# "Polyplane" – an aircraft with nontraditional configuration for very large commercial transport

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The paper is devoted to the comparison of the "polyplane" and reference aircraft of traditional configuration.

The work has been fulfilled in the Moscow Aviation Institute with the participation of TSAGI researchers and leading specialists of Russian Aviation Industry in the frame of ISTC Project. Partners of the project were from Airbus Industries and Rolls-Royce. The objectives of the project were investigations on design, definition and comparative analysis of high range heavy commercial aircraft characteristics with conventional and nontraditional "polyplane" scheme with special lifting system. The scheme was suggested by the authors of the project and protected with a patent.
The design of compared aircraft was carried out for the same requirements. The main versions of the aircraft have to provide the transportation of 616 passengers in three class version on the estimated range 13700 km with cruised velocity corresponded to $M_{cr}$=0.85. The planes have to meet all basic requirements (FAR25, ICAO, 80m box). General views of the compared aircraft are given on figures 1 and 2. The comparison was carried out with the use of the following criteria: lift to drag ratio, take-off mass, relative mass of empty aircraft with operational item, total fuel for the flight.
The comparison of "Polyplane" and basic aircraft polars at estimated altitude and velocity demonstrates that in spite of relatively high minimum drag coefficient $\tilde{N}_{D\ min}$, negative influence of increased washed surface was manage to suppress by decrease of induced drag. At the same time the function $(C_L/C_D) = f(M)$ for "Polyplane" in the area $M > 0.8$ has more monotonous character in comparison with basic aircraft. At $M = 0.87$ the advantage in $(C_L/C_D)$ of basic aircraft disappears. Nevertheless at estimated altitude and velocity for $C_L = 0.5$ the lift-to-drag ratio of "Polyplane" up to 0.8 (4%) less then for basic aircraft.

According to parameter relative mass of "empty aircraft with operational items $\overline{m_{oi}}$" the "Polyplane" aircraft has considerable advantage. Values $\overline{m_{oi}}$ are 0.4574 for "Polyplane" aircraft and 0.4824 for basic aircraft. It is 5.18% higher. It reaches by "Polyplane" advantage on parameter airframe structure mass first of all by decrease (in 1.5 times) of wing structure mass. It is a consequence of change of console wing by lifting system (frame structure). The fuselage mass decreases somewhat too.
This advantage compensates completely insignificant increase of flight control system mass of "Polyplane". In spite of negative influence of lift-to-drag ratio on fuel use, the "Polyplane" estimated take-off mass is 488,21 ton. It is 52,75 ton (9,75 %,) less then weight of aircraft with traditional configuration ($m_0$ = 540,96). That is considerable advantage of "Polyplane" aircraft. It can influence positively on its economic parameters.

In spite somewhat less lift-to-drag ratio in cruise flight "Polyplane" aircraft has noticeable advantage in comparison with basic aircraft in parameters of fuel effectiveness.

For example the flock fuel for "Polyplane" is 206,2 ton and 221,3 ton for basic aircraft what is 15,12 ton higher. The estimated $q_{ò}$ for "Polyplane" and basic aircraft is 23,06 and 24,927 g/p*km correspondingly.

According to the initial requirement the compared aircraft have the same main flight performances: payload, range, cruise flight velocity, take-off and landing characteristics. Nevertheless in the frame of given limitations there are insignificant differences in characteristics of flight profile. For example because of higher start thrust-to-weight ratio “Polyplane” has better characteristics of climb and in spite of less $C_{Lmax}$ at take-off and landing practically the same with basic aircraft take-off and landing characteristics. At the same time the "Polyplane" parameters of manufacturing and operation service will be worse in comparison with aircraft with traditional configuration. It is associated with lower nomenclature of airframe sections and component of on board systems at the basic aircraft.

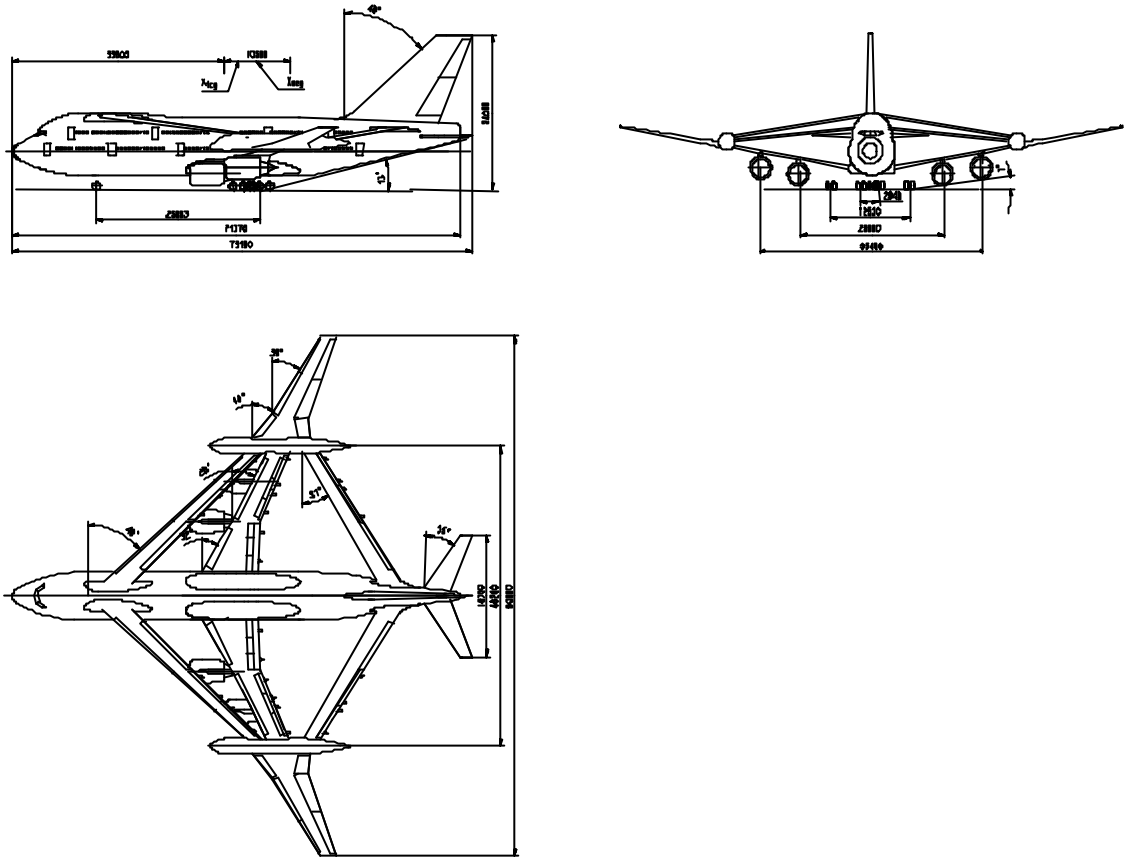

*Figure 1 General view of "Polyplane"*

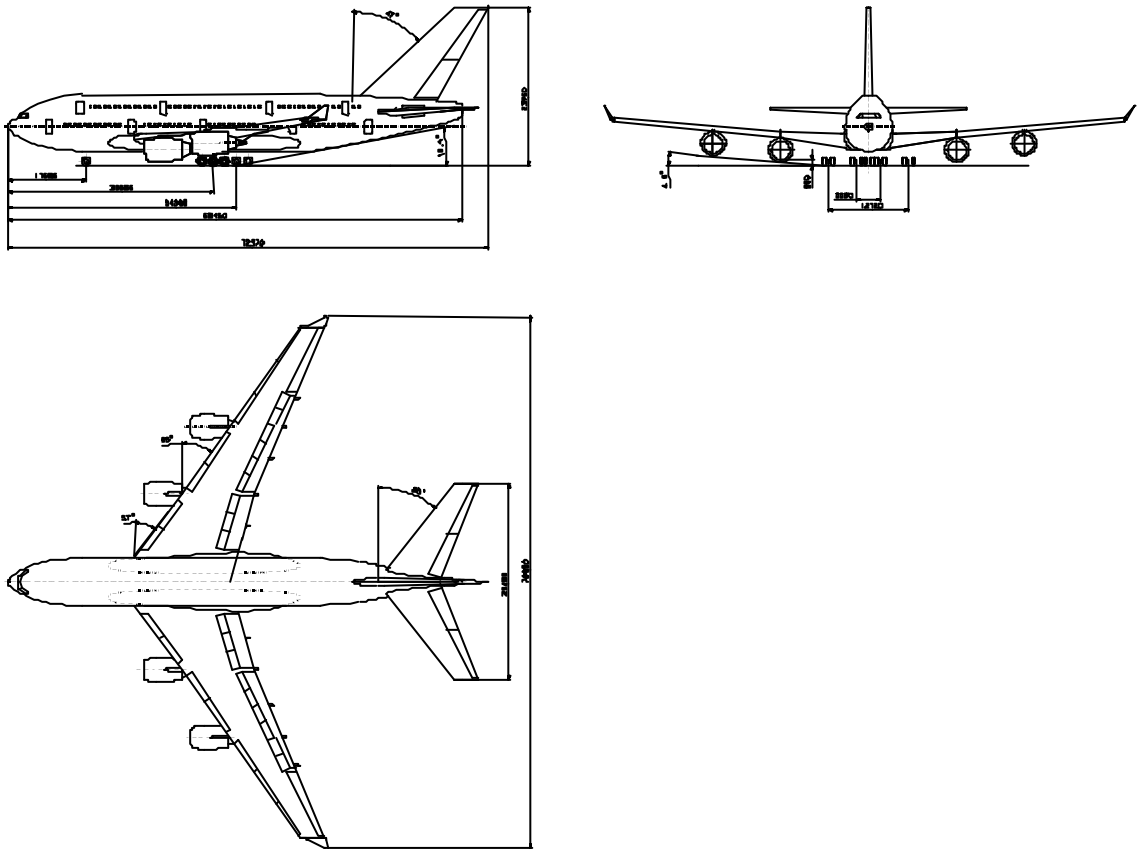

*Figure 2 General view of basic aircraft*