IAF SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)
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NONDETERMINISTIC POLYNOMIAL TIME ALGORITHM FOR ESTIMATION OF SPACE LAUNCH BASE LAUNCH CAPACITY

Abstract

Purpose

When designing the new space launch bases their maximum launch capacity must be defined. The deterministic evaluation of the launch rate can be performed when the entry hypotheses are very simple by dividing the number of yearly working days by number of operations days for a single launch campaign. However, when increasing the number of constraints there are no deterministic methods to account for all complexity of launch rate scheduling. That is why we consider it as an NP (nondeterministic polynomial time) problem.

Methodology

The specific algorithm had been developed with an objective to place the maximum number of launch campaigns in a calendar year with numerous constraints, such as launch range, launch operators' concepts of operations (CONOPS), as well as any kind of probability distribution function, such as favorable weather forecast conditions and ground means availability. The algorithm verifies the validity of conditions and if they are not achieved then it proposes the new launch date performing all the checks again up to the moment when either the date is valid or it is outside of its reference period. The model can be used with increasing level of complexity: from placing the preset launch dates with designated launchers up to placing the random launch dates for random launchers. It is coupled with Monte Carlo method.

Results

Applying the constructed model and varying its parameters, we have obtained the probability distribution functions of launch base launch capacity over thousands of simulations. We have found typically that if Launch Operator minimum CONOPS duration is close to the Launch Range campaign duration the "efficiency" of use of launch slots increases. The convolution of multiple critical paths of the launch base operations creates the threshold effects limiting the launch rate increase. The ideal concurrence between launch systems for launch slots is not a synonym of launch rate increase, if the privileged launch operators have very short CONOPSes. Launch Operator using several launch zones disposes of higher overall launch rate. The same holds for the whole launch base, even though the launch rate is capped by maximum Launch Range capacity.

Conclusions

The simulation capacity of our algorithm gave us the insight in the intrinsic problems and limitations of the launch base with very high launch rates. Also it allowed to simulate the potential solutions in terms of launch base organization, contractual rules towards users and technical facilities to maximize the available launch capacity.