WING-IN-GROUND VEHICLES:
MODERN CONCEPTS OF DESIGN, AUTOMATIC CONTROL, APPLICATIONS

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General concepts of transport flying close to the surface are discussed. Special advantages of WIG-craft or ekranoplane are analyzed. Modern classification of such advanced flying vehicle and its technology is explained. Possible multi-purpose applications of ekranoplanes are stated. Russian experience in ekranoplanes design and construction is described. A special analysis has also been carried out taking into consideration the important (both small-scale and large-scale) possible applications in India and the Indian Sub-Continent.

1. INTRODUCTION

Transport means development level is an important index of economic and defense power for any country. The main transport branches are automobile, train, marine and aviation. Automobiles can deliver cargo and passengers practically to any point of land, but the load capacity is not great. Trains provide the great tonnage, but require an expensive railway network. Ships are very suitable at sea and river transportation, but too slow. The ways of sustainable transport perfection are lying as a rule in combination of advantages of different kinds of vehicles.

Aviation and marine vehicles features integration gives a number of effective results. The most famous of them is a hovercraft which may be considered as the outcome of the attempts to raise the ship up from the water. Hovercraft creates lift due to increased aerostatics pressure in the space between vehicle hull and supporting surface. This static air cushion is created by special blowers that spend a part of the power available on board independently of vehicle horizontal motion speed. The wide use of hovercraft as civil and military transport determines by their great speed (up to 120 km/h) as compared to displacement vessels, and also amphibian abilities.

It should be noted that Russia, in parallel with USA and Great Britain, is the largest hovercraft manufacturer. About 70 amphibian and 115 skeg large and medium vehicles were constructed that accounts for 1/5 and 1/2 of the world fleet.

Hovercraft Zubr (Fig.1) is the most famous of them with its full weight 350 ton and cruise speed around 53 knots [1-3]. Practically all Russian hovercraft have been designed at St.-Petersburg Central Marine Design Bureau Almaz and constructed in this city.

Fig.1. Hovercraft Zubr

In the last decade the hovercraft application waned due to two main reasons: too high fuel consumption and not high enough velocity. Both ones resulted in very limited range of operation. The question arose: what kind of vehicles could partly replace hovercraft and other slow-speed vessels in the market of civil and military transport applications? This paper gives the answer to it: it may be Wing-in-Ground effect vehicles (WIGs) or ekranoplanes as they were called in Russia.

The history of ekranoplanes development in Russia began in the sixties-seventies of the last century. Russia is still a single country which has the real experience of heavy ekranoplanes construction, mainly for the Navy. Nizhni Novgorod and St. Petersburg are the main centers of R&D in this field of highly advanced engineering and future modes of transport.

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2. GENERAL CHARACTERISTICS

Ekranoplane is a winged vehicle with the ability of flight at extra low altitude where the lift/drag ratio grows considerably due to the effect of supporting surface. In this case the dynamic air cushion appears in the space between the wing and “screen” (which may be the surface of water, ice, or land) and its influence is added to the normal mechanism of lift force formation due to different speeds of air flow about upper and lower wing surfaces. It is a phenomenon of aerodynamic, aeroelstic and aeroacoustic effects when flying close to the supporting surface.

Fig.2 shows the first in the world serial-produced ekranoplane Orlyonok designed in Alekseev’s Central Design Bureau, Nizhni Novgorod, Russia, which had the first test flight in 1974. Its take-off weight was 140 ton, the cruise speed was 450 km/h at the altitude of 2m above the surface. It was designed as an amphibious craft being able to carry 2 tanks and more than 100 soldiers.

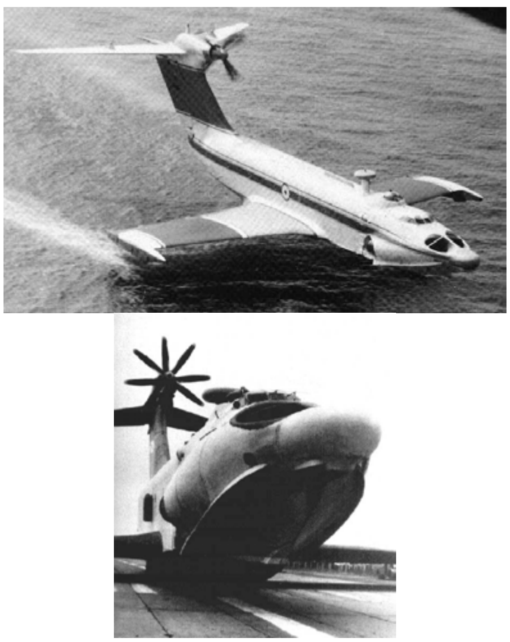

Fig.2. Ekranoplane Orlyonok

Among the most famous Russian ekranoplanes could be mentioned also the missiles carrier Lun of 400 ton weight which had the first flight in 1985 (Fig.3). And also the biggest in the world ever constructed ekranoplane KM having a stunning 540 ton weight with a length of 100m (328 ft.) was the biggest and heaviest flying machine ever made, beaten only 22 years later by Antonov An-225 ‘Mria’.

Fig.3. Combat ekranoplane "Lun"

WIG-effect action weakens with the removal from the screen when the relative altitude of motion $\hat{h}=h/b$, where b is the chord, decreases, and practically disappears at flight at the altitude exceeding $\hat{h}$=0.3-0.4. Therefore advantages of flight "above the screen" are experienced at smaller heights limited by the roughness of the basic surface. As for the screen, any natural or artificial plane smooth surface can be used, but more often ekranoplanes are built for flight above the sea [4-8].

The WIG- effect not only increases elevating force, but also reduces drag. Drag reduces because of the aero elastic effects under the wing and corresponding inductive losses. Besides, the screen stirs to vortices course of air from the bottom surface of a wing to the top, that too reduces inductive resistance of a wing, especially in the presence of end plates.

As in real conditions of operation of ekranoplanes the relative altitude $\hat{h}$ is difficult for lowering below a level 0.1, in most cases the achievable prize in aerodynamic quality due to screen effect does not exceed 45 % though in conditions of "pure" experiment this value reaches 200 %. Full performance of WIG-effect is interfered by roughness of a basic surface. Besides unlike high-speed airplanes ekranoplanes cannot use motion in the unloaded atmosphere at greater altitude for decrease in drag. As a result the advantage ekranoplanes above planes in fuel profitability admits mainly only on average distances (the order of 1000 km), and for greater distances it is disputable. But for ekranoplanes there are many other essential advantages, excluding for fuel profitability.

In order to make the full use of the WIG-effect and to provide high functional characteristics of ekranoplanes as transport vehicles they usually have the following features that distinguish them from aeroplanes:
- wide wing with small aspect ratio that is relatively low attached to the body, or “flying wing” or “combined wing” configuration;
- boundary plates on wings that enhance wing aerodynamics when moving close to the supporting surface, often - float plates;
- developed tail assembly, high fin (or several fins) with rudder, horizontal stabiliser with elevator attached to the fin at the utmost height;
- hydrodynamically clean body with the bottom of increased strength;
- special equipment to expedite taking off from the water and water landing;
- special components and systems of automatic control providing stability, efficiency and safety of motion in different modes.

3. ADVANTAGES OF EKRANOPLANES

The important advantages of ekranoplanes are:
• absence of necessity for runway and possibility to perform special transport operations at amphibian property use (ekranoplanes can fly, float on water and creep out to the shore);

• potentially higher safety of flight due to possibility of urgent ditching;
• reduced requirements to engines operation reliability and, therefore, possibility of their service life fuller use;
• absence of necessity for tight cabin and special life-support systems for crew and passengers;
• ability to carry a freight of large mass and dimensions are higher than for airplanes;
• stealth of motion and very low radar signature by the surface radar;
• high transport profitability on midranges (about 1000 km) in matching with aircraft because of absence of energy consumption for rise on a high altitude;
• cost of construction, maintenance and exploitation below aviation (may be two times lesser).

Some experts think that presently the ekranoplanes can be easily tracked by the surface monitoring from satellites. It is true, but the delay in collecting data on moving ekranoplane will be too great for effective countermeasures.

Advantages of ekranoplane as vehicle can be realized effectively only on the basis of careful working of and optimization of the constructive decisions, thus achievements of modern technologies should have an essential role. Both potential advantages and difficulties of designing of ekranoplane are connected with overlapping at them navigable and aviation qualities. The basic short solved problems of designing and development of ekranoplane can be formulated as follows.

1. The necessarily raised rigidity of the case makes the design heavier.

2. Necessary corrosion stability complicates use of easy to construct aviation materials.

3. The mode of take-off from water demands superfluous energy in relation to cruiser flight of capacity of engines.

4. Absence of necessity for aerodrome does not mean uselessness of specially prepared base for parking, service and repair where equipment, as well as creation of other elements of a special infrastructure of service of ekranoplane, demands means.

5. Essentially nonlinear effects of aerodynamics of flight near to the screen create a problem of stability of motion, where decision calls for the usage of special aerodynamic configuration and special automatic systems connected with the certain restrictions.

6. Simultaneous use in areas of intensive navigation of usual courts and greater ekranoplane demands the special decision of a problem of the prevention of collisions where best variant is allocation for ekranoplane special "corridors" that is impossible without restrictions of zones of navigation at active resistance of traditional carriers.

7. Certification and licensing demands work with IMO, ICAO, national registers, the insurance companies, updating technical, organizational-technical, legal, etc. specifications and certificates are necessary.

Research and developmental work on creation of ekranoplane for various purposes being conducted extensively by Russia, USA, Japan, China, South Korea, Germany, Australia, France, Iran and other countries.

4. CLASSIFICATION OF EKRANOPLANES

In the classification of ekranoplanes two basic attributes are considered usually: take-off weight and a degree of a binding to the "screen", i.e. an opportunity to change the altitude of flight.

Ekranoplanes are divided on small, middle and big (in the long term, probably, very big) depending on weight, the sizes and carrying capacity, conditionally comparing with anyone of the specified classes according to river, sea and ocean conditions of operation.

Small ekranoplanes, projects and which experimental samples are most numerous, can transport from one to 6-9 passengers, have weight upto several tons and the linear sizes approximately upto 10м. A typical variant of small ekranoplane use - a river taxi for transportation of several passengers on distance of 300-500 km with a speed of 120-200 km/h on internal reservoirs or coastal routes at height of a wave no more than 30 cm.

Medium Sized ekranoplanes can have weight approximately up to 300 tones and the linear sizes in some tens of meters. At speed of flight of 200-400 km/h settlement range reaches the order of 2000 km. for an opportunity of operation in the high sea and in local not storm areas of ocean such vehicles should maintain waves in height even up to 2-3 m, and at smaller disturbances to provide practically extremely high operational characteristics. Medium sized ekranoplanes in comparison with small ekranoplanes are much more complex and expensive objects of designing, especially regarding careful working of aerodynamic and constructive schemes, creation of a specific information-operating complex with a full set of necessary functions.

Big ekranoplanes can have weight approximately around 1000 tones and the linear sizes of the order of hundred meters. At speed of flight of 400-600 km/h their settlement range can reach the order 3-5 thousand in km. For an opportunity of uninterrupted operation in the high sea and not in stormy areas of ocean such devices should maintain waves in height around 3-5м.

At last, very big ekranoplanes for enough free motion at ocean should maintain height above the wave at around 5-7 m, which is possible only at the linear sizes more than 100 m and weight some thousand tons. Their speed can be 600-800 km/h and range of flight nearby 10 thousand in km. They can carry out, for example, transcontinental passenger and passenger-and-freight transportations with very high level of comfortableness and safety. There are a few projects for such ekranoplanes.

Depending on an opportunity to leave in flight from the screen for short or long time, distinguish three types of ekranoplanes which have been described.

Type "A":- Ekranoplane which can be maintained only in immediate proximity at "screen" and maneuvering on height is possible only due to change of speed of movement at change of draft of engines, the elevator is not present. Often is called as a vessel on a dynamic air cushion or a vessel-ekranoplane.
Type "B". This type of an Ekranoplane is capable of performing out of Ground Effect flight in the urgent situation of the presence of an obstacle in its path.
Type "C". This type of ekranoplane is capable of long term out of ground effect flight from "screen" and to rise like an aeroplane to greater altitude. Sometimes is called as "Ekranolet". Such vehicle should combine aerodynamic and constructive qualities of ekranoplanes and the aeroplane, that actually leads to deterioration of that and another, especially if to provide an opportunity of flight at really "plane" altitudes in 8-10 km.

Characteristic distinctive attribute of anyone of specified types of ekranoplane is relative lengthening the basic bearing wing. Ekranoplanes of type "A", as a rule, have a uniform wing with lengthening $\lambda \le 1$, type "B" have $\lambda \le 3$-4, type "C" have $\lambda \le 5$.

5.TAKE-OFF FROM WATER

The ability to take off from the water and to land on water provides the ekranoplane with greater independence of motion making possible planned landing or emergency ditching at any point of water surface with acceptable weather and sea conditions. However, a take off directly from the water (without using any elevated runways, catapults or other special take off means) requires the increased power engines to overcome hydrodynamic resistance when accelerating.

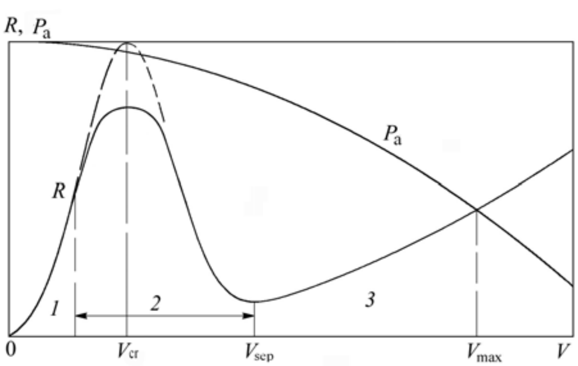

Fig.4. Dependence of drag and available thrust on velocity

The change in relationship of required and available thrust of ekranoplanes engines under take-off against the motion speed is illustrated by typical plots (Fig. 4), where the following characteristic sections are highlighted: 1 - floating, 2 - hydroplaning, 3 - flight close to the supporting surface. To rise off the water at the speed V_{sep} it is necessary to overcome the aerodynamic resistance hump that requires maximum engines thrust at some speed V_{cr} = (0.5-0.6) V_{sep}. When the vehicle body is completely out of water engines are to overcome only aerodynamic resistance growing smoothly with the increasing of the speed. When the value of this resistance coincides with available engines thrust P the maximum possible flight speed V_{max} is reached.

The rougher sea is when ekranoplane is taking off, the more hydrodynamic resistance in hydroplaning mode increases. In Fig.6 dashed line shows the plot R(V) corresponding to the sea that is rough enough to make take off impossible due to deficient engines thrust. Rough sea complicates take off also due to some other factors bound up with stability, increased load factor because of waves impacts, increased control errors, variation of air flow blown under the wing, engines flooding and so on, but power factor is the basic one. Limited ekranoplane seaworthiness is defined first of all by take off possibility since landing is possible on rougher sea, and flight over the rough sea looses efficiency due to higher required altitude but does not become impossible.

Maximum flight speed Vmax may be several times greater than Vsep value. However, maximum efficiency (in the sense of fuel consumption per unit of distance) is achieved at the speed that is less than Vmax and does not require all available engines power. That is why for rather large-sized ekranoplanes it is characteristically to use several engines some of which are the booster ones. Efficient cruise engines that are usually installed at the tail part of a vehicle provide the basic mode of long-distance flight. Booster engines installed at the bow part are used when taking off and, perhaps, when landing and are turned off when flying over the supporting surface. As a rule, booster engines are installed in such a way that air flow created by them is directed under the wing. In some ekranoplane designs it is supposed to use for take off fan facilities similar to those used on hovercraft.

Excessive engine power can allow ekranoplane to rise off the supporting surface, if necessary, and to bring off the flight in airline mode.

6. AUTOMATIC MOTION CONTROL SYSTEMS DESIGN

Trouble-free motion at the altitude of 1-10 m above the disturbed sea surface may be guaranteed by the application of special methods and means of navigation and control capable to solve the following specific problems:
- the precise control of the altitude of motion with error not above 3-10 cm;
- restriction on the angles of airframe inclination for the preventing of undesirable tangency of water by the extreme points of body or wing;

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- ensuring of the vehicle stability as control plant in the circumstances of the action of flake essentially non-linear aerodynamic effects attributed to nearness of water surface (WIG-effect and others);

- non-contact measurement, tracking and prediction of ordinates and biases of the field of sea wave disturbances for the rising of motion control effectiveness.

At the high speed of motion, proper to planes and ekranoplanes, the problem of collision avoidance with conflict vehicles in the circumstances of scarcity of time for maneuvering also originates, which is not characteristic for displacement ships.

All above-mentioned problems have to be analyzed for constructing the automatic motion control system which could meet the modern requirements [1,3]:

It is advisable to consider the following criteria of quality of motion control above disturbed sea surface [9-10]:

- rising of seagoing ability of a vehicle, i.e. its capability to move in given direction and to solve another functional tasks at the largest number of sea-way conditions;
- reducing of fuel consumption;
-depression of vehicle rocking for creating the favorable conditions for crew and passengers or for functioning of on-board equipment.

Naturally, it is impossible to reach the extremum of all these other ones to the rank of limitations. In the number of limitations it is necessary to denote also criteria simultaneously and each concrete case requires to appoint the only main criterion of control effectiveness, transforming the requirement of economical expenditure of control elements resource.

The effect of wave disturbances on the vehicle moving at small altitude or directly along the bound of water surface is complex and can have the following consequences:

- appearance of periodical forces and moments exciting trajectory of motion;
- likelihood of the appearance of abnormal situation or catastrophe due to the impulsive exposures of too large extent;
- creation of significant interference for sensors (radar, sonar and others) of the parameters of motion due to tracking the profile of sea waves.

It is necessary to allow for all these factors at the optimization of motion control laws and the ensuring of the potential characteristics of the seagoing ability of each vehicle. Indeed, it is necessary not only optimization of laws of control in classic meaning, but also optimization of the composition of controlled parameters of motion and the parameters of wave disturbances, the composition and the placing of diverse transducers of these parameters, the algorithms of their integration, the structures of control channels and laws, the tactics of the application of all accessible information and the criteria of the choice of phase trajectory of motion.

The models of sea wave disturbances have a principal significance at the examination of such algorithms of estimation and control. The methods of calculation of spectral and correlation characteristics of wave disturbances on the base of the three-dimensional irregular model of sea waves are described in detail in [3].

The non-contact measurement of the characteristics of sea wave disturbance may be produced on the base of processing of indications of several sensors of sea waves profile each of which includes the precise positioning altimeter and inertial means [8]. Presence aboard of the several sensors, actually measuring the geometrical altitude of flight with reference to disturbed sea surface, ensures also (and first of all) the measurement of the principal parameters of flight - altitude, the roll and pitch angles (as to the difference of altitudes).

The advantages of application of expressly projected phase radioaltimeters in compare with ordinary ultrasonic, radioisotopic or even laser altimeters can be substantiated [10].

7. THE PREVENTION OF COLLISIONS

Owing to the absence of a large interval of height at movement in an operative range of the screen, gross blunders of management, for example, because of refusal of any element of automatics, may lead to very quick development of an emergency. It makes great demands especially on reliability and survivability of the equipment realizing organic laws of management, forces to use a high degree of reservation of this equipment both special algorithms and means of automatic technical diagnosing.

Movements Close to aviation speed of ekranoplanes at extremely small height force to give enhanced attention of the organization of management at flight in front of obstacles, mobile and motionless. If received by means of radar-tracking means or visually the information allows to assume, that the sizes and character of an obstacle can present danger to movement the decision on a divergence with it by (in preference order) maneuver at the rate should be accepted, maneuver on speed, performance as a last resort emergency landing. Automation of acceptance of the similar decision is connected with duly detection of clashing objects, an estimation of parameters of mutual movement and general navigating conditions that demands processing the file of the information. The problem becomes complicated because of the essential deficiency of time for decision-making because of small height of flight and, accordingly, compared with aircraft of a low arrangement of the aerial of a radar the radius of its action cannot exceed several tens kilometers. Special systems of automation the divergences differing both from ship, and from aviation systems of the prevention of collisions therefore are required.

Table 1
Characteristics of Ekranoplanes Stritzh-5, Blue Shark and Chaika-2

Characteristics	Stritzh-5	Blue Shark	Chaika-2
Take-Off Weight, tons	5,2	22,5	50
Dimensions, m	16,4x10,0x5,2	27,6 x 21,4 x 0,8	34,8 x 25,35 x 1,28
Crusie Velocity, km/h	270	300 – 400	350-450
Range of Operation, km	1000	2000	3000
Crew	3	2	4

8. SOME PROJECTS OF PATROLLING EKRANOPLANES

Alekseev's Central Design Bureau, Nizhni Novgorod, develops three projects of ekranoplanes of different weight, which are resulted in Table 1.

The configurations of ekranoplanes Blue Shark and Chaika-2 are shown in the Fig.5-6 respectively.

Now the proprietor and the owner of copyrights of the specified projects is Alekseev's Design Bureau, Nizhny Novgorod.

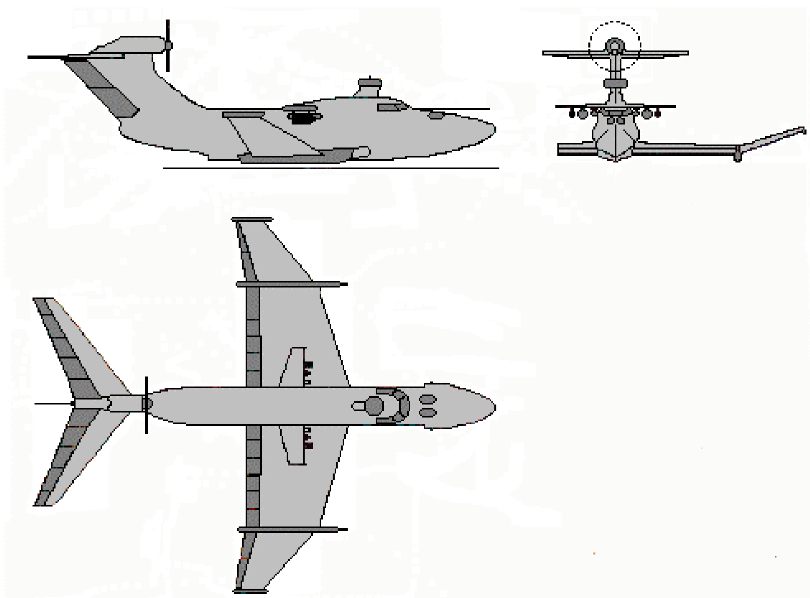

Fig.5.Ekranoplane Blue Shark

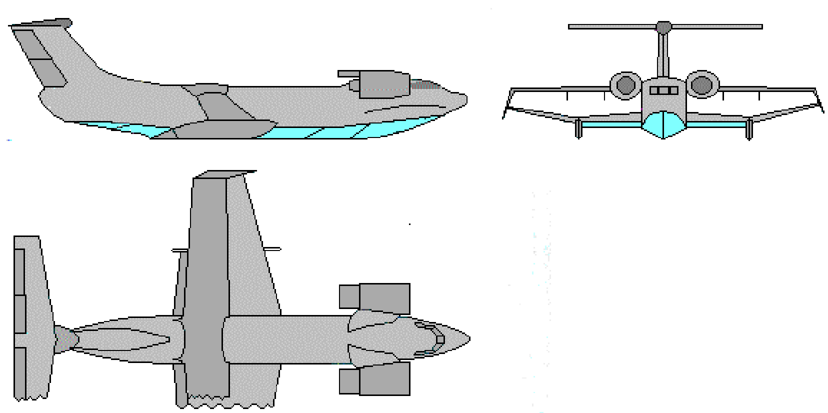

Fig.6. Ekranoplane Chaika-2

9. ASPECTS OF LARGE EKRANOPLANES MULTIOBJECTIVE APPLICATION

It is important the parallel development of some types of ekranoplanes with different properties and opportunity of common use of positive experience saved in each line of development. The ekranoplanes competitiveness would be essentially raised also with a possibility of double application of any their type in different areas that would allow more effectively use of financial and other resources at their development and construction.

At present several ideas of ekranoplanes effective application are exist. Among them are:

- fast transport (passenger and cargo) routes along the coast or between the islands having several runs in 300-1000 km length each, maximum 2000 km;
- cross-country transport routs above desert, water, ice, snow and any other flat surface, (including artificial profiles);
- transportation of fruits and other perishable goods from far islands without aerodromes;
- transport service for fishers fleet and sea petroleum platforms;
- patrolling of the boundary, economic zone, protection against terrorists and contrabandists;
- military application as an assault landing craft crossing mine fields easily;
- military application as an missiles carrier,
- military application as floating aerodrome for short-range planes;
- military application for a submarines detection and attacking;
- aerospace plane horizontal landing on moving ekranoplane and horizontal launch for prospective aerospace planes;
- search-and-rescue operations.

10. SPECIAL APPLICATIONS OF WIG FOCUSING ON INDIA AND THE INDIAN SUB-CONTINENT

Some Applications especially focusing on Indian Sub-Continent:

1) Ekranoplanes can be extensively used for many emergency search and rescue operations (evacuation of people) in many areas in the coastal belt of the Indian Peninsular. India is a densely populated country and sudden evacuation of civilians can be greatly supported be Type “B” or “C” large ekranoplanes in places not easily reachable by ships and too small passenger carrying capabilities of aircrafts and helicopters.
2) Ecological monitoring is a major and a vital issue. The application of ekranoplanes may be very highly useful for such activities.
3) India has a vast cultural heritage and history and is adorned by some very beautiful and attractive tourist destinations of the world. May be used for tourism operations, of visual review of dynamically varying picture of a marine and coastal landscape from an altitude of a deck of a cruise liner.
4) For a country like India which is a major exporter of many variable types of commercial goods, the application of ekranoplanes for the transportation of commercial payloads and weights. It must be noted once again that ekranoplanes provide the great advantage of speed over large payload carrying ships and for cargo aircraft carriers, ekranoplanes have the tremendous advantage of volume and weight of payload.
5) Ekranoplanes may also find significant usage in high speed luxury transportation. The Ground Effect with the supporting air cushion provides very smooth and comfortable ride (up to cruise liner conditions) and with that the great advantage of fast transportation. Thus they may be used as high-speed luxury transport vehicles connecting many important destinations in the Indian Peninsular.
6) WIGs may be advantageous for rapid response to international market fluctuations in the commercial arena of imports and exports. India has a significant role in this sphere.
7) Ekranoplanes may also be used for the quick transportation of many types of perishable goods (for example fishery exploitation).
8) For application as passenger vehicles, ekranoplanes provide a great safety feature in comparison to aeroplanes. Such safety guaranteeing flights may be very helpful for application in the ever increasing transportation market of India.
9) For India, where many times the market depends on cost-effectiveness, it must be noted that ekranoplanes’ cost of production, maintenance, operation and exploitation are in most cases below aviation levels (in some cases up to two times lesser). It may be an important parameter to be considered during the application of such vehicles.
10) Extremely low altitude of flight makes it very difficult for the opponent radar tracking stations to track and launch counter measure for such vehicles. Thus it can be used as a very vital vehicle in many sensitive defense operations against neighboring countries in the Sub-Continent. Such vehicles have very low radar and infrared signature, and even the latest technology existing in the sub-continent find it very difficult to detect.
11) Use as Patrol Vehicles for anti-drugs and anti-smuggling, anti-pirate operations in the Peninsular and coastal regions where ships, hydrofoil vehicles and helicopters are very slow.
12) Usage as an assault vehicle. It can act as the base for missile launch (Anti-Ship, Anti-

Aircraft and Anti-Submarine). Type “B” and Type “C” WIG vehicles are capable of launching missiles not only from the surface close to the sea, but also from great aviation altitudes. In this sense ekranoplanes could effectively support the integration of Air-Force and Navy for the creation of defense potential.

13) A considerable amount of attention is also to be given to the extensive Wing-In-Ground Effect vehicles Research & Development activities being executed in Asia (especially China) and Australia. India, as one of the fastest growing powers in Asia with China, may also be prepared for such modern and technology advanced future modes of transport.

14) WIGs may find some use for operations against ongoing extremist activities (in the Indian Sub-Continent) and may find usage to help towards global security and peace. In many regions where there is not very conducive aviation infrastructure, WIGs application may be considered. There are many small islands in the southernmost part of India near Sri Lanka and they lack developed aviation infrastructure where there are also many often anti-peace disturbances. Other numerous examples include the Lakshwadeep areas in the Arabian Sea, The Andaman and Nicobar Islands in the far east, etc. where quick and emergency aviation and marine operations are not very easy to be carried out.

15) Cost of construction, operation, maintenance is in most cases below aviation (in some cases two times lower when comparing aircraft and ekranaoplane of almost the same dimensions). And these vehicles offer not only extensive aviation utilities, but also may be applied for marine applications offering many usages also to the Navy.

16) Type “B” and “C” Ekranoplanes can be used for very fast (sometimes close to aviation levels) transport of troops and defense armaments connecting many major bases. Thus urgent troop and armaments deployment using WIGs may be a vital task for a country like India.

11. CONCLUSION

The possible efficiency of the development and application of different types of ekranoplanes with automatic control facilities was stated. Several fields of ekranoplanes application besides passengers and cargo transportation are available. Such different application abilities expand ekranoplanes chances for evolution, as the opportunity of common use of positive experience saved in each line of development exists. The demanded characteristics of ekranoplanes can be achieved only at use of the new capabilities of perfecting the systems of navigation and motion control and other modern technologies. The Russian enterprises are ready for international cooperation in this field.

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