

SPACE TRANSPORTATION SOLUTIONS AND INNOVATIONS SYMPOSIUM (D2)  
Small Launchers: Concepts and Operations (7)

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## MATRIOCHKA SPACE PROJECT D2S7

**Abstract**

Matriochka is a two stages experimental rocket created by a student team from ESTACA; a leading space engineering school (France). Main characteristics of this project are the flexibility (payload adaptation) and partial reusability of the first stage. Currently, even with precise physical models, nothing can replace a flight test. That is why Matriochka is a real prototype (cheaper than industrial ones) to test reusability after an atmospheric flight.

First, Matriochka project seeks to offer transport to a wide range of payloads. Consequently, a high flexibility criterion guided the whole design process. Since the payloads of interest mainly vary in their diameter and mass, integration and aerodynamic stability required a particular attention. To deal with this, for example, some foam was employed to ensure a steady contact between the payload and the inner surface of the launcher fairing. Once carved, foam suits perfectly the shape of the payload. What is more, the change of mass and thus the evolution of aerodynamic stability specifications were countered by using sliding fins along the fuselage. Just before launch, the center of gravity of the system will be measured in order to fix the fins to the ideal position.

The design was focused on reusability which involves high expectations on robustness, quality and recovery function. The cost per launch will decrease flights after flights in order to pay off the preliminary investments, but it also contains maintenance costs; that is why number of consumable parts is limited. Maintenance time is also restricted to 3 weeks which is short compared to the 2 years required to realize the launcher. Reusability challenge is also testing carbon structure after ground impact because composite reusability is still in development. How to evaluate number of cycles the structure can undergo, when damages are often invisible? Testing methods such as X-ray can be used, but real tests using prototypes are still necessary.

Finally Matriochka is a small launcher which has to prove that a partial reusability is possible to decrease the global launch costs and also to open potential market with a large capability of payloads. However if private companies have already a potential reusable launcher, a question is still in progress: even if it would be possible to recover a launcher sub-system, how can we prove its reliability for a second flight? For Matriochka, the recovery result will be available next July therefore requalification tests will be developed.