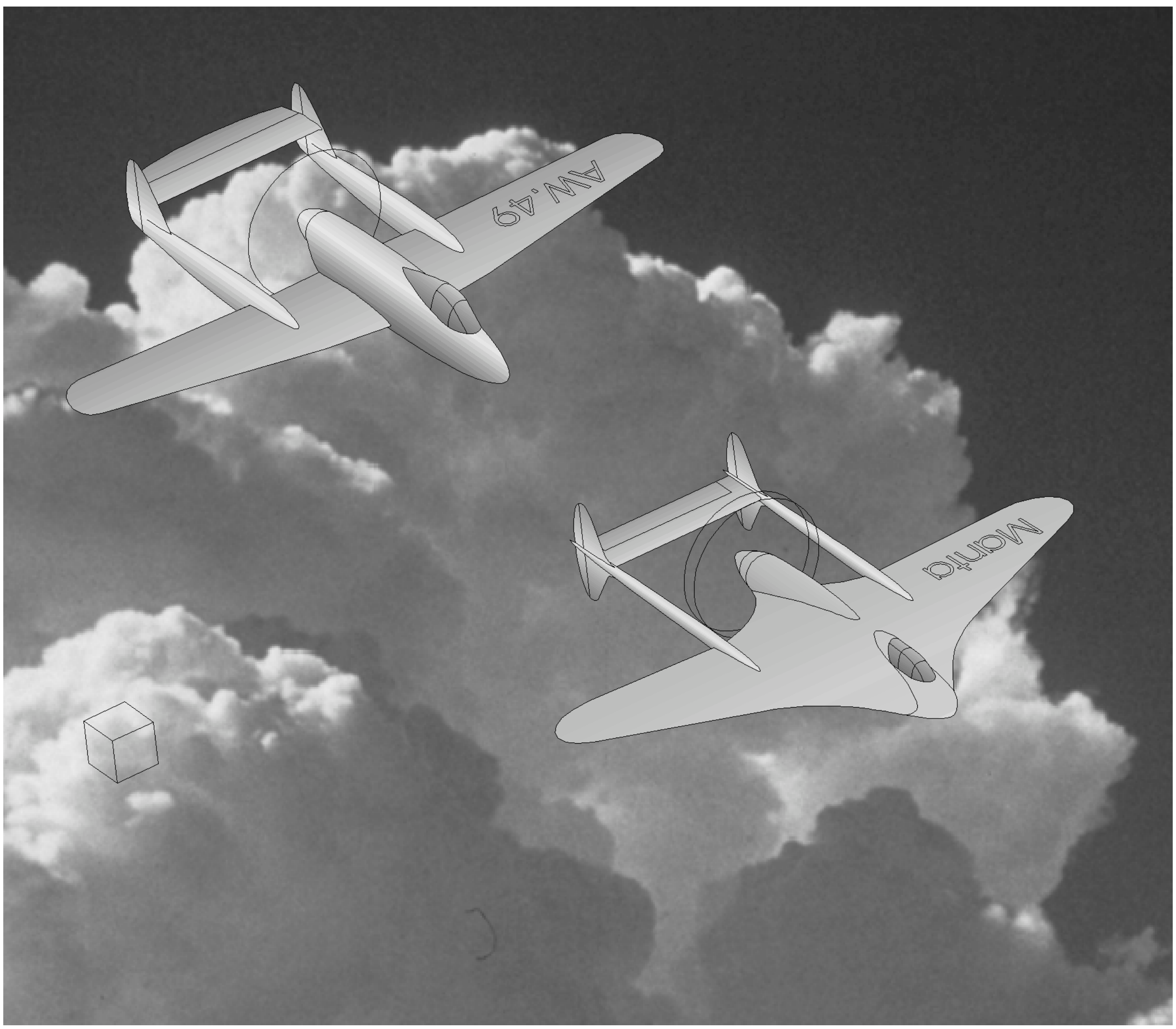
If a rear propeller may be useful to blow on the tail, it is good that it does not blow – contrary to a nose propeller – on the fuselage main body, adding extra drag. Twin-boomers with rear propeller thus have better aerodynamics than classical airplanes, and so: a higher speed or range. If maximum performances are not required, a virtuous circle can occur: for a given speed and range, less power and gasoline is required, thus less volume and weight, thus less drag and lift, thus less power and gasoline, etc. From there come savings in raw materials and work hours.

These advantages can moreover be amplified, benefiting from smooth airflow to optimize wing aerodynamics. The first way is a large fairing between wing and pod. This layout was illustrated by the twin-boom version of the **Mc Donnell Manta** (or Davis Manta), sometimes called Bat. The Manta nickname was used for many other projects, non twin-boom.

Another interesting way with a rear propeller: using a laminar-airflow wing, at its very top without any air vortex due to the propeller (this was a problem for Mustangs, Spitefuls and other classics). The **Armstrong-Whitworth AW.49** is an excellent example of such twin-boomer with laminar wing, at least in its high-speed version, with retractable landing gear.

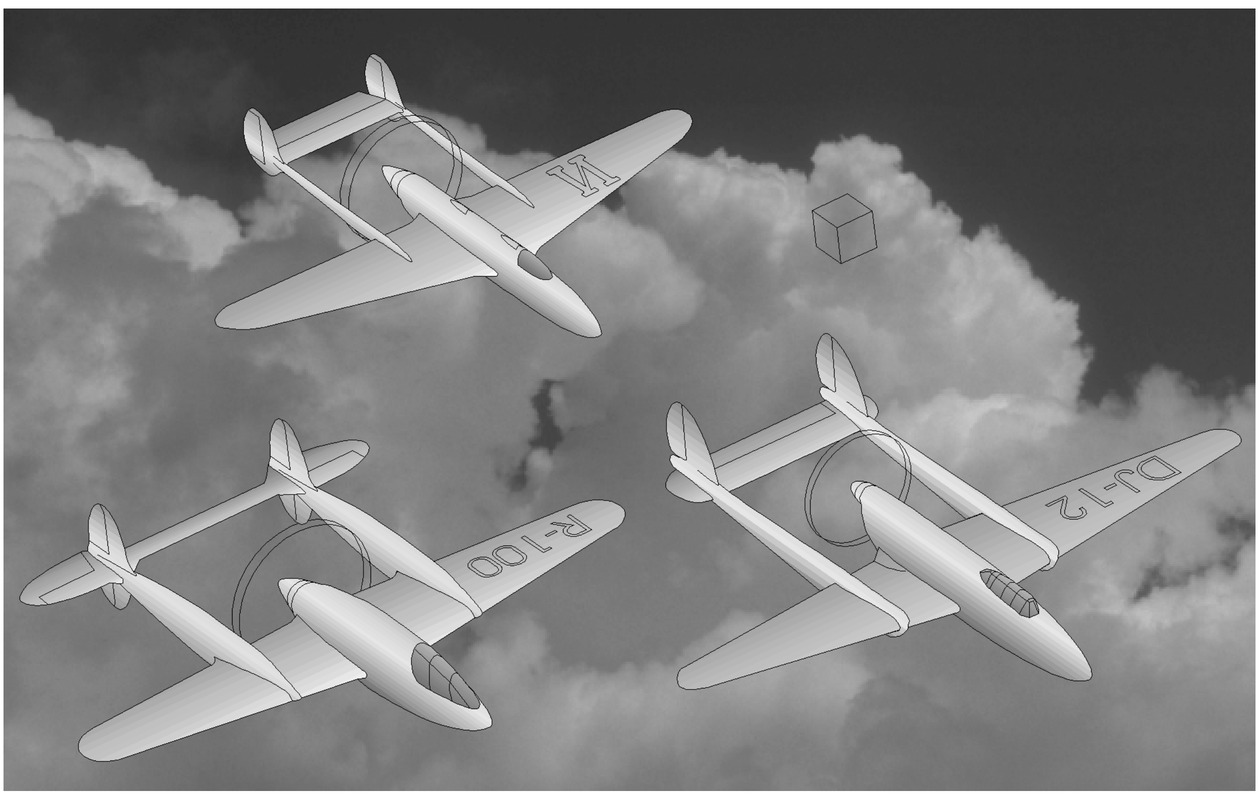


The motorized version of the **TsAGI LS** (Laminarnil Sloy) glider, designed by the Tsyentralniy Aero-Guidro-dinamichyeskiy Institut, concerns mainly the laminar-wing principle; nevertheless, another feature is the *faired canopy*. Of course, the rear-propeller planes are not the only ones with this characteristic – the famous B-29 had a perfectly parabolic nose without having a pusher propeller but it was a multi-engine plane. In the universe of propeller single-engined aircraft, tradition was a nose engine then, aft, a windscreen above – there are of course alternatives, but the main ones are either dragging (engine above the fuselage, as on the Flighstar or Radab Windex) or almost-blind (unusually long or completely horizontal windscreen, or glazed parts surrounding a spinner – as on the SAI 107, Supermarine S.6, Heinkel 119).

The faired canopy was featured on the preliminary draft of the J4M1: **Mitsubishi M-70**. However, the dorsal scoop of this model illustrates a limit: if aerodynamics were too perfect, the airflow necessary to cool down the engine would not be intercepted...

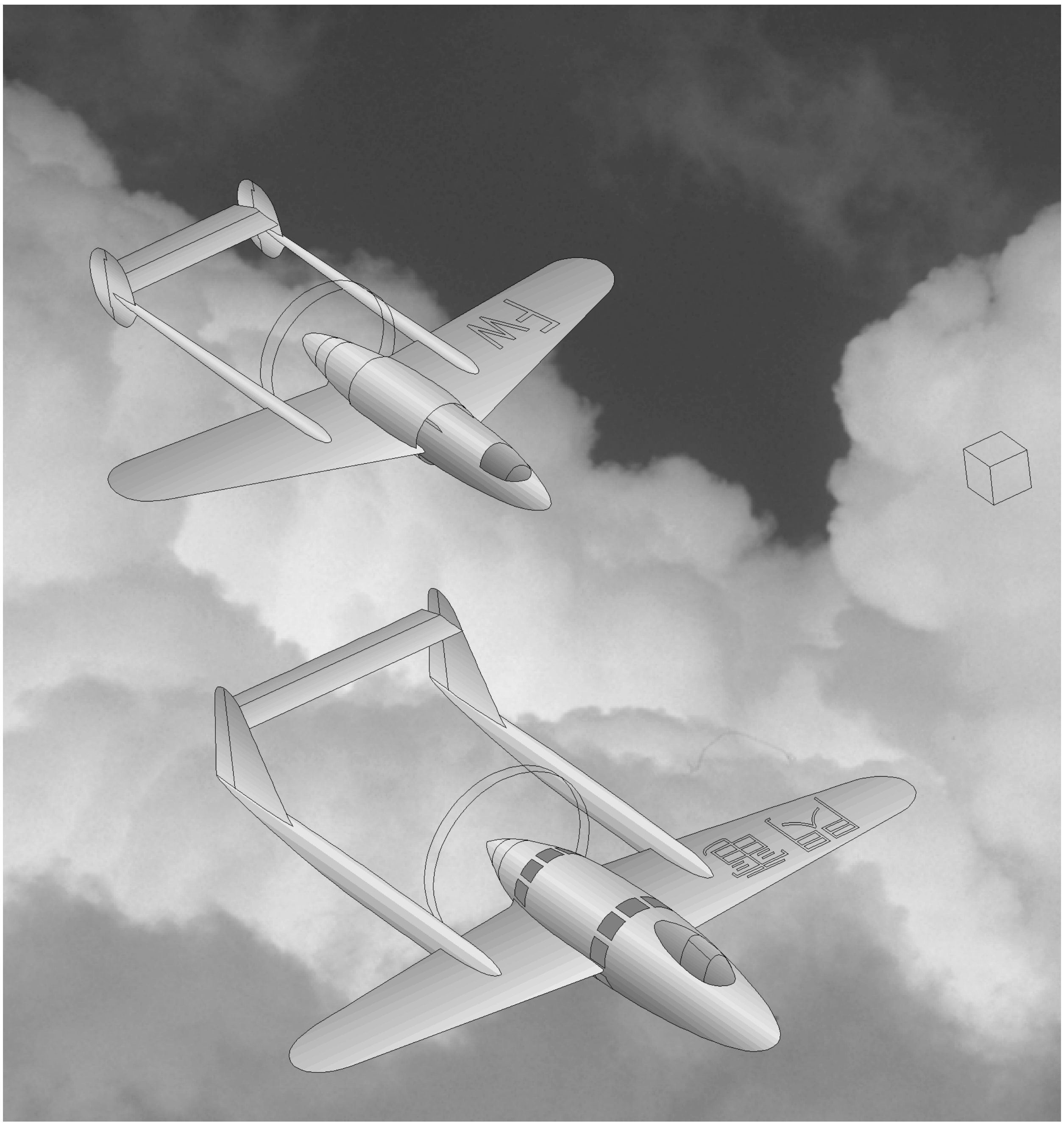
Another aerodynamic optimization came from tandem engines. Classically, the multi-engine planes had 3 dragging bodies: the fuselage and the engine pods. With the twin-fuselage layout (chapter 2), this was reduced down to 2 bodies, but the best was still to reach a single body including both engines, preferably in tandem rather than side-by-side, in order to reduce the frontal area. Of course this solution could be associated to a very traditional silhouette, the fuselage containing both engines, in the nose (with poor visibility, as on the Bolkhovitinov S) or in front and aft of the cockpit (mechanically complex solution, tested on the Arsenal VB-10). Better seemed installing both engines behind the cockpit, driving a propeller (or double propeller, contrarotating) with a long driveshaft, either in front of the nose (R2Y Keiun) or behind the tail (XB-42 Mixmaster). However this solution was rather complex and fragile, and the best was to have the propeller behind the double engine, which brings back to the usual trilogy with rear devices free from tail-support: twin-boom, canard, flying-wing. Several twin-boom projects of the years 1939-45 are concerned: the Manta, already mentioned, was simply based on a ready-to-use double-engine; in the same way, the **Bolkhovitinov I** (I for istribityel) applied to the project Byeryev B-10 the Sparka technique of pairing developed on the traditional Bolkhovitinov S. On the other hand, the **Demaizière-Joffrin DJ-12** had no background to ensure its technical feasibility. The project **Matra R-100** was continued long after 1945 then cancelled.

These central twin-engine planes had the advantage of not creating vortex on the airflow met by their wing, but this is not enough to justify this layout, as traditional models with pusher propellers (e.g. Piaggio 166) do the same. But, avoiding the use of lateral engines, there was no need to have the wing reinforced (which may be complex and heavy) to support engine weight and vibrations. Moreover, if one engine was suddenly jammed, no asymmetrical force was providing unbalance – it was even possible to consider shutting off one engine during cruise flight, to improve range.



In addition to their good aerodynamics, the planes with central engines had an exceptional agility, because the main weights were close to the centre of gravity, with thus very reduced inertia against sudden commanded rotations. Even with only one engine, this advantage was much interesting. Once adopted this principle of a central engine, the twin-boom layout could be selected to avoid a long drive-shaft – forwards (Bell P-39) or backwards (Göppingen Gö 9). An unnamed **<u>Focke-Wulf</u>** project illustrates this, and the problem with an air-cooled engine – requiring a large annular scoop here.

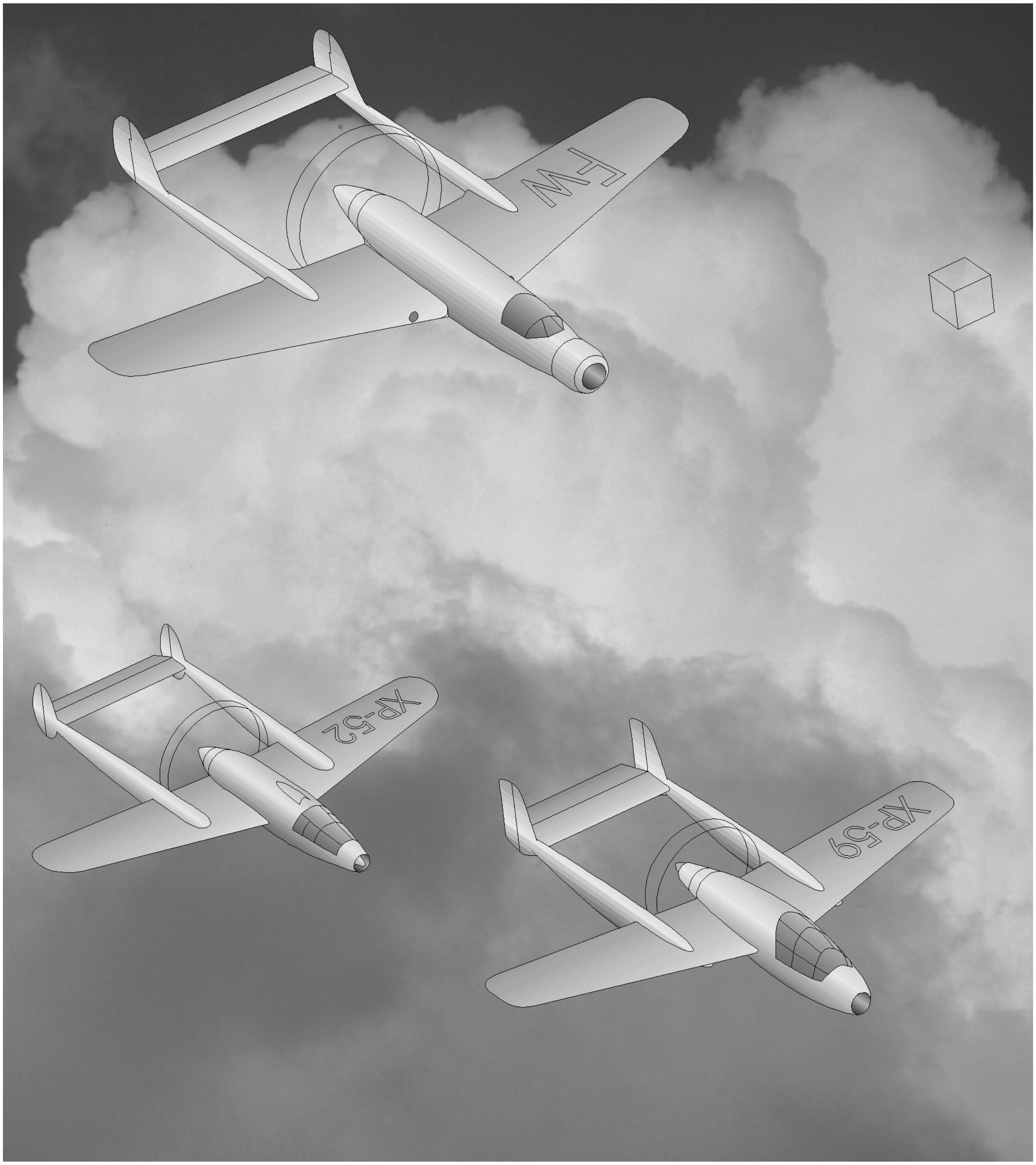
The same situation was dealt differently on one of the **<u>Mitsubishi J4M1 Senden</u>** versions: faired scoops acted by depression, with clean aerodynamics – however overheating may have been a problem at the full-power zero-speed starting point. The same cooling system was considered on a version with single propeller (<u>J4M2</u>?).



Sometimes, agility and efficient cooling were essential, while speed and aerodynamics were not, so the plane nose could be used for a large air intake or radiator – the Hanriot H.110 and 115, before 1939, had explored this way. In 1939-45, the **Bell XP-52** was a good illustration. It was used as a basis for the **Bell XP-59**, bigger and bulky. This one is especially famous for its code having hidden the top secret jet project Bell XP-59A, which was neither twin-boom nor single-engined.

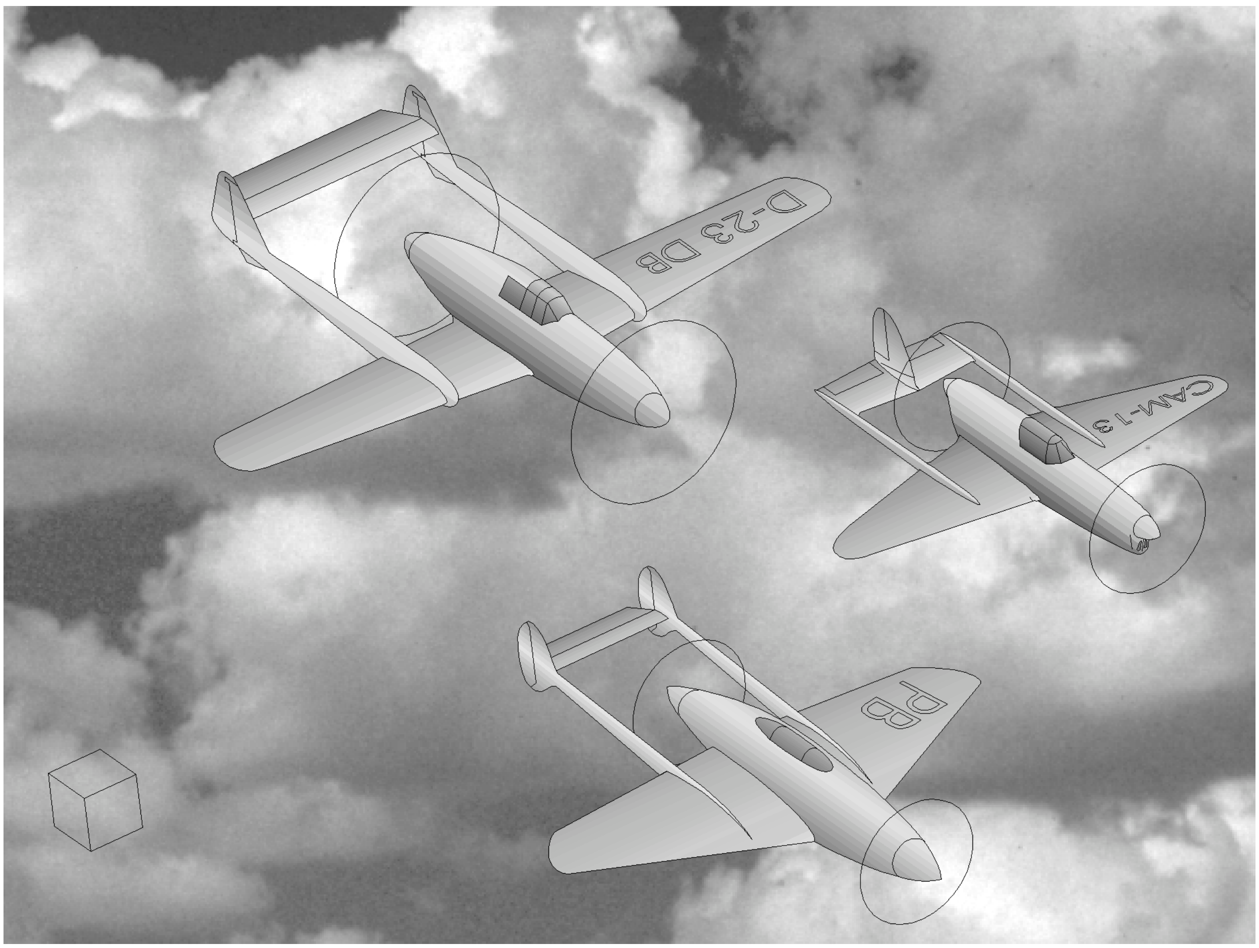
In the same class, a variant of the Focke-Wulf seen previously exchanged its annular air intake for a frontal device.

These models with "nose hole" may be found ugly, while this became a heavy trend among the first jets soon later – anyway, the Yak 23 and F-86A were not unaesthetic.



Driving contra-rotating propellers was complex, and if only one propeller was used: a dangerous torque was encountered – with a risk of crash at takeoff, when the wheels ceased maintaining the plane horizontal. The *push-pull* formula brought a solution to this torque issue. Such a layout had several advantages over competitor twin-engines: improved cooling (no double rear engine), smaller frontal area and higher turn-agility (no lateral engines), increased mechanical simplicity (no coupled engines), acceptable visibility (no double-engine in the nose), reduced vortex on the wing (no double tractor propeller). Of course, the optimum was not reached in each domain, and there were corresponding disadvantages: difficult cooling (rear engine), bad vortex (front propeller), inertia against diving/climbing command (front weight), imperfect frontal area (no faired canopy), poor visibility (cockpit rather rear)...

The overview of the push-pull twin-boomers of those years cannot start with a preliminary draft of the Lockheed Lightning, as this was far before 1939; the Fokker D-XXIII prototype is too old also but not the late version with Daimler-Benz engines (**Fokker D-23 DB**). The small **Moskalyef SAM-13** racer was characterized by a single fin, still improving aerodynamics. And there was also a **Pemberton-Billing** project – these fast little push-pull planes preceded the Aero-Design DG-1, intended to break a speed record.

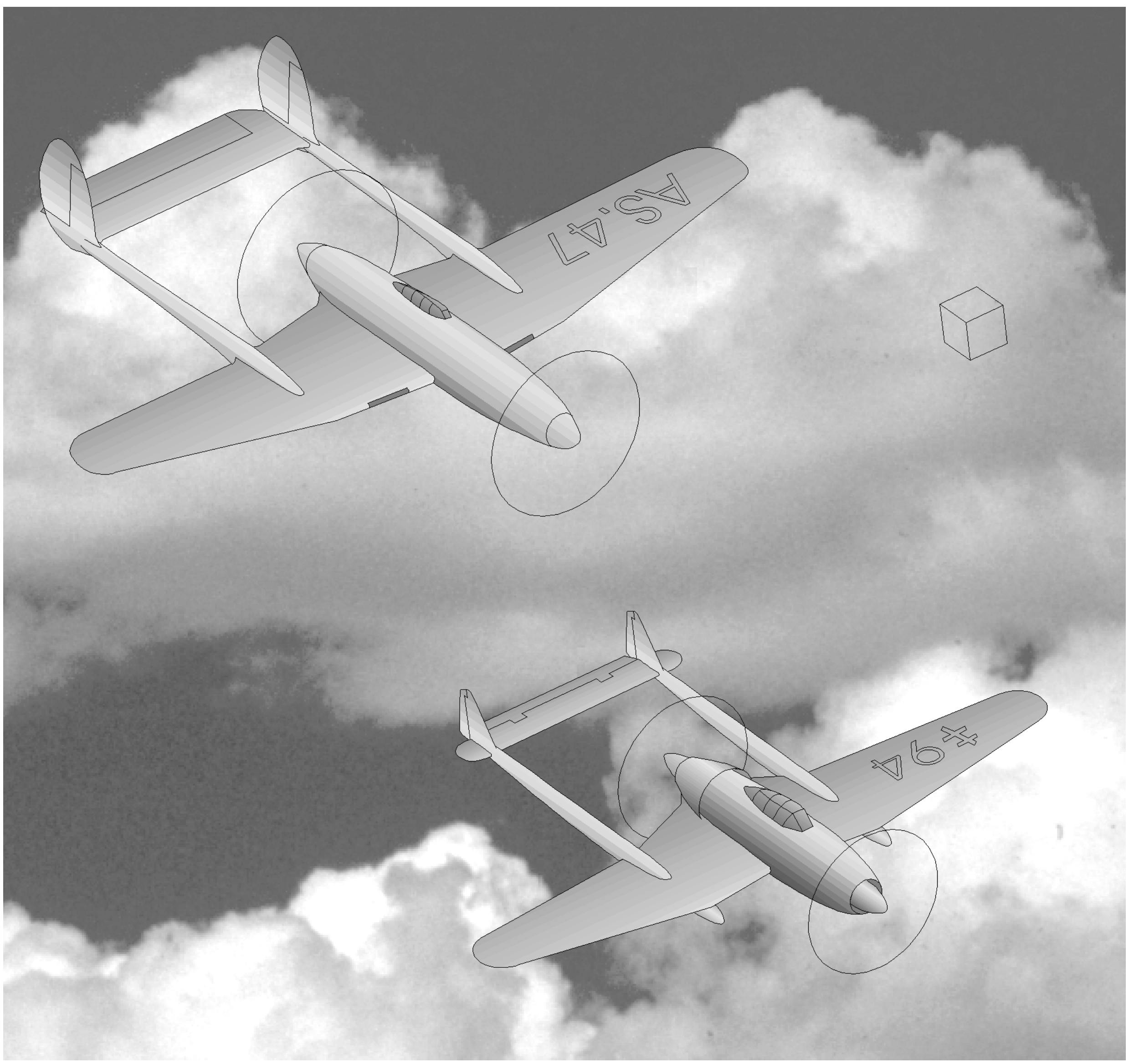


For large airplanes also, the push-pull layout is good. The project **<u>Tachikawa Ki 94</u>** (or <u>Ki 94-I</u>), with its two huge radial-engines, would have been slowed down by a huge drag if a traditional layout with lateral pods had been selected. With the push-pull solution, aerodynamics were even better than on the twin-fuselage Dai San An (page 28).

The **<u>Airspeed AS.47</u>** is similar, with the originality of a laterally shifted tiny canopy. The AS.47 has another characteristic, among the push-pull contemporaries: its two large 24-cylinder engines could have been couples of standard engines (12-cylinders). This would have given a four-engined plane even more aerodynamic than the twin-fuselage Do 635.

On the contrary, the push-pull propellers could have been driven by a single engine, just to solve the torque issue of a powerful engine, without coaxial propellers (XP-59) nor transverse shafts (OSh): the principle of shafts frontward and rearward had been considered on the antique Beilharz and Gibson Twin-plane; the first twin-rotor helicopters employed also this mechanical way, which is not absurd.

Back to the push-pull twin-engines: this principle dates from the Canton-Unné of 1910, and became famous in the 1970s thanks to the Cessna Skymaster. It is compatible with traditional planes, not twin-boom, but requiring a long rear driveshaft (Do 335 Pfeil), a very light rear engine (Aero-Design DG-1), a great rear wing area (canard Rutan Defiant, tandem-wing Moynet Jupiter), an asymmetrical configuration ("DaU", Gotha G VI), or a raised up power plant (Tchyetvyerikov Ark-3 with pylons, SPCA Hermès with low boom).



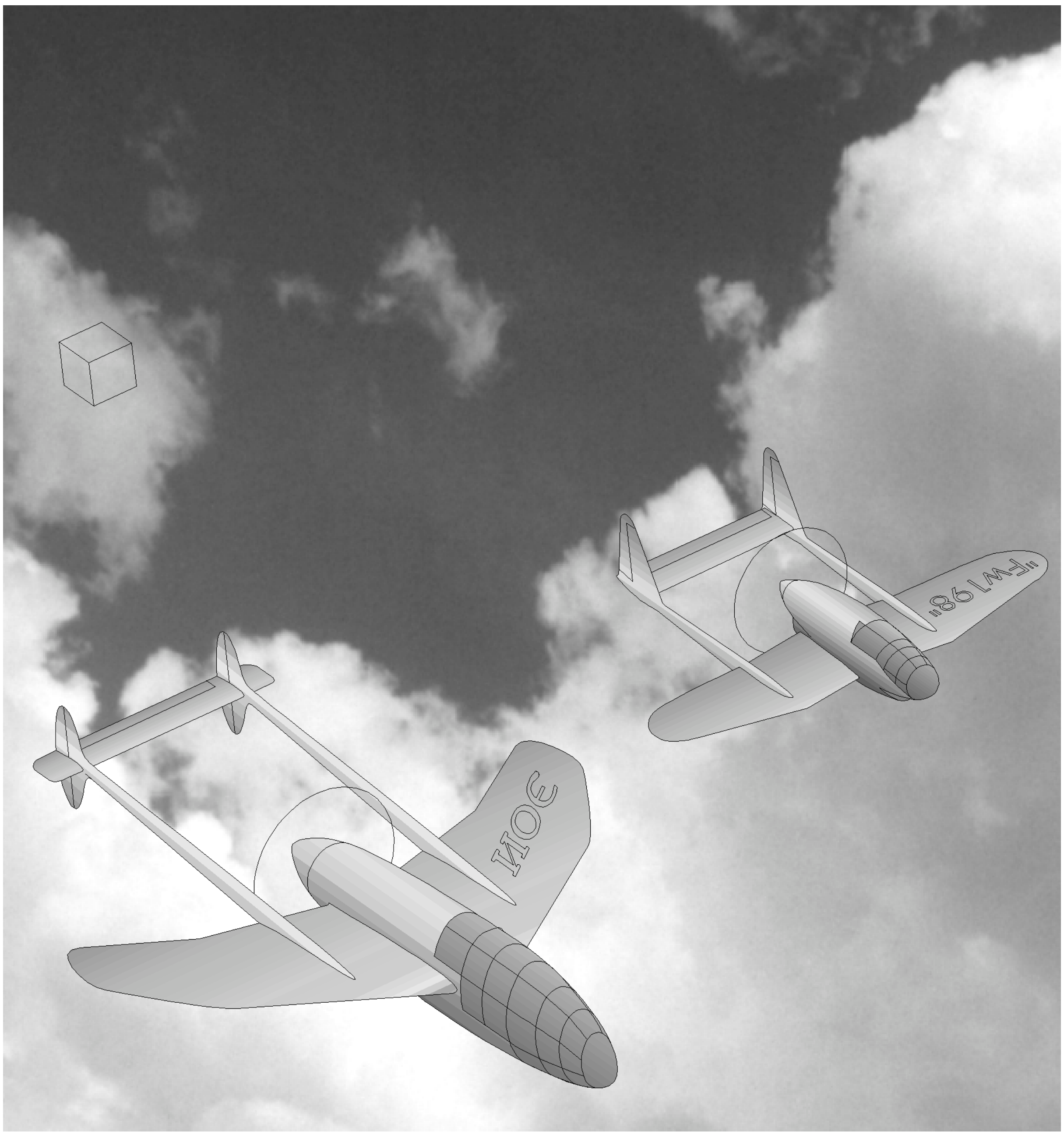
3.4.2 – Functional advantages

Apart of mechanical interests, there are practical advantages using a rear propeller. Removing the power plant from the nose gives room to install a glazed cockpit, a large door, a landing gear or some other device.

Fairing the cockpit in the nose was good for aerodynamics, while it improved also the view forward and even downward. Apart of a panoramic viewpoint in flight, this brought safety to landing on short runway, needing to touch the ground at the very beginning but not before...

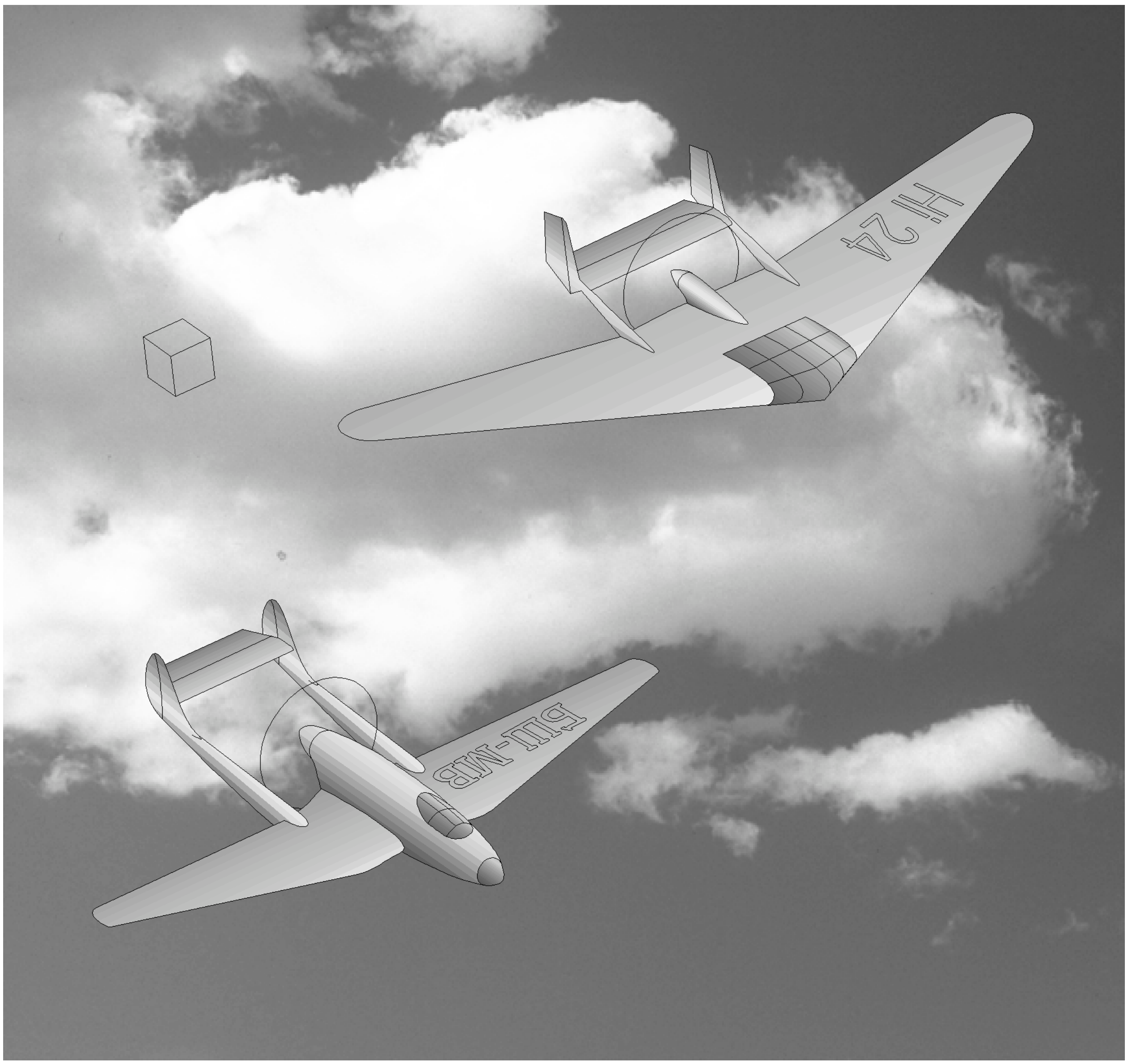
The most famous example was the project De Schelde S.21, but it was designed before 1939; anyway, this model appeared again later with the name **"Focke-Wulf Fw 198"**, according to the press. If all the planes examined lately could be declared new born, the Praga E-51 (Klemm version) would be included among twin-boomers with rear post.

The **Byelyayev EOI** (Experimyentalniy Odnomiestniy Istribityel) was similar to the S.21, apart of its modern wing shape for high speed. Another version was named PBI.



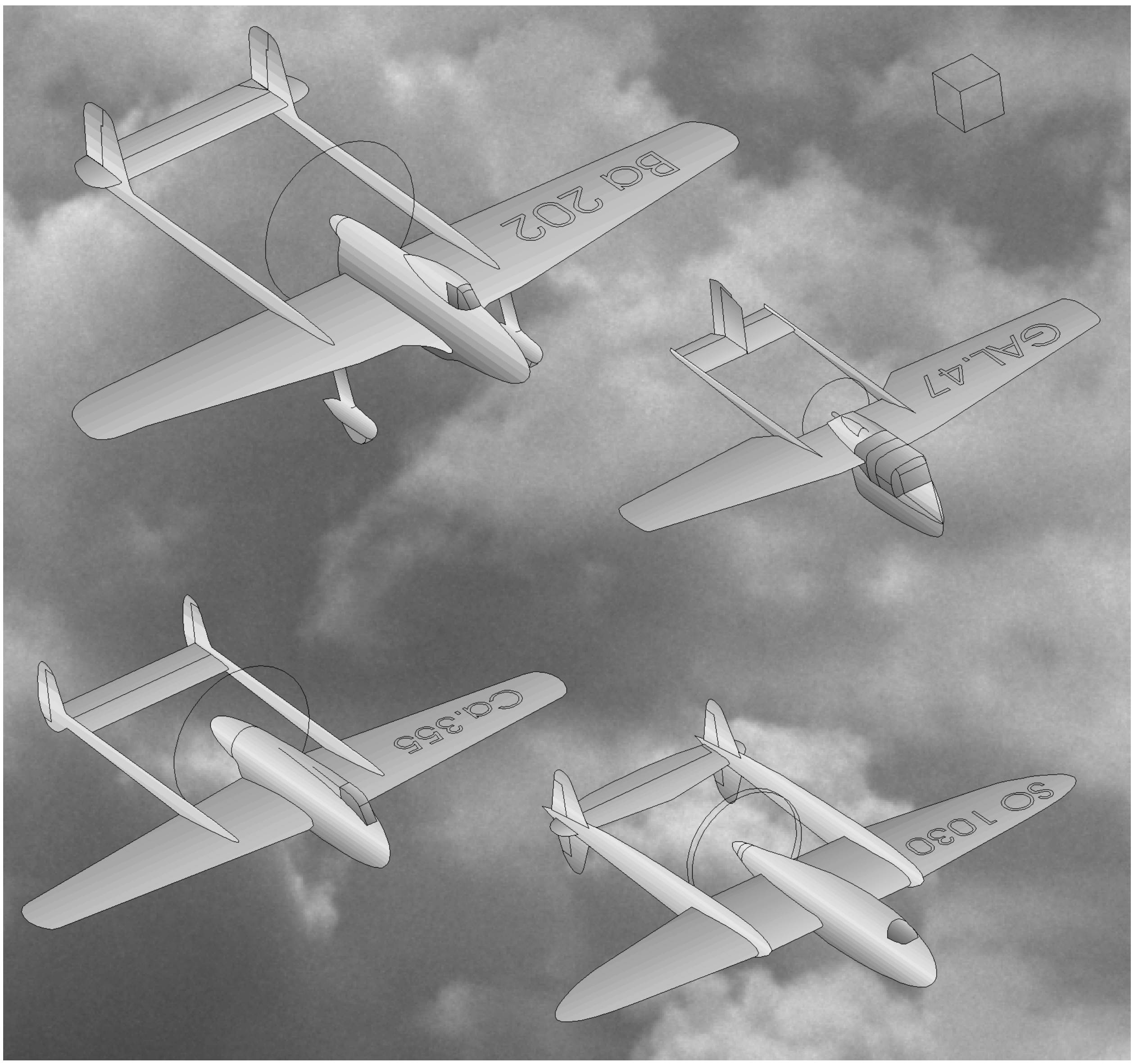
On single-engined aircraft, there is no need of a rear propeller to get an excellent visibility forwards – a raised up engine on pylon (e.g. Be 4) is a traditional alternative, though not very aerodynamic. There is also the possibility of a prone pilot above the nose engine (e.g. SIAI SM.93), though with a poor visibility downward. Associating a rear engine to a prone pilot, the **Hirth Hi 24** provided a solution. Concerning classification, there was almost no distinctive pod on this project, like on the win-boom Northrop-Avion Model I, designed fifteen years before – these models could have been used as transition with the chapter 1.3 in a linear classification of the twin-boom world.

Contrary to the very aerodynamic Hi 24, a model with glazed nose may have a separate windscreen, additional. It is a usual configuration on heavy planes (e.g. B-17) with a passenger in the nose; it is much rarer to find this principle on a single-seater, the dashboard masking the pilot's view, partly – the **Mozharovskiy-Vyenyevidov BSh-MV** (or Arkhangyelskiy Kombain) illustrates however this principle.



Even without glazed nose, a front canopy could provide a good view forward – this is no more original nowadays, since the jet and canard planes made this very popular. Compared to a fragile glass nose, a metal nose brought safety in case of emergency landing in a plowed field, or if the landing gear broke on the runway at high speed.

The **Breda 202** was a perfect example of twin-boomer with short nose. The design of engineer Dupuy and the **Sud-Ouest SO-1030** also had an optimized visibility; they were progenitors of the SO-8000 Narval, developed after 1945. Another example was the project **Caproni Ca.355** in its twin-boom variant. Lastly, the General Aircraft **GAL.47 FOP** (Flying Observation Post) had convex panes to see the ground – as on the later twin-boom Heston A2/45, Latécoère 833, Potez 75, etc. Note the peculiar shape of the wing, reminding the old twin-boomers of Jean Biche, JB.1 to H.115.



Other advantage related to the rear propeller, the possibility of installing a large lateral car-door just above the ground level: for clearance of the propeller, the engine must be high, and as classically the windscreen is located above the engine on a single-propeller aircraft, all the cabin is high, needing to climb into it; on the contrary, a rear engine can be high with a low cabin thus access as simple as in a car. An engine on pylon (e.g. Savoia S-64) would be less aerodynamic, as well as a bulky plane with low cabin and high cockpit (e.g. Grumman Duck).

The main design of twin-boomers with low nose, for those years, is the SECAN SUC.10 Courlis, but like the C-82, F-82 or Vampire, this plane is primarily known for its development after 1945. Other design: the Piper Skycoupe – the basic prototype, famous, was a two-seater with low wing, named PA (then PWA-1); the **PB** derivative was a four-seater, the **PA-7** had a high wing. In the same category was the **Diepen Difoga 421** – with maybe some relationship to the later Fokker F.25 Promotor (there could be a whole family from the former Fokker 147 to the late Fokker P.1 Partner).

The project of Donald **Wheeler**, that would become Puget Pacific Wheelair III-A after 1945, was also a plane with perfect accessibility. In the same category was the tiny single-seater **Adriano Mantelli AM-6**, progenitor of the Alaparma family which went from glider to jet plane. Weighing less than 150 kg (330 lb) and powered by 17 hp, the AM-6 was an Ultra Light. Some authors consider that the **AM-8** and two-seater AM-10 were designed before 1946 also. These small planes featured a bicycle landing gear on the central axis.

At last, let us mention the two-seaters Payen Pa.140 and Pa.141 (or Katy K.60 and K.60B). The single-engined flying boats, symbolized by the famous Nardi Riviera, constitute a nearby case: the airscrew cannot be in the nose because of necessary water clearance, it cannot be raised up without bad aerodynamics, so the best is a rear high position. The **Payen Pa.150 Otarie** embodied this seaplane family in the years 1939-45. Perhaps the Pa.190 Otarie II and Pa.240H, twin-engine amphibious, had the same layout with two coupled engines driving a pair of contra-rotating axial propellers. The family of the Airmaster Avalon, with the project Twin Star 800, recently took again this type of solutions for a twin-boom amphibian.