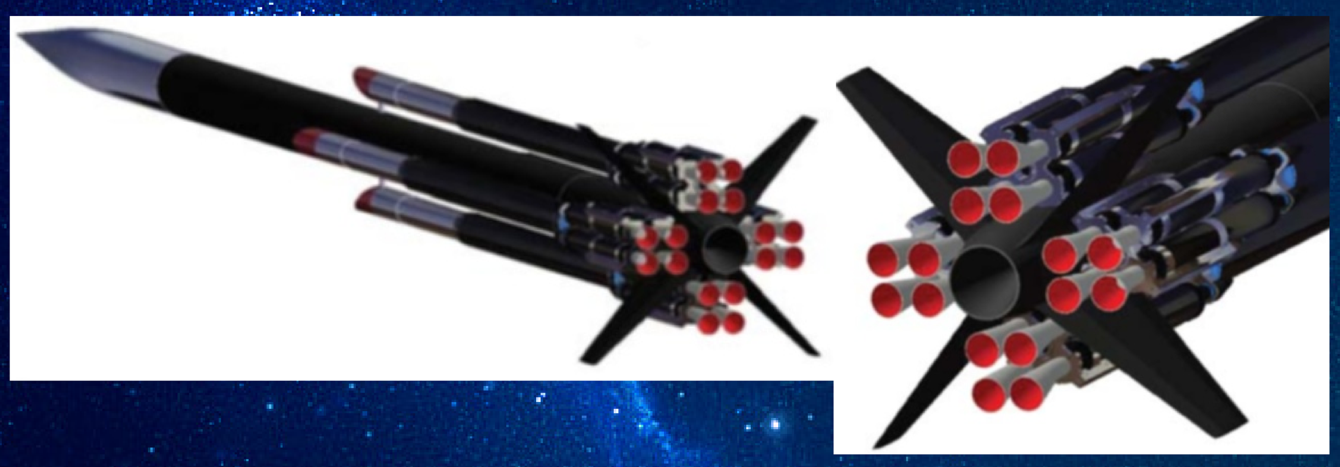
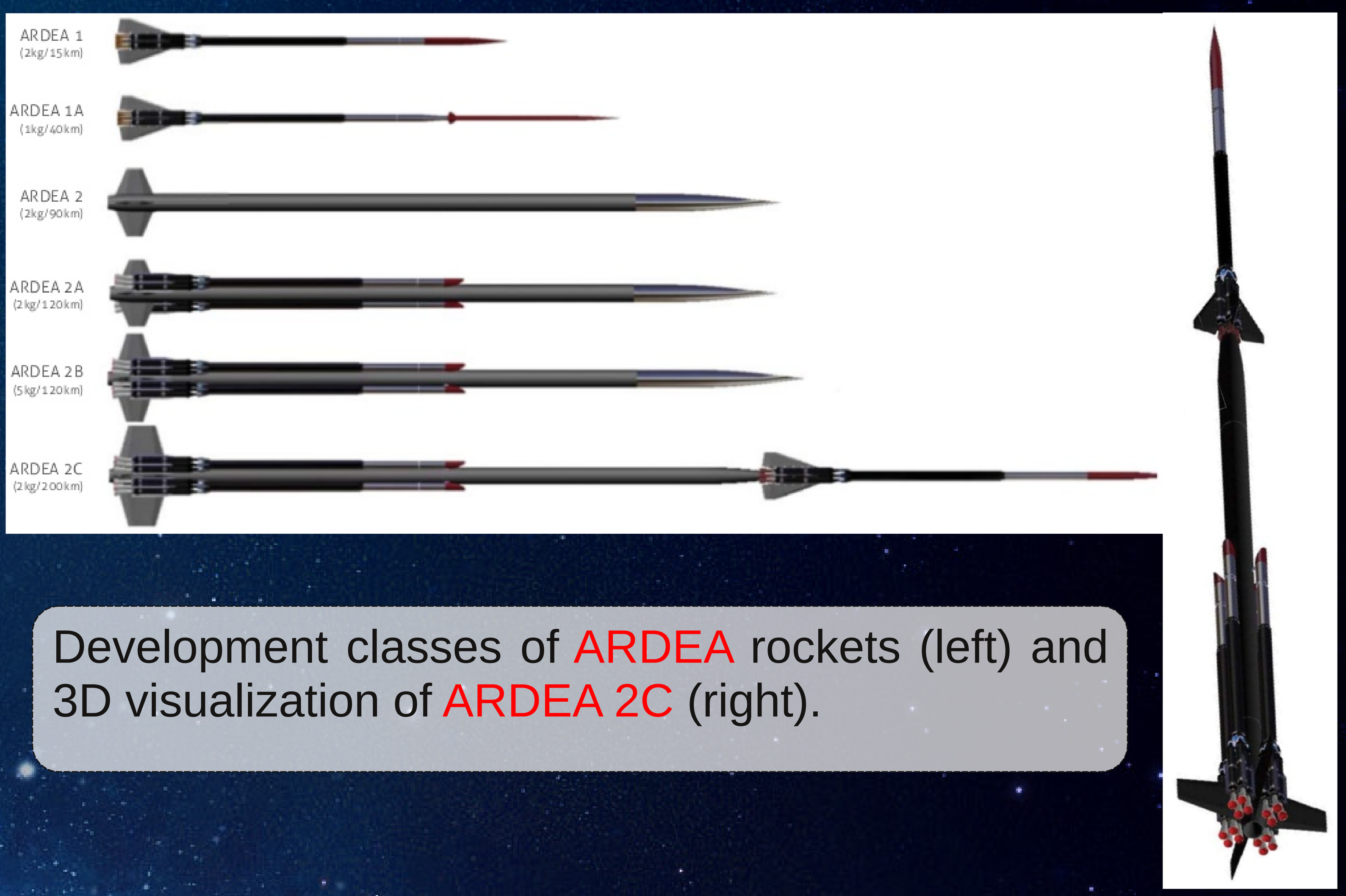
Aim for Rocket DEvelopment for Amateurs



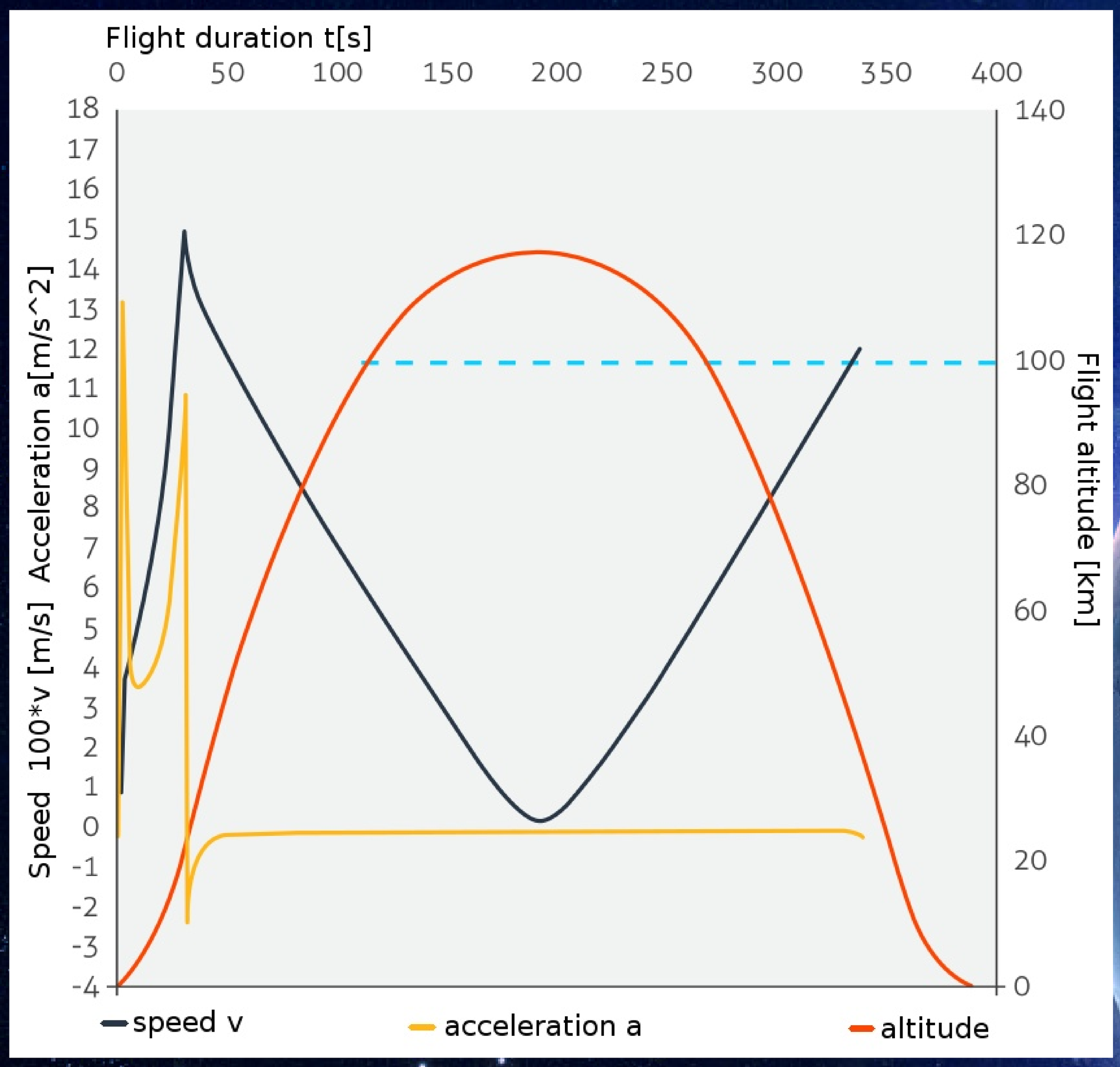
Closer look at ARDEA 2B jets (right) and the whole rocket in 2B configuration (left).

The ARDEA project aims to develop light and affordable small rockets for scientific and commercial use. The ARDEA rockets are designed with hybrid engines, which combine the advantages of liquid-propellant and solid-fuel propulsion systems. While using hybrid rocket engines (as compared to other types of chemical rocket engines), there can be no explosive reaction between the fuel components. This engine is in general extremely safe for usage and production. The construction of a hybrid unit allows an effective control of engine thrust when preserving a relatively simple construction and technological availability.

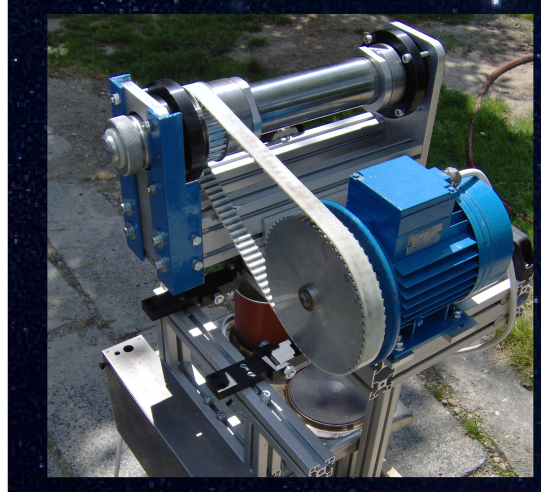
Hybrid rockets are an open direction of orbital and suborbital launchers. The big space agencies so far preferred the development of massive rockets based on liquid-propellant systems. These launchers are, however, difficult to construct and demanding on ground infrastructure and staff. High costs are the main obstacle of a more effective civil space exploitation. Nowadays, there is a rising demand of affordable launchers for small satellites and suborbital scientific experiments. The ARDEA project is therefore a very perspective project, with a high multiplication factor for further development of technologies and scientific research in Slovakia. The development of light and affordable hybrid engines raises a number of technical challenges for the constructor. In the United States Sierra Nevada Corporation (formerly SpaceDev) develops these engines for suborbital space-planes Space Ship One and Space Ship Two (built by the Scaled Composites company). In Slovakia, hybrid engines are developed by rocket constructor Dr. Csaba Boros.

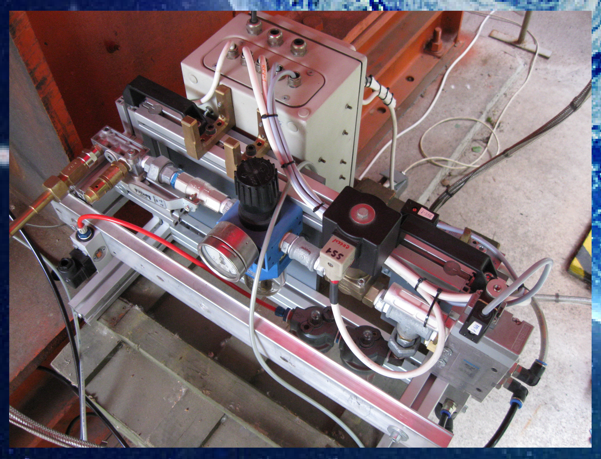


Development classes of ARDEA rockets (left) and 3D visualization of ARDEA 2C (right).



More than 30 successful burns were performed on Mr. Boros's engine. Like the engine for Space Ship One, it uses liquid oxidizer (sweet air), which is due to its accessibility as well as physical and chemical properties the most suitable choice for private developers. Solid-state fuel is wax or a mixture of 60% wax and 40% aluminium powder – this combination is in theory able to deliver a specific impulse of more than 2300 $Nskg^{-1}$ to the rocket, while the average pressure in the combustion chamber is around 3.5 Mpa (in contrast, the SpaceX's classical liquid-propellant engine Merlin1C delivers 2660 $Nskg^{-1}$ at sea level). In comparison to HTPB (a type of rubber similar to tyre rubber) fuel, which is used in Space Ship One/Two engines, wax is much cheaper, creates less smoke when burning and burns 3 to 5 times faster, which results in an easier geometrical shape of the solid fuel. A special type comparison of wax with structural fortification is used in Csaba Boros's engines, so it can withstand high stress loads during the functioning of the engine. Therefore, as soon as some technical problems linked to N_2O properties have been successfully managed, the usability and technological outreach of ARDEA rockets could extend the borders of pure amateur research.





Flight graph for 2 kg payload ARDEA 2A (top) and various testing equipment.

Successful theoretical and practical mastering of hybrid technology is a basis for the development program of ARDEA rockets. The rocket ARDEA 1 is planned first and will serve mainly for practical flight tests of the four engine configuration, having thrust of 1 kN each. The oxidizer will be supplied to engines from one common tank. Estimated lift-off weight of ARDEA 1A is 20 kg and it should be capable to deliver 2 kg of payload to an altitude of 12 km. This payload will be placed in the second stage with a smaller diameter and low aerodynamic friction (passive Dart system), which will detach from rocket's body right after its engines burn-out. In the second development phase, we will use an active variant of the same Dart system with a small additional engine on solid-state propellant. This rocket configuration will have a weight of approximately 22 kg and allows carrying the same payload to an altitude of 40 km.

Rockets ARDEA 1 are meant to be used in the future mainly as accelerating stages for stronger launchers ARDEA 2A or ARDEA 2B and ARDEA 2C. These launchers will have the rocket ARDEA 2 as a basis, which hybrid engine will be oxidized by N2O, having an estimated thrust of 3.5 kN. The engine in ARDEA 2 should work for about 30 seconds. In the configuration with 4 acceleration rockets and the rocket ARDEA 1 as the second stage, there will be enough power to get 2 kg to an altitude of 200 km (an altitude of 100 km is considered as the boundary of outer space). Total weight of this configuration will be 120 kg and total traction of the launcher at lift-off will be almost 19.5 kN. Although, for scientific experiments, a lighter configuration of type ARDEA 2B appears to be more suitable (flight stage ARDEA 2 plus 4 acceleration rockets ARDEA 1). In this configuration, the Boros construction will be capable of delivering 5 kg to an altitude of 120 km. Before rockets ARDEA leave the Earth's atmosphere, our construction team will face many tasks related to reliability and security of these devices at the start. In last preparatory stage, we anticipate the construction of a ground test facility for rocket engines up to a thrust of 10 kN. The priority task is to develop a system for remote control of rocket fueling with liquid oxidizer N_2O, the launch pad and other support devices. Development and construction of ultra-light composite parts for primary elements as combustion chamber, tanks for the oxidizer and stabilizers will be put forward in parallel. In collaboration with SOSA engineers, Csaba Boros develops electronics components for collection, transmission and evaluation of data from rocket engines tests, telemetry and rocket command elements. SOSA itself will focus primarily on the development of payload for the ARDEA rockets.

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