The Aerodynamics Of A Single-Blade Rotor

The Mathematical Model Of Single-Blade Rotor Flight

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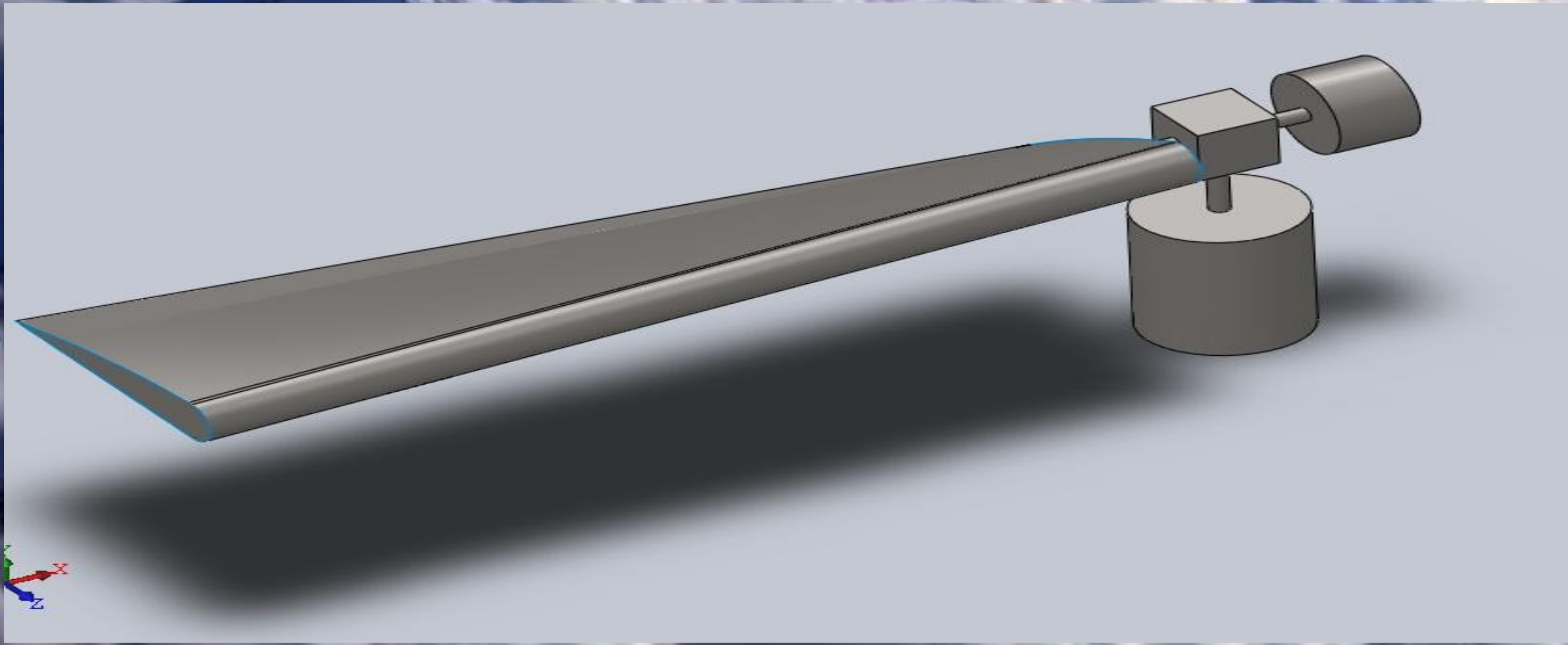
Why did we start our investigation?

- Because of curiosity;
- The interest to the super light aircraft;
- To evaluate the correspondence of obtained results to the real winged seed flight parameters.

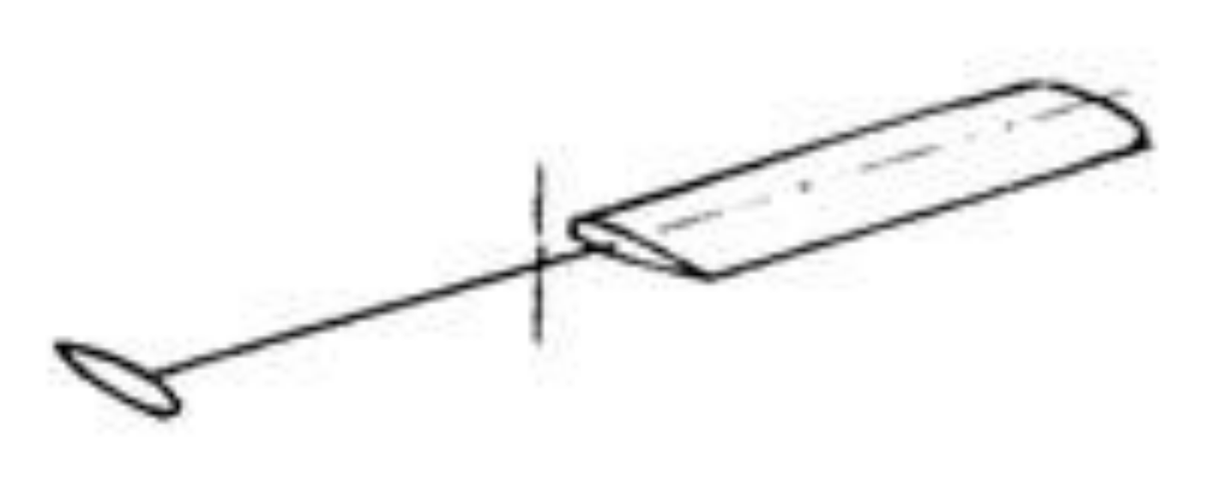
The Aim of the work

- To investigate the aerodynamics of single blade rotor (SBR);
- To construct its (SBR) mathematical model;
- To get acquainted with results of scientific researches in this area;
- To solve the equation of motion of SBR: to find the angular velocity of autorotation.
- To <u>sophisticate</u> the idea of SBR motion.

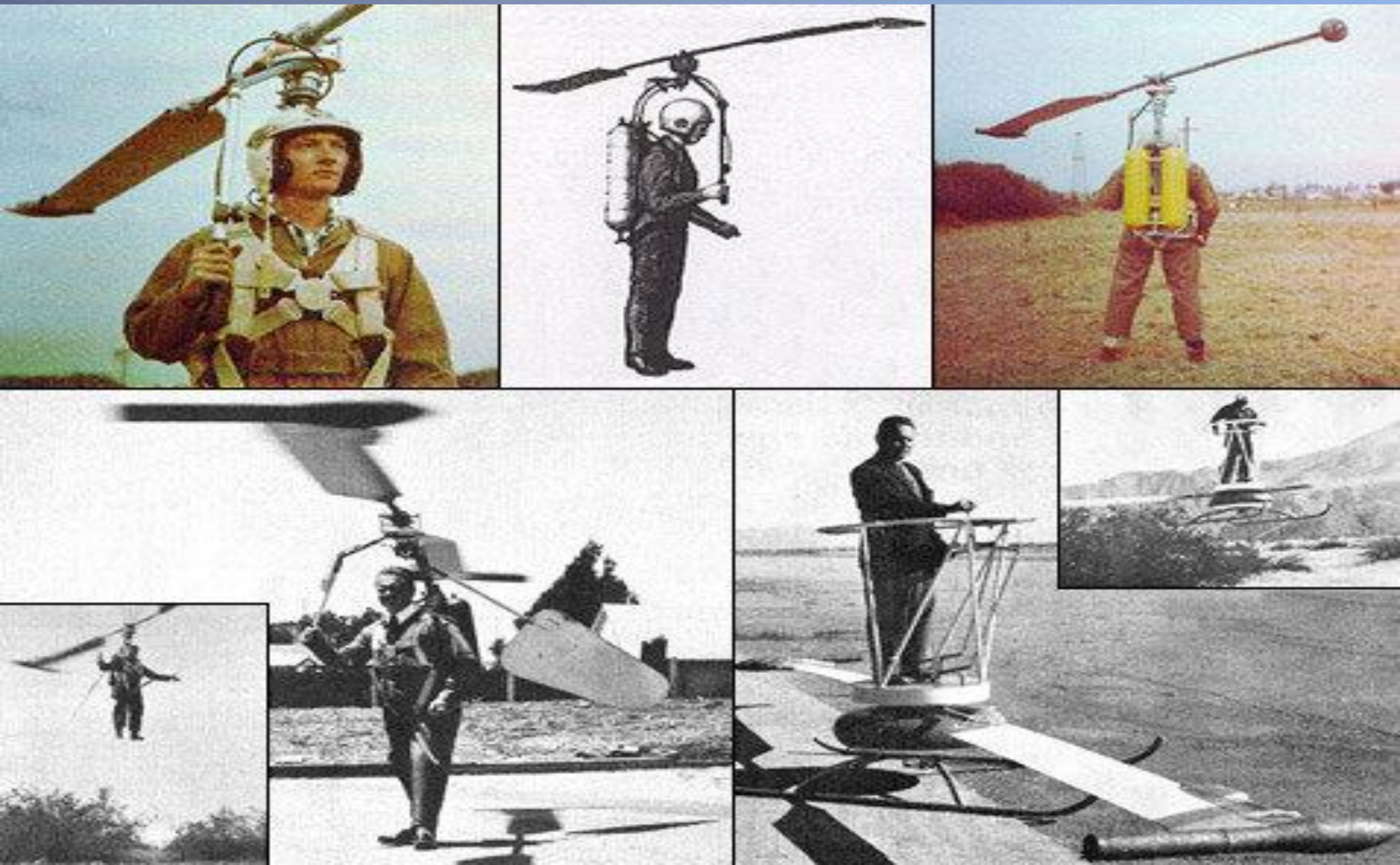
We assumed the model of a winged seed aerodynamics and, based on it, we decided to create the single blade rotor.



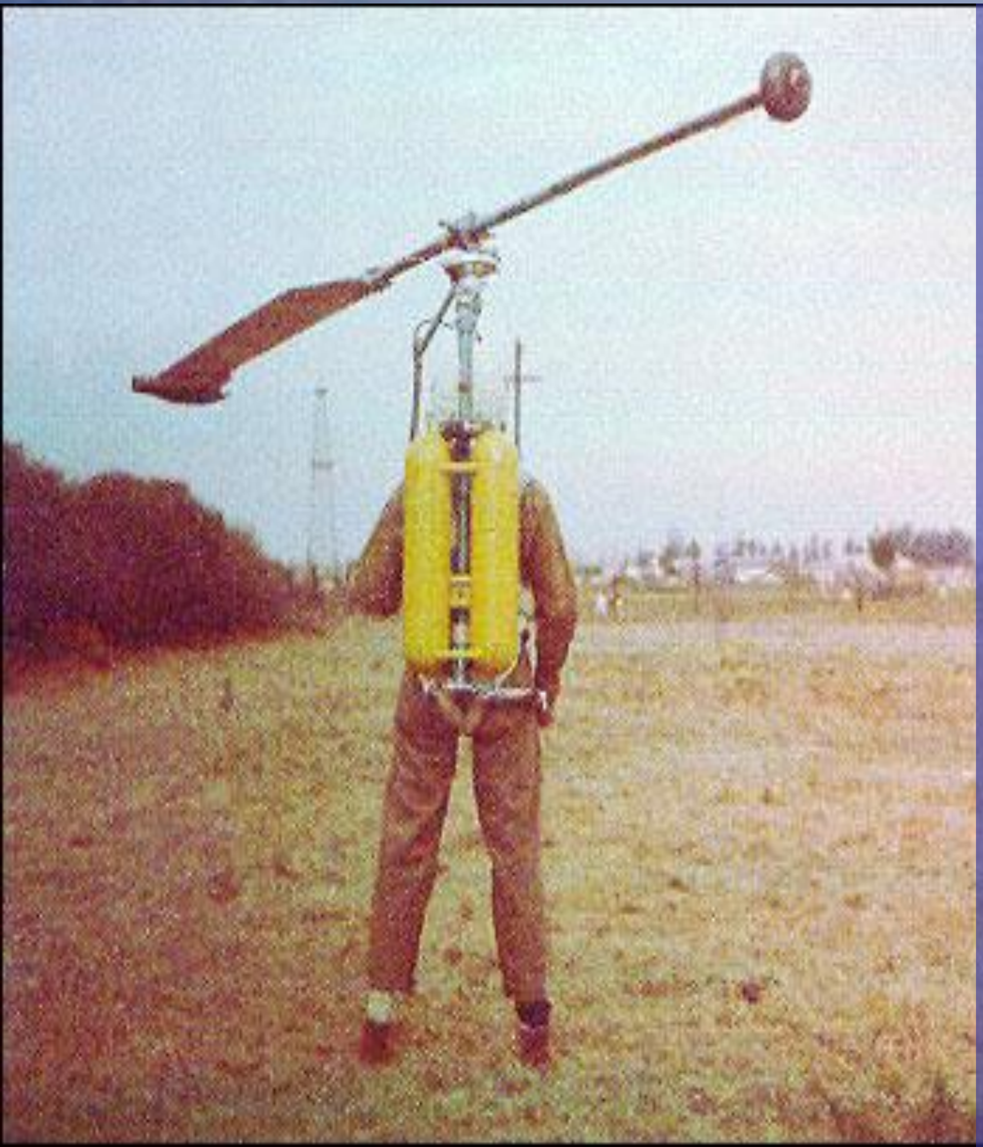
The previous researches that met this topic had created the different models of SBR



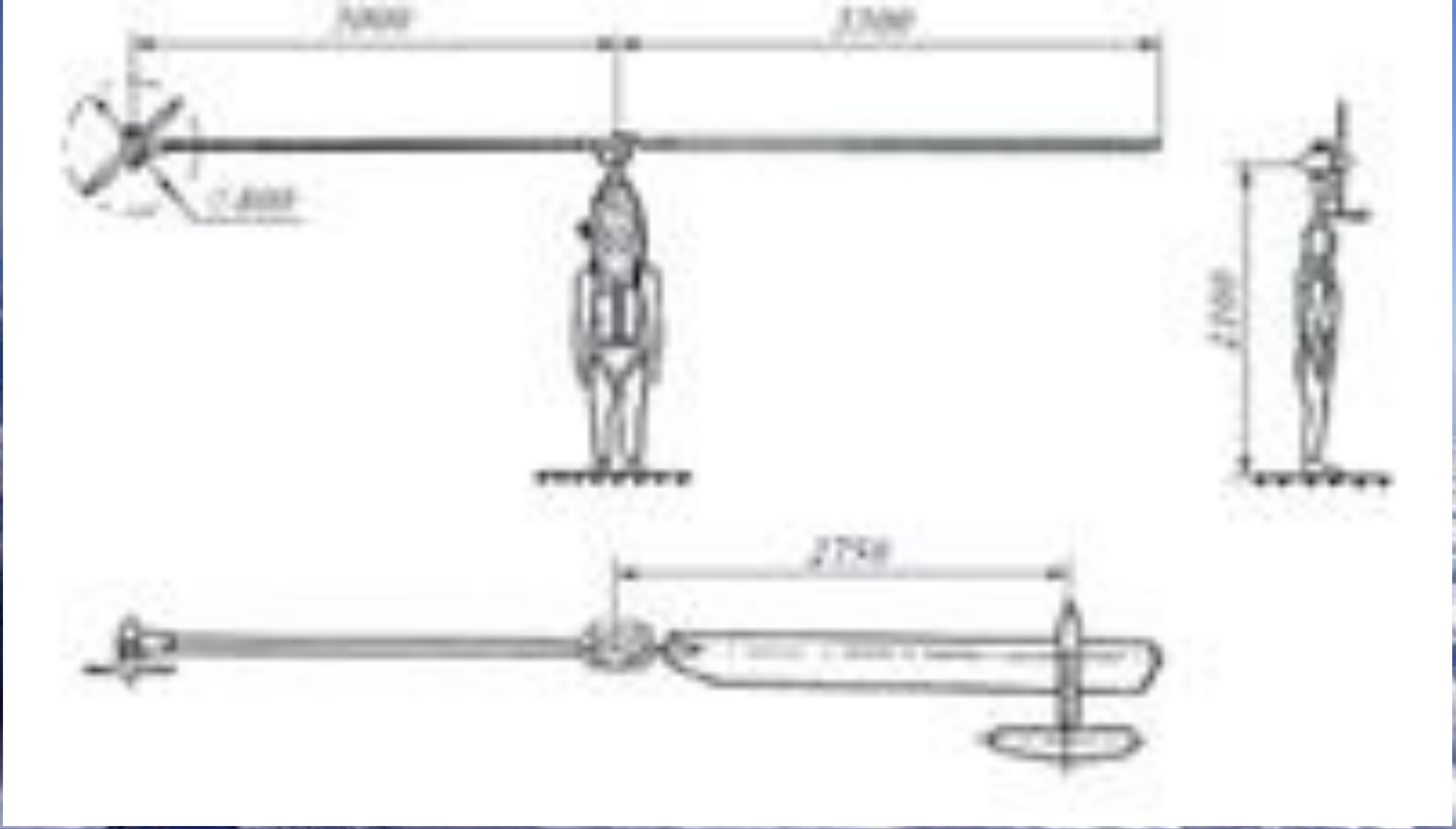
Gluhareff MEG-1x



MEG-1X



MEG-1X was created by American engineer Eugene Gluhareff in 1955. The creator of MEG-1X, following the ancient wisdom “the less, the better”, has coherently thrown out all the excessive details, he did not spare even the blades: only one of them stayed with a jet engine, attached to its end.



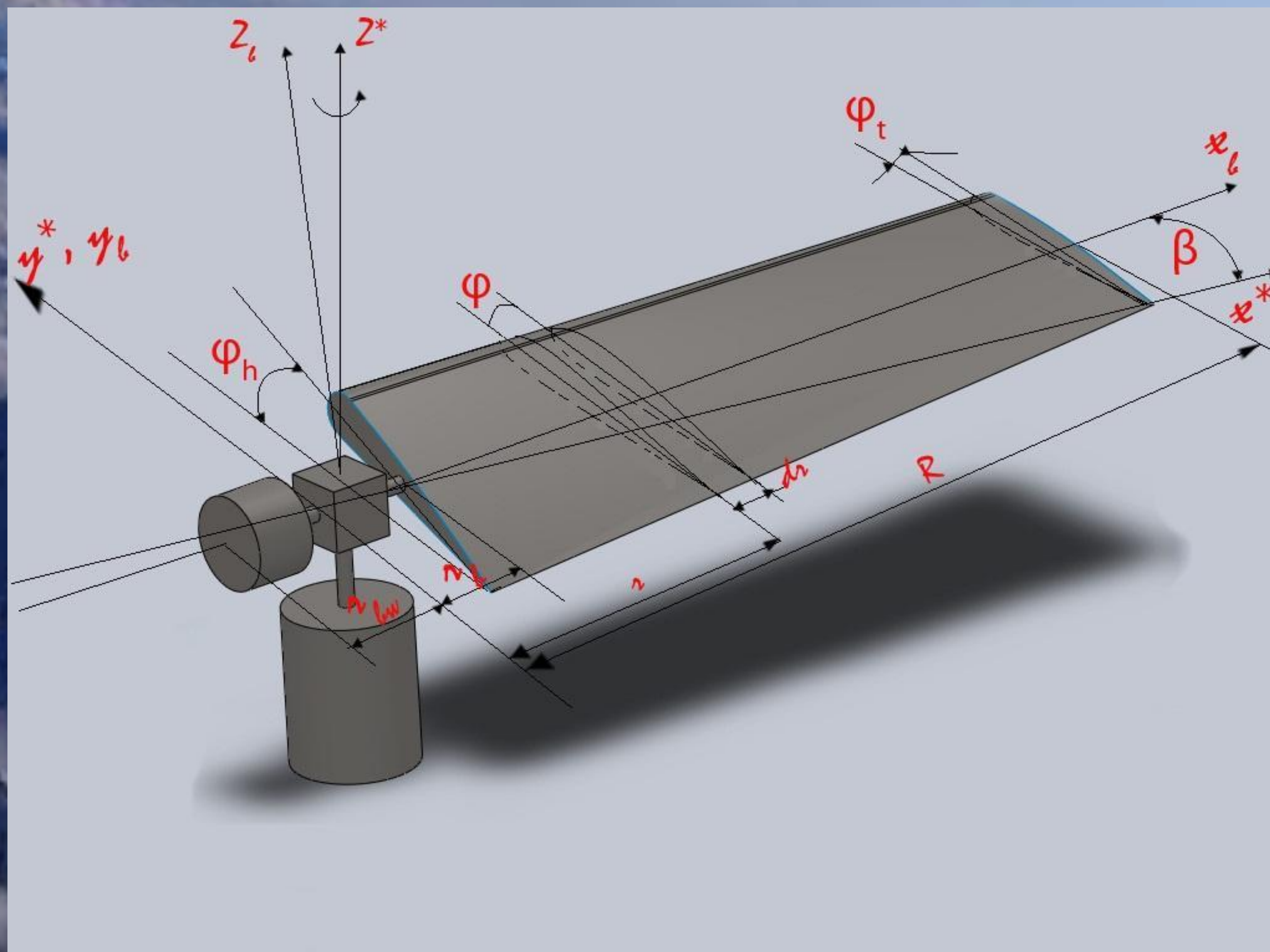
In USSR the pioneer in creation of single bladed helicopter was the student of Kharkov Aviation Institute, Yuri Marinchenko. The original version of helicopter was planned as a backpack weighting 30 kg. He developed this idea during a year and, in 1971 the model was established.

AliSport

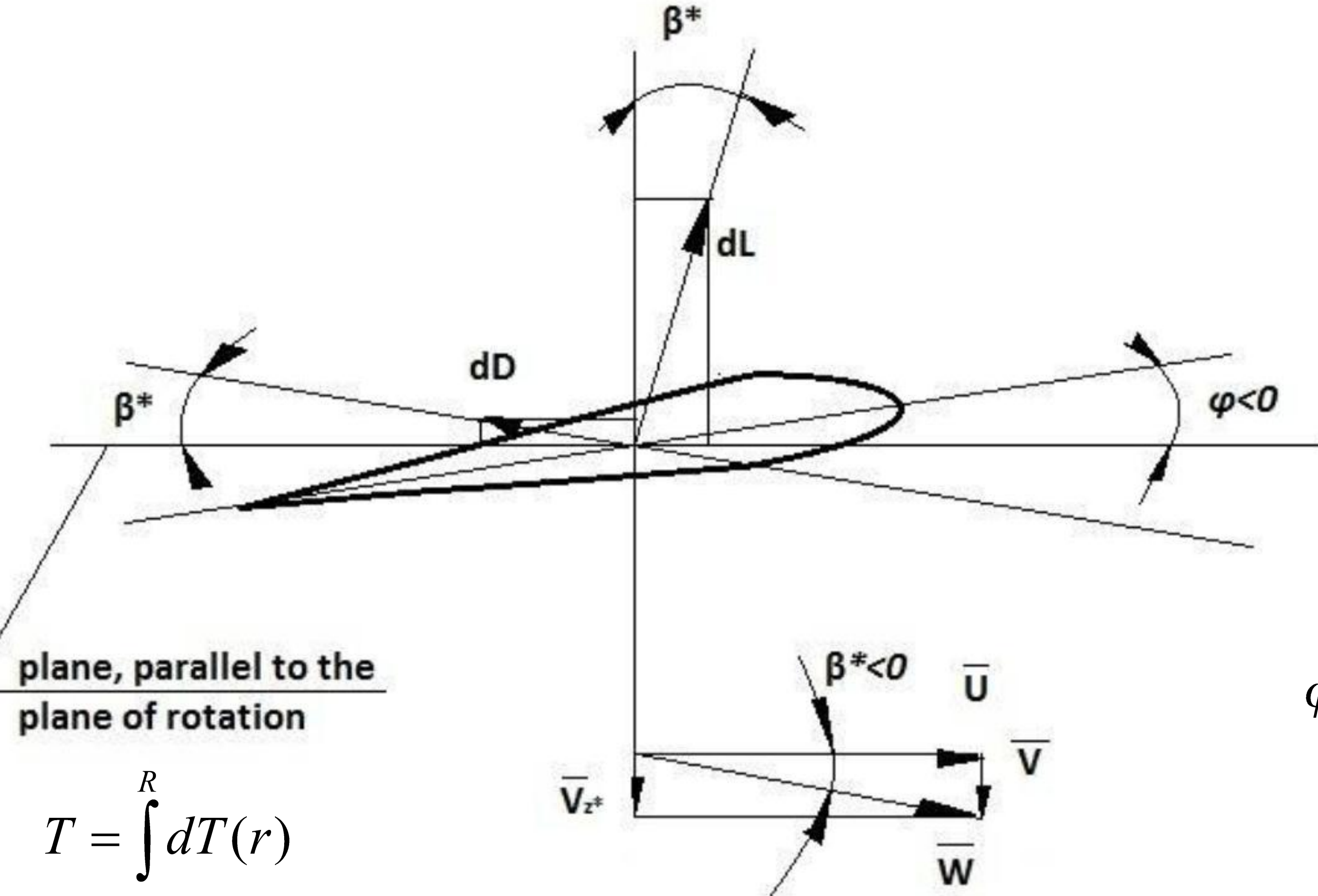
Nowadays the only firm, Alisport, creates the full-size aircraft with single blade rotor.

They created the famous one-bladed gliders.

Mathematical Model



$$
\begin{cases}
\dfrac{dV_{z*}}{dt} = \dfrac{1}{M} \cdot T \\[2ex]
\dfrac{dz^*}{dt} = V_{z*} \\[2ex]
\dfrac{d\omega_{z*}}{dt} = \dfrac{1}{I_{z*}} \cdot M_{z*} \\[2ex]
\dfrac{d\psi}{dt} = \omega_{t*}
\end{cases}
$$



$$T = \int_{r_h}^{R} dT(r)$$

$$W^2 = U^2 + V_z^{*2}$$

$$U = \omega_z^2 \cdot r \cdot \cos\beta$$

$$\alpha = \varphi(r) - \beta^*$$

$$\beta^* = \arctan V_z^* \div U$$

$$\varphi(r) = \varphi(r_h) + \frac{\partial \varphi}{\partial r} \cdot (r - r_h)$$

$$\frac{\partial \varphi}{\partial r} = \frac{\varphi(R) - \varphi(r_h)}{R - r_h}$$

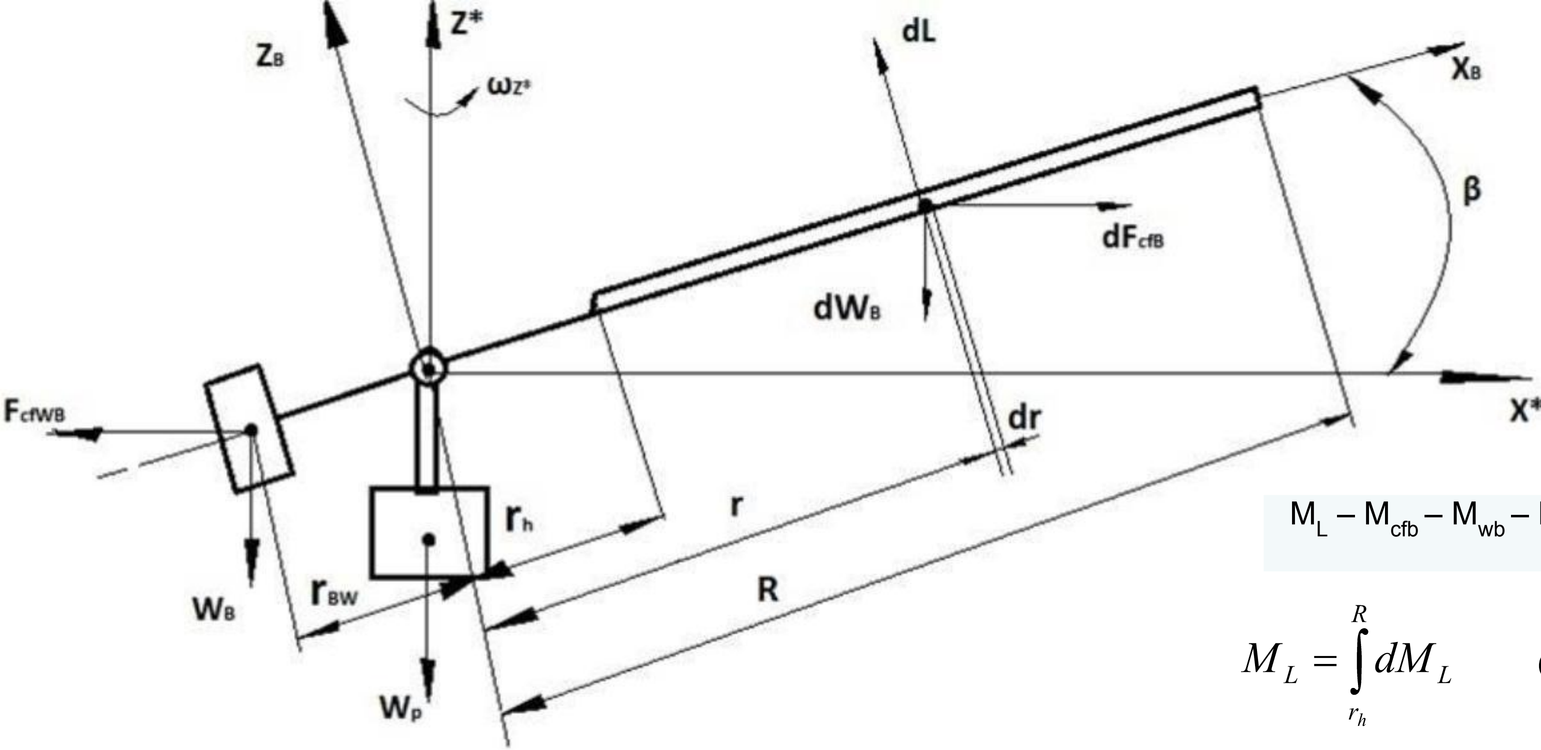
$$M_{z^*} = \int_{r_h}^{R} dM(r)$$

$$dT = (dL \cdot \cos\beta^* - dD \cdot \sin\beta^*) \cdot \cos\beta^*$$

$$dQ = - dL \cdot \sin\beta^* - dD \cdot \cos\beta^*$$

$$dM = dQ \cdot r \cdot \cos\beta$$

$$dL = C_L(\alpha) \cdot \rho W^2 \cdot c(r) dr$$
$$dD = C_D(\alpha) \cdot \rho W^2 \cdot c(r) dr$$



$$M_L - M_{cfb} - M_{wb} - M_{cfw} + M_W = 0$$

$$M_L = \int_{r_h}^{R} dM_L \qquad dM_L = dL \cdot r$$

$$M_{cfb} = \int_{r_h}^{R} dM_{cfb}$$

$$dM_{Cfb} = dF_{cfb} \cdot r \cdot \sin\beta$$

$$dF_{cfb} = dm_b \cdot \omega_z{}^{*2} \cdot r \cdot \cos\beta$$

$$\frac{\delta M_B}{\delta r} = M_B/(R-r_h)$$

$$M_{BW} = \int_{r_h}^{R} dM_{BW}$$

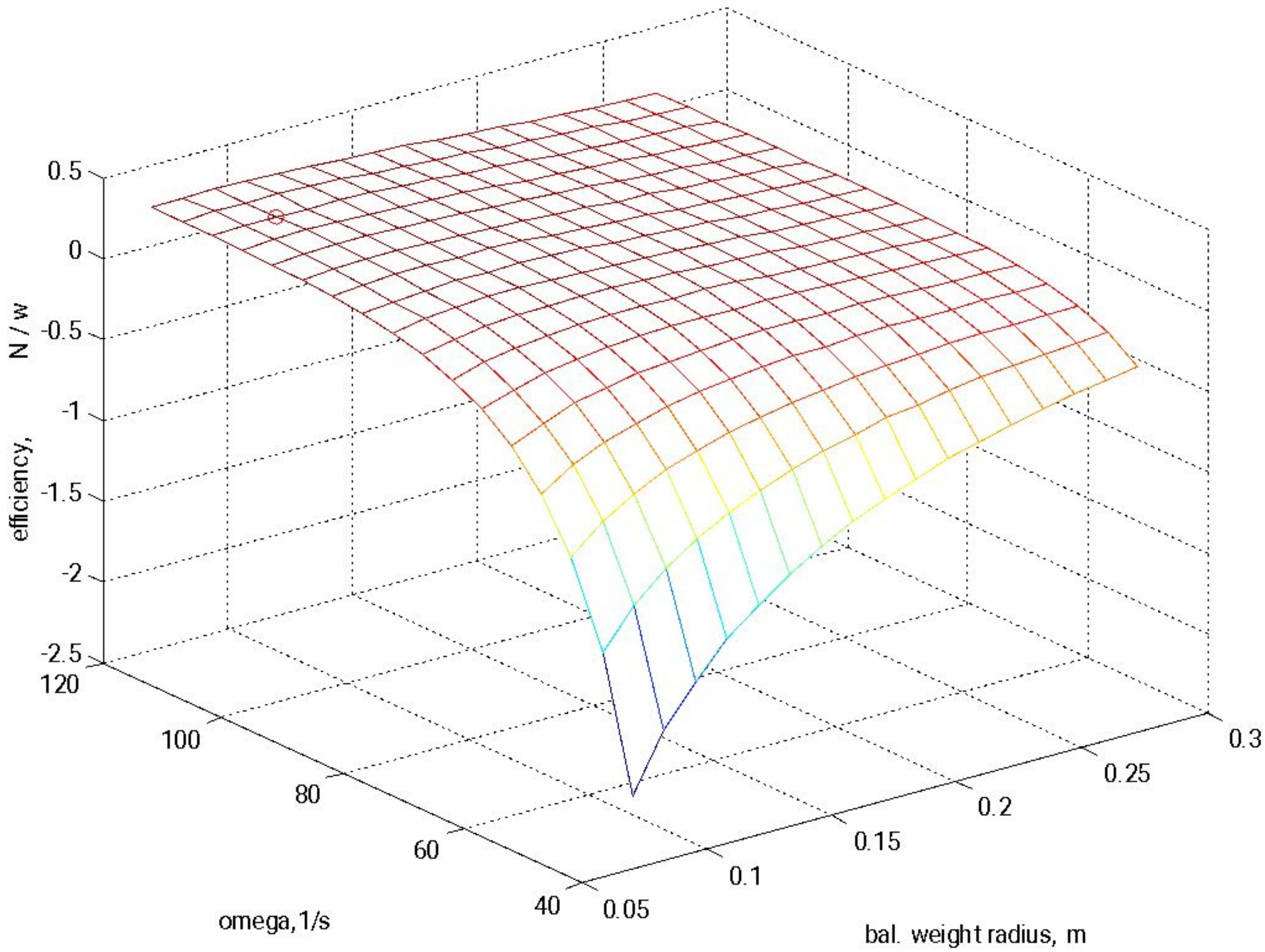
$$dM_{WB} = dm_b \cdot g \cdot r \cdot \cos\beta$$

$$dM_{CfRD} = dm_{RD} \cdot \omega_z{}^{*2} \cdot r \cdot \cos\beta$$

$$M_{CFW} = 1/2 m_w \cdot \omega_z{}^{*2} \cdot r_h{}^2 \cdot \sin 2\beta$$

$$M_{cfRD} = 2\int_{0}^{r_h} dM_{cfRD}$$

$$M_W = m_w \cdot g \cdot r_h \cdot \cos\beta$$


0.5
0
-0.5
-1
-1.5
-2
-2.5
efficiency, N / w
120
100
80
60
40
omega,1/s
0.05
0.1
0.15
0.2
0.25
0.3
bal. weight radius, m

Thank You for attention

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