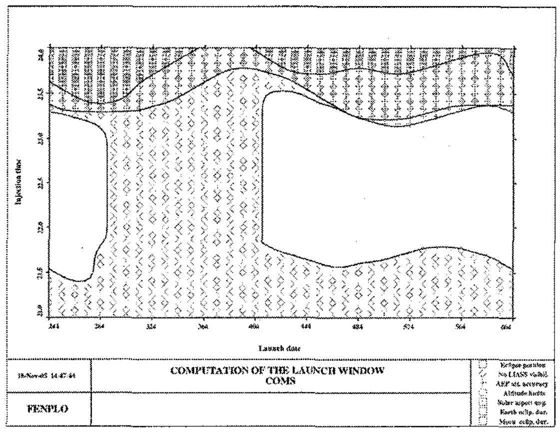

Figure 2b. COMS Launch Window by Ariane-5 in LiASS summer setting.

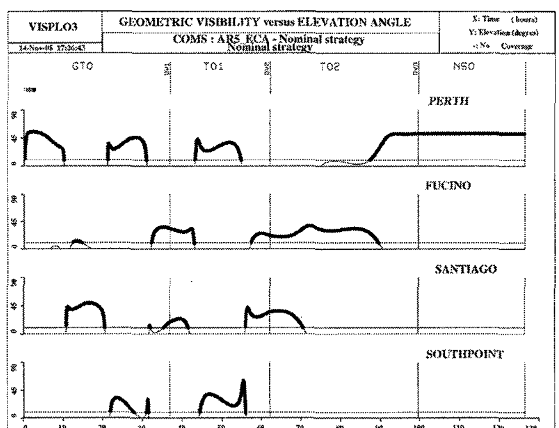

Figure 3. The ground TT&C station visibility check results in Ariane-5 launch case.

3.3 Simulation Results of Atlas Summer Launch Case

This section shows the feasibility of the COMS spacecraft mission from a mission analysis point of view for an ATLAS launch in summer season. The launch window is open daily considering a minimum duration of the launch window of 55 minutes.

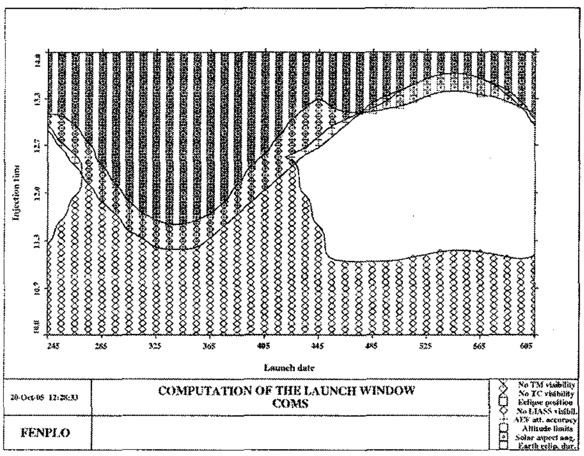

Figure 4. COMS Launch Window by Atlas in summer.

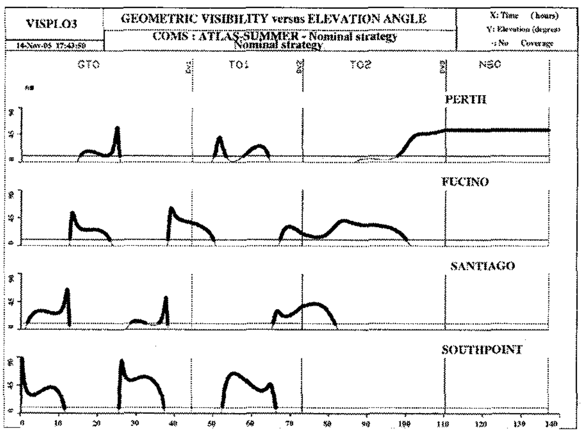

Figure 5. The ground TT&C station visibility check results by Atlas launch in summer season.

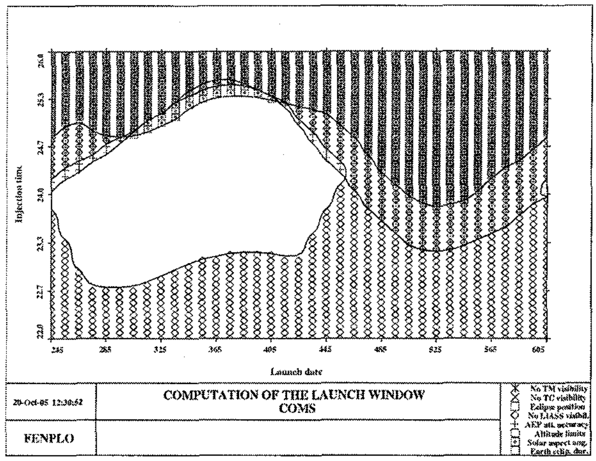

Figure 6. COMS Launch Window by Atlas in winter.

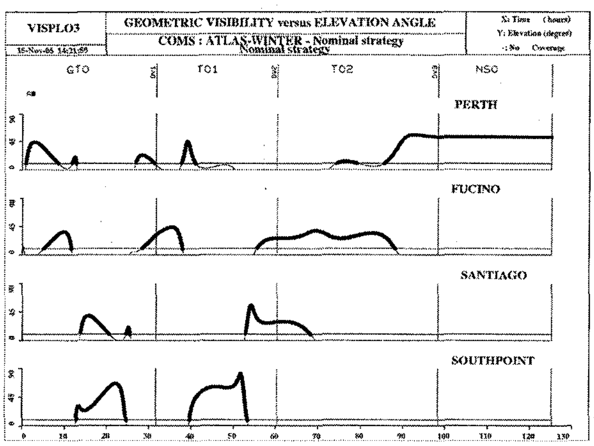

Figure 7. The ground TT&C station visibility check results by Atlas launch in winter season.

3.4 Simulation Results of Atlas Winter Launch Case

This section shows the feasibility of the COMS spacecraft mission from a mission analysis point of view for an ATLAS launch in winter season. The launch window is open daily considering a minimum duration of the launch window of 50 minutes. The COMS spacecraft launch is compliant with the ATLAS launcher in the frame of a GTO launch.

4. CONCLUSION

In this paper, the preliminary transfer orbit mission analysis results were presented. According the results, the COMS spacecraft mission is feasible from a mission analysis point of view.

The COMS spacecraft launch is compliant with the Ariane-5, Atlas summer and winter launch cases in the frame of a GTO launch. This three launch cases can be regarded as the representatives of all launcher nominates. The launch window is open all the days of the launch year.

5. ACKNOWLEDGEMENTS

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