Utilization of simple and double control subsonic aircraft for advanced combat training of the military pilots

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Abstract: *The use of subsonic single control aircraft and especially of double–control ones, instead of supersonic combat aircraft in the military pilot training programs in the operational units, has become a necessity due to the economic and financial world-wide crisis which began during the 70's-80's, with the advent of the oil crisis, affecting many countries, which have their own Military Air Forces.*

Key Words: *subsonic single control aircraft, the flight cost, supersonic combat aircraft*

GENERAL CONSIDERATIONS

The use of subsonic single control aircraft and especially of double–control ones, instead of supersonic combat aircraft in the military pilot training programs in the operational units, has become a necessity due to the economic and financial worldwide crisis which began during the 70's-80's, with the advent of the oil crisis, affecting many countries, which have their own Military Air Forces. This tendency of using subsonic aircraft in military pilot training programs exists especially in countries that have had or currently have financial difficulties. This situation has led inevitably to a quite severe reduction of the amounts allocated to the Military Air Force (MAF), resulting in a drastic reduction of flight hours number and especially of those assigned to the military pilots who usually fly supersonic combat aircraft.
Besides the economic factor which has played a very important role in using the subsonic training aircrafts, currently there are also several objective factors to be taken into account, namely:

1) **the cost of a subsonic jet aircraft** compared with the supersonic one for the same period of time:
   - The cost of a supersonic combat aircraft, at the level of 2008 was on average between 68 and 86 million USD depending on its equipment and facilities
   - The cost of a subsonic advanced training aircraft, is situated on average between 10 and 21 million USD, according to its technical equipment
   - The cost of a supersonic aircraft, compared with that of a subsonic aircraft, is situated in a ratio ranging from 4 to 8 times higher.
2) **the flight cost per hour for a subsonic aircraft**

In a study published by AERONAUTICA – MACCHI, as a graphic (see figure 4), one can see the total costs for a military pilot instruction with a subsonic aircraft in the 1980's: TYPE of aircraft: FOUGA – MAGISTER; T.33; MACCHI 339 – V; MACCHI 339-.L and G.91.-T. From the ratio of total costs and total flight hours, a mean cost for a subsonic flight hour, is derived and presented in fig 2, by type of aircraft:

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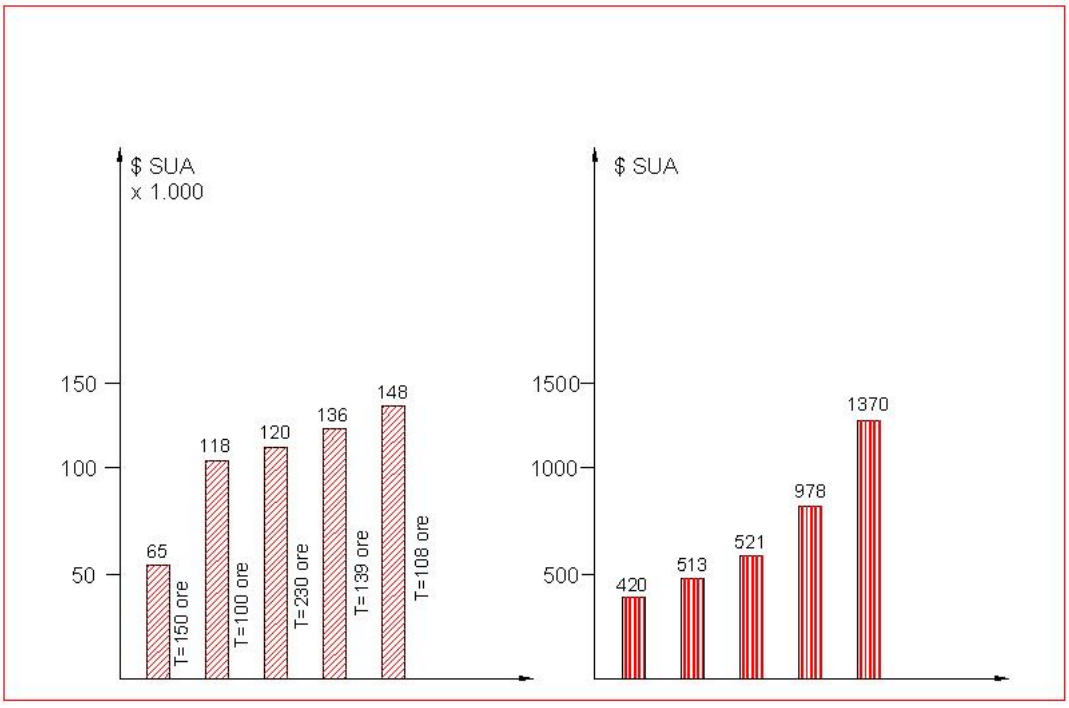

Fig 1 Total cost for a pilot training Fig.2 Flight cost per hour (in USD) per type of aircraft

To update the subsonic jet flight cost per hour during the 80s to current price we took into account the fluctuation of oil barrel price in USD, i.e. the difference between nominal and real value of the dollar during the period 1980 – 2009.

The analysis pointed out that the subsonic jet flight cost per hour ranges between 2,000 and 2,500 USD and differs from state to state, depending on the aircraft costs, the operating costs (on the ground and in flight) the current overhaul costs, etc.

3) **the supersonic jet flight cost per hour** was confirmed from two independent sources, namely:
   - The first source is an article from the Internet, stating the current generation supersonic jet flight cost per hour.

List of combat aircraft flight cost per hour from various sources and their claims:

Gripen	$3,000 – $4,500 USD
F – 16 approximately	$3,500 – 5,000 USD
Rafale	$16,000 USD
F – 22	$19,000 – $40,000 USD
F – 15	$17,000 – $30,000 USD
Eurofighter Typhoon	$14,000 USD

http://hatch.senate.gov/public/_file...nsAndFacts.pdf

EA – 18G expected to cost – $7400 vs. EA – 6B – $17000 + (probably also 200 $ figures)

   - The second source is the Swedish Air Force, which published in 2010, information on the current generation supersonic jets flight cost per hour, confirming in part the above costs. (Fig. 3)

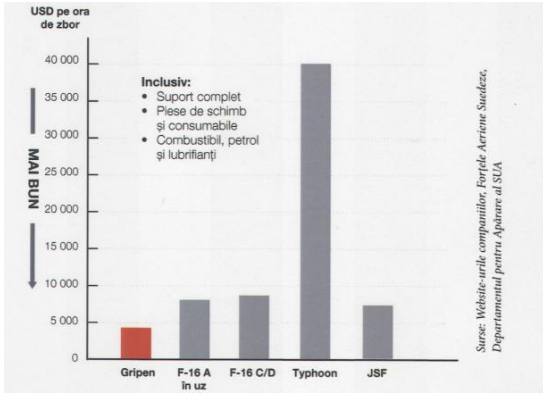

Fig. 3 The flight cost per hour for several combat aircraft

From those data it clearly appears that the supersonic combat jets flight cost per hour amounts to about 4,500-5,500 USD for GRIPEN and F.16 aircraft and up to 30,000-40,000 USD for F15, F 22 or TYPHOON.

Given the above, it came out that the difference between the subsonic combat aircraft flight cost per hour compared to that of the supersonic jet is situated in a ratio of 1 to 2.6 -5.6 times higher and in some cases the report may increase up to 15 times.

4) **Implementation of development and upgrading programs** for training subsonic aircraft in order to improve their technical – tactical characteristics and flight performance.

An important aspect of these programs is the conversion of subsonic dual control training aircraft in a single control version -, with costs as low as possible, as is the case of the Romanian trainer IAR 99 - SOIM, which is to be transformed from the DC version into the SC one. For this conversion to be done with costs as low as possible, it is recommended that the geometry of DC aircraft do not suffer major changes, which involve additional costs.

As it can be seen in Fig. (4 and 5), for D C trainer IAR 99 - SOIM, and the SC IAR 99 (A) - SOIM, the geometry is about the same and from this point of view, the cost of conversion between the two versions will be reduced.

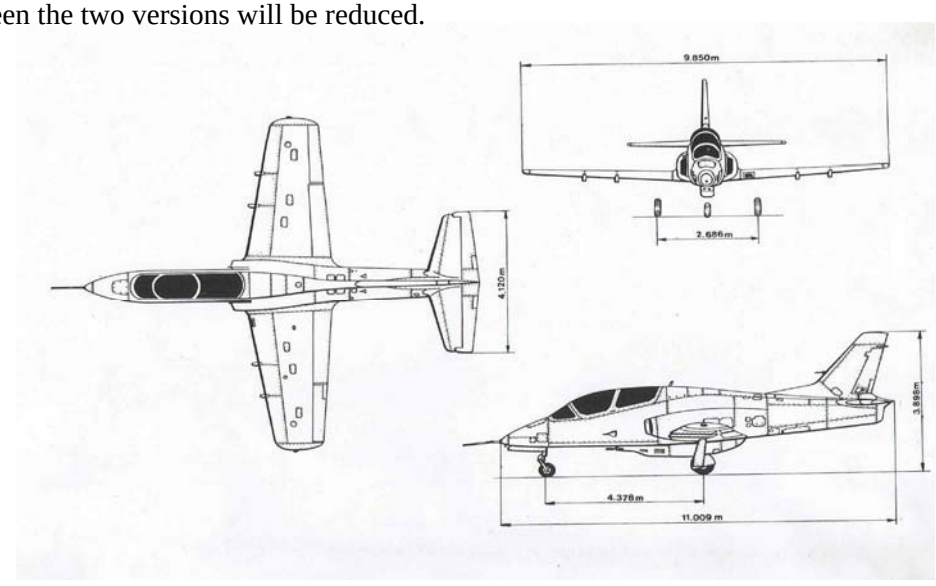

Fig. 4 PLAN VIEW OF THE D C IAR 99 – SOIM

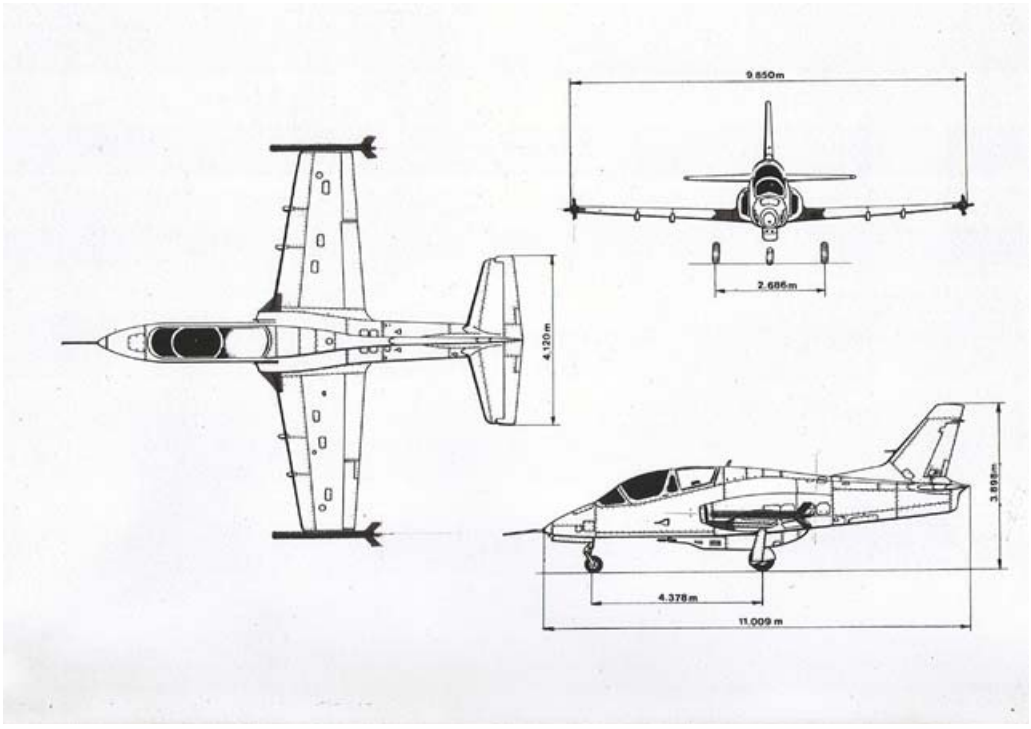

Fig. 5 PLAN VIEW OF THE SC ADVANCED TRAINER IAR 99 (A) – SOIM

The aircraft which entered in service of MAF after 1980 having benefited from the implementation of such upgrading programs, have improved not only their technical and tactical characteristics but also their flight performances. This allowed them to be coopted in advanced training programs together with supersonic combat aircraft; including for the superior stages of combat training .Such is the case with the following aircraft:

HAWK-200(S.C.)

L 159 ALCA (S.C);

Romanian aircraft IAR 99 (RM) - SOIM single or double - command, which is currently subject to a new program of upgrading and re-motoring.

Equipping these aircraft with the latest generation of avionics, upgrading and equipping them with advanced systems of detection, tracking and destroying of subsonic ground and aerial targets, gives them the full quality of advanced training aircraft. Therefore they were used in specific programs such as American JPATS (Joint Program Aircraft Training System), the South - African and Australian LIFT (Lead in Fighter Trainer) or the Russian MIG - AT and others.

5) **Proper equipping and arming** of these aircraft to fulfill in good condition the requirements of the training programs and combat preparation of military pilots.

Currently, these aircraft can be equipped with almost the same type of weapons as the combat aircraft and can perform, within specific speed limit, the same missions as the last ones. Also subsonic trainer aircraft have the latest means of defense, which make them suitable for military pilot training.

6) **The gap reduction between the approach speeds** of subsonic and supersonic aircrafts (Fig 6) is a feature of the new aircrafts allowing their use within the above mentioned programs.

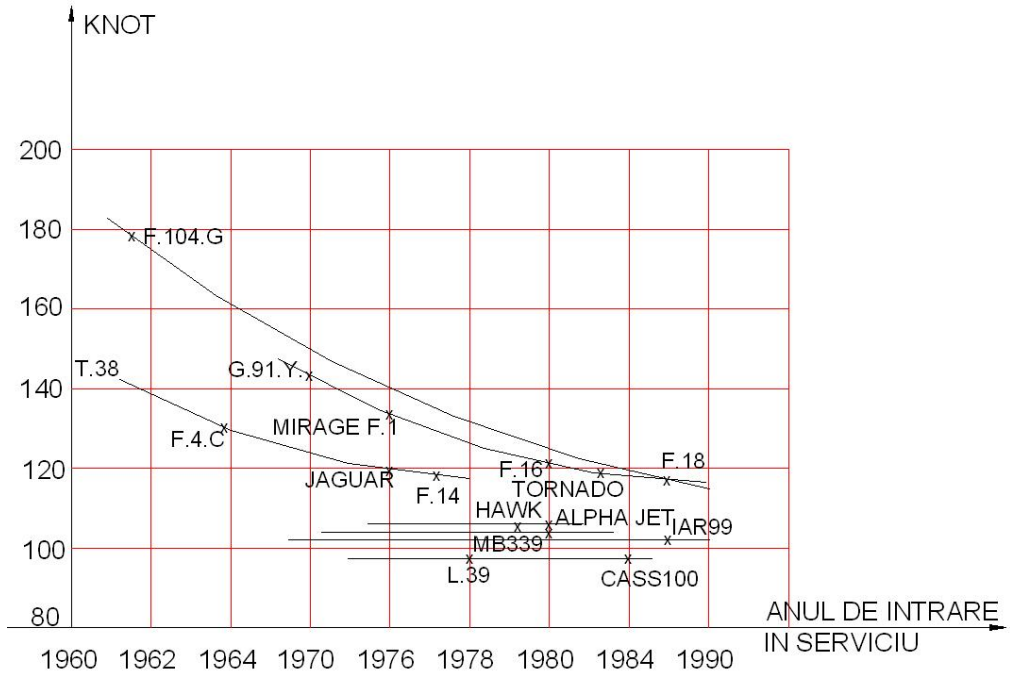

Fig.6 Tendency of the gap reduction between the approach speeds of supersonic combat aircraft and subsonic training aircrafts

A clear trend of reducing the approach speed gap between the combat aircraft and advanced subsonic training program aircrafts is observed, a trend that is still preserved presently.

If during the years 1960 -1970 the gap was about of 70-80 knots, within 30 years this difference dropped to 25-30 knots and still currently decreases, facilitating the maneuvers at low heights and low speeds especially in the tactical and operational field.

7) **Implementation of some development and modernization programs** allowed to current generation of subsonic aircraft for advanced training to fully comply with technical and tactical specifications of most OTAN member states, concerning the requirements that must be met by such airplanes to be competitive in the training and combat preparation of military pilots, including in advanced stages of instruction.

Most states having in possession aircrafts from the above mentioned category have in attention several assessing criteria such as: ease of operation, ascension speed, practical ceiling, maximum speed, approach speed, take off speed, behavior in turbulent atmosphere, level of equipment, and strict observance of international regulations of design and calculation, such as: English military regulation APv. 970, the French one AIR 2002, the American MIL-F 8785 and others.

These requirements may differ from a state to another and may change over time, but what makes them common is the strictly mandatory compliance with the requirements specified by the international regulations and criteria adopted by the most states that manufacture and utilize such specialized aircraft for military training as is also the case of Romania.

Subsonic S C TRAINING AIRCRAFT Preferred instead of subsonic DC AIRCRAFT.

Over time it was observed that the use of the DC training aircraft in the combat training program of military pilots from the operational units had some disadvantages, namely:

- A subsonic aircraft for the military pilot training as compared to a supersonic shall meet the specific characteristics and flight performance, including:

- Flight hour cost of the subsonic aircraft should be as small as possible
- Fuel consumption per hour should be much smaller than that of combat aircraft
- Distance, duration and maximum flight range, should be as close as possible to those of combat aircraft
- Equipment and weaponry level of subsonic training aircraft should be similar or close to that of the aircraft it replaces
- Flight characteristics and performance, except for specific speeds, should be as close as possible to those of combat aircraft, etc.

It was noted that some requirements mentioned above, imposed on D C subsonic trainer aircraft could not be met; among them, some being very important, such as for example, distance, duration and maximum flight range to be as close as possible to those of supersonic combat aircraft. These requirements cannot be satisfied with double planes - order because:

- Generally, DC trainer aircraft are much smaller in size as compared to supersonic combat aircraft and because they have two pilot stations, usually disposed in tandem, the remaining space for the internal fuel tanks is reduced and therefore, their capacity is very small.

Consequently, internal fuel quantity is limited by the space and therefore, performances concerning the distance, duration and flight tactical range, are below those of a supersonic fighter; for example, the Romanian D C training aircraft IAR 99 - SOIM has 1,100 kgf. on board internal fuel which ensures a maximum flight distance of 1128 km.

The conversion of this DC aircraft into the SC version, by suppressing the pilotage station from cabin II will allow installing a new internal tank with a fuel capacity ranging between 350-450 kgf. In this case, the internal quantity of fuel will increase to approximately 1,450-1,550kgf. and because of this, the maximum flight distance will reach 1,590 km. while the operational tactical radius will be 735 km; these characteristics make the new version to be comparable to several supersonic aircraft of reference. Taking into account the 3 additional tanks with a capacity of 220 kgf. each, the total amount of fuel contained by the SC training aircraft IAR 99 (A) - SOIM will be about 2090 kgf., compared with that of the DC version of the airplane, which has only 1540 kgf.(see Fig. 7 and 8).

A characteristic imposed to subsonic trainer aircraft, is to have flight performances, as close as possible to those of supersonic combat aircraft and from this point of view, the performances of the DC training - aircraft, with a slightly higher weight than the SC version are more modest.

Also an important advantage of the SC aircraft is represented by the costs, both of the aircraft itself and the maintenance and operational ones (on the ground and in flight), which are smaller, because this type of aircraft has a fully equipped cabin only instead of two and therefore the operation and maintenance costs are lower.

From this perspective, the cost of the flight hour of a SC subsonic training aircraft is lower as compared to that of a similar DC aircraft.

If one has in view the above and also takes into account the fact that SC aircraft are piloted by a single pilot, the benefits referred to become clear.

In the last period of time, the tendency to transform the DC training aircraft in the SC version -, is in many countries, which also manufactured airplanes, a fact easily observed and as such it should be considered as a positive and necessary factor.

In this respect, between 1990 and 2000, a number of countries (which adopted the financial resources saving program concerning the use of SC subsonic aircraft for pilots

training along with the supersonic aircraft training flights) manufactured SC training light aircraft, by converting the DC training aircraft into their SC version.

Thus, the aircraft manufactured in the Czech Republic - L - 159 with double - control, have been modernized, remotorized and turned into SC training and combat aircraft L - 159 ALCA.

In England, the DC school and training aircraft HAWK - 100 was upgraded and transformed into the SC advanced training aircraft HAWK - 200.

In Italy, according to some information (unconfirmed yet), there is a development plan by which the DC instruction aircraft AERMACCHI - MB - 339 (CD) would probably be turned into a SC training aircraft.

Romania promotes a program for conversion of the DC training aircraft IAR 99 - SOIM, into a SC modern training aircraft, IAR 99 (A) - SOIM (SC), aiming at the same time to implement some programs for the aircraft modernization and fitting with a more powerful engine and a lower specific consumption, preferably of class VIPER RR 680-43 or 632-46 with traction ranging between (4400-4450) lbs. The aim is to bring it to NATO standards, in what concerns the ability of the aircraft to meet a wider range of advanced training and combat missions, compared with the current DC version In order to increase distance, duration and flight tactical range, the capacity and the number of internal and external fuel tanks, were increased.

Their arrangement and structural differences between the DC and the SC training version can be seen in Fig. 7 and 8.

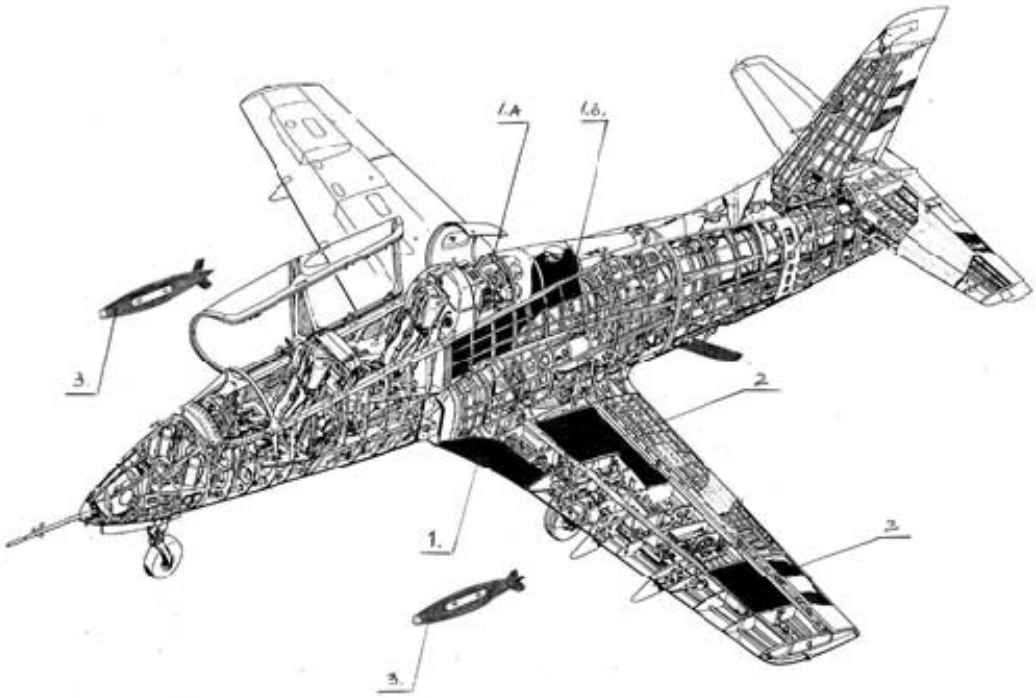

Fig. 7 INTERNAL AND EXTERNAL FUEL TANKS ARRANGEMENT
FOR THE D C TRAINING AIRCRAFT IAR 99 - SOIM,
1. WINGS - FUSELAGE APEX, 2. WING INTEGRATED TANKS, 3. ADDITIONAL UNDER WING TANKS
4. ADDITIONAL UNDER FUSELAGE TANKS 1A and 1B. INTERNAL FUSELAGE TANKS

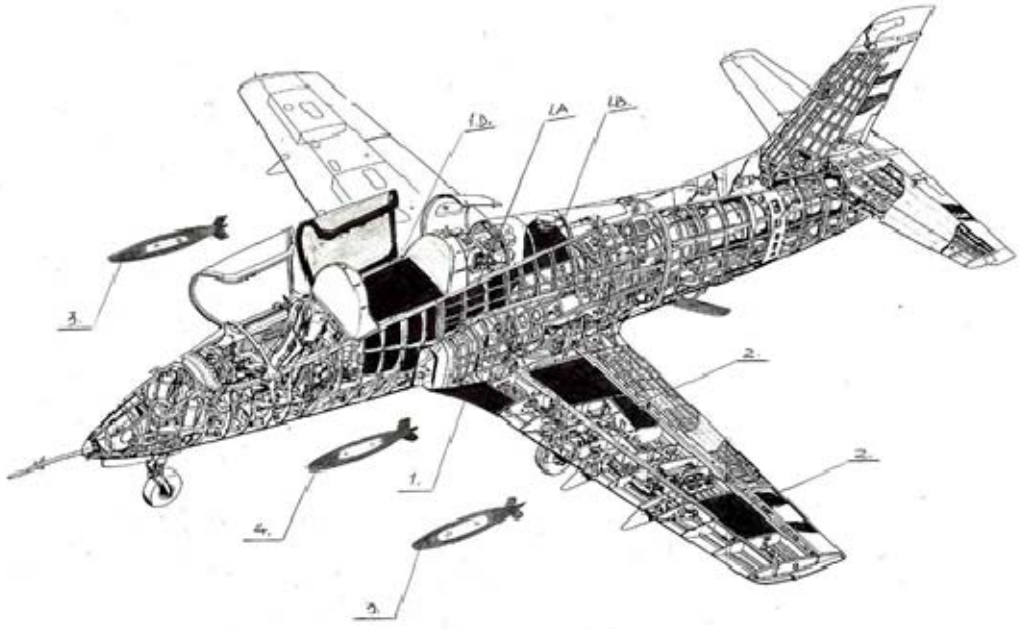

Fig. 8 INTERNAL AND EXTERNAL FUEL TANKS ARRANGEMENT
FOR THE S C TRAINING AIRCRAFT IAR 99 - SOIM,
1. WINGS - FUSELAGE APEX, 2. WING INTEGRATED TANKS, 3. ADDITIONAL TANKS,
4. ADDITIONAL UNDER FUSELAGE TANKS: 1A, 1B and 1D. INTERNAL FUSELAGE TANKS

Applying the programs mentioned, led to improved performance and flight characteristics (set for the green version, (not fitted with avionics or pillars and additional tanks) of a simple aircraft, compared with the dual-control variant, see Table I. Note that the conversion of the DC aircraft into their SC training version, was accomplished in countries with a tradition in the aerospace industry, namely those countries that have designed and manufactured such aircraft as they were able to transform them with relatively low costs, so that the savings obtained by the difference between the cost price of the two types of airplanes and the difference between the flight hours cost, cover and even exceed expenditures made by transforming the respective airplanes. Thus significant savings can be obtained that can be used to increase the number of SC training aircraft of the operational units.

COMPARATIVE DATA OF IAR 99 -SOIM (DC) AND REMOTORIZED IAR 99(A)-SOIM (SC) Tabel 1

PERFORMANCES AND CHARACTERISTICS	**UNITS OF MEASUREMENT**	**IAR 99 – SOIM D.C.**	**IAR 99 (A) – SOIM S.C.**	**OBS.**
ENGINE		**RR VIPER 632 – 41**	**RR VIPER 680 – 43**	
THRUST	Lib. / KN.	4.000 Lib./ 18,14 KN.	4.400 Lib./ 19,95 KN.	
SPECIFIC COMPSUMPTION	$Kgf_C/Kgf_T/h$	0,975	0,736	
WEIGHT	Kgf.	374	379	
WEIGHTS				
EMPTY WEIGHT EQUIPPED	Kgf.	3.220	3.200	
FUEL LOAD	Kgf.	1.080	1.280-1.450	

CREW	Kgf.	180	90	
MAXIMUM TAKEOFF WEIGHT	Kgf.	4.480	4.570	
PERFORMANCES				
MAX SPEED (H=0)	Km./h.	850	895 – 900	
RATE OF CLIMB	m./s.	32	33,73	
MIN. SUSTENTATION SPEED	Km./h.	200	208	
GLIDING LIMIT SPEED	Km./h.	266	273	
CEILING ALTUTUDE v_z = 2,5 m./s.	m.	12.900	13.700	
MAX FLIGHT DISTANCE	Km.	1.128	1.590	
MAX. FLIGHT TIME	ore/min.	2h./42'	3h./48'	
MAX. RANGE	Km.	352	735	
MAX. TAKE-OFF RUN LENGTH(H=15m.)	m.	760	549	
MAX LANDING DISTANCE. (FROM H=15m)	m.	934	522	

NOTE: It is noted that the performances of the two aircraft, (the first aircraft being equipped with a RR VIPER 632-41 engine and the second, probably, with RR VIPER 680-43 or 632-46engine), having the same geometrical configuration (Fig. 4) and about the same aerodynamic parameters, are different, noting that the SC aircraft has superior performances as compared to the DC version. One can conclude that remotorizing the IAR 99 (A) - SOIM (SC) is beneficial, placing this aircraft among the high performance airplanes of this category.

For this reason, since the 1990s, as the Author of the training aircraft IAR 99 - SOIM (DC), project, I have proposed their use in combat units, for military pilots training, thus reducing the number of flight hours with MIG 21 aircraft which were not brought up to date, at the time. As the number of flight hours in operational units at the time, was very small, this proposal could not be materialized.

Now, when the number of flight hours is increasing, this proposal can be applied, as we have the technical capacity to design and manufacture a number of SC advanced training aircraft, and also to use them for pilots training in operational units. This results in the following advantages:

- Saving supersonic combat aircraft resources as its cost is much high as compared to that of a SC subsonic training light aircraft.

The cost of a supersonic aircraft is equivalent to that of 4 to 6 SC training light aircraft and in some cases even more, if we have in view the difference between the cost of a training aircraft, such as SC IAR 99 (A) - SOIM and the cost of a supersonic aircraft, such as F.16, Gripen or Eurofighter, etc.

- Saving funds as a result of reducing the number of hours of flight with supersonic combat aircraft (which have high costs of flight hour) and of using SC subsonic trainer aircraft - (which have a lower cost of the flight hour) in order to increase the number of hours of flight training of military pilots in operational units, which flies, usually supersonic combat aircraft.

In this regard, I consider it is necessary to adopt new training and combat instruction programs for military pilots in accordance with new concepts, based on the experience of countries that since the early 80's, have adopted new methodologies on combat training, meaning the use of alternative flights, both with supersonic and subsonic aircraft, the number of flight hours with advanced subsonic trainers being prevalent.

These programs rely on the Air Force General Staffs requirements stipulating the necessity of providing the operational units with an increased number of SC subsonic training aircraft characterized by lower overall costs, as compared to those for supersonic aircraft. To reduce the, rather high travel expenses of the pilots from the operational units to the specialized military combat training centers, it was necessary for the new advanced training aircraft to be intended directly for operational units and used in their flight program.

The purpose being the saving of financial resources based on which to obtain the increase of the overall number of flight hours for each pilot, in part, with costs to be within the same limit of the allocated funds

In this respect, each operational unit must have a sufficient number of SC subsonic advanced training aircraft for their use with low-cost and no additional travel and accommodation expenses for training pilots in specialized units.

The adoption of such programs, (besides that pilots will fly more hours per year), will have medium and long term economic benefits such as:

- Relaunching of design and manufacturing programs for a significant number of subsonic training aircraft (with costs of 4 to 6 times smaller than those of supersonic aircraft) to complete the number of combat training aircraft required in operational units.
- The social effect of maintaining the design and execution capabilities of the aeronautic industry.
- Saving on this basis, important foreign funds as a result of reducing the number of supersonic aircraft acquired (which very high costs can no longer be covered by many states)
- Maintaining at acceptable levels, the Air Force Military budget funds, without affecting the combat instruction of military pilots, etc.

Finally, why should we prefer the SC subsonic training aircraft instead of their DC version?

A partial answer was given above and in addition it should be highlighted the following:

- Because of the larger capacity of their internal fuel tanks, those aircraft have the distance, duration and flight tactical range, much increased than the DC aircraft.
- Following the removal of appliances and equipment from cabin II, the SC aircraft has a lower price compared to that of the DC version.
- The SC airplane is lighter, which gives it technical and tactical features and better performances as compared to the DC version and in addition, it is easier to operate, which determines also lower costs of the flight hour

In addition, modernizing and remotorizing these aircraft result in several tactical advantages, namely:

- The new aircraft will be equipped with avionics almost identical to that of supersonic combat aircraft of the respective operative unit
- The new avionics along with the upgraded on board systems , especially the weapons system, offers new airplanes, the capacity to fulfill, within specific speed, combat missions, which currently are performed by supersonic aircraft, except the intercept ones, at very high altitudes and at supersonic speeds.
- Being remotorized with more efficient engines, this type of aircraft has gained new features in terms of flight performance and general training, such as:
  - Increase of maximum flight speed
  - Increase of maximum rate of climbing
  - Increase of practical flight ceiling
  - Increase of distance, duration and range of tactical flight

- Reduction of take-off and landing distances
- Reduction of gap between the approach speeds of the SC advanced training aircraft and the supersonic aircraft (see fig. 6)

➢ Completely meet the specifications and requirements of the Air Force General Staffs concerning the application of international regulations on designing, computing, manufacturing, ground and in flight testing, including the flight international certification standards.

Considering the above, the subsonic training aircraft (fig. 9), became suitable for use in combat training programs of military pilots, with significantly lower cost as compared to the supersonic aircraft utilized for the same purpose.

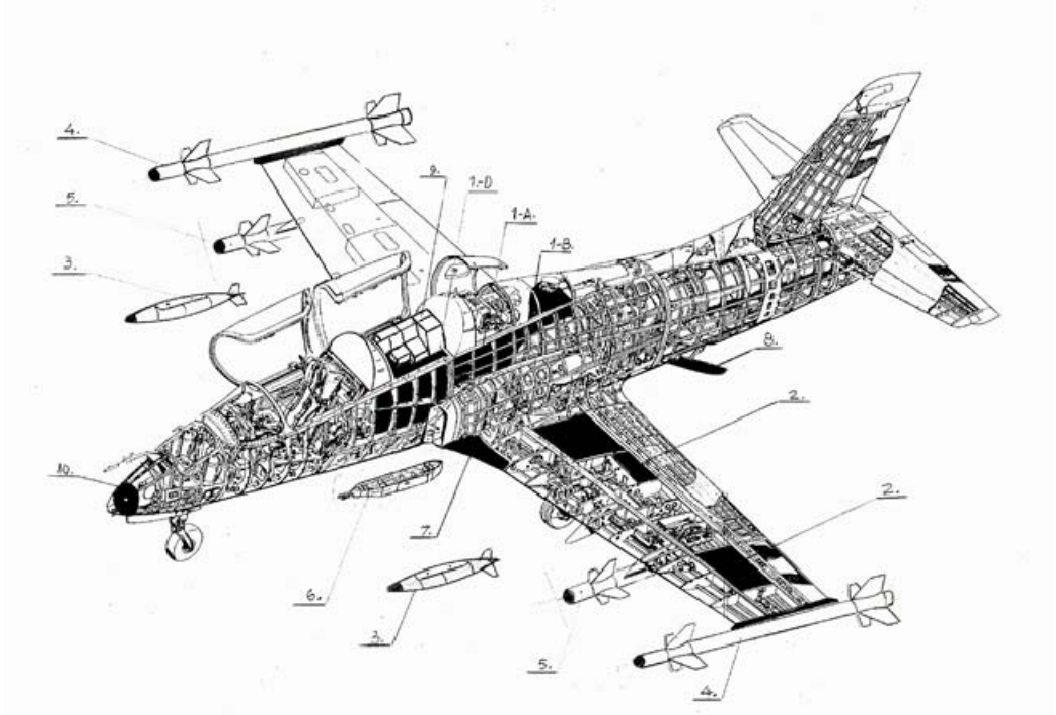

Fig. 9 The weapons system basic version of the SC TRAINING AIRCRAFT IAR 99 (A) – SOIM (1 - A) (1 - B) and (1 - D) FUSELAGE FUEL TANKS, (2).WINGS INTEGRATED TANKS, (3).ADDITIONAL TANKS, (4).GUIDED AIR –TO-AIR MISSILES (5). GUIDED AIR –TO –GROUND MISSILES, (6). CANNON CONTAINER, (7).WINGS - FUSELAGE APEX, (8).AERODYNAMICS BRAKE, (9).RADAR EQUIPMENT, (10).RADAR ANTENNA.

Lately, a series of articles of the specialty press support the idea of using new subsonic training aircraft, especially the SC ones, to be integrate into combat training programs of operational units.

In an article published in TOP - GUN a few years ago, James Elliot, a specialist in military aviation, drew attention that a number of countries, including USA through the JPATS program (Joint Program Trading Aircraft System), Australia and South Africa through the LIFT program (Lead in Fighter Trainer) Russia through the MIG - AT program and others ,have proposed the development of advanced subsonic training aircraft for military pilots – having in view the training in optimal conditions, with much lower costs as compared to those of supersonic aircraft.

The author supports the idea of choosing, as advanced training aircraft, the SC subsonic aircraft version, underlining disadvantages of the DC version such as, and I quote:

- "Certain disadvantages (of the DC aircraft) should be considered in what concerns their combat potential, such as: reduction of internal fuel, higher empty weight, aerodynamics factors (higher drag), a higher cost price etc.

Further he underlines that:

- These disadvantages concerning the combat capacity are compensated by the lower cost of the SC training aircraft as a result of the complete equipping of a single cockpit, compared with two of the DC version, and also by some performances such as: longer distance, duration and flight tactical range, following installation in the space left free in cabin II, of a fuel tank, which increases the internal capacity by about 30-40%.

Considering the financial advantage offered by this new concept on using the SC subsonic trainer aircraft in combat training programs of military pilots, many countries, which have specialists and production capacity, although their economic difficulties, approached the modernization and remotorization programs turning the DC training aircraft into their SC version, to make them available to the Military Air Force from the respective countries. Besides the obvious financial advantage, it was taken into account that, on one hand this new concept will help improving military pilot combat training and on the other hand it will reduce substantially the number of flight events, due to increased number of training flight hours of each pilot, which is a very important factor in both combat training and flight safety increase.

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