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Rear Services Chief on Support, Repair Problems

92UM0366A Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) pp 2-3

[Interview with Air Forces Deputy Commander-in-Chief and Rear Services Chief Lieutenant-General of Aviation Stanislav Georgiyevich Ivanov by AVIATSIYA I KOSMONAVTIKA correspondent under the rubric "Our Commanders": "...The Rear is Becoming the Front as Well"]

[Text] *When you ask a pilot or technician now and then about the activity of the rear service subunits or services, some just shrug in resignation, while others accompany that gesture with strong language. What is going on? Why has the term "obato" [detached airfield technical support battalion] long and steadily been a shorthand term among the personnel of the aviation regiments? And what is ultimately happening with our aviation rear services in general? The specialists that have been assembled "under its banners" work indefatigably virtually around the clock... We will try to investigate this with the aid of Air Forces Deputy Commander-in-Chief and Rear Services Chief Lieutenant-General Aviation Stanislav Georgiyevich Ivanov, who answers questions from our correspondent.*

[Correspondent] Comrade Lieutenant-General, how well have the Air Forces' Rear Services, in your opinion, been able to ensure the necessary level of combat readiness of the Air Forces under contemporary conditions—that is, to accomplish their basic mission?

[S.G. Ivanov] All would probably agree that the improvements in aircraft have brought about increases in the supply of weaponry, fuel and special equipment and an increase in the different types of aviation technical equipment (ATI). The personnel of the Obatos have at the same time remained at roughly the level of 1972, and they are not even fully staffed at that. The scarcity of officers and drivers is especially being felt.

The rate of flight shifts has increased recently in connection with the increased complement of flight personnel. For us it is the opposite—there is actually one driver for two vehicles. Whole regions of the country are not sending us driver personnel, while the faulty system of maintaining the drivers' schools at the expense of the military units continues to exist.

Not a single serious operation begins under wartime conditions until the necessary resources are accumulated, but in peacetime we forget that for some reason. Combat aircraft can fly off thousands of kilometers in just a few hours, but how can the heavy ground equipment be delivered along behind them by railroad or military-transport aircraft?

We are thus actually able to perform something like 60 percent of the necessary level of rear service support for the combat training and combat readiness of the Air Forces. I would say herein that people unfortunately cannot do everything that is required of them. The former excessive centralization has engendered a dependent approach and a lack of initiative and creativity in our work as well. The overall mood of the country is also having an effect.

[Correspondent] The problem of supplying the aircraft with spare parts is becoming more and more acute today, under conditions of conversion and cutbacks in military orders. What is being done in the Air Forces rear services on that score, and what is planned to be done?

[S.G. Ivanov] We cannot influence industry, including the process of manufacturing spare parts. The situation is still tolerable with those of them for which orders are placed systematically for a definite period. The satisfaction of downtime orders for assemblies for which there were no mass orders before will require more time and be more expensive. The aircraft of the Su-17, MiG-23 and MiG-27 generation are being supplied with spare parts. The engineers only have to issue the orders promptly, and see that they move along and land in the right hands. Fourth-generation aircraft are standing idle here. We have information for each aircraft—how long it has been idle, when the order for it went in, when it came in, when it was accepted. The number of different types of spare parts has grown unbelievably with the existing multitude of modifications of aircraft and helicopters. We thus simply cannot get by without some sort of centralized dispatching service in the Air Forces rear services headquarters.

Breakdowns happen out in the local areas. I was recently at airfield X. It turned out that several aircraft were idle there due to a lack of spare parts. It was ascertained, after a careful inspection of the ATI warehouse, that three quarters of the necessary parts were on hand. Neither the chief of the service nor his deputy were on the scene, and there had been no accounting for a long time. The lack of conscientiousness is evident, as they say.

[Correspondent] Far from everything in supply for the Air Forces depends on the rear services nonetheless, since it is, in essence, a connecting and transmitting link between the country's economy and the combat forces of aviation. It should be more clear to you as the chief of rear services—what must be attained from the country's industry to maintain aviation equipment in a combat-ready state?

[S.G. Ivanov] Responsibility, discipline and order must be attained. The smooth ties are being ruptured today owing to the new economic relations, and deliveries are not made in centralized fashion through Gosplan, but rather on the basis of contracts with the producer plants. Not all of the suppliers will meet us halfway. We do not know which is better—for the state to maintain such a monster as Gosplan, which prescribed everything for everybody, or for the Air Forces rear services and the enterprises to keep a special staff of people that would travel around the country and "shake loose" everything they need. While the enterprises can still permit themselves that, organic units for "shaking things loose" are not provided for in the rear services.

I am convinced that industry should be working with the Armed Forces according to state orders and a state plan under any type of economic relations. Resources are expended for the maintenance of combat readiness, after all, and that means that they must be promptly replenished. The wear and tear on aviation equipment thus makes it necessary to plan its withdrawal for repairs, which requires the appropriate deliveries at a certain time. Both the repair facilities and the plants of MAP [Ministry of the Aviation Industry] should thus be linked to the Air Forces rear services by a unified plan.

[Correspondent] Stanislav Georgiyevich, reports at foreign air shows and domestic practices have shown that the means of servicing aircraft should be improved simultaneously with their own improvement. Do the Air Forces' Rear Services have in view the problem of the lack of correspondence of that equipment to the technical level of our aircraft and helicopters?

[S.G. Ivanov] Naturally, we do; that problem, after all, concerns the Rear Services no less than the IAS [Aviation Engineering Service]. Domestic industry is by and large concerned with creating, say, an aircraft, while the equipment for servicing it is developed according to the "whatever's-left-over" principle. The Tu-160, for example, requires 40 units of ground equipment for servicing it. How can it be serviced if it does not land at its own airfield, where they do not have the equipment? That is why the Commander-in-Chief of the Air Forces is requiring that a whole aviation system, including the support equipment, be ordered rather than just the aircraft.

Life suggests a way—design an aircraft that has on-board or externally mounted servicing equipment, eliminating the need for cumbersome, metal-intensive APA [airfield mobile power units], EGU, air conditioners and the like, which have effectively not changed since the time of second-generation aircraft. This would make it possible to increase their autonomy and provide an opportunity to free up our scarce personnel to perform other urgent tasks.

We are working closely with Ministry of Defense NIUs [scientific-research institutions] to improve maintenance equipment. Many of our proposals have been incorporated. A snowblower, for example, has arrived to replace the machinery with old and spent RD and VK aircraft engines. The powerful TAIFUN fire-fighting vehicle was developed with the participation of our colleague Colonel V. Tkachenko.

I would say something at the same time about the other equipment of the Air Forces rear services—bulldozers, cranes, excavators etc. We are unfortunately not the customers here—that equipment is for the national economy. The strength levels of that equipment have dropped to 50 percent over the last two or three years with the rise in prices for it. Whence our capabilities, or more accurately, our difficulties.

[Correspondent] The tension of working in the Air Forces Rear Services is being increased by the difficulties in finding manpower. Material and technical sophistication clearly cannot patch every rip, and there is nowhere to go, as they say, in increasing the intensiveness of the work of the lower echelons. What hopes do you associate with the impending military reform?

[S.G. Ivanov] Our difficulties in staffing started when they began seeking people for the adoption of automated systems for battle management. All of the commandants' offices of the reserve airfields and shops connected with the everyday maintenance of the personnel were cut back in the rear-services units at that time, while the size of a security company was reduced to 60 people. Since that time people here are often replacing two-shift details with three-shift, and vice versa. It is good that they have started talking about that out loud, even if it is late.

Professionals are needed in the Air Forces, and especially in the Rear Services. I am in favor, for instance, of seeing that the driver's position in a vehicle is occupied by a person working under contract. We would solve quite a few problems at once. But unfortunately... Line items for the corresponding payments are not provided for. Say we asked that all drivers of heavy freight trucks were freely hired. They would meet us halfway on that. But no one will agree to come work for us for extremely low wages. It is moreover well known that the budget will be cut considerably next year. Such are our hopes...

[Correspondent] Comrade Lieutenant-General, you did not have to supervise the Air Forces rear services under the administrative-command structure in our country, but it is clear from your answers that many of these difficulties did not exist at that time. What advantages in its work are being created thanks to the new conditions of business operation?

[S.G. Ivanov] We are not feeling any advantages whatsoever in anything—from food to spare parts. Take, for example, the sale of non-working matériel, scrap metal and precious metals. The funds from that go to the Ministry of Defense, and it distributes them at its own discretion. Our financial body is not being supplied, it is not independent. I thus cannot institute any market relations, that right is not given to me.

All officers may receive a food ration starting July 1 of this year. But where do you get the food? The kolkhozes and sovkhozes are not fulfilling the state plan, after all. All of the formations of the Air Forces are thus now concluding contracts with them, obliging them to harvest some of their agricultural produce. We get nothing but extra difficulties from that.

As for involving the motorized equipment in gathering the harvest, that has never been profitable. Last year, while I was at the scene of agricultural operations by our battalions, I saw that we were being given the most labor-intensive, dirty and non-productive work. The daily equipment utilization factor was not more than 0.32. This year, flying from Balashov to Saratov, I saw that there is roughly a tenth of the crops in the fields versus last year, while the standards for the involvement of military equipment are the same.

[Correspondent] Difficulties give rise to the capabilities to surmount them, as the expression graphically says. If that is so, then the specialists of the rear services should become simply all-purpose entrepreneurs in our time by virtue of their degree of determination and the specific nature of their problems?

[S.G. Ivanov] There is no doubt that our people in the Air Forces rear services are staunch and know how to perform the tasks entrusted to them. We have examples where the base commanders are cultivating certain plots and maintaining subsidiary farms on their own airfields, without buying mixed fodder anywhere. If they are selling meat in places, it is mandatorily at state prices. Sometimes its goes here that a person plants an extra tree and is now a hero. I considered and consider that to be work—the supervisor is obliged to display initiative and creativity in the fulfillment of his duties.

[Correspondent] Stanislav Georgiyevich, you have probably had to hear more than once the workers in the rear services indiscriminately endowed with the most unflattering epithets. Are there any grounds for that, in your opinion?

[S.G. Ivanov] We all know about seeing others' faults and not our own. Recall certain processes of recent times. The workers of rear services were in no way mixed up in them, but no family is without its black sheep, as they say. It also happens that some commanders knowingly give their subordinates tasks that cannot be performed. I have encountered such a situation often in one unit. And it is often those very commanders who themselves do not bear any responsibility who are instigated to improper deeds. He whose fingers are light—it lies on his conscience, that is not taught in the rear services. Order in the local areas depends first and foremost on the immediate commander. If he works, then there is no room for dishonesty.

It must also be said that the Air Forces Rear Services do not have an audit service, or more precisely it is one person. Many of the difficulties in monitoring the activity of the units are associated with that.

[Correspondent] It is becoming clear from your answers that the difficulties of the Air Forces rear services are connected not only with the cutbacks in personnel and financing, but also with imperfections in its structure. How did that take shape, and does the opportunity exist to bring it into conformity with contemporary requirements?

[S.G. Ivanov] I will answer that this way. N.S. Khrushchev actually created the RVSN [strategic missile troops] at the expense of the Air Forces. And when the Air Forces were trimmed, they justly decided that the Air Forces Rear Services in their prior form were not needed. Marshal I.Kh. Bagramyan, for example, felt that there was no need for us to have services for fuels, foodstuffs and clothing, and transferred our personnel to the central directorates of the USSR Air Forces Rear Services. Time passed, the Air Forces overall were resurrected, but the Rear Services remained in trimmed-back form. Now the strictest regulation discipline is being hampered, especially for the central apparatus of the Air Forces. Deputies are demanding it be cut back at all forums.

[Correspondent] Comrade Lieutenant-General, what prospects await the Rear Services, and how do they affect all Air Forces personnel?

[S.G. Ivanov] If we are speaking on the larger scale, then first of all, the quantity of support and combat units will be brought into the necessary conformity and, second, those structures will be developed that are vitally essential to the Air Forces under today's conditions. Today, for example, we are studying issues of food supply. Working on computerizing the system for logging and passing along requisitions for spare parts is now at the stage of including the appropriate levels of the larger formations in the system. The system will then correspond roughly to world standards. We know that, since we have studied the experiences of U.S. Air Force supply during the conflict in the Persian Gulf.

As for improvements in the technical sophistication of the Rear Services, studies are underway in all of our subunits, and first and foremost in the trucking and electric-and-gas services.

[Correspondent] Stanislav Georgiyevich, a traditional question in conclusion. Please tell us about the principal stages of your own service. What would you like to say to young officers?

[S.G. Ivanov] I have covered all the steps from pilot to commander-in-chief of an Air Forces directorate. I came here from that post. I had encountered work with the Rear Services much earlier, however, as the commander of a regiment, when I had to take into account the capabilities of the support subunits. Being chief of staff, deputy commander and commander of a large formation, I understood everywhere that one cannot realize anything without a regard for the capabilities of one's own rear services. I served in the Far East and the Transbaykal. A commander there who is not occupied with questions of the rear services simply will not make it through the winter in the literal sense, which sometimes even happened to the "outstanding commanders" who were sent to us as replacements.

I would urge young officers not to shun difficult work at any ranks or in any positions.

Realistic Look at Flight-Accident Factors, Nature Urged

92UM0366B Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) pp 4-5

[Article by Combat Pilot—Expert Marksman Colonel Aleksandr Mikhaylovich Kostikov under the rubric "Combat Training and Flight Safety": "Time for Official Acknowledgment"]

[Text] *The accident rate in the Air Forces is a random and unavoidable attribute of the process of combat training. It is possible to reduce the number of flight mishaps through a rise in the professionalism of the fliers and a systematic approach to organizing their training, not through prohibitions. That is the opinion of Combat Pilot—Expert Marksman Colonel Aleksandr Mikhaylovich Kostikov.*

Combat training for the Air Forces—as a system of measures for the training and education of the personnel and the streamlining of subunits and units to wage combat operations or fulfill other missions in accordance with their purpose—has passed through all of the stages of its emergence, and has been theoretically reinterpreted in its current stage of development and incarnated to the extent of capabilities. It is, at the same time, in need of constant improvement, conditioned both by external factors (the constant upgrading of the combat hardware and the tactics for using its against a likely enemy) and internal ones (the necessity of maintaining the professional proficiency of the fliers are the requisite level. Flight operations and the accident rate are, at the same time, interconnected and represent a unified process in which improvements in the quality of proficiency is one of the principal ways of reducing the number of flight accidents.

Flight training that includes such areas as piloting techniques, air navigation, combat application and tactical flight training (LTP) is pivotal in the professional proficiency of the pilot. Each of the elements enumerated in turn has its own aims and tasks that are in close structural interconnection. It makes sense, when analyzing problems of improving combat training, to dwell just on flight training, insofar as the discussion will at the same time be about the accident rate as a characteristic of that process.

It is well known that the inner source of the development of any situation is the struggle between elements that are opposite in their functions. These are, in flight training, the principle of **"Teaching the troops that which is essential in war"** on the one hand, and **a set of restrictions** on their practical incarnation on the other.

We will consider as an example the dialectic of the process of training a fighter pilot for air combat. Theory and practice herein presuppose a certain degree of freedom—choice from among a multitude of maneuvers and methods of employing the weaponry that are most effective for achieving success. Peacetime training conditions and little responsibility for the quality of combat proficiency compared to excessive responsibility for accidents, however, restrict that choice and narrow the opportunities for mastering the hardware and weaponry, ultimately lowering the level of combat proficiency of the aerial fighter and bringing the very effect of the training to naught.

Under such a "restricted" system even a high proficiency-rated pilot proves with time to be unprepared for operations in any complex situation whatsoever, not only in battle but even on a training flight. His professional skills move to the lowest state according to the degree of organization. The essence of this process is simple: one of its aspects—the set of restrictions—proves to be more active. The continuous augmentation of the quantity of the most diverse prohibitions leads with time to their predominance over the elements of the other aspect—the diversity of the forms of LTP. This leads to a disruption of the equilibrium in the system of training and its degradation; the results of the training do not meet existing requirements or the future.

The conclusion that the state of LTP is unsatisfactory, at the same time, acts as a factor facilitating improvements in the system of combat training and defining new requirements on the part of the Air Forces leadership for raising the quality of it. But in order for there to be a choice, a degree of uncertainty has to be introduced into the training process—that is, the actions of a hypothetical adversary. This requirement also appears in documents as a supplement to the principle of "Teaching the troops what is essential in battle."

Tactical flight training—a constituent element of flight training—includes mastering the techniques of piloting, navigation, the combat application of weaponry and electronic warfare. All of these elements have a unified ultimate aim: the most complete possible realization of the capabilities of the aircraft and its armaments, as well as the skills acquired in the training process, against the background of a varied tactical setting—the essence of tactics! The algorithm of combat training is the same and determines the unified, sequential process of combat training for the Air Forces in peacetime, with a clearly defined task at each stage: if it is the piloting of the hardware, then it is the degree of assimilation of the tactical performance characteristics of the aircraft (the range of altitudes and flight speeds, G-forces, angles of attack etc.); if it is weapons delivery, then it is the ability to employ the whole set of weapons under the appropriate conditions; if it is tactical flight proficiency, then it is the quality of the choice of the most suitable maneuvers for the use of the types of armaments on board, among others.

The step-by-step result is thus in turn in need of the development of criteria for evaluating the various aspects of the process of professional training. It would be expedient, in my opinion, to introduce such concepts as the degree of complexity of the flight assignment, the level of assimilation of the tactical performance characteristics of the aircraft, the degree of comprehensive utilization of the aiming and navigational systems and equipment and a measure of the mastery of the types of armaments. The concepts of the combat-ready pilot, the combat-ready pair, flight and the like are also in need of clarification. It would easily be possible, having elaborated the algorithm of flight training after this (and its should be inherent in the KBP [Combat Training Course]), to transform the composition, structure and organization of the system of training so that the requirement-elements predominate over the restriction-elements in it.

Such a concept as the accident rate must also be made systematic. It is time for official acknowledgment that the accident rate in aviation is a necessary evil in view of the susceptibility of the flight-operations process to random phenomena. Parameters of the environment with probability characteristics, first of all, have an effect on a flight. These include not only the atmospheric conditions, but space factors as well. The random nature of encounters with other aircraft and objects whose movements cannot be made orderly by an air-traffic control system also cannot be ruled out.

Second, the aircraft and their systems, equipment and weaponry employed have a certain degree of reliability. This value, notwithstanding redundancy, is always less than the unit value in probability terms.

Third, the capabilities of the pilot as the chief link in the aviation system are not unlimited. His total reliability in flight cannot be one hundred percent, since the factors with probability features enumerated above are now superimposed onto the guaranteed activity of the person. Flight accidents are thus a consequence not only of mistakes by aircraft crews, but are conditioned to an even larger extent by the unreliability of the hardware and weaponry, as well as other factors that introduce randomness into the process of flight operations.

The lack of professional protections for the pilot, where various agencies try to find in him the chief culprit in accidents, becomes distinctly evident in this sense. Fencing themselves off with decrees, restrictions, prohibitions and instructional "rails" on the actions of crews in flight, they crush the pilot psychologically, not permitting the full assimilation of the aircraft and its weapons, while everything should be the reverse: the pilot, taking a craft worth millions aloft, should be psychologically freed of responsibility for the consequences of all possible random factors that do not depend on him.

This does not, however, make the fliers blameless in all cases in life. They should bear responsibility to the state (in the person of the commanders) for their professional competence and personal preparedness, discipline and execution.

In considering the accident rate as a manifestation of a lot of factors accompanying flight operations and having probabilistic features, the concept of averting flight accidents should thus also provide for measures to raise the degree of reliability of the hardware, equipment and armaments and improve the proficiency of the flight personnel, as well as to create a database on instances that led or could lead to accidents or crashes.

The concept of averting flight accidents should operate as part of the overall system of combat training, supporting the process of professional proficiency with minimal losses of pilots and hardware. The accident rate, first of all, must be considered—I repeat once again—an inevitable random phenomenon in flight operations that arises out of the conditions of existence of the elements subject to probabilistic changes. Second, the concept should represent a set of measures aimed at reducing the rate of accidents. Third, a combination of the structural-functional ties of the bodies controlling the basic process of combat training with the flight-safety bodies must be provided for. And, fourth, a hierarchical structure of responsibility for the state of the accident rate in aviation should be envisaged.

What are the ways of reducing the degree of manifestation of this random fellow traveler of combat training? The principal way is improvements in the whole process of flight operations. Much is already being done in that area. No so purposefully, perhaps, as used to be done in the direction of simplification, but more and more consciously and systematically with every year. Particular attention should be devoted to straightening out the documents for organizing and conducting flight operations, and first and foremost the development of new Combat Training Courses and algorithms of aerial proficiency.

Some fliers are proposing the path of economic incentives for accident-free flight operations. I think that controlling flight safety using bank credits and monetary transactions is hardly possible since, as has already been mentioned, the accident rate is largely a random phenomenon that does not depend on credit. The transformation or simply the improvement of the system of flight training for this purpose really does require additional material funding. And the more that is economized on this path (cutbacks in flying time, reductions in the quantity of ammunition for the mastery of weapons delivery and the preservation of a stereotyped approach to the material vested interest of the flight personnel in raising their qualifications, among others), the greater the harm that is inflicted to the state on the part of the random fellow traveler of combat training—accidents. A conversion to daily incentives deserves attention, but... once more it is the quality of the work.

The path of administrative (to the flight units inclusive) implantation of "specialists" on flight safety with the right to make prohibitions but not responsible for the aerial proficiency of the fliers is being proposed, or more accurately is already being implemented in practice. This is an erroneous approach, in my opinion. After all, the basic process of combat training—flight operations—is planned, organized and conducting by the people answering for it. It is namely they that should be forecasting the accident rate and seeking methods of reducing the likelihood of the manifestation of unfavorable phenomena in the training process. These people should strive for the "dissolution" of so-called flight safety into the unified training process using clear-cut, multi-level and scientifically substantiated measures, along with material and moral incentives.

One also cannot fail to mention such a way of improving the state of affairs as the transformation of the bodies controlling the whole process of combat training, including the Flight Safety Service. Safety is naturally sought largely through the coordinated actions of the agencies affiliated with flight operations. Only a body that analyzes the condition of the hardware and weaponry and the level of training of the opposing sides, works out requirements for the process of combat training and organizes it could be such a coordinating body. This role by all rights belongs to the Combat Training Directorate of the Air Forces. And it is in need of priority in relation to the other agencies first and foremost.

The re-organization of the Flight Safety Service pursues the solution of a most pressing problem—the supradepartmental investigation of flight accidents to uncover their true causes and raise the level of information on everything that is connected with such processes. This would really make it possible to reduce the human losses and material harm that is inflicted on combat aviation by flight accidents.

Aircraft Servicing Science Proposed for Engineer Training

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[Article by Candidate of Technical Sciences Colonel A. Vasilyev under the rubric "At the Higher Educational Institutions of the Air Forces": "What Kind of Engineer Is Needed—*Servicing Science is Proposed as Scientific Theory*"]

[Text] The contemporary organizational development of the Air Forces assumes the skillful utilization of various methods, techniques, forms and directions for training and indoctrinating military-engineering personnel with the necessary qualifications. The assurance of close ties of the theoretical and practical training at higher educational institutions with the requirements conditioning the efficiency of the immediate activity of military engineers in the ranks and the implementation of feedback from aircraft operating practices to the aviation design bureaus occupy an important place among them.

The skills description approved by the Air Forces Commander-in-Chief in 1989, reflecting the requirements of the aviation engineering service for an Air Forces mechanical engineer who is performing technical maintenance, field repairs, storage, transport or modification of aircraft in Air Forces units is an effective means of realizing these requirements.

A comparison of the skills description of an Air Forces mechanical engineer and the set of training programs of the VVAIUs [higher military aviation engineering schools] shows that they do not correspond to each other. This can be seen from the fact that virtually all of the functional-theory and practical requirements of the skills description should be realized by two training programs to which only 4.4 percent of the overall stock of training time is allocated. The remaining disciplines are of a social, general-science, general engineering or aviation-design nature. It must thus be asserted that the pedagogical-training basis is somewhat to the side of the professional-functional basis of the future activity of the mechanical engineer. A graduate of a VVAIU—a future "active" element in the aviation system of operations—in reality receives a set of knowledge, skills and abilities that are of an aviation-design rather than an aviation-operational nature.

This may be illustrated as follows. The complexity of modern aircraft conditions the fulfillment of a series of additional labor functions that have no specific military nature and are performed by the engineering and technical personnel of the air units. These functions constitute the operations of technical maintenance, repair, storage, transport and modification of the aircraft. Many of these operations can be performed only with the aid of additional (in relation to the aircraft) technical devices—the technical maintenance equipment—that does not have the status of a means of waging armed struggle. This equipment is, at the same time, utilized to bring the aircraft into combat-ready condition, and should thus be mastered by the future engineers in precisely the same way as they master the aircraft themselves. The technical equipment for maintenance, repair, storage and transport, however, is not reflected in the schools' curricula for the training of mechanical engineers.

The contradictions between the thrust of the training and the future activity of the mechanical engineer could be illustrated by another example as well.

The aviation specialist knows theory and is able to calculate, for example, the disk of the turbine of an aircraft engine, but he does not have the knowledge or ability necessary to design a fastening for the aircraft engine that would make it possible, during the process of servicing it, to replace it in a few dozen minutes, as is done on foreign aircraft, rather than over days, as occurs today in our Air Forces. The mechanical engineer, with perfect mastery of design-engineering techniques, is not able to straighten out processes supporting the achievement of a planned combat impact within the system of servicing the aircraft at his level of knowledge, skills and abilities. He must be taught this at the cost of time spent inefficiently on teaching the techniques for the formation of the combat potential of the aircraft. It should be noted that these techniques constitute the essence of the profession of specialists from the Ministry of the Aviation Industry (MAP)—the designers and production workers—while the techniques for realizing the combat potential of an aircraft in the servicing process constitutes the essence of the profession of the mechanical engineers, as is the case, by the way, for the aviation engineers of the Air Forces in other fields.

The aviation-design nature of the training of Air Forces mechanical engineers should thus without fail be transformed into an aviation-operations nature for the purpose of raising the effectiveness of the activity of the servicing engineers. The new set of training programs for the VVAIUs for 1991-95, however, once again does not provide for that. This situation can be explained by the following reasons.

The Ministry of the Aviation Industry designs and produces prototypes of aircraft and the equipment for their technical maintenance, repair, storage and transport for the Air Forces, but the complex servicing systems functioning in the Air Forces are not assigned, designed or tested by anyone, and are created virtually spontaneously. The latter is a consequence of the fact that MAP and the Air Forces lack any institutions for the design engineering of systems for the servicing of aircraft and aviation-servicing technological processes where, for example, the formation of the profession of military aviation engineer should occur.

This problem could be solved via the institution of the following teaching disciplines in the training plans for mechanical engineers at the VVAIUs: "Design Engineering of Servicing Systems and Technological Servicing Processes"; "Management of Aircraft Servicing"; "Assessing the Efficiency of Servicing Systems"; and, "The Shaping of the Servicing Quality of Aircraft." About 600 teaching hours would be required for them.

The necessity of fundamental occupation with the development and emergence of the theory of servicing aircraft has long since become acute, in my opinion, insofar as not a single teaching discipline can be effective if it is not based on well-developed scientific theory.

This is conditioned to a significant extent by the fact that the Air Forces lack a scientific school for the preparation of highly qualified scholars in the realm of the theory of servicing aircraft.

Servicing science, the object of research of which should be systems for servicing and technological servicing processes, is proposed as such a scientific theory. Servicing should clearly consists of the following scientific disciplines: serviceology—scientific knowledge of the general laws of the functioning and development of servicing systems and the progression of servicing processes within them; servicetics—scientific knowledge of the methods, techniques, rules and procedure for the design engineering of servicing systems and technological servicing processes; and, servicing metrology—scientific knowledge for measuring the parameters of servicing systems and technological servicing processes, as well as calculating the measures and criteria for evaluating them.

While servicing science is called upon to become the theoretical-scientific basis for the training of servicing engineers, the practical basis could be, for example, the production-training aviation engineering service (IAS) at each VVAIU. Such an IAS should have operating aviation hardware and a full set of the technical equipment for maintenance, repairs, storage and transport of the basic type (types) of aircraft studied at the VVAIU. The procedure for military, administrative and functional relations in such an IAS should correspond to the procedure in operating Air Forces units. The apparatus of the Air Forces Chief Engineer should see in such a subunit an effective means of improving the training of highly qualified engineer personnel, as well as a means of circulating the advanced experience of the engineering and technical personnel of aviation units through the graduates of the VVAIUs.

Is it thus not time to move from the "aviation-design" training of Air Forces mechanical engineers to "aviation-servicing"? This would reduce considerably the cost of servicing aircraft, and would raise their combat readiness.

Professionalization of Service Seen to Aid Operations, Maintenance

92UM0366D Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) pp 6-7

[Article by Major A. Khoroneko under the rubric "Military Reform—Plans and Reality": "And Times Progresses..."]

[Text] The flight shift began with difficulty, slipping like the wheels of a truck in potholes, with all sorts of mis-coordinations and misalignments. Senior Lieutenant A. Slepov was suffering appreciably from the delay in this takeoff—he badly needed this flight so as not to have his break in flying time go beyond what was allowed. Otherwise, after all, he would have to start all over...

It must be said that the state of affairs in the squadron was not too good by this time. Just two pilots—Lieutenant Colonel K. Mendeyev and Captain V. Lapa—were fully prepared to fulfill their combat and training missions. Layoffs longer than allowed by the standards had formed for the rest in night flying and flying at landing and takeoff minimums, as well as in certain types of weapons delivery. And how could there not be breaks as—after an accident that had occurred in the regiment—a whole raft of prohibitions and restrictions had come in that had shattered the plan for the combat training of the flight personnel?

"I am an advocate of any radical measures in support of flight safety," notes my interlocutor, Combat Pilot 1st Class Major V. Machulin. "But you cannot play it safe to such an extent... The lost comrade will not be back, we have to think about ourselves. And what potential for reliability is there in the squadron today if there are essentially just two left in the ranks?..."

Vladimir Ivanovich is drumming his fingers on top of the desk, betraying his agitation. There is something to worry about, too—the runway was prepared in time today (not always the case, by the way), but there is a delay with the aircraft. Four APAs [airfield mobile power units] were planned to support the flights, but only one showed up, the rest proved to be out of order.

Matters are no better with the mechanics. There are 18 of them in the squadron. Only four came to the flight line, and of those, in the opinion of Machulin, only Private Alibekov from the aircraft equipment maintenance group is of any use as a specialist.

"And it is that way almost all the time," said Major V. Machulin of the mechanics. "The question arises of why draftees are needed in the air units. We should have five to seven extended-term servicemen or warrant officers instead of the 18 soldiers in the squadron... I think more would not be needed. They would be professionals, after all!"

Professional, they say—is too expensive a pleasure for the army. I do not think so. Compare the spending on the training and support of, say, 20 soldiers and the five to seven warrant officers who would successfully replace them. If there is any difference, it is not a very significant one. The second argument of the opponents of professionalization of the Air Forces is the housing problem. Excuse me, but a civilian specialist who could in the future become a warrant officer, after all, also needs housing. So what is the difference who gives him an apartment—the Ministry of Defense or the local soviet? It is, after all, essentially the same housing stock here, only various agencies and people engaged in dividing it up.

Almost all the fliers in this and other squadrons support the idea of professionalization of the army in the process of military reform. So who is against it? Leaders who fear commanding professionals, by virtue of their own incompetence or reluctance to change their style of leadership. Specialists whose level of training does not correspond to requirements for professionals. There are such, but not many...

"The army and the commanders are cursed for hazing," continued the conversations with Major Machulin. "Here, fortunately, there are no non-regulation relations in the collective. Why? There is simply no time for the boys to engage in any nonsense. After a detail, to the flights; from the flight to the detail, on watch. Sometimes on their feet from six in the morning until two or three at night. The prevailing system for the completion of service oppresses them worse than the 'old-timers.' Is this normal? No.

"What is the way out? In seeing that everyone goes about his business—the mechanic the aircraft, the operator/specialist the boiler. But if there are no soldiers, you have to think about who to replace them with, how to pay professionals from the supply services. It is difficult to think about it, and even more complicated to find the specialists. It is simpler to leave everything the way it is. That is our misfortune..."

I look at my watch—eleven thirty. The start-time mark went out. Only five of the sixteen aircraft planned for the shift are ready for takeoff. A striking illustration, it seems, for a discussion on the necessity of converting to the professional principle for manpower acquisition in the Air Forces.

It is now clear today that yesterday's schoolboys, having become aviation mechanics, drivers and other aviation specialists by virtue of their "honored duty," cannot ensure the fulfillment of their missions "unquestioningly, precisely and on time." Not because they do not want to but simply because they cannot, owing to poor professional knowledge and skills and a lack of experience. And the officers and warrant officers, however much they try, are not able to patch all the holes.

The roar of the engines of the aircraft taking off proclaimed the start of the flights. The pilots were heading off into the sky, suspended from their earthly concerns for at least a half hour or an hour. That is hardly possible, however. The problems typical of all aviation, after all, are carried along with them like clumps of mud stuck to the shoes on this day as well.

Special Demands of Helicopter Mountain Landings Reviewed

92UM0366E Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) pp 10-11

[Article by Combat Pilot 1st Class Colonel Ye. Varyukhin and Doctor of Medical Sciences Colonel (Reserve) I. Alpatov: "Landing a Helicopter in the Mountains—*Takes Special Preparedness of the Crew*"]

[Text] The tendency to make the missions performed by army aviation more complex, along with the increases in the amount of them, is making itself felt more and more. Life itself is forcing the fliers to take on the fulfillment of the most complex assignments, which include, undoubtedly, landing a helicopter on an unprepared site in the mountains. The conditions of mountainous terrain, minimal permissible dimensions of the site, excessive dust formation that is not eliminated by available methods—all of this determines the exceptional difficulty of performing the landing.

The necessity of mastering the technique of landing a helicopter in the mountains is conditioned by the universal significance of this element of flight under combat or training conditions when landing assault troops, evacuating them or those who have been stricken in difficult-to-reach regions, or providing them with matériel and food. The careful training of the crew across the whole spectrum of issues that define professional reliability and the effectiveness of flight work under extreme conditions is needed for the fulfillment of this mission with a regard for the requirements of flight safety.

One of the chief factors facilitating the successful performance of a landing in the mountains should be considered the psychological preparedness of the crew. They should be firmly convinced of the necessity of landing under such difficult conditions. Such a readiness should be reinforced by a series of individual psychological qualities of the fliers, such as the ability to forecast the situation, high emotional and nervous stability, and the ability to spread their attention and interact correctly with the other members of the crew under extreme conditions. It is no less necessary for the commander to maintain the planned operational tactics, notwithstanding any impediments that arise, and to be able to combine toughness and flexibility in commanding the crew. The crew should naturally also know soundly the flight performance characteristics of the helicopter and the specific features of the techniques of piloting under conditions of mountainous terrain.

The complexity and psycho-physiological tension of performing a landing under these conditions are determined by a number of things. Chief among them probably could be considered the presence of the so-called dust factor (the principal source of dust in some regions is the wind erosion of the mountain rock). The crew is thus not able to perform one of the chief requirements—to blow the dust from the landing site with the airflow from the main rotor before landing. Spatial orientation is virtually impossible for the pilot either by instruments or visually when getting into a dense dust cloud. The presence of natural obstacles in the mountains often forces them to deviate from the optimal path of descent. The controllability of the helicopter is also worsened under the conditions of mountainous terrain. The possibility of being hit by enemy firepower does not always permit the execution of takeoffs and landings into the wind, and forces the taking of extreme, non-standard actions.

We will consider the psycho-physiological features of the pilot's actions when performing the landing. It begins with the choice of the site, the approach to which should be made against the wind, which reduces the likelihood of getting into a dust cloud and will make it possible to compensate to a certain extent for the worsening controllability of the helicopter. The success of the plan overall is determined by how well the crew is able to maintain the landing process, and first and foremost the descent glide path. The dust swirl follows the helicopter in a correctly executed landing, gradually converging with the craft through the expansion of its area but not able to cover it before landing.

One dangerous mistake by the flier in this situation consists of letting the tail boom drop, which leads to the deviation of the airflow from the main rotor down and ahead with all of the attendant consequences. The pilot, noting this, should let out the control stick and try to get rid of the dust swirl, and where necessary repeat the maneuver. The area of the spread of the dust zone should be kept under control during the landing process. For this the pilot should have solid skills that have been brought to the stage of automatic when performing all of the necessary operations. Any disruption of the dynamics of the descent, on the other hand (additional hovering, for example), leads to the helicopter's getting into the zone of heavy dust. If the working conditions of the crew are complicated by powerful vibrations of the craft during the hovering stage, worsening the readout of indicators from the instruments and making the operation of the controls more difficult, he should go around for another pass. This must moreover be done before the loss of visibility of the points of reference, which will worsen with each second.

Another dangerous error when landing on a restricted site in the mountains is overshooting. It is preferable in these cases to undershoot, even if that entails an increase in the steepness of the approach descent.

The correct distribution of duties among all of the members of the flight crew—who also monitor the boundaries of the spread of the dust cloud, and—if they get into it—seek out the necessary points of reference along with the commander and report to him the detection of obstacles—also plays a large role in the prevention of erroneous actions. The correctness of radio communications procedures has great significance under these conditions. Any types of signs—nods, turning of the head, waves of the arms or movements of the hands—anything that could be interpreted in different ways, should be eliminated. If such movements are used, they should be stipulated in advance and clearly defined. Standard radio exchange procedure should be adhered to: it is essential to eliminate exclamations and words like "let's," "start," "end," "increase," "look," "well" and others that clutter speech. Deviations from the standard can be permitted in critical situations, but the commands, reports and other information being transmitted therein should be clear, contain an organizing principle and rule out differing interpretations.

The most important conditions ensuring correct interaction among the members of the crew are their psychological compatibility and the achievement of unity in understanding questions of the behavior and actions of each of them in various cases in a situation that is taking shape. All of the actions of the crew members in a landing should be aimed at mutual assistance, mutual monitoring and increasing the capabilities of each of them through the timely assistance of another. Insofar as this is achieved first and foremost in the process of joint work, it is essential to avoid the formation of a crew immediately before the performance of a difficult mission.

The question of the interaction of an assault team on board the helicopter with the crew requires special resolution. This is especially important in cases where the helicopter is under fire immediately before landing. The necessity of the assault team's leaving it even before landing or at the moment the mountain slope is touched may arise in such a situation. The assault team may at the same time get backed up at the door of the compartment in a fast exit, thereby disrupting the center of gravity. A crew engaged in landing and distracted by fire may prove to be unready for this complication of the situation. The degree of involvement of the copilot in controlling the helicopter—who rarely, while fulfilling individual commands from the commander and performing discrete actions envisaged by the technology, takes part in the uninterrupted control process—gains particular significance under these conditions. The commander could moreover be incapacitated in a combat situation; the controls he is working with could also be disabled. The lack of prompt involvement of the weapons officer under these conditions leads to the appearance of a completely uncontrolled situation. The readiness of the copilot to control the helicopter when performing a difficult assignment is thus an important condition of flight safety and the fulfillment of the combat mission.

Another essential condition of a landing approach in the mountains is its correct structuring with regard to the safety of the subsequent takeoff, including the possibility of a ground roll, an assessment of the positions of obstacles and the danger of coming under fire, among others. The ability of the pilot to predict the development of the whole operation overall should be manifested herein in particular.

It is not advisable to make a survey of the surface at the ground, under conditions of the formation of a dust cloud, through the nose glazing, which makes it possible only to determine the distance to the ground, but rather through the lower forward section of the cockpit canopy framing at a distance of four-five meters, which increases the field of view and makes the survey more favorable for assessing not only the altitude, but also the spatial position of the helicopter (roll, pitch).

Even though the loading of the helicopter is performed, as a rule, under conditions of extreme haste in a combat situation, the crew chief must carefully follow the preservation of the center of gravity. This is all the more important as the pilot cannot check it by hovering in such cases. Course deviations of up to 30-45° are possible in view of the difficulty of maintaining a precise direction in an area of heavy dust. It is therefore essential to make the appropriate corrections in the direction of flight immediately upon emerging from it.

It must be noted in conclusion that the landing of a helicopter in mountains is a difficult but essential element of flight training. Steadfast attention should thus be devoted to mastering it in the process of flight training for the crew.

Altered Cockpit Control Layout in Su-27 Factor in Loss of Aircraft

92UM0366F Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) p 11

[Article by Colonel V. Barachenkov under the rubric "Flight Safety: A Special Case": "Had to Eject"]

[Text] Combat Pilot 1st Class Lieutenant Colonel A. Proshenkov was to perform a training flight into the practice area for advanced aerobatic maneuvers.

After the lift-off of the Su-27 from the runway during takeoff, he set the knob to raise the landing gear to the up position with an accustomed movement. Proshenkov determined through the typical indications that the landing gear had been retracted, the signal light had been actuated in normal fashion. Now all of his attention was on performing the flight mission and monitoring the operation of the engine and aircraft systems.

But something unforeseen happened. The pilot unexpectedly felt an unaccustomed jolt of the aircraft in the practice area while performing a 360-degree banked turn with normal G-forces (more than five). A look at the signal panel—the light was on for the lowered position of the struts. The switch knob for retraction of the gear was moreover... in the down position.

An attempt to retract the gear was not crowned with success. A landing approach... The main and auxiliary systems were turned on, G-forces were created, but the left strut would not go down. The pilot was forced to eject.

So why did the spontaneous movement of the switch knob for the raising and lowering of the landing gear occur? A simple and unequivocal question, at first glance—the pilot is to blame. He had not put the knob in the fixed up position, and it had moved down under the effects of the G-forces. Yes, he had done that operation many times in the process of simulation flights and the performance of actual flights. A stereotype of the actions, leading to error, had thus been devised. This was conditioned by the fact that a mechanism, new to the design, for the control of the braking chute—which restricted the free space around the lever and required a dual action by the hand to put it into the fixed position—had been installed near the landing-gear retraction switch in a refinement of the aircraft after 1988. The mutual configuration of the mechanism of the braking chute and the knob moreover varies on aircraft of different series.

The commission established that the reason for the failure of the left strut to lock was the destruction of the cylinder rod controlling the strut, due to the effects of the non-design loads on it that arose at the time of the unsanctioned lowering of the landing gear.

In conclusion I would like to direct the attention of flight personnel to design changes that require somewhat different skills in the performance of operations for the retraction of the landing gear, as well as individual features of the cockpit layout for various series of the Su-27.

Aerodynamics of 'Cobra' Aerobatic Maneuver Analyzed

92UM0366G Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) pp 12-13

[Article by Hero of the Soviet Union, Honored Test Pilot and Candidate of Technical Sciences A. Shcherbakov and leading specialists A. Klumov and A. Gorlov of the OKB [Experimental Design Bureau] imeni A.I. Mikoyan under the rubric "For the Arsenal of the Combat Pilot": "On the Path to Super-Maneuverability"]

[Text] The maneuver known as the "cobra" was demonstrated for the first time on an Su-27 aircraft by test pilot V. Pugachev in 1989 at the air show at Le Bourget (France). This element of flight, a striking sight—the aircraft, as it were, lies on its back without changing its direction of motion (that is, in horizontal flight) and then quickly returns to the initial position and increases speed rapidly—has also been mastered by other Soviet test pilots on both the Su-27 and the MiG-29 fighter.

The appearance of a new aerobatic maneuver in the arsenal of modern combat craft was not caused by a desire to surprise the audience with an unusual feat alone. The concept of creating a highly maneuverable aircraft that could, through its capabilities, safely go beyond stalling angles of attack and perform controlled flight for a certain period of time—and would have superiority in an aerial battle over other fighters that did not possess those properties—became quite widespread in the middle of the 1970s.

The realization of this concept, against a background of an approximate equality of the maneuverability features and arms-systems capabilities of the opposing aircraft, promised to provide a palpable gain in time for aiming and firing weapons.

The new maneuver has also become one of the first steps on the path to super-maneuverability. It was the result of many years of work by leading sector institutes, OKBs and Minaviaprom [Ministry of the Aviation Industry].

What parameters are associated with going beyond angles of attack considerably exceeding stall angles? A maneuver of the "cobra" type is a brief—lasting 2-3 seconds—removal of the aircraft from horizontal flight to a pitch angle of 90-120° (the angle of attack reaches roughly the same values), with subsequent transition to the initial configuration over the same amount of time. The question arises of just why the aircraft, at such a significant increase in the angle of attack, does not stall, why the flight trajectory is not appreciably distorted and why it does not leave the vertical plane.

There are several reasons. First of all, a strictly defined range of flight speeds is selected for performing a maneuver of the "cobra" type. Its upper bound is limited by the normal G-forces allowable by strength at the maximum lift factor. The indicated airspeed [IAS] for this is 500-550 km/hr [kilometers/hour] for fourth-generation fighters. The nature of wing loading and other elements of the aircraft at angles of attack close to 90°, however, differ markedly from those adopted for strength calculations, and thus entry into such maneuvers is performed, for reasons of flight safety, at V_{IAS} = 350-400 km/hr. The rolling moments moreover affect the behavior of the craft to a lesser extent at low speeds with separation of the airflow from the wing. The high rate of braking of the airframe at large angles of attack, at the same time, requires the establishment of a lower limit of the speed for entering the maneuver out of safety considerations for continuing the flight after completion of the maneuver, as well as in the event of failure of the engines, since one of the principal problems therein remains ensuring the gas-dynamic stability of operation of the power plant.

Second, the flight trajectory depends on the correlation of the forces acting on the aircraft and its attitude. Lift increases sharply below the critical angle of attack on entry into the maneuver, after which it decreases and becomes equal to zero at angles of about 90°, increasing with the further rotation of the aircraft to 120° but with a negative value (Fig. 1). The normal component of engine thrust varies simultaneously according to the sine-wave law, reaching its maximum value at angles of attack within the range of 90°.

The process transpires in the reverse sequence in the return of the craft to the initial attitude.

The difficulty of the task consists precisely of achieving a mean equality of the total of the lift and the thrust components with the weight of the aircraft in the vertical plane over the course of the performance of the maneuver, which will ensure inconsequential distortion of the flight trajectory.

It is very important for preserving the horizontal nature of the maneuver (increasing the impact of the "spectacle") to have as little increase in the normal G-forces as possible at entry into it. The choice of a rate of maneuvering and the optimal flight speed, with a regard for the effects of all factors, is made in practice on the basis of calculations, using a computer, of the dynamics of movement of the airframe.

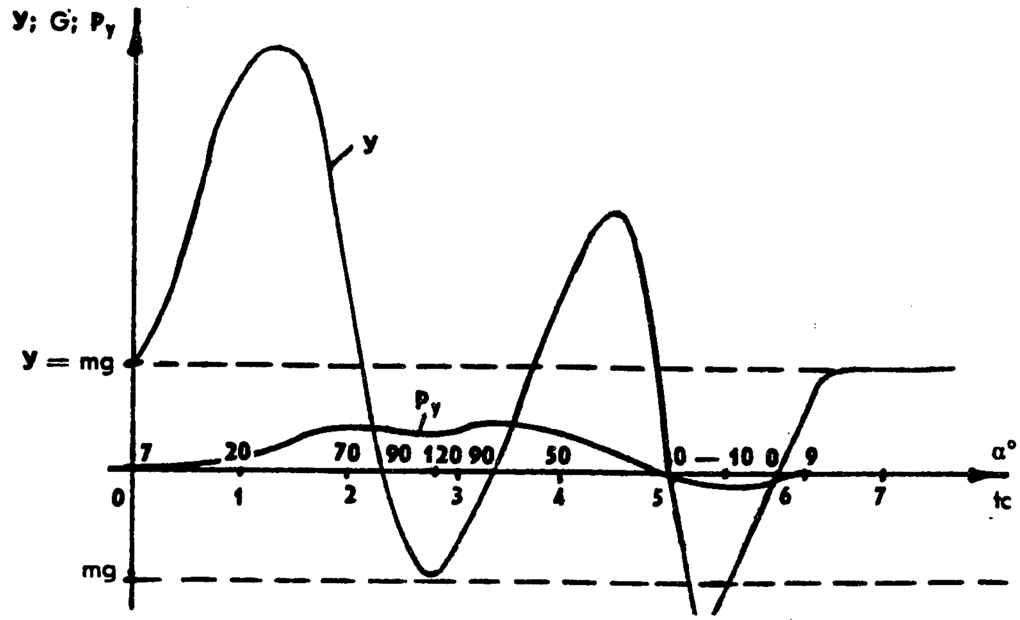

Fig. 1. Correlation of Forces in the Vertical Plane when Performing the "Cobra"

There are other conditions that must be taken into account as well when performing this maneuver. It was no accident that it was stated above that the "cobra" is the first step on the path to super-maneuverability. But it is not yet controllable flight beyond stalling angles of attack. The possibility of performing maneuvers of this type depend substantially on the degree of longitudinal stability of the aircraft at G-forces.

If we consider the dependence of the longitudinal moment on the angle of attack at the neutral and maximum positions of the stabilator for a fourth-generation combat craft (Fig. 2), the following conclusions may be drawn. It is virtually impossible to ensure balance for a statically stable aircraft at angles of attack exceeding 35-40° due to the loss of effectiveness of the stabilizer and the presence of a significant diving moment. Access to large super-critical angles of attack is possible for such a craft only in the dynamic as a consequence of the effects of the maximum possible controlled pitch-up moment from horizontal flight. In that case the behavior of the aircraft is analogous to a compressed spring whose initial value of deformation is set by the longitudinal control, and its rigidity corresponds to the reserve of longitudinal stability.

A fundamentally different picture is observed for a statically unstable aircraft, although the conclusions drawn above for a statically stable aircraft are largely preserved with the operation of automatic devices in the remote-control system (SDU) ensuring stability in angle of attack and G-forces, as well as restricting the reaching of angles of attack greater than the allowable values. All of the corresponding lines of the SDU in the longitudinal channel, as a rule, are disconnected before the performance of similar maneuvers, which makes it possible to reach super-critical angles of attack even under conditions of reduced flight speed with relatively little control influence. The return from super-critical angles of attack, however, occurs only in the case where a longitudinal diving moment sufficient to halt the initial rotation and reach parameters at which the effectiveness of the aerodynamic control surfaces is restored is acting continuously on the aircraft. Otherwise, the use of additional controls—gas-jet thrusters, a parachute or the like—is required. This problem has been solved on the Su-27 and MiG-29 thanks to the successful aerodynamic configuration and the intelligent positioning of the stabilizer.

But this does not exhaust the problems accompanying the performance of this maneuver. They also include difficulties connected with preserving the symmetry of the aircraft relative to the vertical plane, as well as not permitting a stall. It should be noted first and foremost that the aerodynamics of the airframe become non-stationary when it reaches super-critical angles of attack. The forces and moments conditioned by the enveloping of the aircraft by an on-rushing airflow are now defined not only by the values of the angle of attack, slip and angular rotation, but also depends to a marked degree on the speed and direction of changes in them.

Passage across the whole spectrum of angles of attack is moreover accompanied by the destruction and restructuring of the vortex system. This process, as a rule, is of a random nature and leads to the appearance of considerable asymmetrical forces and moments, disrupting the lateral balance of the aircraft. To those are added the

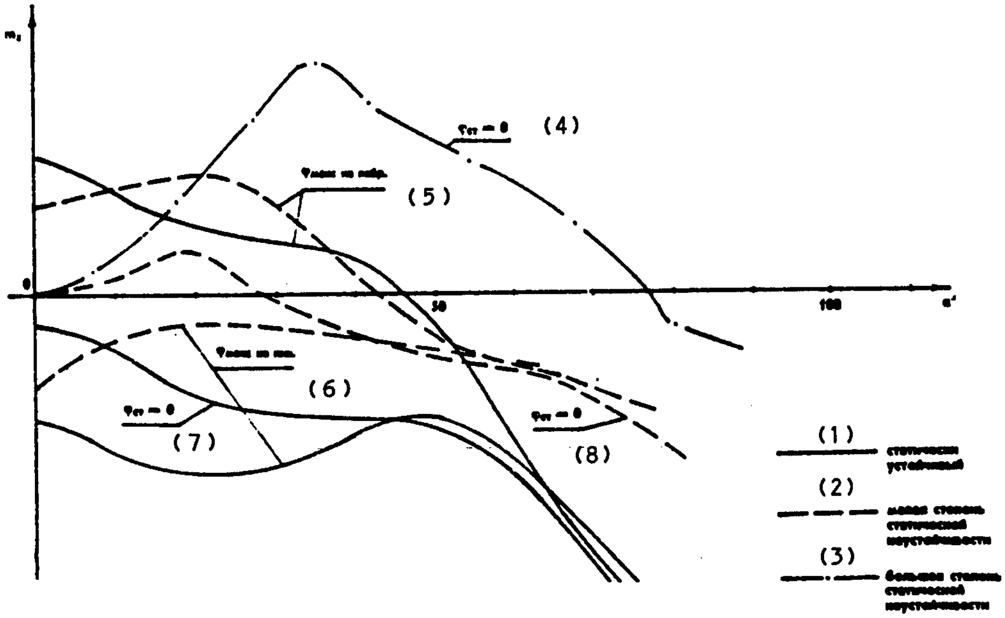

Fig. 2. Static Longitudinal Moments of Modern Highly Maneuverable Aircraft

Key:
1. statically stable
2. low degree of static instability
3. high degree of static instability
4. $\varphi_{static} = 0$
5. $\varphi_{max/pitch\text{-}up}$
6. $\varphi_{max/dive}$
7. $\varphi_{static} = 0$
8. $\varphi_{static} = 0$

gyroscopic yawing moment, brought about by the operation of the power plant at enhanced parameters, as well as the performance of the maneuver with large angular velocity relative in pitch. It can reach values that exceed the available effectiveness of the directional surfaces by $\alpha > 40°$. The effectiveness of the other aerodynamic controls decreases substantially at the same time, since they are enveloped by the vortex turbulence flow, which has meanwhile lost a considerable portion of its kinetic energy due to the exceedingly rapid braking of the aircraft in the maneuvering process.

The asymmetrical moments—which are systematic, that is, are predictable for a concrete aircraft—are thus countered ahead of time with an anticipatory setting of the control surfaces and, in some cases, the creation of different engine thrust. The difficulty of performing the "cobra," however, also consists of the fact that the aircraft has to be held strictly on the vertical plane only using the aerodynamic control surfaces, since changes in the operational parameters of the power plant at large angles of attack are not desirable. This requires clear-cut movements of the controls strictly regulated in time by the pilot, along with knowledge of the nuances of the specific features of the concrete aircraft and, at the same time, precise and rapid reactions to disturbances caused by non-standard phenomena.

Su-27 and MiG-29 aircraft are not devoid of the drawback of stalling. Slip starts to develop with time when exceeding the allowable angle of attack, and the aircraft stalls with a subsequent plunge into a spin. The inertia of the craft, short duration of the maneuver and the preventive actions of the pilot on the controls, however, keep the critical parameters from being manifested.

The successful performance of the "cobra" maneuver thus still depends on how quickly the maneuver is performed: the yawing and rolling moments should not "succeed" in leading to the appearance of slip and roll values that are impossible to counter in the face of the lost effectiveness of the ailerons and control surfaces.

The difficulties of performing the "cobra" were completely obvious from the viewpoint of theoretical substantiation. The merits of the pilots and test engineers who, knowing of them, boldly moved out ahead of theory are all the more significant thereby. And they achieved worldwide renown.

It should be noted at the same time that attempts at the amateur mastery of the "cobra" without thorough special preparation of both the pilot and the equipment are dangerous. The practical application of this maneuver in the line units will clearly be possible only provided its execution is automated.

So just what is the practical value of this aerobatic maneuver? The assumption stated in the press that an aircraft being attacked from behind can "go up into a cobra," let the enemy pass ahead and then use his own weaponry does not seem a serious one to us. A fighter under attack, having "gone up into a cobra" where $V_{IAS} = 400$ km/hr, will reduce its speed insignificantly relative to the attacker but will sharply increase the area to aim at thereby, as well as simultaneously lose the later opportunity to perform even limited maneuvers by having deprived himself of speed. An attacker overtaking a target will moreover most likely not fly along on a straight line, subjecting himself to attack, but will move up and to the side.

One should not, however, entirely repudiate the practical expediency of the "cobra." The last word here should belong to the combat pilots practicing the tactics of maneuverable aerial battle.

The following situation could also be supposed. An interceptor in loiter mode receives information or himself visually detects an enemy, for example a Stealth bomber, proceeding on a converging heading and above. Such a mutual disposition of the interceptor and the target would require a vigorous change in the pitch angle for the employment of weapons, which is possible to realize only by performing a "cobra." The start of the maneuver and the opening of fire, however, should be determined by a special computer for today's fighters.

Aerial Refueling Hose Accident Causes Near Crash, Addition to Manual

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[Article by Captain (Reserve) V. Shvetsov under the rubric "Combat Training and Flight Safety": "An Addendum to the Instructions"]

[Text] *This was one of those rare situations about which there is not a word in the Aircraft Operating Manual on special cases in flight. It had never happened before in domestic aviation, and perhaps not even in world aviation.*

The heavy missile-carrying bomber lifted off from the Kazakhstan airfield on a December night and, reaching stratospheric altitudes, headed east toward the rising sun. The crew had the mission of finding an aircraft carrier from one of the NATO countries in the Pacific Ocean, far in the tropics, and, if possible, discovering its intent.

This sortie was to last 19-25 hours without a landing, and thus both an outbound and an inbound aerial refueling were in store.

Six hours of the flight are past. The craft was over the Sea of Okhotsk when the time approached for the rendezvous with the tanker, which had taken off from a Far Eastern airfield. It appeared up ahead and above, first as a tiny silver dot and then, growing more and more, it was transformed into an enormous, two-hundred-ton, four-engine object.

The commander of the missile-carrying Tu-95 turboprop—Major N. Biryukov, a forty-five-year-old veteran of long-range aviation—converged deliberately and carefully, holding the heavy craft in the wake of the tanker and somewhat below. Then the bomb bay doors opened wide and the thick "elephant's trunk" of the refueling hose extended from it for some dozens of meters, ending with the heavy metal drogue. The crew of the bomber had to approach and intricately put it onto the nose refueling probe. Then, while maintaining the speed and interval flawlessly, they had to take on 35-40 tons of kerosene.

Refueling is considered to be the pinnacle of flying skill, which can be reached only with long and dogged practice, and the payment for that is premature gray hairs and neuroses. But when they say of a pilot, on the other hand, that "He flies the whole radius with two refuelings!" that means, in pilots' circles, that they are talking about an ace, the likes of which there are few. Often when flying these missions, especially in heavy turbulence, the pilots would take off their leather jackets or flight suits and literally wring them out, soaked with sweat.

It was hellish work. Some could not stand it and refused, and they were then transferred to other aircraft. They were not condemned. Those who completed the program to master refueling through to the end became the principal "draft" force in the regiment. They were given the most difficult and the longest flights. They "hung" for dozens of hours over the Atlantic, Arctic or Pacific oceans, they even got to the Indian.

Such crews, by the way, enjoyed well-deserved honor and respect. They were often met at their home airfields by a brass band after especially difficult and crucial flights, announcing the gratitude of the command, while roast pig or even a little brandy awaited them in the mess so as to ease their fatigue and nervous tension.

N. Biryukov was one of the pioneers in mastering refuelings and had performed dozens of them, maybe even hundreds, and thus after two or three minutes of precise maneuvering he extended the retractable part of the probe and the hose drogue fitted tightly to it. This all went as usual, each member of the crew calmly and cleanly carrying out his business, issuing and receiving commands. Knowledgeable and confident people going about their favorite work. Nothing foreshadowed any misfortune.

The disaster happened in the fifth minute of refueling. The tanker, by some "whim" of the autopilot, turned sharply to the right, and the hose snapped right under its "belly." Its now free end, spraying a thick cloud of kerosene vapor, flew at the bomber like a gigantic writhing snake. By some miracle missing the propellers of the engines, it settled onto the right wing between the fuselage and the third engine, extending for the whole length of the aircraft and running past the "stern" for another 10-15 meters. It was these ill-fated meters that mercilessly whipped about in the turbulent airstream, and the monstrously heavy whip of the hose was hitting against the aircraft tail fin and stabilizer, against the control surfaces. The radio operator reported that pieces of the skin were flying off of them.

On the intercom, silence. The crew was ready for everything, they knew their actions to get out of any situation. But this was the first time this had happened, and actions to get rid of it had yet to be devised. There had been breaks of the hose in refueling practice, but they had all occurred at the drogue itself or three to five meters from it, and the aircraft had returned safely carrying, as they all joked later, some "nose-drip" on the probe. There could be no discussion of somehow dumping the drogue from the probe here—it was tightly gripped from the twisting. Speed and heading maneuvers produced no results.

The situation became critical when the hose came to lay across the elevator and pushed it down. The craft headed toward the gray, cold waves of the Sea of Okhotsk. The commander and co-pilot Captain N. Zaytsev were able to restrain its movement into a dive with improbable efforts. But the speed of descent increased: ten, fifteen, twenty meters a second.

The altitude approached two thousand meters. The flight deck was depressurized. The co-pilot made a desperate effort to free them from the deadly "boa constrictor." He opened his vent window and, overcoming the dynamic pressure, seized hold of the hose with his left hand, and with the right tried to cut it with a knife saw. But the small, pocket saw only scratched the thick surface, armored with metallic mesh.

The water was coming irreversibly closer.

"Do not panic! Prepare to bail out! Flight technician open the lower hatch!" ordered the commander.

It was criminal to drag it out any longer—it was not now an issue of saving the aircraft, but of the lives of the crew members. The speed of descent had reached thirty meters a second.

Flight technician A. Garmash hung back. He could not betray, abandon the craft he had gotten used to, had become one with for many years, touched with his hands, "treated kindly" with rags. But there was now no other way out, even though it gave few chances for the crew. Would you hold out for a long time in the icy water, soaked through, in a little inflatable raft? Help would scarcely come in time!

When there were no more hopes for a favorable outcome and the crew was preparing to jump, waiting for the final command, a flash of inspiration came to senior gunner and radio operator V. Kireyev: "The gun, the top gun! What if...?" the thought flashed in him.

"Commander, may I try to shoot the hose off from the upper gun mount?"

"Good, go ahead, there's no other way out."

Viktor aimed the barrels at the hose, and fired first one and then another long burst. After the third the dangerous part of the hose snapped off and, performing some sort of incomprehensible dance, flew off backward. Every sighed in relief. The life that had almost slipped away belonged to them again, and nothing now threatened it in the near future.

A little more than an hour later, having curtailed the performance of the mission, the bomber landed safely at a back-up airfield in the Far East. The pilots and technicians who approached it could only shake their heads—a plane had not returned from a mission in such condition since the war. Clumps of the skin dangled from the tail, stabilizer and control surfaces, and the bent wing spars and ribs could be seen in the holes ripped in them. The crew stood off to the side, all smoking silently... No one approached them with questions.

So this flight ended safely. Warrant officer V. Kireyev received the Order of the Red Star and a valuable gift from the Air Forces Commander-in-Chief. From the crew—gratitude. And a new paragraph appeared in the Operating Manual in the section for special cases—go out for a refueling only with loaded guns, and use them in similar situations to shoot off the hose. A paragraph born in the air.

Tashkent Concern Seeks Venture Partners for Rodless Piston Engines

92UM0366I Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) p 15

[Advertisement]

[Text] RODLESS ENGINES are power, reliability, economy and small dimensions.

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Problems of Commercial Shipping on Military Aircraft Reviewed

92UM0366J Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) pp 16-17

[Article by Captain V. Mayorov under the rubric "Headed Toward Restructuring": "Crumbs From the King's Table—*Are What the Fliers Get for Commercial Shipping*"]

[Text] *We are awfully strange people. We come up with an intelligent idea and then contrive to surround its realization with various conditions that essentially bring all the good intentions to naught. And then we get surprised and spread our hands—wonder of wonders, nothing comes out right here once again.*

The USSR Council of Ministers Decree No. 413 of 25 Apr 90, titled "The Shipment of National-Economic Freights by Aircraft and Helicopters of the USSR Ministry of Defense, USSR Ministry of Internal Affairs and the USSR State Committee for Security," was undoubtedly a sensible one. One cannot find as anything but absurd a situation in which transport aircraft of the Air Forces were running empty, say, from the Far East to the Ukraine and back. In the face of our total scarcity, where valuable freights can sit for months without reaching the consumer, the shipment of "air" by aircraft is, you will agree, simply stupid. It was namely the fliers who were the first to raise this problem, at a time when the first timid features on market relations had begun to appear in the press. The military pilots are state people and think in terms of the state. They thus put the question point-blank—how long will we burn "excess" kerosene and use up the aviation hardware itself without rhyme or reason? Are there really no smart heads that could figure out the losses from such mismanagement?

They found some smart heads. They figured it out and gasped. That is, they thought in the government, look exactly how colossal the income is that could be extracted from shipments by military aviation. Our state is so immense that some places, as the song says, can be reached only by aircraft. And so, after a while, the notorious decree was born that defined the procedure for shipments by transport aircraft and helicopters through direct contracts with the enterprises and organizations of ministries, agencies and ispolkoms of the local Soviets of People's Deputies, as well as the settlements for those shipments according to the rate scales in effect for USSR MGA [Ministry of Civil Aviation]. The fliers were permitted to keep some of the receipts (30 percent) themselves, to provide material incentives for servicemen and manual or office personnel performing or supporting the shipping and for the social development of military installations.

A truly Solomonic decision had truly been made, it seemed. Advantageous to the national economy and advantageous to the fliers. Matters began to whirl; the crews of the transport aircraft and helicopters began making commercial runs. Proposals to conclude mutually advantageous contracts began to pour in from all over. Cooperatives, joint ventures and commercial organizations displayed particular energy. The businessmen, tormented by the monopoly and sluggishness of civil aviation, rushed to the military, who had both plenty of capabilities and were not coddled by agreements. One-time rush shipments on the basis of written requests from customers with a guarantee of payment, after all, were also permitted aside from contracts. The playing field, as we see, was wide open—pay the Air Forces and gain profits. The first earned money began appearing on the accounts on the military units. One could only be glad...

But soon the military cooled appreciably toward commerce. What was the matter?

When the fliers made the first runs and counted up their "profits," they asked in all fairness why the devil the crews were running around over thousands of kilometers and living without their families for weeks at a time. For crumbs from the king's table? Some of the money from the totals earned, after all, went for reimbursing additional expenses connected with the freight shipments and the operation of the aviation hardware, among other things. An Il-76, for example, made an intermediate landing at a civilian airfield and topped off its fuel—2,730 rubles on the spot. Add to that the expense for travel allowances for the crew—when staying in a hotel costs 8-12 rubles today and lunch in the cafeteria is not cheap. And they have to provide incentives for not only the crew members, but also those who were supporting these shipments, out of the crumbs that are left. Add to that everybody's "cut."

The fliers of the subunit that is commanded by officer Yu. Voronov started making commercial shipments as of September of last year, and they have earned 35,692 rubles over the five months. They coughed up 24,984 rubles of that to the Union budget. After paying for all the services connected with delivering the freight, incentives for the personnel and social development, there were 5,342 rubles left (!). It is funny if you take into account that there are 37 officers or warrant officers without apartments in the squadron, of whom 25 are members of flight crews, including "Afghan vets." And what can you do with such a sum?

The fliers are right who say "So why, strictly speaking, should we pay triple to the cooperatives for foods and other goods that we ourselves are delivering to them?" And indeed, why? Why, for example, should the commander of a detachment, Military Pilot 1st Class Major A. Karpov, who has lived with his family of five in private apartments for several years now, work for somebody else? I understand—the country is poor, and one cannot count on being a lord here. No, the military are not against commercial shipments. They are doing them, after all, for money and not for thanks. Only where is that money going? The union budget is such a vague and incomprehensible concept today that you have to be a genius to understand it.

And since we declared that there are no alternatives to the market, let's think in economic categories and not be engaged in robbery in broad daylight. Honor and praise to the cooperatives and businessmen who have sized up the opportunities of air shipping so quickly. But why do the military fliers have to remain the ones who are shortchanged, huddled with their families in private apartments and experiencing other material difficulties? If the state is not able to provide amenities for the everyday life of their armed protectors, then let them at least give them the opportunity to earn money honestly. You see, the opportunity would appear for the officers and warrant officers to invest money in cooperative apartments and in share-based construction.

But we can only dream of that today. You can put whatever spin on it you like, but commercial shipments are simply unprofitable for the Air Forces today! And I can illustrate what commerce is today using the example of one of the troop units of VTA [military-transport aviation]. I have in front of me an estimate of the expenses for that unit for 1991 on Form No. 6 for extrabudgetary funding, "Paid Shipments of National-Economic Freights by the Aircraft of the USSR Ministry of Defense." The document is unique in its own way. Judge for yourself—the proposed monetary receipts are 500,000 rubles; 350,000 are subject to turnover to the income of the union budget, and 30,000 of the rest will go for the operation of the aviation hardware, 22,000 for additional expenses in freight shipment, 15,000 for travel allowances for the crews and 48,000 for the accumulation fund of the Air Forces staff of the ZavVO [Transbaykal Military District]. All in all, just 20,000 rubles remains for social development and 15,000 for material incentives for the personnel.

What is that money today, when prices have leapt upward several times over?! And try and "get" anything for it! Would you like to know, by the way, the incentives for some fliers based on the results of the past year? By all means. Assistant craft commander Captain V. Yermolin—50 rubles, the same as for navigator Captain V. Pochikaylo and senior flight technician Captain S. Garannikov. I assume no commentary is needed.

That is how one poorly thought-out decision has driven any desire to engage in commerce out of the fliers. And that is too bad. The idea of air shipments itself, I repeat, was a sensible one. I was talking with many pilots, officers at command posts and other specialists, and they were all saying "Give us the opportunity, and we will find customers ourselves." The Air Forces CP chief in the ZavVO, Colonel N. Shevchenko, expressed this opinion: "Today neither the command bodies of air traffic nor the flight personnel have any vested interest in commercial flights, even though it is namely in our region, where the road network is poorly developed, that they could bring great profit. And there are opportunities for it. We could create a base to accumulate the freight, and with the prompt notification of the customers try to give the 'green light' to commercial runs, even introduce the position of shipping dispatcher... Just give the crews some freedom and they, when landing at intermediate airfields, could take on freight, naturally after the appropriate back-up calculations. This is a far from complete list of the proposals that we expressed at one time or another to the officials of the military department of the CPSU Central Committee, who came out specially to see us and study the issue. But there is still, as they say, 'neither answer nor greeting.'"

Colonel Shevchenko, in my opinion, has expressed some very practical ideas. The more so as there is no getting rid of customers. In December of last year, for example, the directors of the "Service-Center Transbaykal" joint-stock company came to the Air Forces command of the ZavVO with a proposal for the joint shipment of national-economic freights and a certain quantity of passengers, in the form of bartered flights on the basis of a bilateral agreement. They also expressed a readiness to act as the general customer in organizing air shipments. It was proposed that the fliers acquire shares, with the appropriate dividends, for the purpose of effective collaboration. The joint-stock company, by the way, was already making use of the services of the military fliers, shipping video gear, household appliances, shoes and other goods on the aircraft. Representatives of this intermediary organization with whom I was able to talk did not conceal the fact that they wanted to set up close and mutually advantageous collaboration with the Transbaykal fliers.

It is another matter that not everything in the proposed contract suits the fliers. First of all, the discussion should still concern freight, since the compartments of the transport aircraft are not equipped for passengers. Second, the crews are performing first and foremost missions of combat training, and make incidental commercial runs only where possible. The contract with the customer who would be called the general customer would foist partly crushing terms on the fliers. And if for some reason the freight was not delivered to its destination, the customer would have the right to seek arbitration and demand reimbursement for losses. And finally, military aviation cannot be the aviation company of any commercial organization, even a very rich one. The optimal version, as it is assumed at the Air Forces headquarters for the ZavVO, is the conclusion of contracts for a series of runs (five or six, for example). The arrival of other profitable proposals cannot be ruled out, after all, and then the military fliers would have the right to select the one most acceptable to themselves. It is strongly recommended in this regard that the Air Forces commands in the districts study the customer, his ability to pay and the aim of the shipments so as to avoid troubles that have, by the way, already occurred.

The question could naturally arise for the reader—what are all these arguments for? It is also clear that if commercial shipments are not profitable for the fliers, they will engage in them only from time to time and unwillingly. It has been reported in the press, however, that military-transport aviation has even now earned millions of rubles, including in foreign currency, for commercial shipments, even with today's deductions for the budget. And I would not like to create the impression that air-freight shipments are hopeless and lacking in promise for military fliers and their multitude of customers. The decision has currently been made to change the percentage of deductions from commercial shipments in favor of the fliers—they will get 70 percent of the profits today. And that is now a real incentive. And as they say, God grant that this decision acquires a legal basis as soon as possible and does not get tied up in bureaucratic delays.

Use of Petroleum-Gas Product as Aviation Fuel Considered Promising

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[Article by TsIAM [Central Institute of Aviation Machine Building] staff members Academician O. Favorskiy and senior scientific associate N. Dubovkin with TsAGI [Central Aerohydrodynamic Institute] lead designer V. Zaytsev under the rubric "Problems, Searches, Solutions": "There Will Be Fuel!"]

[Text] *"We must immediately expand the industrial production of new types of it," feel TsIAM staff members Academician O. Favorskiy and senior scientific associate N. Dubovkin with TsAGI lead designer V. Zaytsev.*

Who among the fliers responsible for organizing flights has not lately had to count up literally each ton of kerosene so as to ensure the fulfillment of the assignments? It is no secret that there will be a crisis of liquid hydrocarbon fuels by the beginning of the 21st century. The old oil fields are being depleted, and new reserves are being found more and more rarely and further and further from the locations of refining and utilization, which is raising the price of motor fuel considerably and causing shortfalls in it. There are 15-20 million people a year with unsatisfied demand for air shipments from the USSR Ministry of Civil Aviation, and it is getting harder and harder for the military to fulfill its plans for combat training. Searches for alternative sources of energy are becoming more and more urgent if one takes into account the ecological crisis as well, to which the use of traditional motor fuels is making an inordinate contribution.

There are proposals to utilize solar, nuclear and some other types of energy in aviation, but there is unfortunately not yet any cause to speak of their rapid assimilation owing to many technical difficulties. It will scarcely be possible to make widespread use of, say, alcohol as fuel for aviation engines in the near future due to the comparatively narrow raw-materials base, even though its use for ground transport would obviously be more warranted, the same way as industrial gases and biogas could be used for electric-power engineering.

Liquid hydrogen is a promising source of energy. It has the highest mass heat value of all the liquefied gases. The extremely low boiling point, low density and some other properties, however, seriously complicate the mass utilization of hydrogen in aviation, despite the fact that its use in space engineering has been assimilated quite well, and successful flights of a Tu-155 aircraft whose engines were operating on hydrogen have even been made. But where can the "excess" energy be gotten for its energy-intensive production? Hydrogen will thus probably also not be used in large volumes in aviation very soon.

There is, however, another source of energy that is attracting more and more attention from aviation scientists and practitioners—liquefied natural gas [LNG]. Its cost is relatively low, and rich fields of it have been discovered in many regions of the country that will be enough for decades. The extraction and preparation process for one cubic meter of petroleum moreover releases up to 80 cubic meters of so-called casinghead or petroleum gas, and tens of billions of cubic meters are released in a year at all of the country's oil fields.

A comprehensive analysis performed by TsIAM and TsAGI in conjunction with the Gazopererabotka [Gas Treatment] VNIPI [All-Union Scientific-Research and Planning Institute] has shown that the most convenient and acceptable mixture for both the designers of airframes and the manufacturers of the aviation gas fuel is a mixture of saturated hydrocarbons, from propane to hexane inclusive. Fuel with this composition has been given the name of condensed aviation fuel (CAF). About

2.5 million tons of wide fractions of light hydrocarbons are obtained from every 10 billion cubic meters of petroleum gas, from which the CAF yield is about 40-50 percent. Technological studies have shown that only an insignificant retrofitting of the gas refineries is required for the production of CAF, while the technology will be a waste-free one since a different valuable by-product—the propane/butane fraction that is so essential to household needs and automobile transport—is obtained in the production of CAF from the wide fractions of light hydrocarbons. The cost of the CAF is expected to be roughly half that of aviation kerosene, and obviously even lower in the future.

Also of no small importance is the fact that CAF surpasses aviation fuel in power and a number of operating measures. It will provide significantly better starting properties for an engine at low ambient temperatures in particular. The new fuel is ecologically cleaner and less aggressive, since it is virtually lacking in sulfur compounds, aromatic or unsaturated hydrocarbons, resins, asphaltenes and other harmful substances.

Taking into account the advantages of the new fuel, TsIAM and TsAGI, in conjunction with the OKBs [Experimental Design Bureaus] of general designers M. Tishchenko and A. Sarkisov, decided as early as 1982 to conduct the corresponding bench testing of an engine and flight tests of a helicopter using the by-products obtained from petroleum gas as the aviation fuel. One TV2-117A engine with a refined fuel system and designed to use both condensed aviation fuel and kerosene was tested in 1985 using commercial butane and propane/butane mixtures recommended by the Central Institute of Aviation Engine Building as imitation CAF. The engine operated in stable fashion using all the types of fuel. The irregularity of the temperature field of the gas in front of the turbine and the basic parameters of the engine were the same as in the operation of aviation kerosene, but the consumption of fuel was 2-6 percent less.

Flights tests of a modified Mi-8T helicopter using an imitation CAF—normal brand B butane—were conducted across the whole operating range of altitudes and flight speeds. The engine started on the first try both when cold and when hot. The engine operated in stable fashion and had good pickup in all flight modes. The gas content of the air in the cockpit of the helicopter and around it was tens of times lower than that permissible under health-safety norms, while the exhaust gases contained no condensed (sooty) particles. There was no detection either of carbon on the walls of the combustion chamber, turbine blades and exhaust pipe or of damage to the hot duct of the engine, which also confirmed the assumption of the good operating properties of CAF fuel and the possibility of increasing the operating life of the engine. Questions of the utilization of CAF in aircraft are being studied at the OKB imeni S.V. Ilyushin, OKB imeni A.S. Yakovlev, OKB imeni O.K. Antonov and other enterprises of Minaviaprom [Ministry of the Aviation Industry].

It has been proved that engines can be dual-fueled, that is can operate both using aviation kerosene and using CAF, which is exceedingly important in operation and will help to speed up the conversion to the new fuel. Many problems will of course have to be solved when creating a series-production model of a helicopter, aircraft or dirigible using gas mixtures other than kerosene as a fuel. Light fuel tanks with an operating pressure of about five atmospheres must be developed, for example, due to the fact that CAF has to be kept under pressure to maintain a liquid state. Funds will have to be invested in the creation of booster pumps, monitoring and measuring gear in aviation designs, the refinement of the two-fuel system for the automatic control of the engine, including for the purposes of automating the conversion from aviation kerosene to CAF and back, as well as refueling and CAF storage equipment suitable for airfields and systems to ensure the highly explosion-safe operation of the engine and the aircraft. This problem (entirely solvable, as preliminary studies and tests have shown) cannot be under-estimated, even though petroleum gas has much less danger of explosion than hydrogen.

The tasks are difficult but can be accomplished, since a great deal of experience has been accumulated in working with petroleum gas in this country. The new fuel will obviously find application first of all in the northwestern and eastern regions of the country and, in general, in the areas of assimilation of new fields, where the utilization of the aircraft and helicopter fleet is made more difficult due to the scarcity and difficulty of delivering kerosene.

The principal portion of the aviation fuel in the northwestern regions of the country is shipped in during no more than seven months of the year by water, and the rest by railroad. Such long shipments and prolonged storage of a large quantity of fuel are expensive, as a consequence of which its actual cost is more than doubled. And if fuel still has to be transported by helicopter, say, the shipping cost for even 100 kilometers becomes commensurate with its initial price.

Many of these problems could be solved with the use of condensed aviation fuel, since it will now be able to be obtained in the near future with the aid of small modular-unit field installations that have already been created by Minneftegazprom [Ministry of the Petroleum and Gas Industry] and Minkhimmash [Ministry of Chemical Machine Building] right at the oil fields, as well as at practically any point on the rights-of-way of the pipelines along which the wide fractions of light hydrocarbons are transported. The raw-materials base of CAF will be even broader in the long run—it will be obtained during the production process for synthetic liquid fuels from coal, shales and other relatively cheap and accessible raw materials. Minneftegazprom could in principle take on not only the manufacture of the CAF, but also its transport and storage, including at the airfields, and monitor the quality of the fuel.

Even the local and most realistic and efficient conversion of helicopters and aircraft just in the northwestern and eastern regions of the country to fuel obtained from petroleum gas would allow not only the intelligent utilization of a most valuable fuel that is being senselessly destroyed in flares as well as the economy of no less than 0.5 million tons of acutely scarce aviation kerosene thereby, but also the comprehensive solution of a series of important regional and nationwide national-economic problems. It seems essential to combine the resources and efforts of all interested parties, possibly making the task for a start the conversion of all helicopters tested and operating to CAF.

An interesting and very promising idea already has everything for successful implementation except... financing. But it is precisely that issue—the appearance of an actual customer—that will determine the future fate not only of the fuel, but the future of aircraft as well. Many already understand this. It is hoped that those on whom the decision depends will understand this more quickly, and that in just 2-3 years it will be possible to have a real national-economic impact.

Overview of U.S. Air Force Pilot-Training Program

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[Article by Doctor of Military Sciences Colonel A. Drozhzhin and Candidate of Military Sciences Lieutenant Colonel A. Kokorev under the rubric "In the Air Forces of Foreign Armies": "The Training of Flight Personnel in the U.S. Air Force"]

[Text] *The role of aviation in military conflicts that are conducted using conventional weapons is growing continuously. The potential capabilities of combat hardware and weaponry, at the same time, can only be realized by highly skilled flight personnel, as was confirmed once again by the war of the multinational forces against Iraq, where the pilots proved to be the masters of the situation. Readers of the journal are asking in this regard that we talk about the training of military pilots in foreign countries.*

The discussion on that score is begun by Doctor of Military Sciences Colonel (Retired) A. Drozhzhin and Candidate of Military Sciences Lieutenant Colonel A. Kokorev.

(Based on materials in the foreign press.)

The Americans have always given priority in the waging of combat operations to their own Air Force. The leadership of the U.S. armed forces assigns a role of no little importance to aviation cadres, and especially the flight personnel, among the set of measures to raise their aerial might. The system for training them embraces a broad network of military and civilian educational institutions, and consists of the following stages: 1—the selection of candidates; 2—initial training; 3—combat-pilot training; 4—mastery of tactical fighters, ground-attack aircraft or reconnaissance aircraft; 5—practicing of methods of combat application; and, 6—further improvement of flight skills in the aviation units and subunits.

The first two stages are typical of pilots in all branches of the U.S. Air Force, including tactical, military-transport and strategic, while the latter are only for fighters, ground-attack aircraft and reconnaissance aircraft. The pilots of bombers, transport aviation and tankers are sent to the line units as co-pilots after the completion of flight school, and are trained in the course of combat training. Only experienced cadres with large amounts of total flying time and who have passed special examinations are assigned to strategic aviation.

1. The selection of candidates is accomplished in extremely careful fashion and is constantly improved. Those desiring to become an air force pilot submit an application for acceptance into the service at a recruiting station. The candidate should conform to the established regulations according to many measures—level of physical and mental development, absence of a criminal or court record, loyalty to the state order, technical fitness and no alcohol or tobacco habits. Those who come from the ranks of servicemen must furthermore have a satisfactory service record.

Up to two thirds of those who have submitted applications are weeded out in the initial professional selection. The necessary competition is maintained through advertisement of the high pay and opportunities to take correspondence courses and acquire a prestigious civilian field over the time of contract service. It is, however, becoming more difficult and expensive to do so for a number of reasons.

The physical condition of American youth has worsened steadily over recent years due to their sedentary lifestyle, the excessive increase in videotape recordings, computer games and riding around by automobile, excess weight and the use of drugs, among other things. Service in the armed forces is becoming less and less attractive under the influence of the ecological and pacifist movements. The prestige of the Air Force increased, it is true, after the successful combat operations by aviation in Iraq, but that has not conclusively solved the problem.

The need for personnel has also forced them to make up by increasing the proportional share of immigrants from South America and Asia, including women in military service and reducing requirements for the intelligence and health of the entrants. The new aviation hardware and maintenance systems are, at the same time, making the requirements more severe for education and technical literacy. Statistical calculations show, for example, that U.S. Air Force requirements for electronics specialists will triple by the year 2000.

Entrants are accepted for basic flight training at the schools of the Air Training Command (ATC) from among:

—those who have completed the military aviation school (academy) of the Air Force at the Colorado Springs Air Force Base (Colorado);
—the graduates of civilian higher educational institutions;
—NCO personnel and DoD employees after completion of Air Force officer training schools, as well as officers who have completed their contract service, have been discharged and have decided to return to the ranks after more than six months (if the break in flying time was less than half a year, they are sent to line units immediately).

The **Air Force Military Aviation School (Academy)** is the most prestigious of the higher educational institutions. Young men 17-22 years of age who have completed general colleges enter it. The term of study is four years. About 4,500 cadets are studying simultaneously (12 percent are women) with an annual completion rate of about 1,000 people.

Technical sciences and liberal arts, foreign languages and air navigation, among others, are studied at the school. One can gain knowledge of personnel work, procurements, finances and reconnaissance. Personal computers are being used more and more widely in the teaching process. About 500 cadets in the senior class complete familiarization flights on gliders and motorized gliders, helicopters and T-41 aircraft during their training time. The total flying time on the T-41 is 22 hours. This aircraft is considered to be the simplest—from 1.5 to 4.5 hours are allocated to mastering it in civilian organizations.

Some 27 percent of the entrants are dropped over the training period. The graduates are given diplomas for their higher and general military education with the conferring of the initial officer's rank of "second lieutenant" and a bachelor's degree. Almost all of the higher command positions in the Air Force are occupied by people who completed this training institution at one time.

Courses for pre-induction training of reserve officers (the ROTC courses) exist *at 600 civilian higher educational institutions.* They train up to 60 percent of the total officer corps, including up to 1,000-1,100 future pilots each year.

A student studying at higher educational institutions and taking these courses signs a contract for a certain term of service in the Air Force reserve or in the aviation of the regular armed forces. Training in the courses is subdivided into two-year (basic training) and four-year (enhanced training). A total of 180 hours of training are allotted to classes on the principles of military science, history and traditions of the armed forces, weaponry, physical training, work with maps and aerial photos and the devising of command skills. In the four-year training, another 300 hours in the second two years are allocated for the study of principles of military arts, organization, equipping and purpose of the branches of the armed forces, the arms of service and the tactics of small units, command and control, communications, engineering, rear services, legislation and the duties of the commander. The graduates are awarded the rank of "second lieutenant" upon completion of their studies.

Students at universities and colleges who are taking ROTC courses are paid a monthly stipend of up to 100 dollars—200 dollars during periods of summer training camps—to cover expenses for training, textbooks and laboratory work.

Individuals who have completed the full course of secondary education or a four-year civilian college without ROTC courses may complete training at the Air Force Officer Training School at Lakeland Air Force Base (Florida) if they desire. Its annual graduation rate is 2,000-3,000 officers ("second lieutenants"), some of whom are sent to flight schools at their request.

NCO servicemen and DoD employees (primarily the Air Force) make up a significant portion of the contingent of future pilots. They complete the Air Force Officer Training School over 12 weeks, and receive the rank of "second lieutenant" before entering a flight school.

The number of officer pilots who served out their terms earlier under contract and have expressed a desire to return to the ranks fluctuates within the range of 200 a year. They are obliged to complete basic flight training again in order to meet their goals after that long an interruption in their flying.

Matriculants who have not previously served in the armed forces complete a six-week service-wide training course at the only basic training school in the Air Force, at Lakeland Air Force Base. This is essentially a course for a young soldier. Military skills are instilled in the course of training, and selection according to physical training, moral qualities and discipline is continued. The training of cadets in subordination and the ability to work as part of a collective is considered to be most important. Men and women are trained together.

The time allotted to the course—1,008 hours—is divided up as follows: 360 hours for drill training; 336 hours for sleep; 126 hours for eating; 50 hours of personal time; 40 hours of physical training; 40 hours on weapons, regulations and subordination; 26 hours of general training; and, 30 hours of medical exams, injections, tests and the like. The cost of the training is 105 dollars a day. The number of those dropped reaches eight percent of the entrants.

Those who have completed this educational institution enter the Air Force Officer Training School located at the same base. The teaching at the school makes it possible to obtain the primary officer's rank and, at the level of other officers, the opportunity to begin flight training.

2. **Initial pilot training** is conducted at the five flight schools of the U.S. Air Force ATC. As was already noted, only officers from among the graduates of the Air Force Academy, those who have completed four-year ROTC courses at civilian higher educational institutions and the graduates of the Air Force Officer Training School, as well as officer pilots who have renewed their contracts after a prolonged interruption, are accepted for training at them.

Servicemen who are assigned to non-flight duties—officers in operational planning, ground-control-intercept controllers, aviation physicians and the heads of departments of various scientific and technical organizations participating in the development, testing and evaluation of aviation weapons systems—also master the rudiments of flight training in short-term familiarization courses at these same flight schools.

The initial pilot training course is 49 weeks. Some 500 hours of theoretical classes, 179.3 hours of flying time on T-37 and T-38 aircraft (42.7 hours of that solo), 72 hours of "flying time" in simulators and 120 hours of physical training is planned over that period.

The training process is divided into three stages.

The first stage—four weeks—is devoted only to ground training, in the process of which flight assignments are planned, actions in special cases in flight and safety measures are practiced in the aircraft cockpit and instructions, electronic equipment, main and back-up airfields and crew rescue systems are studied.

The second stage—initial flight training—lasts for 20 weeks and is performed on the T-37 aircraft. Takeoff, landing and basic aerobatic maneuvers in a practice area are practiced, four hours are given over to the instruments, nine to routing (one of which is solo) and eleven to flights in formation (two solo) during the training process. There are 58 flights in all (nine solo) with total flying time of 75.7 hours (12.4 solo). There are also 28 "flights" on the simulator with total flying time of 35.5 hours, distributed as follows: 22 "flights" (32.5 hours) for practicing piloting technique for instrument flying and navigation, and six for studying the actions of the pilot in special situations in flight.

It is considered essential that friendly relations be established between the instructor and the trainee starting from the very first flight in a trainer. Instructions, with the maximum independence, should be simple and understandable, and the aerial situation should be made continuously more complicated and brought closer to a combat (real) one, which will increase the interest in flight training.

One or two principal trainees and two or three affiliated trainees are assigned to each instructor for the whole training period. He bears personal responsibility for the principal ones; for the affiliated ones he is responsible only for the fulfillment of assignments (each affiliated trainee is the principal trainee of another instructor). There are generally an average of 26-29 instructors and teachers (servicemen and civilians) for ten trainees.

The third stage—basic flight training—lasts 24 weeks and is carried out on the T-38 aircraft. The practicing of elements of flight "pattern work," training in advanced aerobatic maneuvers in the practice area, instrument flying and headings, precision formation flying and familiarization flights with the instructor at supersonic speeds all continue—80 flights in all lasting 101 hours (of which 24 flights with a total flying time of 30 hours are solo). There are 26 "flights" totaling 33.8 hours on the simulator as well.

The trainees simultaneously complete courses in theory and professional improvement in the second and third stages. Among the things they study during theoretical training (267 hours) are the aircraft and the engine, aerodynamics, air navigation, meteorology, aviation medicine, psychology, the organization and planning of flight training, safety measures on the ground and the specific features of night flying. The officer's improvement course (140 hours) includes studying the role and place of the United States in the world, the rights and obligations of Air Force officers, the procedure for the completion of service and the fundamentals of leading subordinates.

All sections of the program are completed with performance-graded tests given by the instructors of other flight schools and the academy, as well as higher military educational institutions. The trainee is given three days to train and retake a test if he fails to pass it, and if he fails again he is dropped from flights and given the opportunity to train for another ten days; after a third unsuccessful attempt, he is dropped due to poor progress.

The workday of the trainee lasts 10-12 hours during training. One sortie for two workdays is planned when making flights with the instructor, and another one, solo, for two workdays in mixed flying. Flights not performed during the week, regardless of the reasons, are shifted to Sundays.

Young pilots who have successfully completed all three stages of training are divided into two categories for further training: FAR—fighter, assault and reconnaissance (usually about 40 percent of them) and the second, the TTB—tankers, transports and bombers. The assignments are made by special commissions, taking into account professional data, instructor recommendations and the desires of the pilot himself.

Then, in the 49th week, the pilots in the FAR category perform three solo formation flights apiece with a flying time of 4.2 hours each and one (1.2 hours) for formation maneuvers, while the pilots in the TTB category make four instrument flights (5.4 hours).

After this the student is awarded the qualification of pilot, with the awarding of a diploma and the pilot's "Golden Wings" insignia, and is sent to complete further service.

Initial flight training of one pilot, at 1986 prices, cost an average of 370,000 dollars. This system of pilot training, however, no longer satisfied the aspirations of the U.S. Air Force by the end of the 1980s. The arrival of new combat aviation systems in service required the specialization of the trainees by the type of aircraft sooner and the replacement of the obsolete inventory of trainer aircraft. Therefore, starting in 1989, the U.S. Air Force ATC began to make a transition at the flight schools to the concept of specialized dual-purpose (dual-stage) training with 86 hours of flying time, of which 13.7 hours are solo, in the initial stage on the T-37 trainer (or a more advanced one in the future). A division of the trainees by categories is made after its completion, and the second stage of training on trainers—the basic flight training—begins for them.

The trainees in the FAR category receive 107 hours of flying time on the modernized T-38 aircraft. Aerobatic maneuvers at low altitude, formation flying and solitary maneuvering constitute the foundation of their training. The trainees in the TTB category are given 102.5 hours of flying time on the specialized Beechjet 400A aircraft (still called the T-1A), whose piloting and navigational equipment makes it possible to practice the skills of piloting the KC-10, KC-135, C-5, C-141 and C-17 heavy aircraft.

The replacement of the T-38 aircraft with a craft being created according to a concept that has received the name of RAFT is planned for the fighter pilots after the year 2000. The initial training on a trainer will in that case remain unchanged. The basic flight training for a FAR pilot will be accomplished using a new aircraft with flying time of 132.6 hours, while the TTB pilots will use the T-1A aircraft with flying time of 102.5 hours.

A course of combat training with a significant quantity of flights and flying time will be instituted with the arrival of the new type of fighter trainer at the schools.

The program for the course of training of the TTB-category pilots consists of ten exercises: 78 flights of a total of 102.5 hours. It envisages training in day and night flying, in clear and bad weather, at low, medium and high altitudes, air navigation, the performance of long-range flights to other air bases, pre-landing maneuvering and landings.

After its completion the young pilots will be sent to the units, where they will complete their emergence to the level of combat-ready pilots by mastering the aircraft from the copilot's seat and taking part in all measures for combat training. A more complex program of further training awaits the graduates in the FAR category when they are mastering combat craft in the TAC units. It consists of the following three stages: combat-pilot training (introductory course), mastery of the combat aircraft and a course of rehearsing methods of weapons delivery with a total flying time of 120 hours. The pilots complete this program immediately upon completion of flight school over the course of 20 weeks.

3. **Combat-pilot training** is accomplished at the 479th TFAW at Holloman Air Force Base (New Mexico) with about 120 aircraft. The young officers receive 28 flights apiece (36 hours flying time) on the T/AT-38 aircraft—which has a reinforced wing, sights, a gun camera, weapons control panel, pylons for attaching training bombs, missiles and pods with 7.62mm machineguns—over the ten weeks.

Some 18 flights are planned to restore skills: one familiarization, six formation, two by instruments, one performance-graded and eight solo to practice elements of advanced aerobatic maneuvers. Later specialized flights—ten of them—are distributed according to the category of pilots as follows: for air-supremacy fighters (F-15), six for advanced aerobatic maneuvers and four for practicing elements of air combat; for ground-attack aircraft (A-10) and tactical fighters (F-111), four for navigation at very low altitude, five to practice executing strikes against ground targets with simple and complex types of maneuvers, and one in formation flying in a wing at very low altitude; for the pilots of multirole aircraft (F-16, A-7), three in the practice zone rehearsing piloting techniques and seven executing strikes against ground targets.

4. The pilots are sent **to the course for mastering combat aircraft** for up to three weeks. The commanders of the training squadrons may alter the program and sequence of flights or elements of them proceeding from the local conditions, the capabilities of the subunits and individual features of the pilots or crews.

Over that time the pilots or crews complete 100 hours of theoretical training and carry out from four to seven flights in combat units that are part of the Tactical Air Command. There can be from one to four training air squadrons in each TFAW equipped with combat aircraft. The number of flights depends on the type of aircraft: four on the A-10, for example, or five on the F/RF-4 and F-16, six on the F-15 and seven on the F-111.

5. **Practicing methods of combat application** is considered to be the principal course of training for the pilots. They complete about 200 hours of theoretical classes over that time and make an average of 54 flights, spending up to 75 hours in the air (depending on the type of aircraft). The principal sections of the course are: general flight training; tactical methods of executing strikes against ground targets and attacks on airborne targets; performance of aerial reconnaissance (for reconnaissance pilots only); and, combat application of EW aircraft (only for crews of this type of aircraft). Each pilot who comes into the squadron, regardless of his experience, is permitted to make flights only in good weather with a

ceiling of no less than 300 meters and horizontal visibility of no less than 5,500 meters. The sequence of performance of the exercises is strictly observed when assimilating this program, and each subsequent flight is made against a constantly more complicated tactical background. The table presents as an example a training program consisting of ten sections for a pilot on the F-16 tactical fighter.

Program section		including:			
		with instructor		solo	
	Total flights	Flights	Elements practiced	Flights	Elements practiced
1	2	3	4	5	6
Mastery of maneuvers used in aerial battle	6	1	attack of airborne target	1	attack of airborne target
		1	methods of disengagement from attack	1	methods of disengagement from attack
		1	all methods of attack of airborne target	1	methods of escaping attack
Interception of airborne enemy	1	1	search, identification and attack of target alone and in pair		
Mastery of elements of aerial battle	3	2	battle in pair against solo fighters and pair, repulsion of attack, disengagement	1	battle against pair (pilots unacquainted)
Use of air-to-air weaponry	2	1	practice launch of AIM-9L missile	1	practice firing of cannon against aerial target
Tactical devices for waging aerial battle	3	1	pair fighting against four enemy aircraft	1	pair against pair; defensive battle
				1	four against six MiG-23s
Methods of employing nuclear weapons	3	1	all methods of visual aiming		
		1	all methods using on-board radar	1	two practice bombings—two bombs visually, two using on-board radar
Methods of employing air-to-ground weapons	6	1	practice bombings; 12 bombs on each sortie		
		1	from horizontal flight		
		1	from dive; after climb and dive		
		1	reaching target area and carrying out strike (with enemy resistance)	1	reaching target area and carrying out strike (with enemy resistance)
		1	performance grading: bombing of two targets (Mk-82n bombs)		
Night strike against ground targets	2	1	aerial navigation at medium altitudes; bombing	1	bombing illuminated target with weak air defense
Use of Maverick air-to-ground missiles	2	1	methods of employing missiles singly and in pair	1	practice launch of Maverick missile with strong air defenses

Program section		including:			
		with instructor		solo	
	Total flights	Flights	Elements practiced	Flights	Elements practiced
Mastery of tactical devices for the performance of combat missions	4		instructor as wingman; all flights against background of complex radar environment with strong enemy air defense resistance	1	leading pair to fulfillment of battlefield air-interdiction mission (Rockeye bombs)
				1	leading pair for direct air support (Mk-82n bombs)
				1	leading pair as part of a flight for interdiction of area of combat operations (Mk-84 bombs)
				1	leading pair to suppress enemy air defenses; four aircraft (Mk-82n bombs)
Performance-graded flights	3		trainee himself plans flights and prepares wingman (instructor); conditions: ratio of forces 2:1 in enemy favor; intercept from ground mandatory; a "shot-down" aircraft immediately leaves the area of combat operations	1	as part of group of four aircraft; strike against airfield (Mk-84 bombs)
				1	same
			Monitoring: video recorder and gun camera	1	leading four aircraft; strike against airfield air defenses; enemy attacks with larger (double) forces
Total	35	17	Total	18	

The pilot (or weapons officer) should, aside from the performance-graded flights, pass a written test on his knowledge of the on-board weaponry, study the flight area and the location of targets on the practice range and receive a positive certification from the squadron commander. The pilot (or weapons officer) receives the status of combat-ready with the successful completion of the tests and completion of the course of combat application. His conventional service in a line unit then begins (possibly the same one in which he had completed his training).

The training of a pilot in U.S. Air Force tactical aviation to the level of combat-ready thus takes 15-16 months, in the course of which he makes 230 flights with total flying time of 313 hours; 61 of those flights—85 hours—are on a combat aircraft.

6. Further improvements of flight skills are made by the fliers in the line units, and moreover in most intensive fashion and in combination with participation in exercises. The pilot should have no less than 120 hours of flying time on a combat aircraft and 60 hours in a simulator over the first half year he is in the unit, as well as pass written exams on armaments, matériel, tactics and other disciplines.

More than 60 percent of the pilots in the U.S. Air Force (and 25 percent of the officers in other branches of the armed forces) are currently the graduates of prestigious universities and other higher educational institutions whose tuitions are very high. About 10 percent of the fliers completed the Air Force Academy, and roughly 30 percent are former NCOs, DoD employees or officer pilots who have returned to service.

The most typical features of study in the flight cadres of the U.S. Air Force are thus careful and continuously improved professional selection of young officers on a competitive basis, almost mandatory higher education receive before going to flight school, solid technical knowledge, impeccable health, the maximum occupation of the student during the working day, the comprehensive nature of each flight and independence in planning it, friendly mutual relations between instructor and student (with a quantitative ratio of 1-2:1), mandatory fulfillment of the training plan right up to flights on

Sundays, the active utilization of simulators and the ever-growing use of personal computers for theoretical and practical studies.

U.S. Air Force Airlift, Preparations for Desert Storm Described

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[Article by Candidate of Technical Sciences V. Dubrov under the rubric "Aviation in Local Conflicts": "In Search of New Tactics"]

[Text] *The series of articles titled "In Search of New Tactics" was still being prepared for publication when a new military conflict with the participation of the United States broke out in the Persian Gulf. The official grounds for it was the occupation of Kuwait by Iraqi troops.*

Despite the participation of troops from a number of other countries, including Arab ones, in the conflict under the flag of the United Nations, a reaction by the Americans to the threat to the interests of their oil companies can be discerned here overall. The Pentagon was not concealing beforehand, however, that American military might will be oriented in the future toward countering "regional threats to U.S. interests" rather than the hypothetical possibility of "war in Europe," as had been the case before.

Aviation played a special role in the combat operations, making use of the experience accumulated in previous local wars as well as employing a number of methods of waging armed struggle that have no prior analogues.

At the request of our readers, we are continuing to publish materials on the further search for new tactics in the combat operations of aviation. We propose to discuss the operations that have received the names of Desert Shield, Desert Storm and Desert Sword using the example of the war in the Persian Gulf. We offer here the first article in that series.

(Based on materials in the foreign press.)

1. Operation Desert Shield

The operation to prepare the multinational forces (MNF) for war against the occupiers began in August of 1990—the moment of the occupation of Kuwait by Iraq. It lasted until January of 1991, and received the code name of Desert Shield. During this period the U.S. Air Force was shipping troops to the area of the future conflict, as well as training personnel with an orientation toward the achievement of a specific goal—the freeing of the occupied territory of Iraqi troops.

The MNF command supervised the aerial shipments and disposition of military matériel in the theater of operations during the course of the operation.

The task of transporting personnel and cargo to the theater was performed by the Military Airlift Command (MAC), using C-141 Starlifter and C-5 Galaxy strategic transport aircraft, as well as C-130 cargo planes and KC-10 Extender tankers. MAC allocated up to 90 percent of its own forces—476 aircraft—to the operation. About 120 C-9, C-10 and Boeing 707 passenger and transport aircraft from the reserve civil air fleet were also involved in the shipments.

A quite sharp increase in the activity of MAC operations compared to prior local wars and exercises was characteristic of this operation. The average monthly flying time for the crews tripled and reached 300 hours. The crew of a C-5 aircraft, numbering nine men (of whom three were pilots), made up to 20 runs to the Near East during the operation, with some of them lasting up to 30 hours. They were ready for a return flight in 12-14 hours. The routing was 11,500-15,000 km [kilometers] long, and was covered in an average of 20-25 hours. Intermediate stops were made in the Azores Islands, Germany and Spain, where the crews were changed where necessary. The refueling of these transports was performed in the air by KC-10 tanker aircraft.

According to the results of the operation, efforts were distributed as follows: the C-141 transport aircraft (cargo capacity of 34 tons) made 5,440 runs over 162 days, the C-5s (capacity about 80 tons) made 2,600, civil aircraft made 1,900 and C-130s and KC-10s made 1,000. The number of personnel transported was 385,000, with the mass of the cargo delivered 320,000 tons. Some 1,538 flights by C-141 aircraft and 269 by C-5s were required to redeploy one standard division with a full set of armaments. The reliability of the equipment was 85-90 percent (one aircraft, a C-5, crashed when landing at an airfield in Germany) with an overall volume of air shipment of 5.3 billion ton-km in this operation. The loss of personnel was 105 people who died through a failure to observe safety precautions.

It was no secret that the principal wager was being placed on aviation. The ground offensive was to begin after the completion of the aerial operation and the winning of air supremacy. The three-fold numerical advantage in aircraft (with clear-cut centralized command and control of them and streamlined combat support) was considered to be a guarantee of the achievement of complete control of the airspace not only over Kuwait, but over Iraq as well. One of the chief problems was organizing the interaction between the aviation of the allies and U.S. Air Force, army and naval aviation.

The combat operations were planned to be implemented in two stages—before and after the transition to an offensive by the ground troops. Aviation was to perform two "classic" missions in the first of them: win supremacy in the air and perform battlefield air interdiction; in the second, it was to provide close air and fire support for the attacking troops.

The plan for waging combat operations was composed with a regard for strategic reconnaissance data from the U-2 and TR-1 aircraft, as well as space reconnaissance from the KH-11, Lacrosse and Magnum satellites, among others, equipped with cameras with a high resolution capacity (specific objects one meter apart can be distinguished in the photos).

Operational information came in from tactical reconnaissance performed by RF-4C aircraft and detachments of drone aircraft that provided data in real time. E-3A Sentry (Air Force) and E-2C Hawkeye (Marines) aircraft, on around-the-clock patrol shifts in the air and monitoring the area of proposed combat operations, were also included in the system of reconnaissance.

Subunits of combat aircraft arrived in the theater of operations from the United States, England, France, Italy, Canada and other countries according to a stipulated schedule. The number of aircraft was to be brought to roughly 2,000 (according to intelligence data, Iraq had 600-700 combat aircraft) in accordance with the assigned (three-fold) superiority.

The conflict in the Persian Gulf was to be distinguished from past local wars by the increased use of the latest aviation hardware. The combat capabilities of the manned TR-1 high-altitude reconnaissance aircraft, the E-3A Sentry airborne command post/long-range radar detection aircraft, EF-111 EW aircraft (used before only in the raid on Libya), the Tornado fighter-bomber, the F-15E multirole aircraft, the F-117A Stealth tactical aircraft, the F/A-18 naval ground-attack/fighter aircraft, the A-10 assault aircraft, the Pioneer remote-piloted aircraft and the E-8 "battlefield" electronic surveillance/target-designation aircraft were all to be checked out for the first time under conditions of real resistance from enemy air defenses.

The list of the types of new armaments is also impressive: ship- and submarine-launched Tomahawk cruise missiles, SLAM long-range guided missiles, JP233 cluster bombs to disable airfield runways and ALARM antiradar missiles.

The new aviation hardware was supplemented by models that had already been tested "for durability" in Vietnam and in the Near East. They included the B-52 strategic bomber, the U-2 reconnaissance aircraft, the F-111 fighter-bomber, F-15 and F-16 fighters, the E-2C Hawkeye airborne command post/long-range radar detection system, A-6 and A-7 naval attack aircraft and the F-4C Phantom EW aircraft. It is characteristic that various models of the B-52 and F-4, "veterans" of local wars that had entered service with the U.S. Air Force at the end of the 1950s, continue to serve in good working order, in the opinion of experts.

The new aviation hardware and high-precision weaponry forced the flight personnel to achieve maximum combat effectiveness. The methods of training for the combat operations that were selected were distinguished from those practiced "on the range" first and foremost by their singlemindedness. The specific features of the area of the proposed struggle, the enemy—whose condition was ascertained and clarified by all types of reconnaissance—and the substance of the principal combat missions envisaged by the plan of operations were all known. The personnel knew who they were fighting, and it only remained to clarify how to fight.

A method based on the reproduction of an active enemy under natural conditions began to be practiced in the American Air Force after the war in Vietnam. They were able to create a system of air defense of a "likely enemy," consisting of the search and fire equipment he possessed, at the Nellis test range. Two "aggressor" squadrons were assigned there and equipped with F-5 fighters playing the role of MiG-21s, manned by experienced pilots imitating enemy tactics. The personnel of line units took part (once every 18 months) in Red Flag exercises at this test range.

The personnel of the 4440th Training Group, which had completed the Red Flag exercises, was sent to Saudi Arabia at the start of Desert Shield. Changes were made there in the program of exercises in conjunction with the MNF headquarters that were dictated by the requirements of the specific situation.

Ground targets on the practice range, as well as the lethal fire zones of air-defense systems, were thoroughly modified in accordance with those changes. Mock-ups of several Iraqi airfields, munitions dumps, bunkers, oil storage tanks, bridges, surface-to-surface missile positions and air-defense missile systems (actual size) appeared there after a month and a half of work. The simulated radar stations emitted signals on the frequencies of the future enemy. A warning was issued automatically on entry into the zone of detection and tracking ("lock-on") of enemy radar, as well as on the launch of missiles, after the interception (receipt) of those signals by on-board warning gear. The evasive maneuvers (protective measures) employed were recorded by video cameras installed at the boundaries of the zones. The decisions made by the pilots to overcome the air defenses and their practical realization were demonstrated and evaluated at post-flight critique and analysis.

An actual French-produced Mirage F-1 aircraft acted the role of "airborne aggressor" (analogous craft had earlier been procured by Iraq and were in its Air Forces). Methods of waging aerial battle at medium ranges under nighttime conditions were practiced for the first time after an eight-year interruption. The problem of supporting strike groups of tactical and carrier-based aviation with fighters evoked particular concern from the command (it is set forth in detail in the article "Group Aerial Battle" in AVIATSIYA I KOSMONAVTIKA, 1991, No. 8). They were not able to find a variation of the classical 2:3 ratio in the course of practical search, however. The composition of the fighter-support detail contradicted the principle of economy in the expenditure of forces as before.

Particular importance in the Desert Flag exercises (the temporary name of the Red Flag exercises) was assigned to working out the optimal composition of the strike groups, structuring the combat formations and transforming them in the course of a raid. The "weapons principle" that had been worked out in past local wars as taken as the foundation—the lead groups were made up of "breakthrough" aircraft with antiradar missiles, and following behind were aircraft with guided bombs or missiles operating against selected targets and bombers in conventional configurations, with non-guided weapons. The possibility of organizing operational interaction among the strike groups and combat helicopters performing special auxiliary assignments was considered for the first time.

The tactical decisions made in these exercises were also evaluated with demonstrations of cases of aircraft "shootdowns." The altitude, speed and maneuvers of the aircraft were recorded by a recording device, and a hit on it by an anti-aircraft shell or missile was noted by a bright mark on the display. The vulnerability of the method of waging battle (or group attack), tactical device or battle formation that had been selected was established by the number of losses sustained. Subunits that successfully completed the Desert Flag program were considered ready to wage combat operations in the Persian Gulf region.

(Continuation to follow)

Usefulness of 'Meteor' Weather Satellites Detailed

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[Article by V. Kalinkin and V. Glebov under the rubric "Space Science for the National Economy": "The 'Meteor'—The Meteorologists' Helper"]

[Text] Weather forecasters have always faced an extremely difficult task—ensuring the reliable forecast of the weather. Predicting weather for a day, say, requires gathering information from an area with a radius of about 3,000 km [kilometers] (roughly 28 million km^2), and for a few days it must be gathered from half the Earth's surface, with the regular receipt of meteorological reports on a global scale for a longer period of time. This task cannot be performed by any country in the world, however, using only ground-based meteorological equipment.

Space meteorology has opened up fundamentally new opportunities for weather specialists to gather meteorological information. A satellite collects dozens of times more information in one orbit than ground-based weather stations do in the same amount of time.

The Meteor space weather system has been in operation in our country for more than 20 years to provide hydrometeorological support for the national economy, improve the technology of space weather observations and serve the interests of science. It currently includes specialized second-generation Meteor-2 satellites and the more advanced Meteor-3. These satellites are placed into orbits close to circular, with an average altitude of 950 and 1,200 km respectively. The inclination of the orbital planes relative to the Earth's equator is 81-83°. The Meteor-3 has a mass of about 2.2 tons and a maximum size of 12 meters with deployed solar arrays. Its active existence lasts two years; the Meteor-2 lasts one year.

The main task of the space weather system is the gathering of global information in the visible and infrared spectrums.

There are extensive regions on our planet where weather information comes in extremely rarely to ground weather stations. These include the polar regions and deserts, high mountains, oceans etc.

Only a satellite system makes it possible to fill in the gaps and accomplish tasks of hydrometeorological support whose performance is often simply inconceivable using traditional means and methods, due to the enormous expenditures of time and money.

The space photographs encompass from tens of thousands to millions of square kilometers at once. The Meteor satellites are also able to make real-time direct transmissions from orbit by television channels. They provide an opportunity for all interested weather services, with the aid of simple equipment, to receive pictures from the area of their activity directly from the satellites as they pass over.

Two or three satellites whose orbital planes are dispersed along the longitude of an ascending node by roughly 60° are functioning continuously in the Meteor system to provide daily global and local weather observations.

This system is able to support the receipt of televised images of the illuminated side of the Earth no less often than twice a day, and images in the infrared spectrum at any time of day no less than four times. The satellite can gather weather information from roughly 20 percent of the Earth's territory in one orbit, while a system with two or three satellites can collect this information twice in the course of a day from 70-80 percent of the surface and transmit it to Earth, both in the mode of immediate transmission in real time and in the mode of recording the information with subsequent transmission to regional receiving and data-processing centers located in Moscow, Novosibirsk, Khabarovsk and Tashkent.

Scanning television systems have been installed on the Meteor-2 and Meteor-3 systems, operating in the visible band of the spectrum with a resolution of 2.5 and 1 km respectively across a field of view from 2,500 to 3,200 km, along with scanning infrared radiometers to obtain thermal images and construct global photo-mosaics and temperature maps of the Earth's surface with a resolution of 8 and 3 km respectively across a field of view from 2,100 to 2,700 km. They also have multichannel radiometers to obtain information on the vertical distribution of temperatures in the atmosphere, infrared spectrometers, apparatus for radiation measurements in near-Earth space and apparatus for performing scientific—including international—experiments. A spectrometer/interferometer created by scientists in the USSR and the GDR was installed on the Meteor in 1976-79, and high-precision measurements of the spectrum of emissions in the "Earth's surface—atmosphere" system were obtained with the aid of it.

Space meteorology has made it possible to raise fundamentally the quality of analysis and forecasting of weather-forming processes over the oceans and difficult-to-access regions on land, which occupy fourth fifths of the Earth's surface. They are also making clarifications in weather maps for populated regions as well.

The opportunity has appeared to make a detailed study of the distribution of clouds over the Earth's surface, to determine with greater precision the position, activeness and direction of movement of cyclones and atmospheric fronts, to track the positions of precipitation and evaluate the effects of terrain on the formation of clouds.

The Meteor satellites have become an irreplaceable and effective tool for studying the ice situation over the world's seas and oceans. Television pictures from space make it possible to determine the cohesion of the ice, ascertain major channels, clearings and water openings and to single out accumulations of ice cakes. The use of satellite weather data when running ships in the Arctic provides our country with an annual savings of 40-50 million rubles. This information makes it possible to determine the temperature and assess the height of the leading edges of clouds, including on the dark side of the Earth, with a precision of up to one kilometer, which is especially important for aviation.

Satellite weather information has become mandatory in pre-flight preparation of aircraft crews and for the compilation of forecast maps of dangerous weather phenomena, especially along routes running over oceans and mountainous, polar and desert regions. Optimal headings for ships and aircraft—for which storm warnings are regularly issued—are selected according to the space forecasts. The space pictures help hydrologists analyze ice phenomena in lakes and major rivers and orient the river fleet correctly relative to the times for the start and end of navigation.

Meteorological data on the snow cover makes it possible to predict flood waters, which is extremely important for the builders of railroad trunk lines, dams and bridges and the inhabitants of regions closely adjoining rivers and lakes.

The use of satellite meteorological information makes it possible to ensure the trustworthiness of weather forecasts for three days by more than 80 percent.

The overall economic impact from the use of meteorological information is more than 1.2 billion rubles a year.

The satellite data, aside from its principal—weather—purpose, have also become a source of valuable information for many sectors of the national economy—hydrology, oceanology, climatology, geology, agriculture, forestry and urban development, among others.

Command and control of objects in space, including the Meteors, is accomplished by the personnel of space units using the equipment of ground control systems, including the Flight Control Center (TsUP), Ballistic Center, control equipment located at command and measurement complexes on the territory of our country, technical equipment and communications and data-transmission channels.

The control process is a continuous one for a Meteor satellite. It is shaped by the performance of a number of specific tasks, of which the principal ones are: the formulation and issue of command-program information to control the operation of the meteorological system and supporting systems (on-board radio, systems for orientation and stabilization, power supply, thermal regulation and many others); gathering, processing, analysis, documenting and depiction of telemetric information; diagnostics and forecasting of the state of the satellites, measurement of the parameters of movement, calculations of the elements of orbits and target designations for ground command and measuring equipment; and, planning of the operations of all satellite and ground systems.

The TsUP is a most important link in the ground command and control system, and it has a powerful information and computer system based on highly productive and specialized computers with a total productivity of more than 10 million operations per second with general, systemwide and special software.

The TsUP formulates the command and program information for each satellite and transmits to the control equipment of the command and measurement complexes on automated channels of exchange among machines, which provide for their transmission to the Meteors. The receipt of telemetric information and its preliminary processing and transmission along communications channels to the TsUP, as well as radio monitoring of the parameters of the orbit, are also accomplished in these sessions.

Changes in Use of Space Assets Can Reveal Military Intentions, Plans

92UM0366O Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) pp 39-40

[Article by Colonel V. Romanov under the rubric "Space Science: Military Aspects": "Intentions on Earth By the Activeness in Space"]

[Text] An analysis of the evolution of methods of waging modern combat operations by the U.S. armed forces shows that their increased effectiveness is largely conditioned by the employment of space technology. It should be recalled that data obtained with the aid of space hardware was also used for military purposes in the 1960s—at the dawn of the development of practical space science—but by and large at the strategic level. The circle of tasks that are being realized with the aid of that data has been expanding to the extent of improvements in satellites.

The local wars of recent years with the participation of the U.S. armed forces confirm the trend of the ever greater utilization of space hardware to support troop operations. This is especially instructive from the standpoint of the conflict in the Persian Gulf region, which, in the estimation of American specialists, became the "first war of the space era."

It would be expedient, under the conditions of the ever closer integration of military space activity with the activity of armed forces overall, to address the typical features of it that could be utilized as revealing indications of changes in the state of ground groupings.

One such trait is the change in the ballistic structure of the orbital groupings of space vehicles, pertaining first and foremost to the system of visual reconnaissance. This type of space armament reacts quite flexibly to changes in the military-political climate and the state of troops in this or that part of the globe.

The fact that groups of space reconnaissance vehicles are arranged from a calculation of the necessity of viewing specific sectors of the earth's surface with a certain discreteness, insofar as various portions of the earth are passed over with varying periodicity due to the laws of ballistics (the polar regions are covered more often than equatorial ones), is a well-known one. A permanently operating group of space reconnaissance vehicles, therefore, carries out the observation of assigned targets (regions) at certain time intervals. The frequency of its observations can be increased to the extent of changes in the operational climate through the more frequent overflight of a space platform over the territory being monitored. Such an augmentation of capabilities could be accomplished either via the launch of additional space vehicles for a given type of reconnaissance (during the conflict in the Falkland Islands, for example, or the Arab-Israeli war) or through changes in the ballistic structure of the group already functioning in orbit (as was done in preparing for the air strike against targets in Libya).

An analysis of the organization of combat operations in the Persian Gulf has shown that the decision to augment the capabilities of the orbiting group of spacecraft with Keyhole (KH-11, KH-12) electro-optic surveillance was made by the space command of the U.S. armed forces long before the start of combat operations by the ground groupings of the multinational forces (MNF). Both of the variations for augmenting capabilities were realized in practice therein—correction of the orbits of the space platforms was carried out, and the composition of the orbital group was increased (true, not through the launch of new spacecraft, but rather via the operational utilization of vehicles in the orbital reserve). If one takes into account that the augmentation of reconnaissance capabilities in one section, as a rule, takes place to the detriment of reconnaissance in other sectors, this action could be considered one of the traits indicating the start of advance preparations by the MNF for the Desert Storm operation.

The group of DMSD weather-support spacecraft was re-arranged in analogous fashion.

A shift in the operating modes of special on-board gear is another typical feature of the functioning of space information vehicles that could be categorized as an indication of changes in the activity of armed forces.

The U.S. electronic reconnaissance craft of the Aquacade and Shalle types that are intended for monitoring the changes in the electronic environment and the interception of information from radio and radio-relay communications and television channels, for example, observe the earth's surface in an eight-hour daily functional mode in their everyday activity. They were converted to around-the-clock operation before the start of the conflict, making it possible to detect the activity of air-defense radar in the southern part of Iraq and track the dispositions of Iraqi Army command posts and the conversations of tank crews.

An analysis of intercepted radio traffic and combat orders, in the aggregate with data from visual reconnaissance, ensured the receipt of a trustworthy picture of the scope of Iraqi aggression against Kuwait and made it possible to designate targets for air strikes in the impending air offensive operations. The augmentation of the capabilities of space electronic reconnaissance could consequently be included among indications revealing the process of preparing troops for active operations, and since the areas of observation of the satellites have limited dimensions, it is clearly possible to speak also of the area of possible increase in that activity.

The quite strong interconnection of the nature of the operations of satellite communications systems with the actions of armed forces makes it possible to uncover even elements of direct preparation for active combat operations. A ban on the use of some support networks of satellite communications (the Autovon satellite communications system, for example, in the interests of the interaction of formations and units in regions directly adjoining the area of combat operations) was also instituted with the switchover to wireline command and control roughly five hours before the start of the ground phase of the Desert Storm operation.

Even a cursory survey of the revealing indications thus shows how essential surveillance of military space activity is to support the performance of purely "Earth" missions. It is all the more topical with the coming, as was noted above, of "wars of the space era." If we take into account what the military leadership of the United States is investing in this concept and the waging of broad-scale combat operations in space and from space, then the task of surveillance of the situation in that potential theater of operations gains vitally important significance for the defense of our country. The presence of a modern system of surveillance of the space situation will make possible the timely informing of the state leadership of the intentions of an opposing side in order to take suitable reciprocal actions within the framework of the defensive nature of Soviet military doctrine. That is why the system of monitoring the space situation must be improved even against a background of cutbacks in the appropriations for the development of the armed forces.

Survey of Space Military Activity in Relation to International Law

92UM0366P Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) pp 40-41

[Article by Candidate of Legal Sciences Colonel I. Kotlyarov and Candidate of Technical Sciences Colonel V. Frontov under the rubric "Space and Law": "Under the Aegis of the United Nations"]

[Text] Space activity has made it necessary to establish both a legal regimen for outer space itself and the legal regulation of its research and utilization. This has been reflected in a whole series of issues. The Treaty on the Principles of the Activity of Nations in Researching and Utilizing Outer Space, including the moon and other heavenly bodies, that was concluded in 1967 at the initiative of the USSR occupies a special place among them.

What should space activity be understood to mean? First and foremost the performance of various operations on earth in connection with the launch of a spacecraft, the placement of man-made items into near-Earth orbits, interplanetary space, the surface of the moon and other heavenly bodies, as well as the actions of people and the operation of automated apparatus and instruments on board spacecraft, including the entry of people and the placement of instruments into open space or onto the surface of heavenly bodies.

It must be said that international agreements defining the altitude boundaries of outer space are currently lacking. An ever greater number of nations, however, favors counting it as starting at an altitude of 100-110 km [kilometers] from the earth's surface.

Outer space, including the moon and other heavenly bodies, is not subject to national appropriation, either via the proclamation of sovereignty over them or via occupation or other means.

The principles and norms of international space law are made more concrete in the regulatory legal-document relations among nations. They are developed in the agreement to rescue cosmonauts, the return of cosmonauts and craft launched into space (1968) and the Convention on International Responsibility for Damages Caused by Spacecraft (1972). The latter in particular stipulates that the state bears absolute responsibility in the event of damages caused on the surface of the Earth, to aircraft in flight or to a space object.

The Convention on the Registration of Objects Launched into Outer Space (1976) obligates the state of registration to send to the UN Secretary General information on each space object placed onto its register (the name of the launching state or states, the designation or recording number of the object, the date, the territory or place of launch, the basic parameters of the orbit and the general purpose of the space object), as well as to inform him of any objects that are no longer in orbit around the earth. This register is handled by the USSR Academy of Sciences in the Soviet Union.

The international legal regulation of space radio communications is exercised on the basis of the International Radio Communications Convention (1982, Nairobi) and the Radio Communications Procedures (1979, Geneva).

The basic set of problems arising on an international scale in connection with the utilization of space radio communications gear is under the purview of the International Telecommunication Union (ITU), whose functions include the distribution of frequency bands for radio-electronic equipment, coordination of the activity of nations and organizations aimed at raising the effectiveness of the utilization of radio-frequency resources and ensuring the interference-free operation of radio equipment.

The 41st Session of the General Assembly of the UN in 1986 adopted the "Principles Pertaining to Remote Probing of the Earth From Space." The term "remote probing" signifies soundings of the earth's surface from space using the properties of electromagnetic waves emitted, reflected or dispersed by probing objects for the purpose of improving the utilization of natural resources, improving land use on earth or protecting the environment. This activity may be carried out without the consent of the states whose territory is being sounded, but it should not be detrimental to the rights or interests of those countries.

Questions of restricting the military utilization of space are gaining particular significance under contemporary conditions. Effective mechanisms prohibiting the use of advanced technologies and the performance of research in space in the interests of creating new types of space weaponry should be found within the framework of international space law.

The Treaty Prohibiting the Testing of Nuclear Weapons in the Atmosphere, Outer Space and Underwater (1963) plays a most important role among international agreements.

The provisions of the treaty, for example, prohibit testing in space an X-ray laser and other new types of weaponry using the energy of a nuclear explosion.

The Convention to Ban Military or Any Hostile Use of Means of Affecting the Environment (1977) contains prohibitions on the use of means that could be utilized "for altering—via the intentional control of natural processes—the dynamics, composition or structure of the earth, including its biosphere, lithosphere, hydrosphere and atmosphere, or outer space."

There also exist bilateral agreement between the USSR and the United States restricting various types of military activity in space.

The Agreement on Steps to Reduce the Danger of a Nuclear War (1971) envisages the immediate mutual notification of the appearance of jamming of early warning systems or the corresponding communications gear. The necessity of banning any interference whatsoever with the normal functioning of that equipment was thus indirectly acknowledged.

The Treaty Restricting Anti-Missile Systems (1972) contains mutual obligations "not to create, not to test and not to deploy systems or components of ship-, air- and space-based or ground-mobile anti-missile defense."

This treaty bans in particular the development, testing and deployment in space of systems and components of anti-missile defense based on new principles of physics.

The Agreement on Steps to Improve Lines of Direct Communication (1972) envisages the creation of two additional communications channels between the USSR and the United States using satellite systems. "Each of the parties," moreover, "affirms its intention to take all possible steps to ensure continuous and reliable operation of the channels..."

This provision bans the creation of any interference whatsoever in space and earth radio equipment, as was also mentioned in the agreement on lines of direct communication.

The international-law permissions and prohibitions in force in the military realm are presented in the list below.

We note in conclusion that the development of a system of reliable international treaties and agreements subject to monitoring and able to rule out the use of force in space and from space against the earth, along with the adoption of effective political and legal measures to avert the militarization of space, are topical tasks whose fastest possible resolution affects the vital interests not only of the states possessing space-technology potential, but also the whole international community as well. By eliminating the possibility of the spread of the arms race into outer space, it will be possible not only to make a substantial contribution to reinforcing international security and reducing the levels of military confrontation among nations with differing social orders and the most major military and political groupings, but also to open up real prospects for the transformation of space into an arena for the broad creative collaboration of all states for the good of the progress of civilization. Making outer space a realm of intelligent activity that meets the highest ideals to the attainment of which the best human minds of all peoples and eras are summoned, in other words, is possible only provided that the principles of the "star world" are affirmed.

Not only the future of mankind on the planet Earth, but also the fate of civilization in the Universe depend on which trends gain the upper hand in the activity of nations in researching and utilizing outer space.

Types of Military Activity in Space

NOT STIPULATED by international law:

- 1. Creation, testing and deployment of anti-satellite weapons in space.
- 2. Performance of applied-military space experimental research, with the exception of testing of components of anti-missile systems and means of affecting the environment.
- 3. Creation and testing in space of electro-optic and radio-electronic jamming.

PERMITTED by international law:

- 1. Utilization of surveillance satellites and space-based remote sensors for monitoring purposes.
- 2. Utilization of communications systems and navigational and meteorological means.
- 3. Utilization of military personnel for scientific-research purposes..

INCOMPATIBLE with international law:

- 1. Placement of nuclear weapons and other types of weapons of mass destruction in orbit around the Earth, on heavenly bodies or in orbits around such bodies.
- 2. Testing of nuclear weapons in outer space.
- 3. Placement of military bases and performance of military tests or maneuvers on heavenly bodies or in orbits around them.
- 4. Hostile actions or use of force on heavenly bodies or in orbits around them.
- 5. Development, testing or deployment of space-based anti-missile systems or components of them.
- 6. Military or hostile utilization of means of affecting the natural environment in outer space.
- 7. Creation of interference with space-based remote sensors, as well as some radio lines for space communications.

Growing Hazards of Orbiting Space Debris Addressed

92UM0366Q Moscow AVIATSIYA I KOSMONAVTIKA in Russian No 9, Sep 91 (signed to press 19 Sep 91) pp 42-43

[Article by Candidate of Physio-Mathematical Sciences V. Dolgikh and Candidate of Technical Sciences V. Odelevskiy under the rubric "Problems of Space Science": "Is Space Junk Dangerous?"]

[Text] **"Man should understand that he is not a random natural phenomenon, independent of nature and acting freely."—V.I. Vernadskiy.**

Some now understand that it is becoming crowded in the "boundless expanses" of space. Flights there entail an ever-increasing risk. A technical policy without regard for the consequences and a reluctance to go in for "extra" expenditures in the creation of launch vehicles and space vehicles have led to the fact that an inconceivable quantity of man-made debris—man-made particles from a micron to meters in size—is now flying around the Earth in all kinds of orbits. It poses almost no danger to the inhabitants of Earth since, descending with time, it burns up in the atmosphere, with rare exceptions. The situation is quite different in Earth orbits, however...

The increasing activity in outer space by many countries and consortiums is leading to its intensive pollution with objects of artificial origin. Their total mass, according to estimates by American scientists, has now surpassed 3,000 tons. Existing man-made pollution thus poses a very real danger to space vehicles. Here are some examples. Cosmonauts in the course of a flight on the Salyut-7 orbital station in July of 1983 detected a cavity about four mm [millimeters] in diameter on the outside glass of one of the viewing ports, formed by a blow from a man-made particle. At the same time, during a flight by the Challenger space shuttle, a crater 2.5 cm [centimeters] in size appeared on its front window. The cause was a collision with a particle just 0.2 mm in diameter. About 2,000 holes and cavities with diameters of 40-300 μm [microns] were detected on insulation panels and aluminum flaps removed from the Solar Max satellite. This damage, including from meteor hits, took shape over four and a half years.

Outer space is polluted with man-made particles of various origins. The smallest of them (1-10 μm) consist of aluminum oxides. These particles are formed as the result of the operation of the solid-fuel booster units of space vehicles, wherein they can be up to 40 percent of the mass of the solid fuel ejected. Some 5×10^{16} particles are formed, for example, in the operation of an American booster of the MARS type, used to alter the parameters of spacecraft orbits. Each of them is capable of making a pit or breaking through an opening 10-300 μm in diameter.

Larger particles are formed as the result of the flaking of paint and thermal coatings from space objects under the effects of microscopic particles of aluminum oxides, oxygen atoms or solar radiation. Even larger ones are obtained when particles able to damage the protective screen or the pressure-hull wall hit space vehicles and fragments of them. A multitude of quite large elements are formed when the pyrotechnics of a spacecraft are actuated, in the performance of various experiments or the elimination of satellites by destruct mechanisms. Space is also cluttered by the spent last stages of launch vehicles and spacecraft that have ended their active existence. Only five percent of all 7,000 space objects being tracked by the North American Air Defense system (NORAD) are functioning satellites, with all the rest space debris.

Debris and particles are encountered and destroyed in the process of spacecraft movement. This leads to a further increase in the quantity of fragments and their overall mass. The overall mass of secondary particles broken off the surface in the effects of small particles on aluminum parts can exceed the initial mass by 200-1,000 times, and even more if they hit the solar arrays. It is very important to note that some of them alter the plane of their orbit with time and, in the process of subsequent collisions, are spread over a year or a year and a half along an ellipsoid that can encircle the entire globe. This leads to relative velocities in a head-on encounter that can exceed 15 km/sec [kilometers/second]. The greatest quantity of secondary fragments will virtually always be at the altitude of the collision. If it occurs at altitudes of under 600 km, the small fragments "settle" toward the Earth quite fast, slowing in the atmosphere. This effect leads to the fact that the lower the orbit of a satellite, the less the likelihood of a collision with it.

The consequences of a hit depend on many factors. A man-made particle, for example, is capable of punching through an aluminum wall 10 times thicker than its own diameter at collision speeds on the order of 10 km/sec. The typical size of the damage when it hits glass can exceed the dimensions of the particle by 20-100 times.

According to statistical data, about 3,870 observable fragments had been formed as the result of 131 instances of the deliberate or accidental destruction of a space vehicle, and existed in outer space, by June of 1988. It is known that half of them are of American origin, and 37 percent Soviet. More than two thirds of all the destroyed satellites are moreover ours, although they were destroyed at lower altitudes and their remnants enter the atmosphere more quickly. The overall "contribution" of the United States to the general clutter of the near-Earth space is thus greater than that of the USSR. The formation of small secondary fragments, aside from the special destruction of satellites, is one of the factors leading to an increase in the volumetric pollution of outer space with an unchanged mass of space objects.

We are getting closer and closer, to the extent that launches of space vehicles continue, to a situation where the quantity and mass of newly formed man-made particles will exceed the quantity and mass of particles "settling" to Earth under the effects of the atmosphere. This process should lead after a time to the impossibility of further use of outer space at altitudes where a critical density of space objects has been reached.

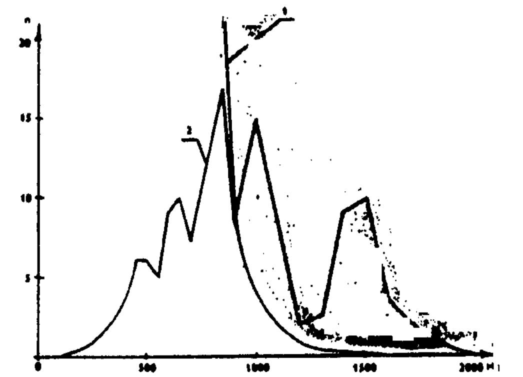

Fig. Dependence of the critical quantity of space vehicles and fragments (n) on altitude (H). The shaded region is where the value of n is exceeded.

That critical number decreases with increases in the altitudes of their orbits, since the time of ballistic existence increases sharply. The dependence of the critical quantity of space vehicles and large fragments on the altitude of the orbit is presented in the figure *(1)*. The density they have reached is also shown for comparison *(2)*.

The quantity of man-made particles, due to their prolonged existence at high altitudes, will increase due to collisions—quite slowly at first—and thus the mass of space objects exceeding the critical value could be detected too late. Outer space, like a grinding mill, will then begin to grind up the satellites into man-made particles. That level has evidently already been achieved at altitudes above 1,000-1,200 km. The process is not yet transpiring in very noticeable fashion, since the typical time for this grinding up is close to 1,000 years; that time could be reduced significantly with further fragmentation, however. It will be reduced to 100 years in the next 30 years, and to 10 years by the year 2050, with preservation of the existing rate of satellite launches. Taking into account the fact that a space vehicle can be disabled by hits from solitary particles, it could with great likelihood sustain intolerable damage in polluted orbits. Flights at altitudes over 1,000 km could thus become dangerous by the years 2020-2050.

The utilization of outer space in the future will be determined largely by the "ecological" situation in it being formed in our time. The duration of the existence of man-made particles and fragments depends on many factors, but first and foremost on ballistic factors (the ratio of the mass of the object to its target area). An aluminum ball three mm in diameter at an altitude of 1,000 km, for instance, will last eight years until its entry into the dense layers of the Earth's atmosphere, while a ball of 30 mm in diameter under the same conditions will take 80 years. The particles more than a few millimeters in size that are now at altitudes of 1,000 km will thus not disappear until the 21st century.

The danger for manned flights at altitudes of 200-500 km is still very small, but they could become extremely risky with the increasing dimensions of orbital stations and growth in the volumes of space debris. Opportunities to improve the situation radically do exist. They will depend largely on efforts by all of the countries launching space vehicles, aimed at reducing the pollution of outer space. The clutter in space must be reduced first and foremost by modernizing the last stages of launch vehicles and spacecraft. They should enter the dense layers of the atmosphere as quickly as possible after being spent, and not be eliminated via destruct mechanisms. The additional appearance of debris that occurs, for example, with the actuation of pyrotechnics cannot be permitted in the functioning of these objects. Space vehicles should have protection for vitally important compartments and systems to protect against particle hits. And finally, it is time to set about the creation of space vehicles able to collect the debris in orbit. We will obtain an opportunity to make orbital flights under sufficiently safe conditions in the future through the comprehensive employment of these and other measures.

This is, however, a complex and expensive matter that requires the combined efforts of all nations that are realizing space programs. The pollution of outer space around the Earth is a global problem, and it has no national boundaries.

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