# The USSR "Ekranoplan"

**by Johan de Villiers**

For years during the Cold War, U.S. Intelligence agencies observed fast moving Russian planes, flying low level over the Caspian Sea. These machines resembled planes with the outer halves of their wings

removed and were quickly named the "Caspian Sea Monster". Also known as the KM, in the top secret Soviet military development program, it was over 100 m long weighed 540 tonnes fully loaded, and could travel at over 200 knots at an height of 3 meters above the ocean.

Subsequently, with the end of the USSR, these airplanes were found to be called "Ekranoplans" by the Russian, derived from the French word "Ecran" meaning "screen" and Russian "plan" for "plane". It thus literally means "screen plane" and is designed to fly only meters from the surface of the oceans using something called ground effect to evade radar. Ground effect is an aerodynamic phenomenon, which occurs when an aircraft is in close proximity to the ground and is also known as Wing in Ground (WIG). Once airborne, the Ekranoplan can move over sea, ice, and snow or level land with equal ease, though flight over land would involve extreme risks unless the surface is completely flat. This kind of ability would make for super transport capabilities in a heavy lift plane.

Looking back at the history of the Ekranoplan, some experimental machines were first developed in Scandinavia before the start of WWII. During the 1960's however, the Russian ship designer Rostislav Alexeev and the German aeronautical engineer Alexander Lippisch made great strides in improving the technology independently of each other.

The Soviet leader Nikita Khrushchev quickly saw the benefits of developing this technology further and provided funding for the Soviet Central Hydrofoil Design Bureau (CHDB) lead by Alexeev at the time. The Caspian Sea monster first spotted by the US Military weighed in at a massive 550 tons and could reach a top speed in excess of 400 knots at a flying height of 66 feet.

The two most successful Ekranoplans were the 125-ton Orlyonok (A-90) produced between 1979-1992 and the 400-ton Lun-class developed in 1987. Originally, the A90s were destined to be high speed military transport planes and were based around the Black Sea with some deployment around the Baltic Sea fleets. They could carry in excess of 100 tons of cargo at the time. Of the 120 ordered by the Russian Navy, only 30 were eventually produced.

The Lun-class Ekranoplan (also known as Project 903) was intended as a missile launcher platform. It was called Lun after the Russian name for a bird of prey

- hen harrier. It carried six Moskit cruise missiles (SS-N-22 Sunburn in NATO classification). A direct impact of four of these missiles was guaranteed to sink any known vessel at the time, including the larges US flight deck carrier.

No landing gear was provided and thus the Lun required a special floating dry-dock. Powered by eight turbojets, it required a crew of 11 people and could remain autonomous for 5 days. The Lun-class vehicles had a top speed of 297 knots flying in ground effect and 550 knots at altitude with a lifting power of 984 tons.

Unfortunately, after the death of the Russian Minister of Defence, Ustinov, funding was stopped for the Ekranoplan program and only three Orlyonok and one Lun-class ekranoplan remained at the Russian naval base of Kaspiysk. After the collapse of the USSR, ekranoplans were produced by the Volga Shipyard in Nizhniy Novgorod for non-military use.

Getting back to explaining ground effect, it allows for a reduction in drag (therefore creating better lift!) as the aircraft approaches an height equal to its wingspan above any level surface, owing to a cushion of high-pressure air created between the wings and the surface (land or sea). It becomes most efficient at an altitude of approximately one half of the aircraft's wingspan and is commonly used by helicopters to increase lift before transitional speed is reached.

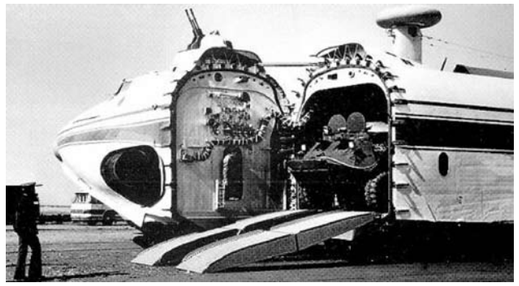
Ground effect vehicles (GEV) thus not only can evade radar as mentioned, but also uses a lot less energy owing to the additional lift being afforded without an increase in engine performance.







Ekranoplans are also known as sea skimmers, Wing-in-ground-effect-ships (WIGS) or flarecraft. Interestingly, the International Maritime Organisation (IMO) has classified GEV as ships, although the only difference between them and proper airplanes are that they can only operate with the use of ground effect. (Their operating altitude, as explained earlier, dependant on their wingspan of course!)



In addition to the better fuel efficiently offered by an Ekranoplan owing to Ground Effect, there is also the safety benefit of flying close to water in the event of an engine failure as heavy ditching can be avoided owing to the close ground proximity.

The disadvantages of these machines are unfortunately also numerous. For starters, flying at very low altitudes, above the sea, is dangerous if the plane banks too far to one side while making a small radius turn. Reliable navigation at low altitude and poor longitudinal stability were two major problems that the Ekranoplans faced during development. Current developments to address these issues include special automatic control systems and special high accuracy altimeters for small altitude measurements with lesser dependence on weather conditions. It has been found that "phase radio-altimeters" are more suitable for Ekranoplans as compared to laser, isotropic or ultrasonic altimeters.

In addition to that, an Ekranoplan must always takeoff into wind, which on the sea, means straight into the waves, creating additional drag and a reduction in lift. The Russians came up with two solutions to this problem. By placing the engines in front of the wings, more lift could be provide. In the case of the Caspian Sea Monster, 8 massive turbojets were used, some only for the actual take-off!

A second solution was to raise the main body of the aircraft mostly out of the water, allowing for an easier takeoff.

An additional issue that have delayed the development of these craft is the classification and legislation to be applied by the IMO, which were originally developed for catamarans, hovercraft and hydrofoils!

**The International Maritime Organization (IMO) recognizes three classes of ground effect craft:**

1. Type A cannot operate out of ground effect. (GE)
2. Type B can jump to clear obstacles by converting kinetic

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energy (speed) into potential energy (height), but cannot maintain flight without the support of the ground effect.
3. Type C is certified as aircraft, with the ability to operate safely and efficiently out of GE.

**Three different wing designs were developed for the Ekranoplan:**

- The Inverse delta wing allowed for stable flight in ground effect through self-stabilization. This is the main Class B form of ground effect craft.
- The Ekranoplan wings were significantly shorter than comparable aircraft, and this configuration required a high aft-placed horizontal tail and front-aft wings to maintain stability.
- The Tandem wing could have two configurations.

1. A biplane-style Type-1 utilizing a shoulder mounted main lift wing and a belly-mounted sponsons similar to those on combat and transport helicopters.
2. A canard-style type-2 with a mid-size horizontal stabilizer near the nose of the craft directing airflow under the Main Lift Airfoil. If used with a double wing system, it provided for a self-stabilizing platform.

## Conclusion

After the end of the Cold War, Ground Effect Vehicles have been suggested for a number of military and civilian roles, primarily in the heavy lift arena for airplanes exceeding 500 tons. With the inherent risk in untested technology and the decline in defense, spending/ research funding worldwide, the environment has not been conducive for GEV development.

Current roles being considered for WIG planes are either for trans-oceanic cargo owing to their ability to cut resupply times by as much as 60% owing to their increased speed of in a small form factor, for recreational use or large transport ferries.

In 2007, Russian vice-premier and defense minister Sergey Ivanov announced the development of a wing-in-ground-effect vehicle called the Be-2500. It will be an ultra-heavy transport amphibious airplane with a weight of 2500 tons and a useful payload of 1000 tons. With a wingspan measuring 125 metres and a length of 115 metres, it will have a cruising speed of 400 knots and a speed in ground effect of 240 knots. That would make it bigger than the world largest plane, the An-225! For some stunning video footage of these leviathans in actions, have a look at:

**http://www.youtube.com/watch?v=YSYmSnpQ360 and http://video.google.com/videoplay?docid=2200021317530929051#**

**Safe Flying!**


# Sukhoi T-50 Stealth Fighter

Earlier this year, Russia surprised the military aviation community by conducting their first test flight in a prototype of their radical tactical stealth fighter, the Sukhumi PAK FA T-50. This is the first stage of re-vitalising the aging post-cold-war Russian Air force in order to compete effectively against the latest 5th generation fighters from the West and o capitalize on the lucrative military export market. Countries that traditionally do not have access to US military hardware, will now have the first viable alternative to source 5th generation fighter jets.

Considering that the American F-22 is already nearly two decades old, the country is desperate to stake a claim in this strategic arena of air defence. The T50 PAK-FA is seen as a low risk design, following the Russian philosophy of "evolution", rather than the "Big Bang" approach of design favoured in the West, by trying to start from scratch with most or every key portion of a fighter design.

Viewed as the first joint development by the Russian and Indian governments, a market of 1000 aircraft over the next 40 years is being projected with delivery date scheduled for 2012 and a further 60 aircraft by 2016. Originally proposed in the late 1980's, two designs were proposed in the form of the Sukhoi Su-47 and the Mikoyan Project 1.44. The PAK FA T-50 will utilise and incorporate technology from both of these designs, especially with the radical reverse delta wing of the Su-47.

The Sukhoi T50 is designed to compete head-on with the American F22 Raptor (Lockheed Martin/Boeing) and the F35 Lightning II (Lockheed Martin) and will replace the much feared Mig 29 Fulcrum and Su-27 Flanker that are currently in use by the Russian Air Force.

With an maximum take-off weight of 37000 kg, wingspan of 14m and total length of 19.8m, the T50 is expected to achieve a cruising speed of 1 800 km/h. Maximum speed is rated at Mach 2.45 (2 600 km/h) at an altitude of 17000m (45 000ft). The Sukhoi's service ceiling will top out at 65 600 ft (20 000m) with a maximum g-load in excess of 11.0!

The PAK-FA is also fitted with unusually robust high sink rate undercarriage, intended for short take-off and landing (STOL) operations from a variety of airstrips. The aircraft is also designed to compete against the F-22 in traditional Beyond Visual Range (BVR) and Within Visual Range (WVR) air combat.

Like the latest fighter aircraft from the US, the T-50 will be employ stealth technology with an exceptionally small radar cross section (RCS) (less than 1/40 of the Su-35!) and in addition to have super cruise capabilities. Although the project is heavily classified, it is rumoured that the latest air-to-ship, air-to-ground and air-to-air missiles will be fitted as well as limited artificial intelligence in the onboard targeting systems. The 1500 array radar system should significantly reduce pilot workload and full bi-directional data links will allow information sharing between in-flight fighters and ground command control centres.

Although the T-50 has no conventional rudders, it twin vertical tails are fully movable and is supplemented by dedicated horizontal stabilizers. That design seems to be very similar to the V-tails used in the Northrop YF-23 during the 1990's and even the F22. Interestingly enough, it is clear that there is wing leading edge devices fitted above the jet engine intakes that could prove to be challenging for signature control.

The T-50 airframe design shows VLO (very low observable) shaping of the wing and tail surface area, as well as the forward fuselage and inlet. This should make it very competitive against the US F-22 Raptor. However, the aft fuselage and nozzle shaping is inferior the latter and shares the same deficiencies as the F-35 Joint Strike Fighter.

The airframe design of the airplane will allow manoeuvres such as flat turns, or even turns where the bank angle is opposite to a conventional banking turn. This in effect means that the machine can execute, without difficulty or high energy bleed, turns away from beam aspect threats without significant exposure of the lower fuselage. The F35 Joint Strike Force in turn has unavoidable susceptibility to detection, tracking and missile shots during such executions. Seeing that the T50 employs supersonic cruise capabilities its window of vulnerability is very much shorter than the F22 when attempting to evade a tail aspect threat.

Originally, reports suggested that the Saturn 117s engines would be fitted to the T-50, but it turns out that a completely new jet engine has been utilised, of which the specifications are still secret. Each of the twin engines can however independently vector its thrust in any direction to produce a twisting force on the airplane. This makes it the first 5th generation fighter than can do full 3-D thrust vectoring in all three axis of pitch, yaw and roll.

Owing to this three-dimensional thrust vectoring, aerodynamic drag, radar signature and structural weight are reduced. Close to 70% of the outer surface of the jet will be made of composites and nearly 25% of the total weight of the aircraft as well. The fuselage reportedly is made of 75% titanium alloy. Early reports suggest that the avionics will include three X-Band radars on the front and sides of the aircraft, used in conjunction with L-Band radars on the wing leading edges. The cockpit, reminiscent of the Su-35, will include two Multi-function displays (MFD) and a single large Heads-up Display (HUD). In addition to that, the T-50 will also have optical/IR search and tracking systems as standard.

Russian Prime Minister Vladimir Putin described the T-50's first flight as a "big step forward," but admitted, "A lot remains to be done in terms of engines and armament."

The latest US defence simulation tests shows that the Sukhoi T-50 will be inferior against the joint manoeuvrability and invisibility to surface radar, of the F-35/ F22 combination. In conclusion, some observers believe that the future might not be that bright for the new Russian fighter, claiming that the engines are untested and that the country lacks the materials to manufacture a competing 5th generation fighter. A number of defence analysts believe that fitting modern avionics to the older generation jets might be more expedient, seeing that the Russian military lacks modern communication systems and the latest satellite navigation to interface with such a fighter jet.

Conversely, it has been noted that the T50's extreme manoeuvrability/controllability design features will give it the potential to become the most lethal and survivable fighter ever built for air combat engagements. Only time will tell!