1. Project Title

M-55 LAUNCHER -
Airborne Micro-Satellite Launch Complex Based on M-55 Stratospheric Aircraft

2. Project Managers

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3. Participating Institutions

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3.3. ARSENAL Design Bureau, St.-Petersburg.

4. Status

Under preparation

5. Project Description

INTRODUCTION

Spacecraft Launch Service forms an important component of the space technology that enables us to place satellites into orbit. **Airborne Micro-satellite Launch Complex,** based on M-55 stratospheric aircraft is aimed at providing a cost effective and convenient solution to organisations that specialise in launching small and super small satellites, 10 to 150 kg in weight, into near Earth orbits.

As miniature components and powerful microchips are increasingly being used in the design and development of nano- and micro-satellites the new range of satellites are becoming smaller in size, less costly and more powerful in performance and functionality. These satellites have proven versatile instruments for performing many different functions such as environmental surveillance, traffic control, wireless communications, remote education and medicine and location based services. The control and command links for such satellites require minimum capacities and allow us to use relatively simple ground-based mission control stations.

Small satellites are rapidly establishing their positions in the niche space programs. Evolution in the space technology resulting from miniaturisation and decreasing cost has made it possible for many universities, laboratories and private organisations with interest in scientific research, education and commercial interests to engage in space activity. Indeed, many countries with limited financial resources are now developing their own space programs. In the last decade countries such as Algeria, Argentina, Australia, Brasilia, Czech Republic, Chile, Denmark, Egypt, Iran, Malaysia, Morocco, Nigeria, Pakistan, Republic of Korea and Turkey have joined the space club with their own micro and nano-satellites.

Some of the examples of private and publicly funded micro and nano -satellite projects in the United States include Ionospheric Observation Nanosat Formation, University Nanosatellite Program, Coner Satellite Constellation, EMERALD and Constellation Pathfinder. In Britain, the Surrey Satellite Technology Ltd. is currently developing several multi-satellite projects including DMC (Disaster Monitoring Constellation).

Using traditional space techniques, the injection of small satellites onto near Earth orbit is performed through piggyback launch onboard the large dual or multiple payload rockets. Although the launch of such kind is less expensive than the customised platform, there are limitations in this system:

- Launch is dependent upon the availability of a slot and parameters of the main payload to be deployed;

- Limited opportunities for launching small satellites into equatorial and low inclination orbits, that is essential for countries in the South Asian and Pacific Region;
- Additional efforts and costs are involved in transporting satellites to foreign launch sites and pre-launch trials;
- Enhanced technical and financial risks due to injection of multiple heterogeneous payloads from one launcher.

The technical and physical limitations of piggyback injections on the one hand and the increasing demand for micro and nano-satellite means that new launch service is now required that is specially designed for launching micro-satellites.

Mobile Airborne Micro-Satellite Launch Complex, developed within the framework of *M-55 LAUNCHER* project, provides an ideal solution for the launch of a small satellites. It provides precise injection of micro-satellites, up to 150 kg weight, into near Earth orbit from any country having standard airport runway facilities for normal take-off and landing. It provides an efficient and cost effective launching system that has the potential to satisfy growing demand for micro satellite launch services especially in less-developed counties.

WHAT IS M-55 LAUNCHER

M-55 Launcher is a Mobile Airborne Micro-satellite Launch Complex with the following components:

- M-55 Stratospheric plane-carrier;
- Two stage rocket-carrier fixed on a special platform on the plane “back”; its target is to deliver useful payload (acceleration block and micro-satellite) onto transfer orbit of 200 km altitude;
- Acceleration block for injection of micro-satellite from the transfer orbit onto operational orbit.

M-55 PLANE-CARRIER

M-55 high altitude subsonic aircraft is an all metal twin-boom high-wing monoplane of normal configuration with a straight high-aspect ratio wing, a twin-finned tail unit, tricycle nose-

wheel landing gear and equipped with two turbo fanned Russian D-30V12 engines that has passed complete endurance life tests.

This aircraft is designed by MYASISHCHEV Design Bureau (Zhukovsky city, Moscow Region) and constructed at Smolensk Aviation Plant (SmAZ Ltd.).

The first flight of M-55 was successfully performed in 1988. At present there are two M-55 are in operation and a further two planes are being produced.

Since 1995 M-55 "Geophysica" has been used in many international research studies of the Earth's atmosphere, supported by the European Union. The aircraft has proven its high safety record and performance by flying in critical climatic conditions over the Arctic, the Antarctic, the European and the equatorial areas.

The table below presents the main performance of M-55 plane-carrier.

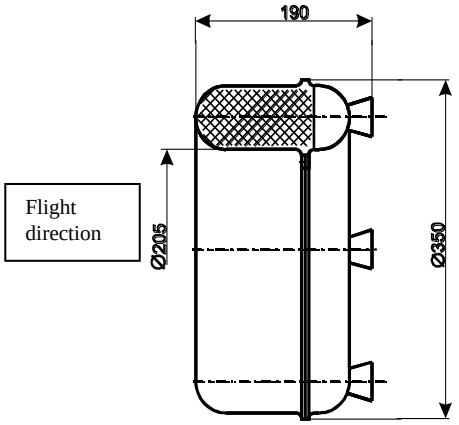
Crew	1 pilot
Power plant: - Engine - take-off thrust, kg	 - by-pass turbojet D-30-V12 - 2 x 5000
Aircraft overall dimensions, m:- length - wing span - height	 - 22.87 - 37. 5 - 4.83
Masses and payloads, kg: - take-off - useful payload - fuel	 - 27500 - 5500 - 6000
Performance: - service ceiling, km - max speed, km/ h - cruise speed, km/ h - flight endurance, h	 - 20. 4 - 750 (M=0.70) - 600 to 650 - 4.2
Basing	Concrete II class (L=2000m, B=42 m), H < 4000 m, t= from – 40 to + 60^{o} C

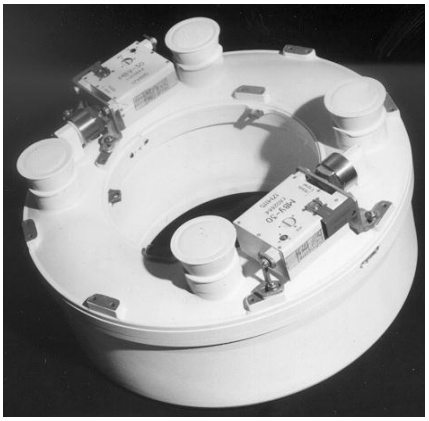
TWO STAGE ROCKET-CARRIER

There are a number of two-stage rockets currently available in the market capable of inserting 100 - 150 kg micro-satellite into 200 km transfer orbit from the M-55 Stratospheric aircraft. The choice of rockets can be decided upon during the process of the project. For the purpose of current estimations we consider a rocket unit of plug-in (capsular) type, with a start mass of 5500 Kg, with solid propellant first stage engine and the liquid propellant second stage engine with pulse J=330-370s.

ACCELERATION BLOCK

Acceleration block TOR for the M-55 LAUNCHER project is designed and developed by ARSENAL Design Bureau (St.-Petersburg). This system is based on the solid propellant rocket engine, 17D712. Since 1989 more then 70 engines of this type have been used onboard the "Cosmos" satellites without failures. Mass of the equipped engine is 17 kg including 8 kg of propellant.



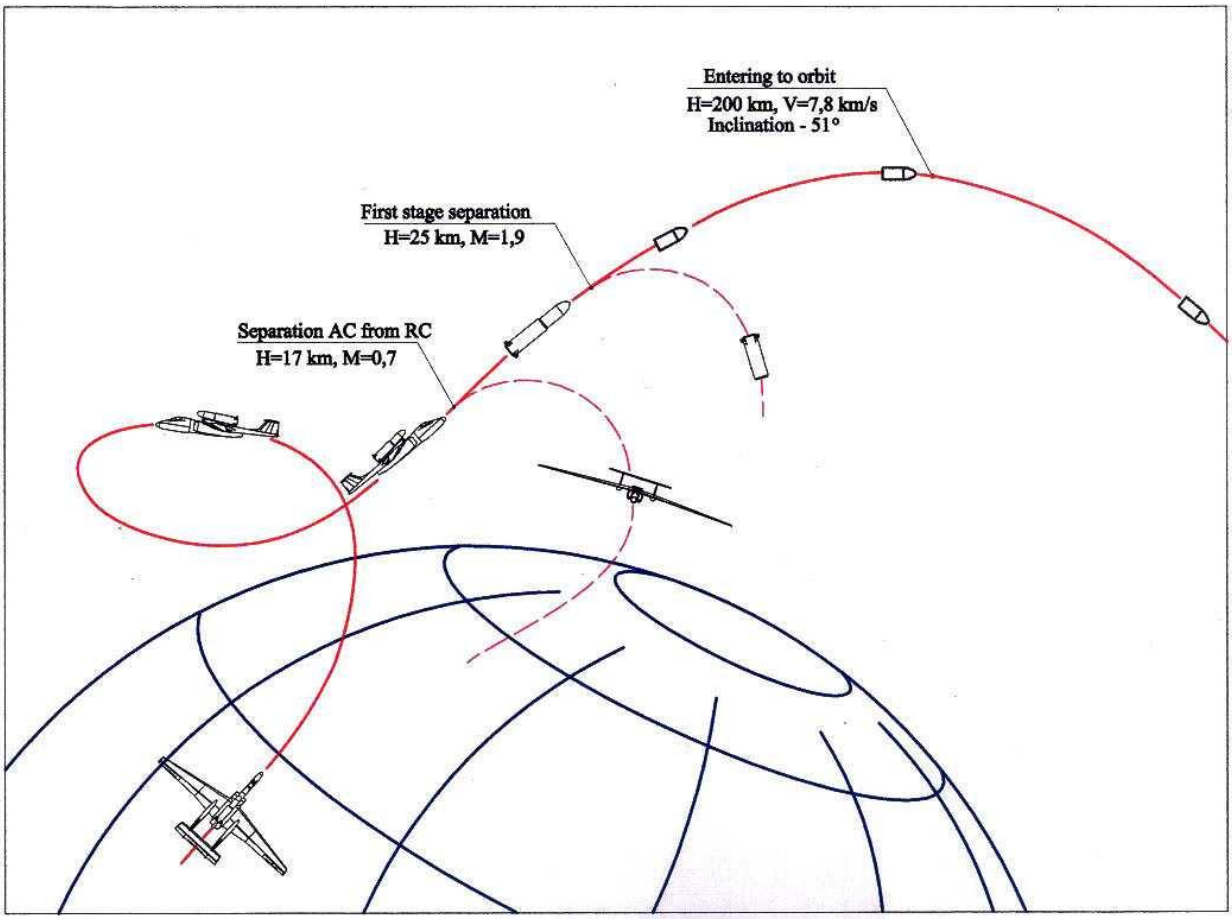


17D172 engine

To create the TOR acceleration block the 17D172 engine is additionally equipped with carrying pipe-like construction, stabilisation and control devices and separation unit. Acceleration block TOR can be used both in the single stage and in the multiple stage variants. Use of TOR in multistage scheme significantly increases its energetic capability and the range of available inter-orbital passages. TOR is stabilised by rotation. The TOR-micro-satellite couple is twisted and then after completing the inter-orbital manoeuvre TOR provides the deceleration of twirl. The control system is autonomous. TOR does not need electrical links with rocket carrier and micro-satellite. Mass of one-stage TOR is 24 kg and its dimensions are 0.4 m both in length and diameter.

SCHEME OF LAUNCH

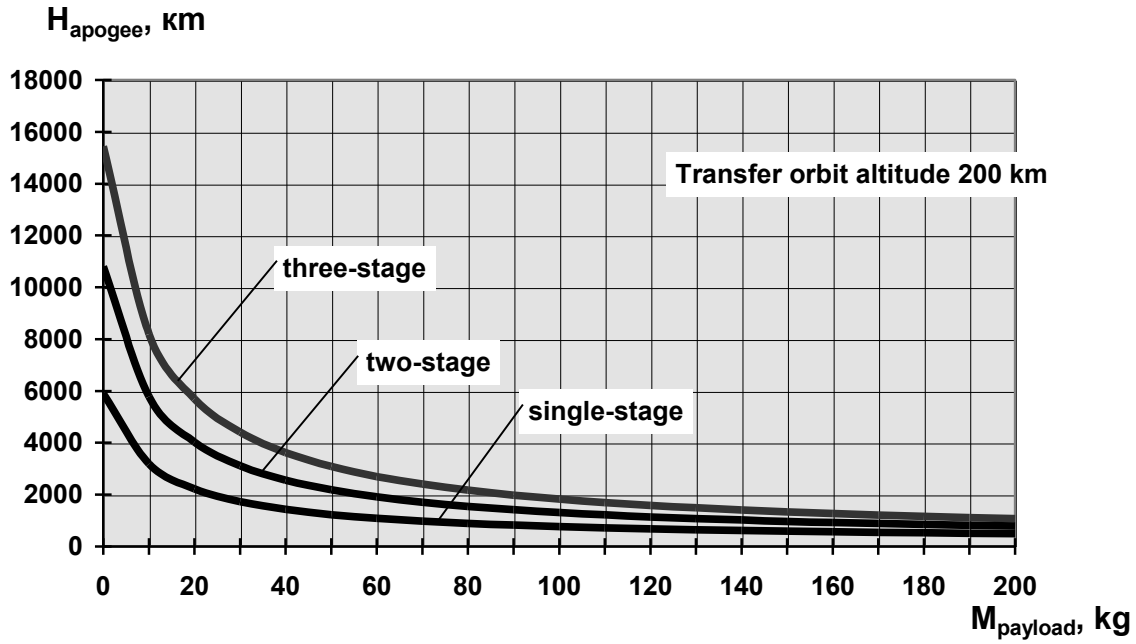
The launch process of micro-satellite onto near Earth orbit takes place in two stages. In the first stage, micro-satellite and the acceleration block are delivered into the transfer orbit at the altitude of 200 km. The rocket starts from M-55 plane-carrier (PC) at the altitude of 17 km. This step is illustrated by the figure below.



Calculations made for the rocket-carrier (RC) of 5500 kg mass, latitude of start 47^0 and inclination of orbit $51^{0,}$ have shown that the mass of payload (micro-satellite plus acceleration block), which can be inserted onto 200 km circular orbit, ranges from 100 to 150 kg depending on the RC parameters.

In the second stage of the launch process the single-stage TOR acceleration block performs the task of transferring of satellite from the intermediate (200 km) orbit onto the operational orbit with apogee from 700 km to 3000 km, for the micro/nano satellites of mass of 120 kg and 10 kg respectively.

The capabilities of a single, two and three-stage TOR acceleration blocks for the transferring of useful payload from 200 km circular orbit to the higher elliptic orbits are illustrated in the following diagram showing the altitude of apogee (km) versus mass of satellite (kg).



Some estimates of the orbit parameters provided by the two-stage TOR are given in the table below (the altitude of transfer orbit is 200 km).

Mass of satellite, kg	Perigee, km	Apogee, km
50	1064	1191
100	735	781