AEROSPACE REUSABLE COMPLEX FOR MICROSATELLITES LAUNCH (ARC) *STORMVÖGEL*

Appointment

- ARC is designed to launch micro and nano satellites into low-Earth orbit for reusable use with minimal payload cost

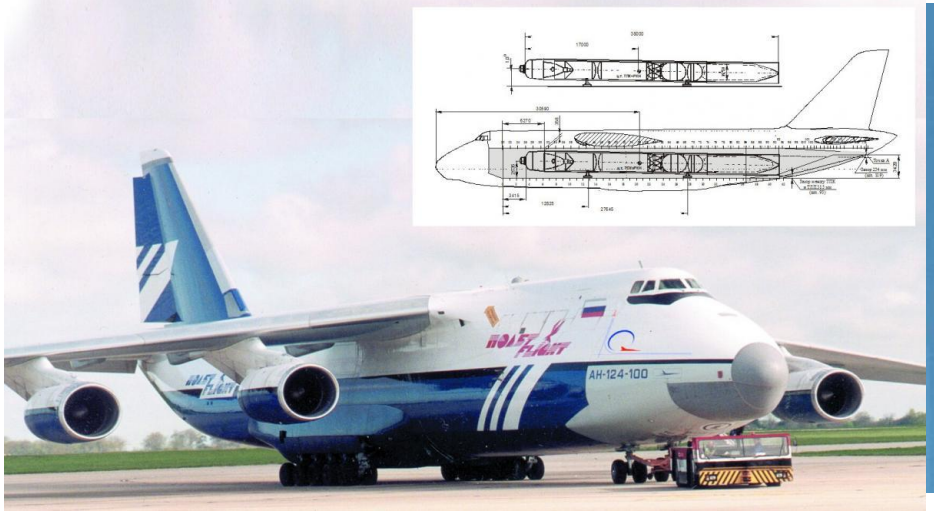
ARC concept

- Modern multistage space rockets can burn up to 80% of the mass of fuel stored in the first stage of rocket while claiming to stratosphere. Therefore, aerospace launching systems are very relevant, allowing to save fuel by launching a rocket from an aircraft at an altitude of 8 ... 12 km.
- Hence, efficacy of launching systems may be a deal-breaker for space projects on low budgets.

Air launch projects with external and internal position of the rocket relative to the aircraft

SpaceShipTwo

Pegasus



Launch from the An 124-100 cargo hold

Why?

- - Because of Initial thrust-to-weight ratio that is 0.2 when starting own jet propulsion engine (JPE) at 10 km altitude instead of 1.2 min for conventional rockets launched vertically from the Earth. Its decreases the starting mass of rocket plane of ARC.
- - Because of transonic speeds in atmosphere lift of rocket plane with aerodynamic wing while rising to stratosphere. This give low aerodynamic losses and eliminates gravitational loses

Advantages

- Air launch of rockets from an aircraft carrier, in comparison with their launch from stationary ground-based launchers, makes it possible to increase the carrying capacity of rockets, reduce the cost of the payload for launching satellites, expand the range of realizable orbital inclinations and increase the launch frequency.
- Usage of non-cryogenic environmentally friendly fuel
- Reusable configuration

ARC Operation

ARC system is facilitated by a rocket-carrying vehicle with high aerodynamic capabilities.

- ARC vehicle gets airlifted by an aero-towing aircraft - without starting its own engine at first.
- At an altitude of 9…12 km above the Earth, the towing aircraft disconnects, and ARC starts its own JPE. At this stage ARC raises to 30 km altitude (at subsonic speeds).
- At altitudes above 33 km, ARC increases pitch angle, give maximum available power to JPE and switches to a supersonic gain of speed in stratosphere and start ballistic movement at higher altitudes .
- At altitudes of 60 to 80 km, after ARC exceeds the first space velocity, the payload is being released.
- Using aerodynamic breaking, the ARC slows down, switches to a sonic flight mode, returns to the landing zone and makes an aircraft-type landing.

It is possible to start launching rocket plane using an aero-towing vehicle. Capability towing of rocket plane is up to the altitude of 9...12 km with standard equipment

Grob 520	Pilatus 12

Description of ARC

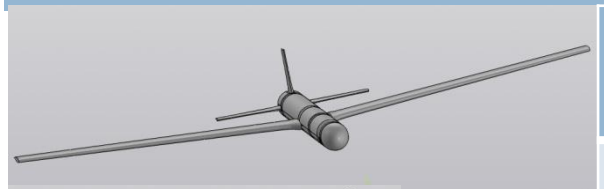
- The complex is a rocket plane with a high aerodynamic quality, at up to sound speeds, starting from the Earth without applying a rocket engine, but with the help of a high-altitude aero-towing vehicle.
- At an altitude of 9…12 km above the Earth, the towing vehicle disconnects rocket plane and begins to jet propulsion with a climb up to 33 km at subsonic speeds. At altitudes above 33 km, the rocket plane switches to a supersonic gain of speed at stratosphere, increases the pitch and, while exceeding thrust-to-weight ratio 0,9 start the ballistic flight.
- At an altitude of 60 ... 80 km, after achieving velocity of 6500 km/s, the payload is separated. With the help of aerodynamic braking, the rocket plane slows down, switches to a sonic flight, returns to the landing zone and makes an aircraft-type landing.

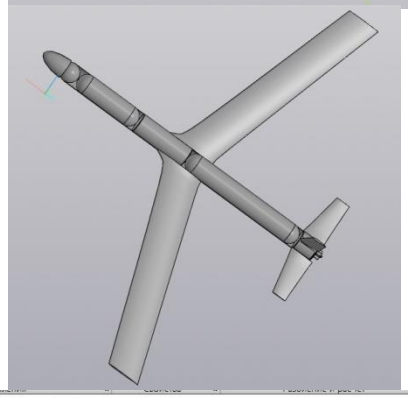
Jet propulsion engine

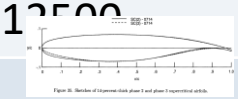
- The liquid-propellant rocket engine of ARC is built according to the scheme with a displacement oxidizer / fuel supply with decomposition of hydrogen peroxide on catalyst and then afterburning oxygen and Atcetame50/50 in the combustion chamber. The pressure source of the displacement system is high pressure helium ballonet. The fuel tank and oxidizer tank are equipped with a temperature control system. Environmentally friendly components are used. As a fuel oxidizer - 85% hydrogen peroxide, as a fuel - liquid Atcetume50/50 .

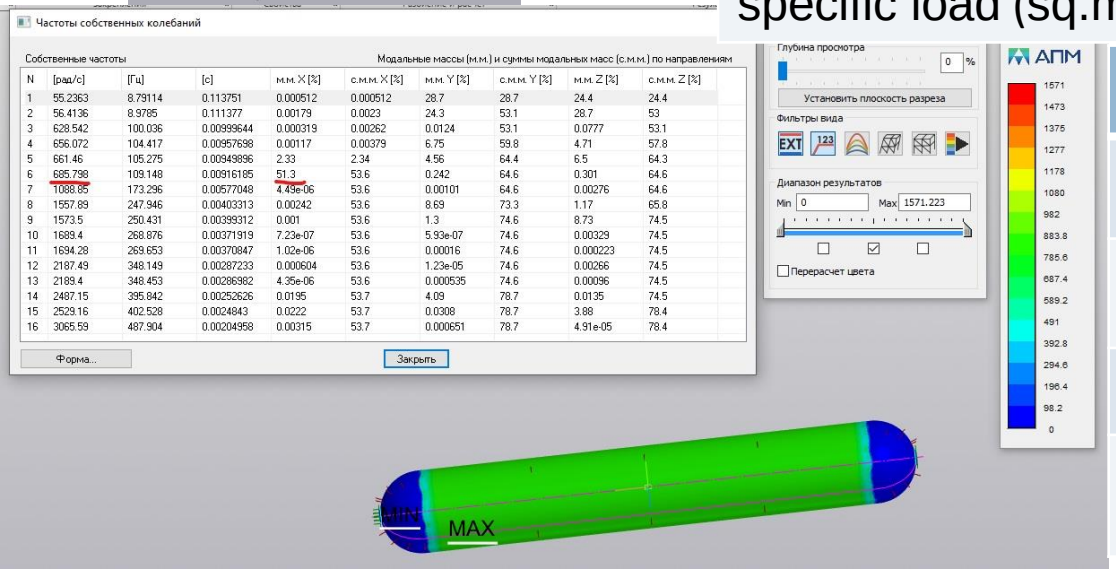
Rocket plane design

Stormvögel





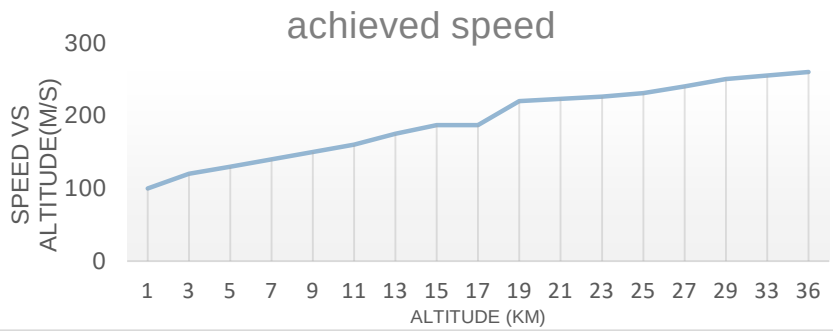
4; 6-chamber JPE (max trust of 400; 600 kg), (s)	280…300
Empty mass (kg)	120
Fuel mass (kg)	1580: 2000
Pay load (kg)	150
Wing span (mm)	12500
Air foil SC3 – 0714 transonic	
specific load (sq.m.)	106

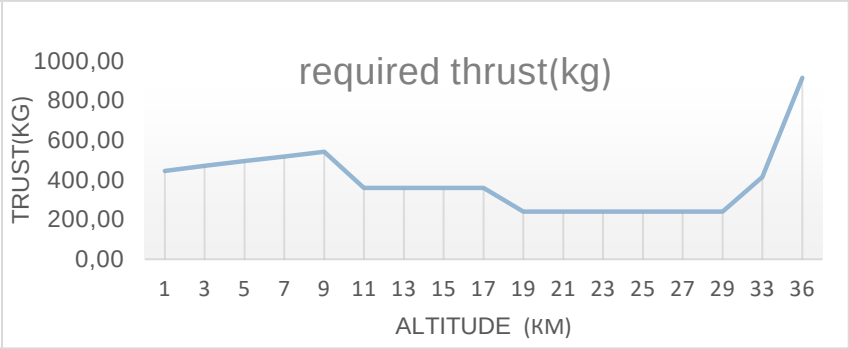


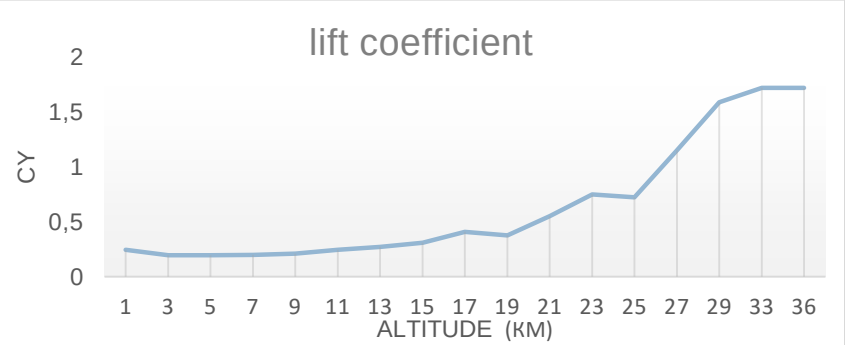
N	[рад/с]	[Гц]	[с]	м.м. X [%]	с.м.м. X [%]	м.м. Y [%]	с.м.м. Y [%]	м.м. Z [%]	с.м.м. Z [%]
1	55.2363	8.79114	0.113751	0.000512	0.000512	28.7	28.7	24.4	24.4
2	56.4136	8.9785	0.111377	0.00179	0.0023	24.3	53.1	28.7	53
3	628.542	100.036	0.00999644	0.000319	0.00262	0.0124	53.1	0.0777	53.1
4	656.072	104.417	0.00957698	0.00117	0.00379	6.75	59.8	4.71	57.8
5	661.46	105.275	0.00949896	2.33	2.34	4.56	64.4	6.5	64.3
6	685.798	109.148	0.00916185	51.3	53.6	0.242	64.6	0.301	64.6
7	1088.85	173.296	0.00577048	4.49e-06	53.6	0.00101	64.6	0.00276	64.6
8	1557.89	247.946	0.00403313	0.00242	53.6	8.69	73.3	1.17	65.8
9	1573.5	250.431	0.00399312	0.001	53.6	1.3	74.6	8.73	74.5
10	1689.4	268.876	0.00371919	7.23e-07	53.6	5.93e-07	74.6	0.00329	74.5
11	1694.28	269.653	0.00370847	1.02e-06	53.6	0.00016	74.6	0.000223	74.5
12	2187.49	348.149	0.00287233	0.000604	53.6	1.23e-05	74.6	0.00266	74.5
13	2189.4	348.453	0.00286982	4.35e-06	53.6	0.000535	74.6	0.00096	74.5
14	2487.15	395.842	0.00252626	0.0195	53.7	4.09	78.7	0.0135	74.5
15	2529.16	402.528	0.0024843	0.0222	53.7	0.0308	78.7	3.88	78.4
16	3065.59	487.904	0.00204958	0.00315	53.7	0.000651	78.7	4.91e-05	78.4

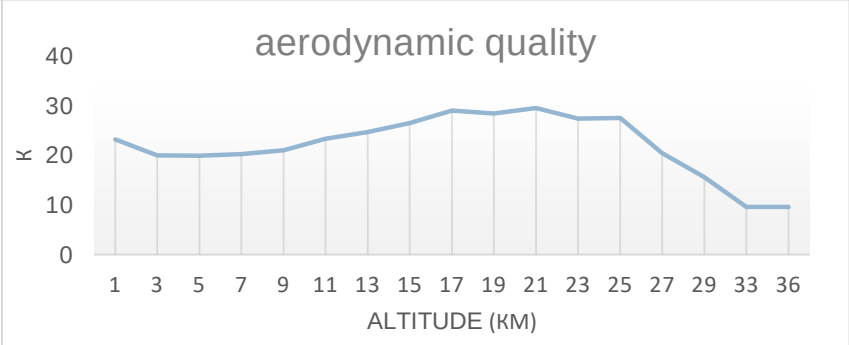
wing narrowing	0,89
root chord , 14% (mm)	1320
terminal chord , 11% (mm)	1180
wing twist (deg)	-1.5
length (mm)	10660

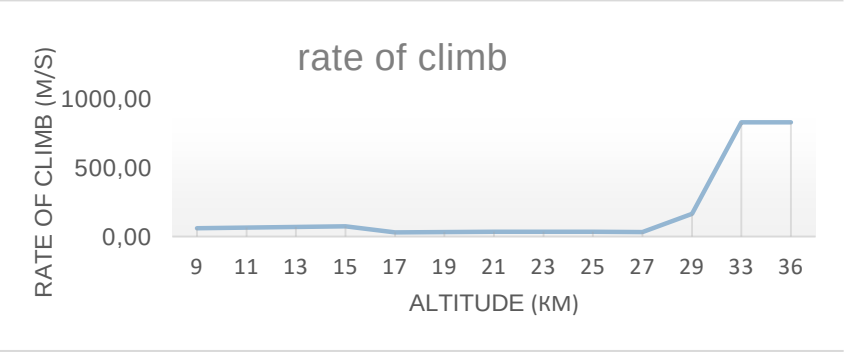
Calculated parameters of rocket plane launch in atmosphere









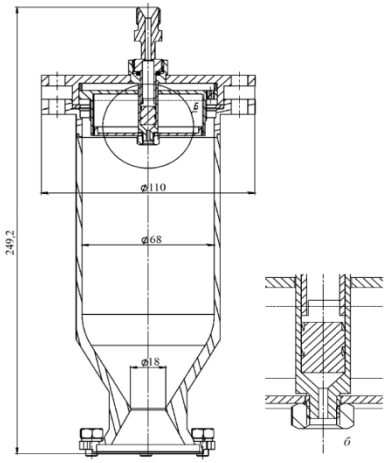


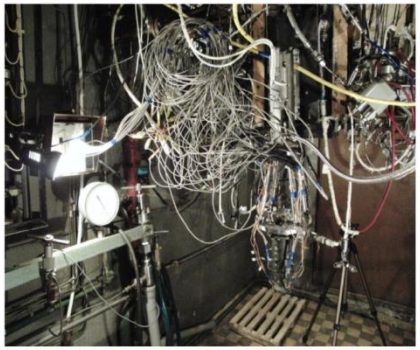
Starting mass (kg)	1750
airspeed at 33 km (m/s)	255
Fuel needed to lift 33 km (kg)	692
thrust-to-weight ratio at the start of ballistic flight	0,9
Work time of JPE in atmosphere (minute)	10,7
Work time of JPE for ballistic flight (minute)	4,8
characteristic speed (first stage) (m/s)	6594
Pay load (first stage) (kg)	150

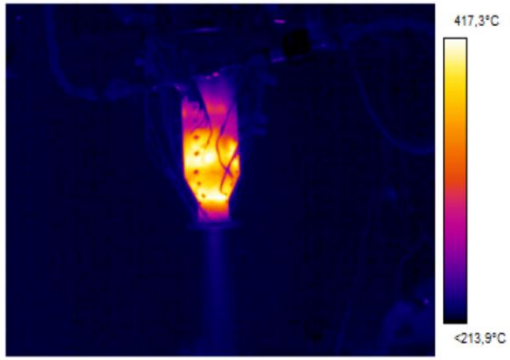
Prototype engine

The design of the prototype rocket engine - MT (MAI) 500N

Stand and Thermal conditions during engine tests

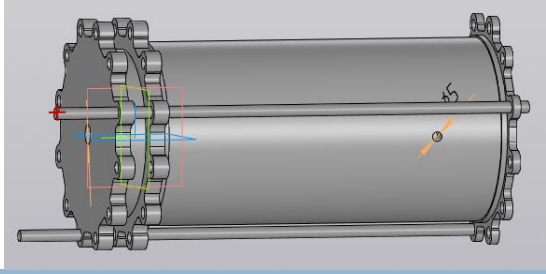




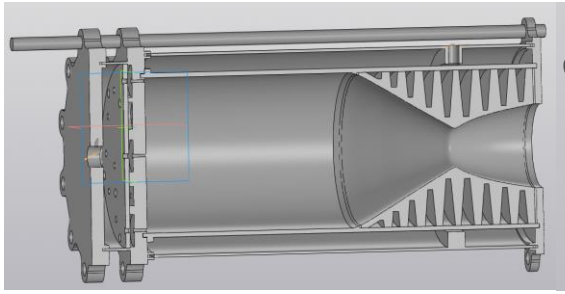


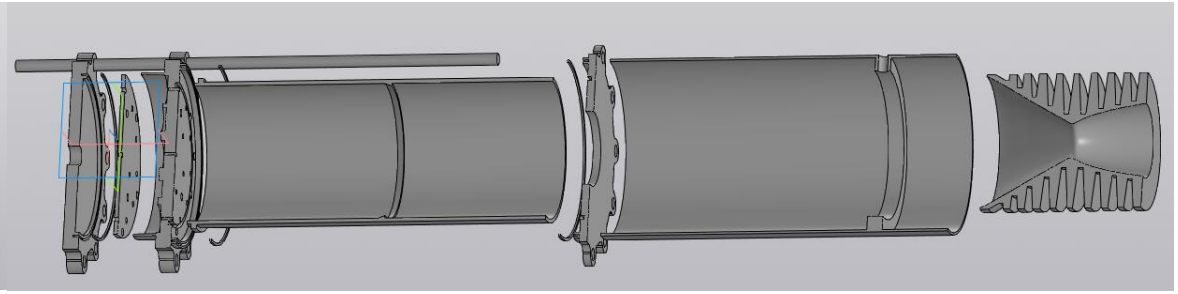
for peroxide and Kerosine fuel components

Our Jet propulsion Engine



- Using the tested prototype of the MAI JPE, we will create a modified version of such a JPE with new fuel component and thrust of 100 ... 120 kg and with a cooled wall of the combustion chamber with fuel. In addition, in order to reduce the cost of the design, achieve reusability and the required duration of the JPE, a single-use ceramic refractory liner of the critical section will be used. This changings will help to achieve suitable specific impulse of 280…300s.





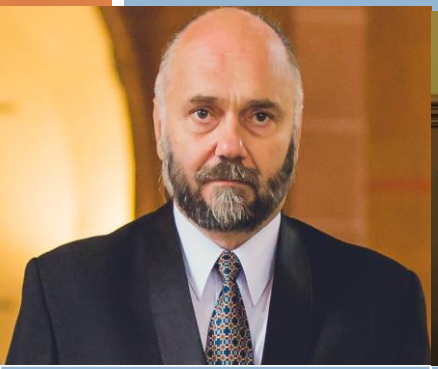
Expected characteristics of JPE

- Thrust -1000... 1200 N per engine chamber
- Fuel components - oxygen peroxide and Atcetum50/50
- Specific impulse – 280…300s
- Excess oxidant (peroxide - 0.9 ... 0.915)
- Combustion chamber temperature - 1600 degrees C
- Pressure in the combustion chamber - 22 ... 27 atm
- The catalyst is a silver mesh.
- Duration of work - 25 min
- Motor provides multiple switching times
- Design contains disposable ceramic liners of combustion chamber and throat

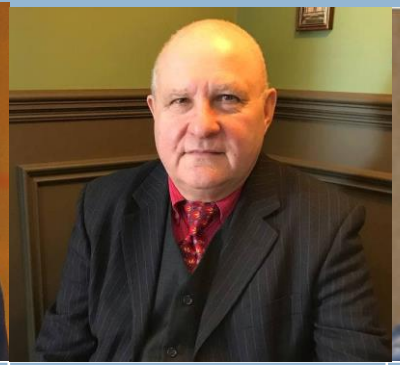
Conclusion

- The use of environmentally friendly propellants in combination with a simple displacement system for supplying its components makes it possible to simplify and lighten the design of a rocket plane and radically reduce the cost of launching a payload into near-earth orbit without being tied to a specific cosmodrome or airfield infrastructure.
- Using aerodynamic capabilities of a rocket plane significantly decrees gravitational and aerodynamic losses fore not expensive use
- The ability of the rocket plane to fly at high altitude can be used for reconnaissance functions.
- The flight prototype can be created within 1 year and investments of about 4 million USD.

Leaders of our crew



Alexeii Laponohov



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Per aspera ad astra