

SR-10

Training aircraft

Engineer Note
Moscow, 2009



APPROVE

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« » _____ 2009

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Introduction

Entering the service of the AF of up-to-date aircraft systems (AS) with new operational capabilities imposes increased demands towards the training level of the graduates of flight institutions of higher education. A modern pilot should possess the whole wealth of knowledge, skills and abilities allowing him to use the combat potential of up-to-date and perspective AS in all their application conditions to the full extent.

The existing flight personnel training system based on the use of practically one type of the training aircraft (L-39) and the use of the combat aeronautical engineering (MiG-29, Su-25) in the training process is physically and morally outdated and does not comply with up-to-date requirements. Moreover, this training system is not reasonable according to the criterion “efficiency/cost”.

The improvement of the flight personnel training system should be intended, first of all, for the formation of the rational training aircraft fleet that provides for the implementation of the reasonable stage-by-stage approach to the training and the use of training aircrafts (TA) adapted for the tasks of a corresponding training stage at every stage.

The criteria of TA reasonable fleet formation for flight institutions of higher education should be the provision of a given number of flight personnel training with the required training quality with minimum training costs.

As a rule, the TA reasonable fleet includes three types of aircrafts providing the carrying out of the preliminary, basic and higher training. The optimization of the TA fleet characteristics based on principles of methodical unification and succession, the stage-by-stage increasing of methodical possibilities (“from simple to complex”) and complementarities with the consideration of up-to-date requirements to military pilots’ training will make it possible to create conditions for the further harmonic mastering of a combat aircraft. This approach will provide the achievement of a high quality of pilots’ training and minimizing of their training costs.

The most important component that ensures the efficiency improvement of the pilots training process is the education integration providing for the methodic and information integration of training in auditoriums, on training simulators and during the flight. An integrated training complex (ITC) combining the TA, simulators and classrooms should be created for every training stage, which are built on the basis of interactive automated training systems. At the same time, all ITC shall form the uniform through system of combat pilots’ training on the methodical basis.

One of the implementation conditions of perspective ITC creation projects in new economic conditions is their profitability, which is provided, first of all, by the volume of the serial production of corresponding TA. Increasing of TA serial production volumes can be achieved, on the one hand, for account of the sales markets expansion, first of all, foreign ones, which is provided by the consideration of their requirements, on the other hand – by the modification of a corresponding TA of another purpose, first of all, acrobatic ones. The latter is of immediate interest for the TA of the primary and basic training. That is why, the project of SR-10 aircraft creation provides for its development in two main modifications – training and acrobatic.

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Purpose of the aircraft SR-10



Training variant

- ▶ training of the pilot technique and standard, advanced and higher operation in accordance with tasks of the initial and basic flight training;
- ▶ training of navigation fundamentals and flight operation en-route using the standard navigation equipment;
- ▶ instrument flight rules operation;
- ▶ group formation flight training in couples.



Acrobatic variant

- ▶ training of the pilot technique and standard, advanced and higher operation separately and in complex in full range of the aircraft APC;
- ▶ practicing of reverse aerobatics;
- ▶ mastering of sports aerobatics;
- ▶ participation in aircraft sports competitions.



Flight personnel training concept of the air force of the MF

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Basic provisions

The flight training concept means the system of fundamental views to interrelated programs of the flight training, the type of training complexes, their composition and technical characteristics that provide for the effective training of fighting capacity of military pilots.

The concept of perspective system of flight training of pilots and navigators of the AF includes the stages of the initial, basic and advanced flight training in flight institutions of higher education, and the training of the combat-ready flight personnel in combat maneuver units and training centers in accordance with the Training program.

Initial flight training

It is a set of actions directed to the determination of the professional competence of a future student in the flight work and the formation of his initial skills of the piloting technique, the spatial and visual orientation.

Basic flight training

It is a set and practical mastering of the training aircraft and a student's training of the piloting technique and navigation in the daytime and at night for the purpose of training a future military pilot.

Advanced flight training

It is a set of actions intended for the young pilot's combat training fundamentals on a combat training jet aircraft in the daytime and at night in simple and intricate meteorological conditions for the purpose of training a combat-ready pilot.

Each stage of the flight training has clear goals and objectives, which are followed at training complexes according to the stage.

Every ITC should consist of a corresponding TA and ground training facilities.

The TA of the initial training should be meant for the professional selection of future pilots and their teaching of fundamentals of piloting and navigation technique.

The TA of the basic training should provide the formation of solid piloting and navigation skills in the daytime at VFR and IFR, at night at VFR in the altitude and speed range characteristic for combat aircrafts in accordance with the specialization of a future military pilot. It should be an aircraft with TJE or TPE, with the aircraft control and navigation equipment (CNE), similar to the CNE of the advanced training TA. At the same time, such TA should be significantly cheaper than the advanced training TA of a corresponding profile.

The advanced training TA should provide the formation of solid piloting and navigation skills in the daytime and at night at VFR and IFR, and the combat training fundamentals in accordance with the specialization of a future military pilot. It should be an aircraft with TJE, APC and CNE similar to a corresponding combat aircraft.

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Analysis of TA and OT fleet used in flight training systems of the AF and main foreign countries

	Initial flight training	Basic flight training	Advanced flight training
USA	T-6B «Texan-II» 	T-6A «Texan-II» 	T-38 «Talon» 
Great Britain	T-67M 	Tucano T.1 	Hawk-T.1 (T.1A) 
Korea	KT-1 	T-37 	T-50 
Brazil	T-23; T-25 	T-27, EMB.325 	AT-29 
Turkey	T-41, SF-260 	T-37 	T-38 
Japan	F-2B 	T-7 	T-4 



Conclusion

- The flight personnel training system of the AF in foreign countries provides for three stages of flight training – **initial, basic, and advanced**.
- The flight training is performed at TA (OT) adapted to tasks of a given stage of the flight training at every stage.
- The feature of the flight personnel training system is the use of a uniform TA at the stage of the initial and basic flight training and combat (operational) aircrafts at the advanced training stage.

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Key features of TA (OT), used in training systems of the AF in foreign countries

Characteristics	TA IFT			TA BFT					TA AFT		
	T-6B	T-41B	TB.30	T-6A	T-37	Hawk-T.1	M-311	T-7	T-38A	Hawk-100	HJT-36
Country	USA	USA	France	USA	USA	Great Britain	Italy	Japan	USA	Australia	India
Engine unit, type/q-ty x power, hp	TPE 1 x ...	RE 1 x 210	RE 1 x 300	TPE 1 x 1100	TJE 2 x 460	TFE 1 x 2420	TPE 1 x 1447	TPE 1 x 450	TFE 2 x 1216	TFE 1 x ...	TFE 1 x 1410
Aircraft length, m	10,3	11,51	7,59	10,16	8,93	11,85	8,43	8,59	14,4	11,4	10,9
Wingspan, m	10,1	11,85	7,92	10,18	8,2	9,39	8,43	10,4	7,7	9,08	10,0
Wing area, m ²	-	22,02	9	-	17,1	16,69	12,6	16,5	15,8	16,7	-
Crew position	tandem	tandem	tandem	tandem	tandem	tandem	tandem	tandem	tandem	tandem	tandem
Takeoff weight, kg	2550	1120	1250	2857	2980	7760	3150	1585	5485	9100	4500
Max. speed, km/h	585	250	380	574	580	1000	540	298	1380	1000	750
Operating ceiling, kg	-	5200	7000	10670	11800	14600	9150	-	16300	13600	9000
Operational range, km	-	1630	1300	1574	1500	1040	-	850	2125	2520	775
Limit load factor, unit					+6/-2,4	+7/-3,5					+7/-2,5



Conclusion

The world experience analysis shows that the following aircrafts are used for:

TA IFT aircrafts with a reciprocating engine and weight up to 1500 kg are used, as a rule,

TA BFT – aircrafts with TPE or TJE weight up to 5000 kg,

TA AFT – aircrafts with TJE weight approx. 9000 kg.

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Training aircraft

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Analysis of requirements to the APC of training and combat aircrafts for different flight personnel training stages

Key APC	Requirements of the AF to the TA			Su-49	Yak-152	L-39	Yak-130	TA SR-10
	TA IFT	TA BFT	TA AFT					
Engine unit, type/q-ty x power, hp	RE 1 x ...	TFE 1 x 1900	TFE 2 x ...	RE 1 x 420	RE 1 x 360	TFE 1 x 1900	TFE 2 x 2500	TFE 1 x 1850
Crew position	tandem	tandem	tandem	tandem	tandem	tandem	tandem	tandem
Takeoff weight, kg norm/max	$\frac{<1300}{1500}$	$\frac{3000}{1310}$	<5500	$\frac{1300}{1310}$	$\frac{1286}{1320}$	$\frac{4450}{4700}$	$\frac{5500}{8700}$	2700
Max. speed, km/h	>280	800	>850	315	375	700	1000	845
Operating ceiling, km	>4,0	до 12,0	>10,0	6,3	3,6	11,4	12,3	6,0
Operational range, km	>750	1200	>2000	1550	1000	980	2100	1200
Limit load factor, unit	+8/-4	+7/-3	+8/-3	+11/-7	+8/-6	+8/-4	+8/-3	+9/-6
Landing speed, km/h	100-120	160	180-250	115	120	180	185-250	210



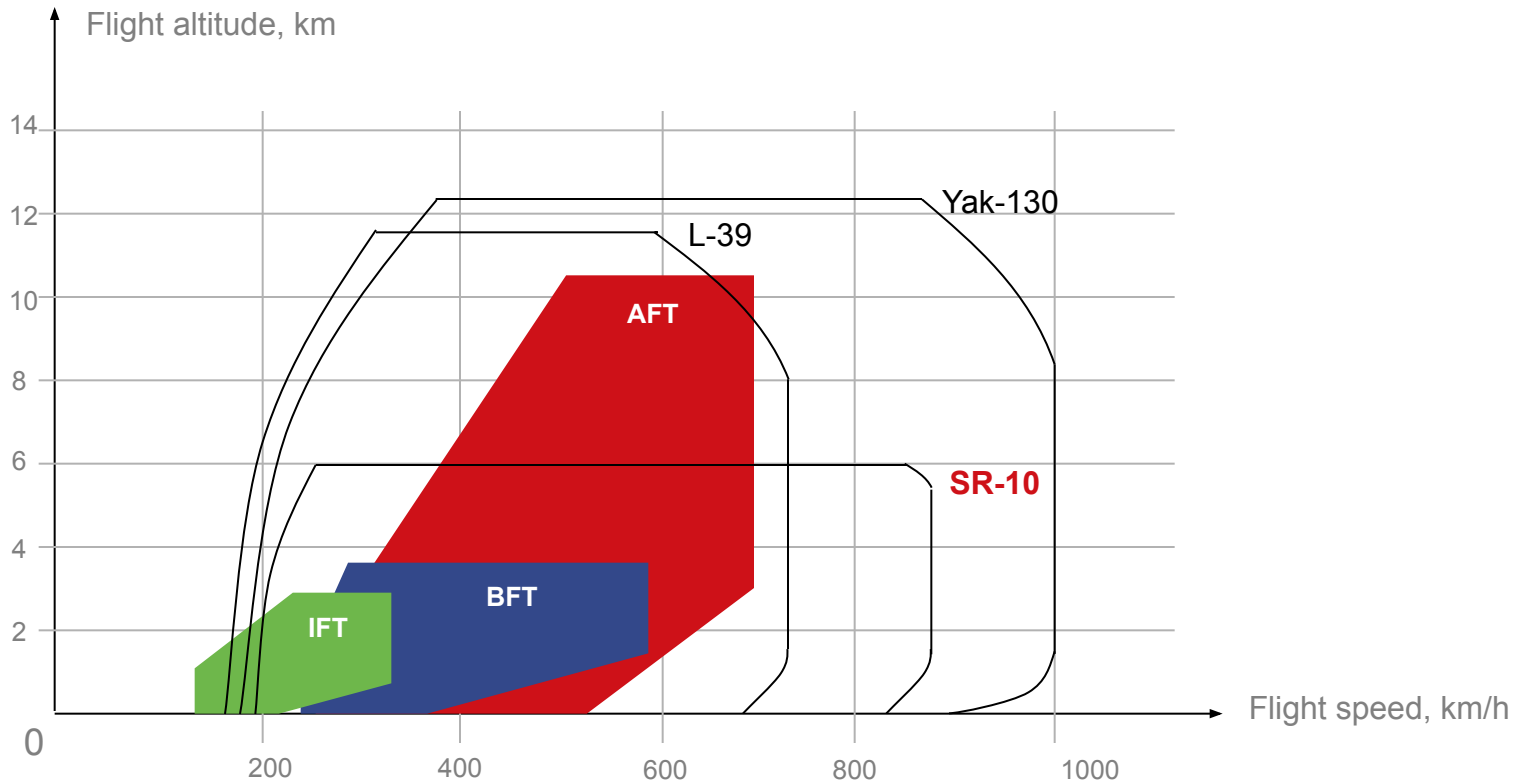
Conclusion

According to its APC, the TA SR-10 complies with requirements imposed to the APC of the TA BFT best of all and can further replace L-39 at AFA (MI) used for the initial and basic flight training.

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Role and place of the aircraft SR-10 in the flight personnel training system



Conclusion

The analysis of conditions of tasks and exercises fulfillment of the flight training stages shows that according to its APC, the TA SR-100 provides the solution of tasks of the initial and basic flight training.

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Technical characteristics of the aircraft SR-10

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General information

The aircraft SR-10 has been developed by OOO “KB “Modern Aviation Technologies” in accordance with the initiative procedure as an acrobatic jet aircraft with the dimension up to 2700 kg. This aircraft can be produced as the training variant designed for the basic flight training of students – future military pilots – for the operation of up-to-date combat jets.

Up-to-date, commercial technological solutions are used in the aircraft construction to the maximum degree. It allows, on the one hand, to minimize risks and costs for the aircraft creation, on the other hand – to create a relatively cheap aircraft complying with modern requirements.

The aerodynamic composition of the aircraft was selected based on the condition of achieving high maneuvering characteristics and high structural strength, and minimum airframe weight with given geometric dimensions. The aircraft is built according to a standard aerodynamic scheme enabling maneuvering at wide angle of attack.

The aircraft uses the mechanical power-boosted control system. The control loop provides for the factory setting of gear ratio for acrobatics and training aircraft variants, which determine their control characteristics. To provide the flight safety, the control loop can be added with the maximum mode limiting system MML-10 (first of all, for the training variant).

The airframe is made with a high degree of integrity, when the wing and the hull form the uniform all-body that provide high values of aerodynamic quality. The tricycle-equipped landing gear with a nose-wheel.

The head of the hull includes: the nose section with the equipment, the front gear bay, the pressurized double cockpit with a lamp. The middle part of the hull includes: the equipment compartment behind the cockpit, the hull fuel tank, side air intakes. The wing spars are attached to the power frames, side beams with attachment points of main gears are located along the sides. The aft part of the fuselage includes: the engine compartment, the life support and air conditioning systems. The vertical and horizontal empennages are attached to the aft part of side beams.

The set of the base case airborne equipment is minimum that provides the aircraft operation according to its purpose and includes the general aircraft, instrumentation and radio communication equipment of domestic and foreign production. The selection of the foreign-made equipment is dictated mainly by the absence of domestic analogs of the required quality and based on weight/dimension indicators. Variants of the airborne equipment kitting, including additional one will be determined upon coordination with Customers.

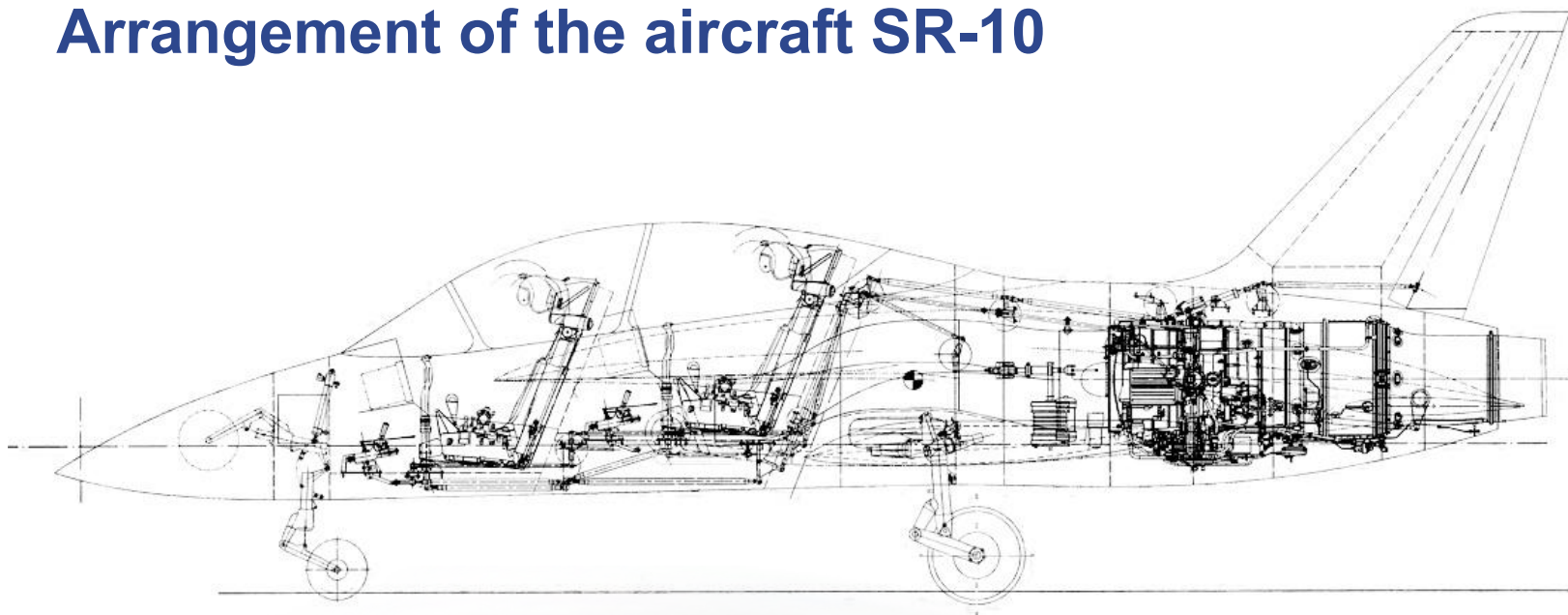


The base variant of the aircraft SR-10 provides for the equipping with the dual-flow turbojet engine AI-25TLSh.

The aircraft is equipped with catapult chairs K-93. Together with the protective equipment the chairs provide safe escaping of the crew from the aircraft at speeds up to 950 km/h within the limits of operational range of altitudes, including modes $V=0$, $H=0$. Automatic devices of the chairs provide safe escaping of the crew from the aircraft for both one and two people.

Generally, the technical characteristics of the aircraft and its aircraft performance characteristics conform to the world level.

Arrangement of the aircraft SR-10



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Main aircraft performance characteristics of the aircraft SR-10



Main aircraft performance characteristics

2 persons	Crew
700 km/h	Maximum flight speed
900 km/h	Maximum horizontal flight speed
0.85	Maximum M value
190 km/h	Liftoff speed
185 km/h	Landing speed
520 km/h	Cruising speed at H=6000 m
60 m/s	Maximum climbing capacity at the ground
290 m	
7 rad/s	Minimum radius of the stable turn
1500 km	Maximum roll angle rotational speed
6000 m	Maximum distance Practical ceiling

2400 kg Weight characteristics

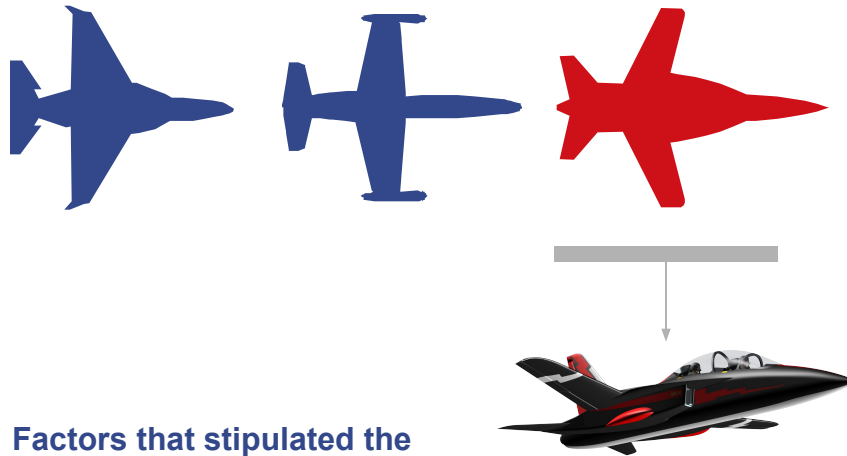
2700 kg	Standard takeoff weight
2000 kg	Maximum takeoff weight
2700 kg	Standard landing weight Maximum landing weight

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Substantiation of the airframe construction and aerodynamic design of the aircraft SR-10

Variants of aerodynamic arrangement



Factors that stipulated the selection of the aerodynamic arrangement of the aircraft SR-10

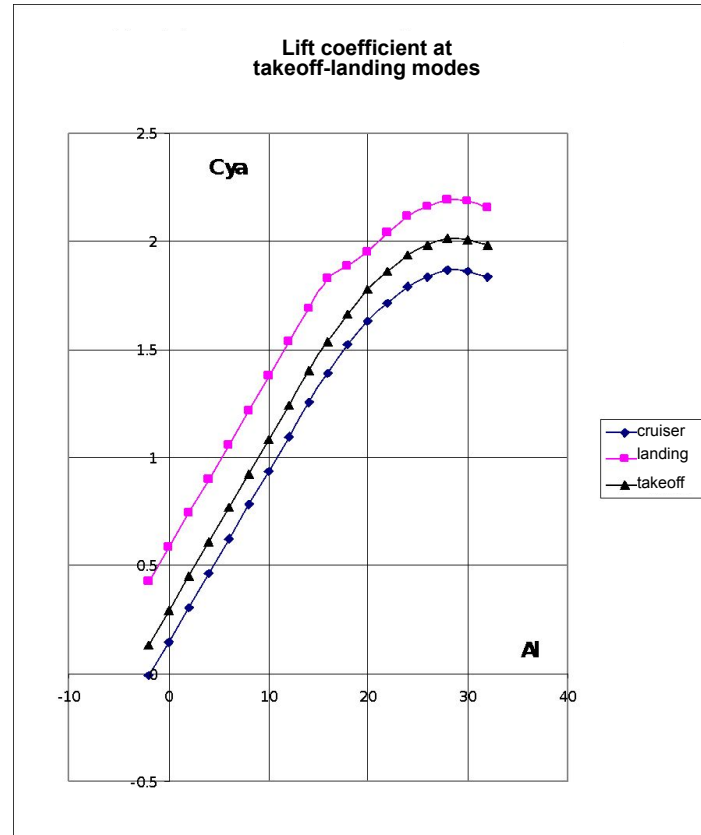
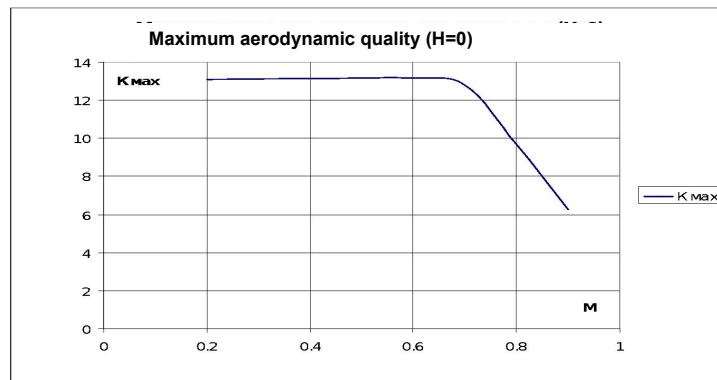
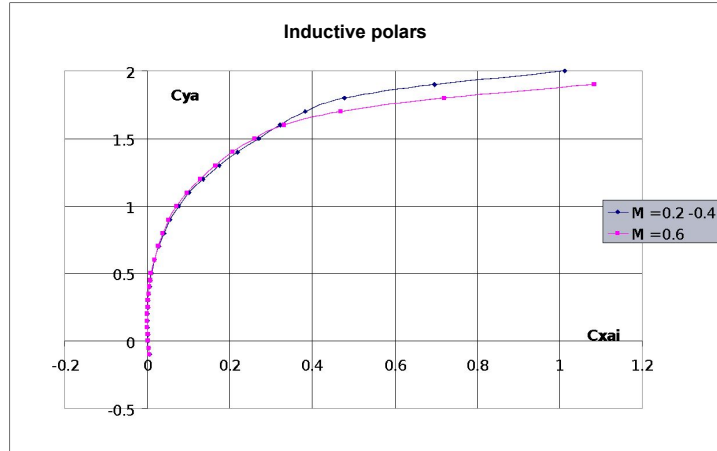
- High maneuver characteristics
- High speed characteristics
- Low takeoff and landing speed
- Minimum airframe weight at given geometric dimensions
- Providing of high structural strength at high values of standard overload (up to +11g)

Features of the selected aerodynamic design of the aircraft SR-10 airframe

- ! The key feature of the aerodynamic design – a **high-wing aircraft with the wing of moderate sweepforward and advanced root swelling.**
- ! Aerodynamic wing profile with the relative thickness
- ! The airframe is made according to a standard aerodynamic design.
- ! The hull of traditional form with side air intakes.
- ! Control elements:
 - slot flap with the variation 15° (takeoff mode) and 40° (landing mode);
 - ! -longitudinal channel– all-moving horizontal empennage (variation angles – $-20^\circ \dots +15^\circ$);
 - lateral channel – ailerons (variation angles– $\pm 25^\circ$);
 - track channel – rudder (variation angles – $\pm 27^\circ$).



Aerodynamic characteristics of the aircraft SR-10



Conclusion

The preliminary calculation of airframe aerodynamic characteristics by empirical engineering dependences by means of recalculation of prototype characteristics showed that the level of ADC at the selected aerodynamic design corresponds to requirements to the ADC of the acrobatics aircrafts of this class. For the purpose of receiving more exact assessments of the aircraft ADC, it is necessary to carry out experimental investigation in the wind tunnel, and the computational modeling by means of computing aero-hydrodynamics.



Engine unit of the aircraft SR-10

AI-25TLSh



Main performance characteristics of the power unit

Max. propulsion, kgs	1850
Max. specific consumption, kg/kgs-h	0,58
Bypass ratio	1,98
Inlet diameter, mm	540
Length, mm	3358
Engine dry weight, kg	350
Gas temperature Gt, K	1310
Pressure increase ratio Pk	9,6



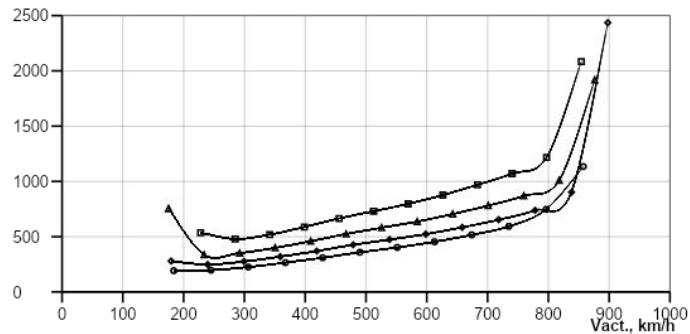
Currently, the possibility of installation of a serial engine – **AI-25TLSh** – on the aircraft **SR-10** is studied in a constructive way.

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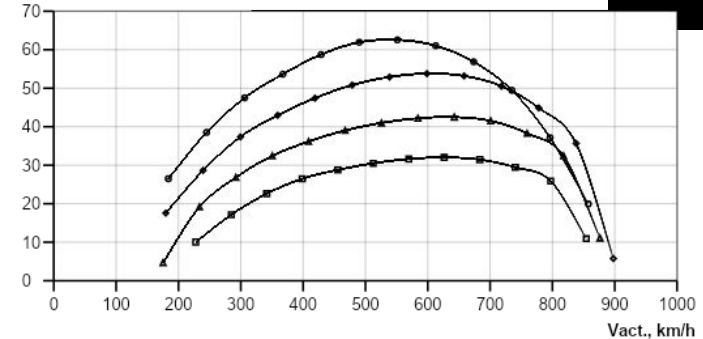
Altitude-velocity and maneuver characteristics of the aircraft SR-10 with the engine AI-25TLSh

Rturn, m



Dependence of the radius of stable turn on the actual speed

Vacc., m/s



Dependence of the power climbing capacity on the actual flight speed



Conclusion

The preliminary calculation of the altitude-velocity and maneuver characteristics of the aircraft SR-10 was carried out by means of the empirical engineer dependences based on the preliminary ADC and characteristics of the engine **AI-25TLSh** for MCA conditions. The engine operation mode – combat, average flight weight – 2150 kg, fuel reserve – 50%.

The level of altitude-velocity and maneuver characteristics of the aircraft SR-10 conform to requirements to specified characteristics of acrobatic aircrafts of this class.



A set of airborne equipment of the aircraft SR-10

Aircraft instrumentation

- gyrohorizon AGR-29
- directional system Installation Kit*
- satellite navigation system GPS Garmin 430*
- air signal system (pressure instruments)
- radio altimeter
- radio compass
- radio landing aids (glideslope group)

It is possible to install a similar equipment of the domestic production

Radio communication equipment

- radio station «Yurok-M1»
- intercommunication device SPU-34
- Identifier of ATC
- Identification system

Aircraft systems and equipment

- power-supply system
- power unit control system
- fuel system
- hydraulic system
- pneumatic system
- anti-icing system
- maximum performance limiting system MPL-10
- air conditioning system
- objective control means



Conclusion

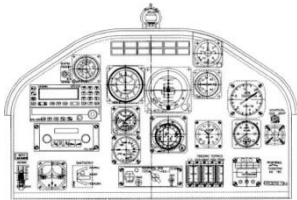
1. The set of airborne equipment provides the solution of tasks in accordance with the purpose of the aircraft **SR-10**.
2. According to the Customer's decision, it is possible to replace the equipment of foreign production subject to availability of domestic analogs of appropriate quality.
3. At the Customer's option, it is possible to install different variants of additional equipment.

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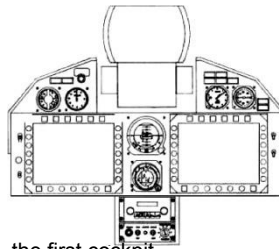
Variants of control and navigational equipment of the aircraft SR-10 cockpit

Variant of the cockpit panel 1

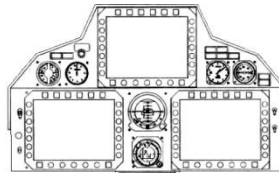


the first cockpit

Variant of the cockpit panel 2

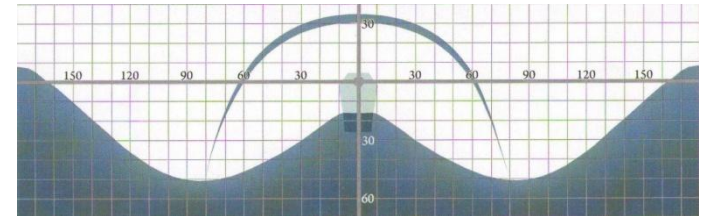


the first cockpit

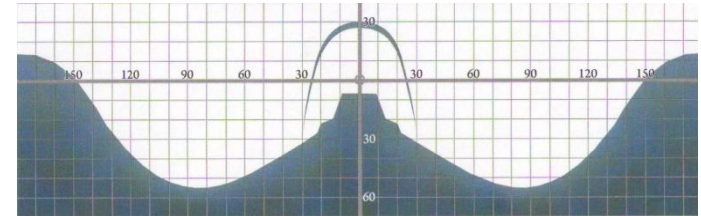


the second cockpit

Overview diagram



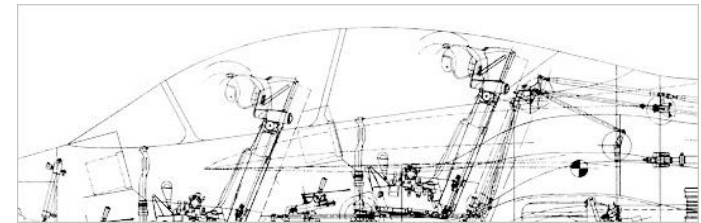
the first cockpit



the second cockpit

The cockpit panels are made on the basis of standard pointer-type instruments with the traditional placing of the main group of aviation instruments and the power unit control instruments.

The cockpit panels are made on the basis of LCD with the backup by the main group of standard aviation instruments. The conclusion of standard frames of aviation and control (equipment and system condition) information is provided for on the LCD, including information frames characteristic for combat aircrafts.



Currently, the possibility of installation of two types of cockpit panels was studied in a constructive way – the traditional panel on the basis of pointer-type instruments and the perspective on the basis of liquid-crystal indicators.

The selection of the cockpit panel type can be performed by the Customer based on financial or other conditions. Building the training variant of SR-10 aircraft, it is possible to install cockpit panels on the LCD base, which are unified with the control and navigational equipment of prospective combat aircrafts of “fighter” type.

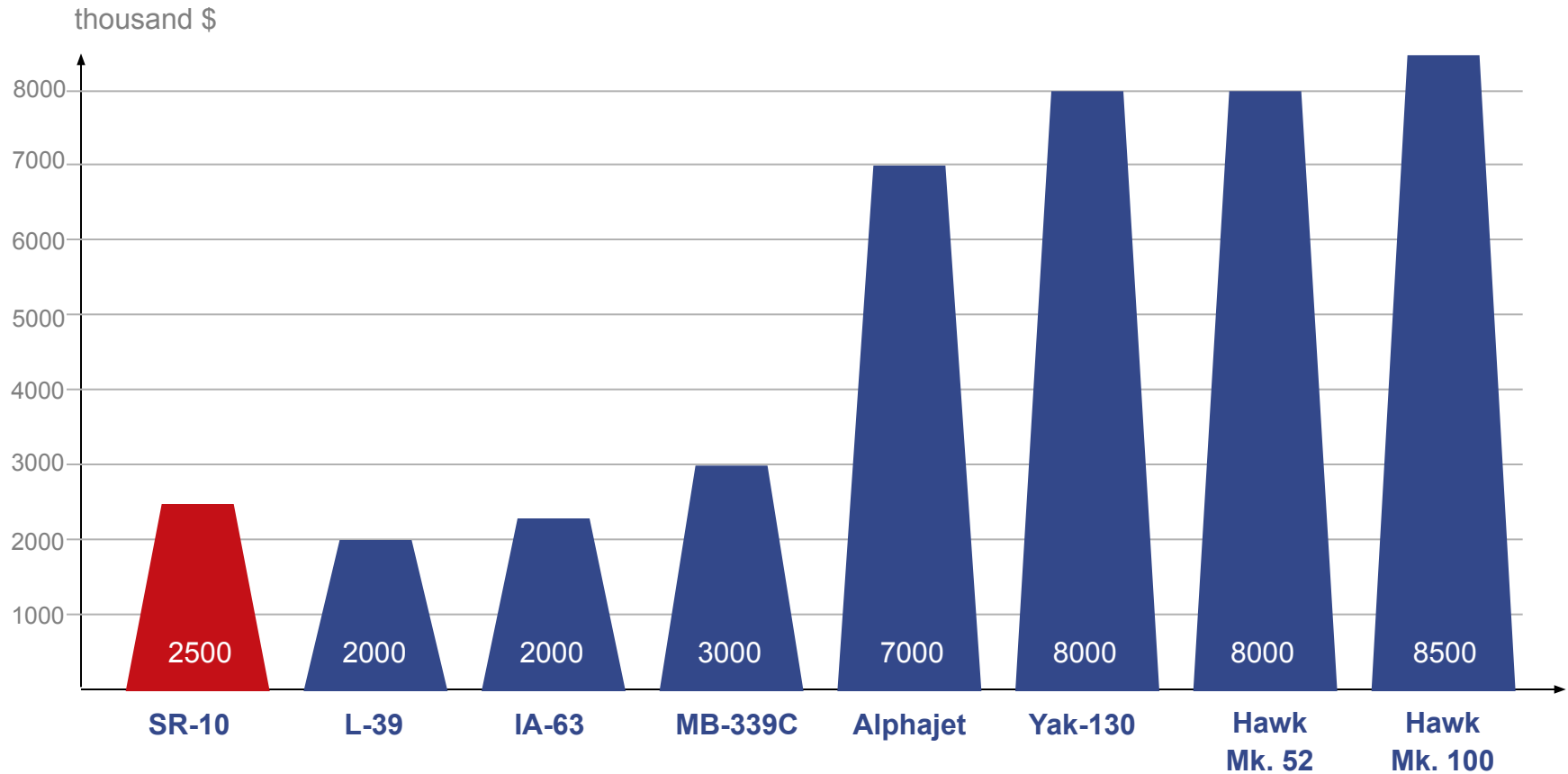


Integrated assessment of the training aircraft SR-10

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Technical and economic indexes of the TA SR-10

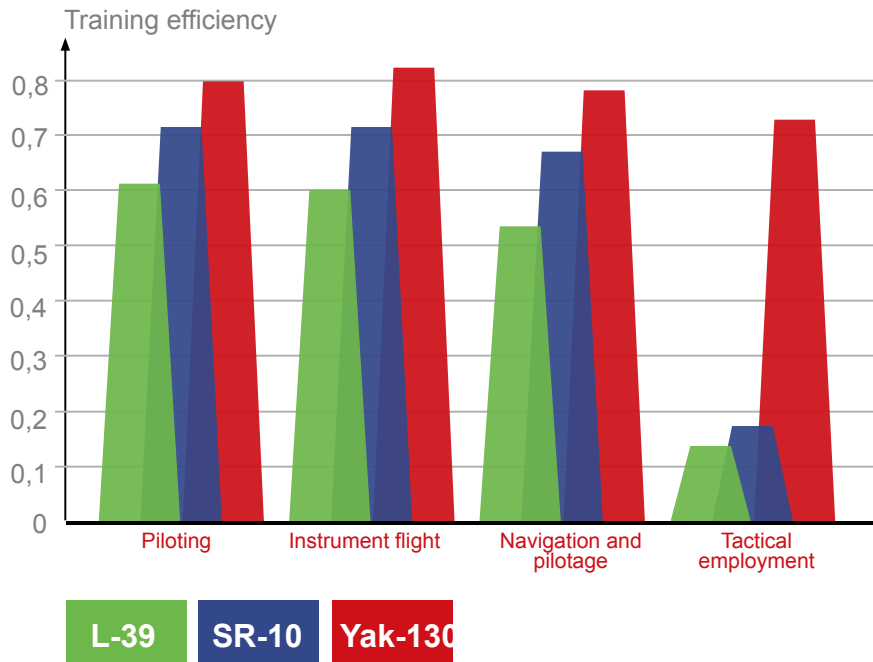


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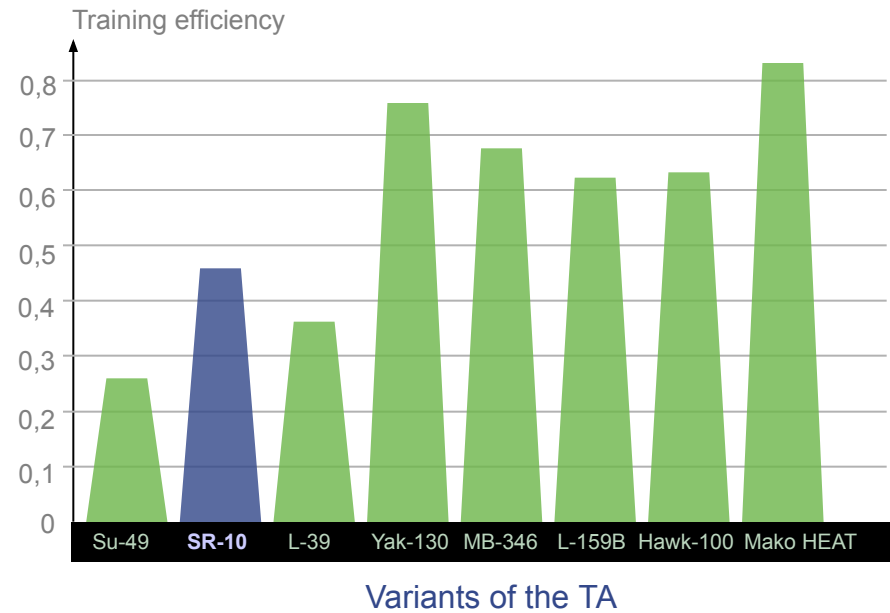


Technical and economic indexes of the TA SR-10

Training efficiency of the TA(OT) for mastering of different tasks during the flight personnel training for combat aircrafts of MiG-29 type



Comparative assessment of the training potential of SR-10 and other TA(OT) during the flight personnel training for combat aircrafts of MiG-29 type



Conclusion

The training efficiency of the TA SR-10 is 10% higher on the average than the efficiency of its next analog – the TA L-39. It is conditioned by the best aircraft performance characteristics and the application of the up-to-date set of airborne equipment.

The training efficiency of the TA SR-10 comparing to similar indexes for the OT of advanced training of Yak-130 type is lower, first of all, during tasks connected with practicing of tactical employment elements. That is why, the application of the TA SR-10 in the flight personnel training system is reasonable at stages of the initial and basic training with the consideration of its technical and economic indexes.

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Business-plan of the aircraft SR-10 creation

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Conditions of the aircraft SR-10 project implementation

One of the main conditions of implementing the commercial project of the aircraft SR-10 creation is its profitability that in the aggregate, together with potential risks will determine its investment attractiveness.

To provide the profitability of this project, the aircraft to be created is oriented potentially to quite a wide market, both domestic and foreign. For this purpose, this aircraft is being developed in two main modifications – training and acrobatic.

The training modification of the aircraft SR-10 is oriented to the needs of the AF flight institutions of higher education and potential foreign customers. A number of countries of the Central America, Africa and Asia are considered as potential importing countries, with which the high level of military and technical cooperation is observed.

Recently, the growth has been observed in the market of jet acrobatic aircrafts, first of all, among domestic and foreign commercial and private flying clubs. That is why, the acrobatic variant of the aircraft SR-10 is oriented to the needs of this market.

To improve the competitive attractiveness of the aircraft SR-10 both in the domestic and the foreign markets, the designer pays particular attention to the level of its technical and economic indexes (first of all, the market price and the operational cost). For this purpose, the variability of equipping the aircraft with the power unit and the airborne equipment is provided for too, that provides the possibility to offer this aircraft in quite a large price range, depending on financial possibilities and wishes of a potential customer.

To reduce the risks' level during the aircraft creation, up-to-date technologies are applied, at the same time, the well-tested technological solutions have the preferential power. The latter provides also significant reduction of terms and cost of the aircraft creation.

The preliminary analysis shows that the project as a whole has a high level of investment attractiveness and can be implemented for 3...4 years. The project recoument will be three years at most.



Assessment of potential demand for SR-10 in the domestic and foreign markets

Potential demand of the foreign market for the training variant of the aircraft SR-10

Region	Q-ty ofTA		Potential Importing countries	Forecast of export potential until 2020
	TA IFT	TA BFT		
CIS	~ 50	~ 100	CIS countries	~ 100
Europe (without CIS)	~ 900	~ 1600	Serbia, Croatia, Greece, Cyprus	~ 100
North America	~ 400	~ 1300		50
South and Central America	~ 600	~ 1000	Venezuela, Bolivia, Peru, Argentina (?)	~ 300
Near and Middle East	> 700	> 1000	Syria, Yemen, Iran	~ 100
Asia (without CIS)	> 500	> 600	India, China, Vietnam	~ 200
Africa	> 600	> 800	Algeria, Angola, Egypt	~ 150
Australia and Oceania	> 200	> 200	Malaysia, Indonesia	~ 50

Potential demand of the foreign market for the acrobatic variant of the aircraft SR-10

Potential buyers	Forecast of demand for this type of aircrafts	Assessment of the potential market for the aircraft SR-10
Foreign market		
USA	50	5
England	10	2
SAR	15	1
Australia	10	2
France	15	3

- 1 The export potential of the aircraft SR-10 in the training variant is determined, mainly, by the level of political relations and military-technical cooperation of Russia and potential importing countries. The preliminary forecast of the export potential of the training variant of the aircraft SR-10 during the period until 2020 can be assessed in the volume up to 1000 aircrafts.
- 2 The market of acrobatic jet aircrafts is fast-developing in the present time, first of all, among commercial flying clubs. The forecast of potential sales of the acrobatic variant of the aircraft SR-10 in the domestic market is assessed in the volume of 50 aircrafts, in the foreign market – 120 aircrafts.



Conclusion

- 1 The current flight personnel training system of the air force, which is based on the use of practically one type of a training aircraft (L-39) and applying of the combat aeronautical engineering in the training process does not conform to modern requirements and is not reasonable according to the criteria “efficiency/cost”.
- 2 The APC of the aircraft **SR-10** to be created do not conform to requirements imposed to the APC of training aircrafts of the initial and basic training and can replace the training aircraft L-39 in the AFA in the future.
- 3 The aircraft aerodynamic arranging is selected based on the condition of achieving high maneuver characteristics and high constructive strength and minimum airframe weight with given geometric dimensions. The aircraft is built according to the standard aerodynamic design that enables to maneuver with large angles of attack. The aircraft is traditional in terms of control that provides the possibility of its application as the training aircraft. The mechanical flight control boost system is used in the aircraft. The control loops provide for the factory setting of the transfer ratio for acrobatic and training variants of the aircraft that determine characteristics of its controllability.
- 4 The airborne equipment set as the base case has the minimum composition providing the aircraft SR-10 application as training, and includes general aircraft, aviation and radio communication instruments of domestic and foreign production. In the constructive way, different variants of the airborne equipment are provided for, including optional equipment in accordance with the Customer’s needs.
- 5 The base variant of the aircraft **SR-10** provides for the equipping with the dual-frow turbojet engine AI-25TLSh. At the same time, the possibility of installation of a number of other engines of similar dimensions and thrust-to-weight ratio was worked out for the aircraft at the Customer’s option.
- 6 The aircraft construction uses up-to-date but well-proven technological solutions to the maximum degree. It allows, on the one hand, to minimize risks and costs for the aircraft creation, and on the other hand – to create a relatively cheap aircraft that conforms to modern requirements.
- 7 For the purpose of increasing the profitability and the level of economic practicability of the aircraft **SR-10** creation project for the account of the potential sales market expansion, the working out of this aircraft in two main modifications is provided for – training and acrobatic.
- 8 The current level of the technological backlog allows to forecast the completion of the aircraft **SR-10** creation works in 2011. Serial supplies of the training aircraft SR-10 will be possible, beginning from 2012.

