AIRCRAFT MEANS APPLICATION FOR SUBORBITAL TOURIST FLIGHTS AND COMMERCIAL SATELLITES LAUNCHING INTO AN ORBIT

E. Dudar *, A. Bruk **

*** NPO MOLNIYA, Moscow, 125459, Russia, Novoposelkovaya str. 6**
E-mail: edw@pochta.ru Phone: +7- 495-497-49-61 Fax: +7- 495-497-49-53
**** Experimental Machine Building Plant (EMZ) named after V. Myasishchev, Zhukovsky, Moscow region, 140185, Russia, Narkomvod str. 1 E-mail: mdb@mail.sitek.net, rkabm@progtech.ru Phone: +7-916-680-07-93 Fax: +7- 495-728-41-30**

Keywords: *Suborbital, Tourism, Air-Launch, Configuration*

Abstract

Here is the review of researches regarding the initial design development of an aerospace transport system for rendering services in the public space tourism domain. It is shown that in the nearest future it is expedient to develop a suborbital version of the system comprising a subsonic carrier, a space vehicle and a ground infrastructure. A solid propellant rocket engine is supposed to be installed on the space vehicle as an acceleration rocket engine. Possible variants of extra applications are discussed.

1 Introduction

In the first decade of the XXI century prerequisites were outlined for development and operation of suborbital transport systems (STS) capable to carry out a wide range of missions among which the most demanded is services in the space tourism domain. As compared with the orbital space transport systems the cost of STS development is rather lower. The number of applied critical technologies and the risk of the project are essentially decreased.

The first embodied commercial project of a space vehicle of tourist class is the Spaceship One with two-fuselage carrier White Knight developed by Burt Rutan. At present works on further upgrading of this suborbital transport system with the increased passenger capacity up to six space tourists on board the space vehicle – are coming to the end.

Along with two-stage suborbital systems projects, designs of a one-stage tourist space vehicle that can takeoff independently using its own turbojet engines have appeared. Acceleration up to the suborbital trajectory, as well as it is performed in a space vehicle of the air start, is carried out using the rocket engine. There are also some projects of tourist space vehicles starting vertically using a launch rocket vehicle of a light class.

2 Russian Projects of STS

One of the first projects of a suborbital passenger system (SPS) – on the base of the fully reusable version of MAKS aerospace system – was developed by NPO ‘Molniya’ at the end of the 80th under the leadership of G. Lozino-Lozinsky [1]. The space plane having 52 passengers on board had to start from AN-225 carrier and to accelerate, using two RD-701 three-propellant engines up to the velocity close to the circular. In this case suborbital flights on intercontinental routes were possible, for example from Moscow to Rio de Janeiro for about 4 hours (staying at zero-G conditions during ≈ 40 minutes). Later a reduced version of this system, with one engine for air-launch from AN-124 (Fig. 1), was developed.

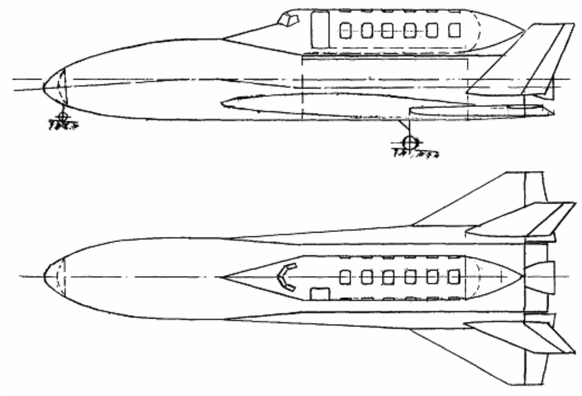

Fig. 1. SPS Version for Air-launch from AN-124 (NPO 'Molniya', 2002)

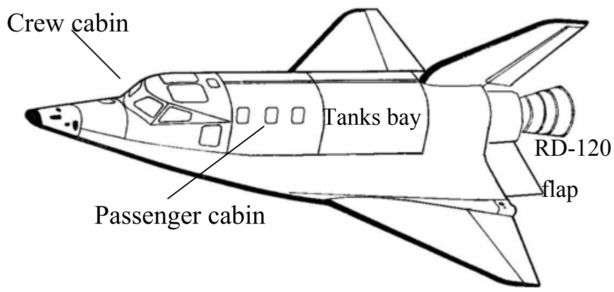

Fig. 2. Suborbital Space Plane on the Base of MAKS Orbiter (NPO 'Molniya', 2006)

SPS project was conceived as the ensuing development of MAKS system [2], its realization and application are feasible only after obtaining sufficient statistics on the reliability of a new liquid propellant rocket engine and of the tanks combined thermal protection and thermal insulation system. In 2006 in NPO 'Molniya' a technical proposal [3] on the suborbital tourist space plane was prepared on the base of the orbiter vehicle configuration for MAKS system and its experimental prototype – MAKS-D demonstrator of technologies (Fig. 2). The full-size propulsion unit was replaced by the oxygen -kerosene engine from the second stage of 'Zenit' rocket launcher. Within the volume of the payload bay the tanks with fuel components are located as well as the passenger cabin integrated with the crew cabin into a common pressurized bay. The suborbital transport system (STS) having a crew of two pilots and six passengers on board after air launch from AN-225 or AN-124 carrier is capable to achieve Mach number 10. The STS launching mass is 56t. Duration of staying in zero-G conditions at the altitude up to 150 km is about 15 minutes.

The project of C-XXI suborbital transport system (Fig. 3) was developed at Myasishchev Design Bureau (MDB) on the base of M-55 high altitude carrier (Geophysica) [5]. The C-XXI system enables minimum required endurance of staying in zero-G conditions - within 3...5 minutes with climbing up to the maximum flight altitude 101...105 km.

Fig. 3. C-XXI Suborbital Aerospace System (MDB, 2004)

The use of solid propellant rocket engine as a booster with maximum thrust 6.3 tf and with specific impulse in vacuum 290 s is envisaged. Having the takeoff mass 3.5t, the space vehicle should accommodate 1 pilot and 2 passengers. The space vehicle full scaled mock-up has been displayed at international exhibitions (Fig. 4). Later the extended version of the tourist space vehicle was designed (1 pilot + 4 passengers) with the launch mass 5.5 t.

Fig. 4. Suborbital Space Plane of C-XXI System (MDB, 2004)

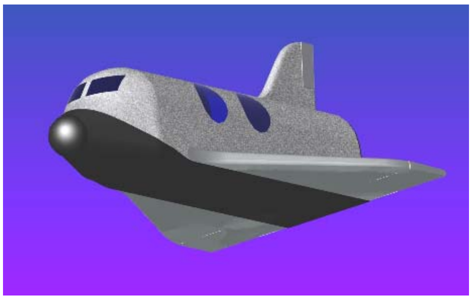

Fig. 5. 'Oduvanchik' (Dandelion) Suborbital Space Vehicle (MGTU named after N. Bauman, 2008)

The similar by dimensions suborbital space vehicle is developed in MGTU named after N. Bauman (Fig. 5) for vertical start using the rocket booster operating at the hybrid fuel (liquid oxygen + solid propellant). It is typical that in this project the aerodynamic configuration is applied that was tried out earlier at the 'Buran' winged spaceship. At launch mass 5.5 t (without taking into account the rocket booster) in the space vehicle 1 pilot and 4 passengers can be accommodated [6].

The advantages of the space vehicle with horizontal air launch (Fig. 1...4) include a significant decrease of the rocket booster dimensions and the absence of estrangement fields (the rocket engine is not released at flight). At the same time the space vehicle of the vertical start (Fig. 5) does not have a sustainer rocket engine, its design is simpler, and development and manufacture are cheaper.

Optimization of Suborbital Space Vehicle Layout

In 2008 MDB in cooperation with NPO 'Molniya' prepared the Feasibility Study for the suborbital aerospace system M-91, with increased dimensions, and that could be competitive in comparison with other suborbital systems of tourist class (Fig. 6, Table 1). As a carrier it is offered to use the reconstructed transport aircraft 3M-T that transported the 'Buran' orbiter and tanks of 'Energia' rocket to Baikanur launching site. The increase of the number of passengers, space tourists, up 14 will allow to shorten the terms of M-91 suborbital aerospace system payback, that makes it more attractive for private investments. 3M-T payload capacity (up to 45t) provides the ability to apply well developed materials and reliable technical configurations reducing to minimum technical risk and decreasing the costs of development. After preliminary project researches in NPO 'Molniya' the aerodynamic configuration was formed for the suborbital space vehicle of canard configuration with rotary nose horizontal surfaces (canard) providing a pitch balance at high angles of attack 45...50° when entering the dense atmosphere layers (Fig. 7).

Fig. 6. M-91 Suborbital Aerospace Tourist System on the Base of 3M-T Carrier (DB, NPO «Molniya», 2008)

The lower surfaces of the wing, wing extensions and nose fuselage form a smooth integrated lifting surface of a large area generating effective aerodynamic braking on the upper part of the re-entry trajectory and decreasing the landing velocity up to 240 km/h.

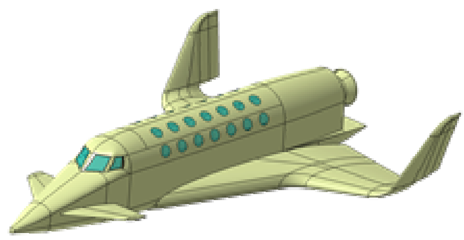

Fig. 7. Suborbital Space Plane of M-91 System (MDB, NPO «Molniya», 2008)

In order to provide a convenient maintenance of the solid propellant power plant the vertical tail is designed as two tail fins. In the tail part under the rocket engine a balancing flap is located.

Main Performances of Two Versions of Aerospace Vehicle Developed for Suborbital Space Tourism

Table 1

Carrier-aircraft type	M-55	3M-T
Air launch state: flight altitude, km flight velocity, m/sec	 16…17 180…200	 7…8 140…150
Vehicle's take-off mass, t including rocket booster, t	5.1 2.2	27.7 15.1
Vehicle's size: length, m wingspan, m	 8.7 7.1	 17.5 12.1
Number of pilots Number of passengers	1 4	2 14

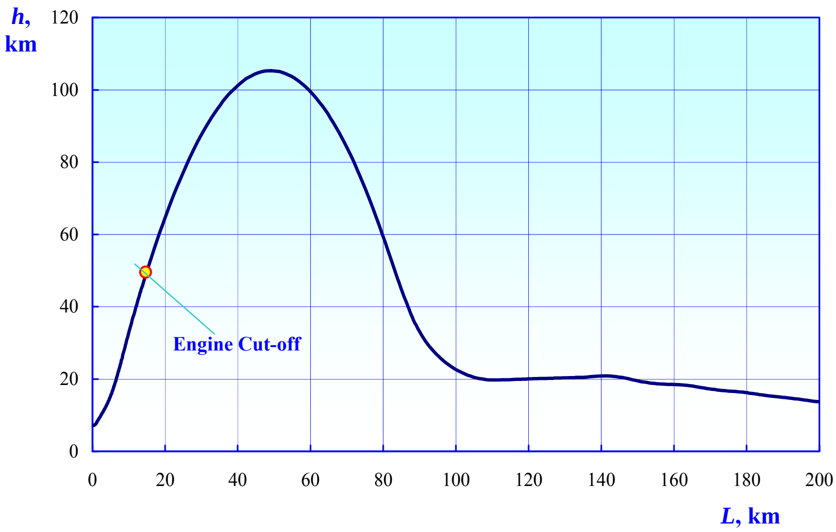

Fig. 8. Longitudinal flight profile of suborbital tourist space vehicle

Elevons provide the pitch control (together with the rotary nose horizontal surfaces) and roll control. In the nose and tail parts the units of jet control system engines are located that are operated in the rare atmospheric layers. According to the preliminary estimations the space vehicle launch mass, including the solid propellant acceleration rocket engine will be 27.7 t. It is offered to use the engine with the thrust linearly decreasing from 90 tf at the start up to 45 tf at the 50^{th} second of operation. In this case high start thrust-to-weight ratio reduces gravitational energy losses, and the leaner decrease of the thrust allows reduce the longitudinal g-load. At the point of the solid propellant rocket engine cut-off (Fig. 8) at the altitude 48 km the space vehicle achieves the velocity ≈ 1100 m/s at the angle of trajectory inclination 70°, that enables to reach the altitude 105...110 km.

Maximum temperatures of heating in the nose point of the fuselage are achieved at the end of the acceleration (~220°C) and when entering the dense atmospheric layers at the altitude 20.5 km (~220°C). Such comparatively low level of temperatures allows not to use the thermal protective coating .

One problem of the suborbital space vehicle – is the high level of normal g-loads when entering the dense atmospheric layers at large angle of the trajectory inclination. The formed aerodynamic configuration allows to reduce normal g-loads to 4,2.

The M-91 aerospace system can have a cargo modification to inject small payloads into orbit. In this case the same carrier is used with the mounting points, and the solid propellant rocket engine of the suborbital space vehicle is acting as the booster of the 1st stage of the air launch rocket vehicle. It is expedient to apply in the 2nd stage of this air launch rocket the 30tf oxygen-kerosene booster from 'Angara' launcher upper stage. According to the preliminary estimations the payload mass at the low orbit with inclination 51° can be ~ 1t.

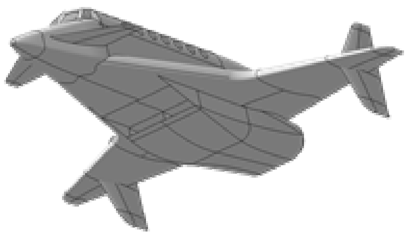

Fig. 9. Preliminary vision of one-stage space vehicle of tourist class:
NPO «Molniya», MDB, 2008

M-91 aerospace system will enable to perform research missions concerned with key technologies development for winged elements of the advanced rocket-space systems. M-91 suborbital aerospace system is capable to become a commercially effective system to render services in the domain of public space tourism. However this project has some disadvantages as well which include: a short residuary service life of 3M-T carrier, a need in lifting facilities to place the space vehicle on the mounting points. The alternative can be a one-stage space vehicle having in addition to solid propellant rocket engine two turbojet engines of AL-31 type (Fig. 9).Turbojet engines provide takeoff, climb and flying into the area of the rocket engine start, and in case of a failure they enable return to the base aerodrome.

Conclusion

Russian enterprises having participated in the development of 'Buran' reusable spaceship possess the scientific-technical potential to design a competitive project of suborbital transport system intended to render services in the domain of public space tourism.

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