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THE SCOPE OF APPLICATION FOR PASSENGER AND CREW RESCUE EQUIPMENT IN MILITARY-CIVILIAN LIGHT MULTIPURPOSE AIRCRAFTS[2,3]

The need to enhance safety levels has been an issue since the appearance of the first flying machines. Due to the high standards of design, production and operation aviation risks can be regarded low compared to other forms of transport. Military aircrafts pose a greater risk owing to their nature of application so they require crew and passenger rescue equipment that is different from civilian-run aircrafts. The primary function of this is to save the lives of the persons who are on board the aircraft and to increase their survival chances. The danger stems from airspeed, height and the conditions of landing. My study focuses on the category of military-civilian light multipurpose aircrafts, examining the relations of reconnaissance and destruction in NOE flying, and the operational settings for guided crash, using ejection seats, parachutes, airbags, the GRS system and escape crew capsules.

LÉGIJÁRMŰVEK UTAS- ÉS SZEMÉLYZETMENTŐ BERENDEZÉSEK ALKALMAZÁSI LEHETŐSÉGEI EGY KATONAI-POLGÁRI VEGYES FELHASZNÁLÁSÚ KÖNNYŰREPÜLŐGÉP ESETÉN

Az első repülőszerkezetek megjelenésétől felmerült az igény a biztonsági szint növelésére. A tervezés, gyártás és az üzemeltetés magas színvonala miatt a repülési kockázatok a többi közlekedési formához képest alacsonynak tekinthetőek. A katonai légijárművek alkalmazási jellegükből adódóan nagyobb veszélyeztetettségűek, ezért a polgári üzemeléstől eltérő személyzet és utasmentő berendezéseket igényelnek. Ezek alapvető rendeltetése a légijárművön tartózkodó személyek életének és testi épségének mentése, túlélési esélyeik javítása. A veszélyforrás a repülési sebességből, a magasságból, illetve a földet érés körülményiből ered. Tanulmányom kifejezetten a könnyű, katonai-polgári vegyes felhasználású repülőgépek kategóriájára fókuszál, megvizsgálva a földközeli repülés felderíthetőségi, megsemmisíthetőségi viszonyait, az irányított lezuhanás, katapultálás, ejtőernyő, légzsák, GRS teljes gépet mentő rendszer, valamint a mentőkapszula működési környezetét.

INTRODUCTORY THOUGHTS

The need to enhance safety levels has been an issue since the appearance of the first flying machines. People's mistrust originates in the most important two elements of flying: height and speed. Despite the outstandingly great values of the current level of operational safety the development and developing of rescue and survival equipment has not stopped and offers further prospects. Owing to their scope military aircrafts pose a greater risk than civilian flying. Accordingly, crews – passengers – leaving the aircraft in an emergency situation is more typical in military flying, and thus it requires rescue equipment that is different from civilian-run aircrafts.

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It is worth examining the potentials and limits of currently used equipment through the technical solutions of rescue equipment and procedures used in aviation, and based on that search for new directions for future developments that can efficiently ensure an optimally high level of safety for light aircrafts.

In view of the low take-off weight, the similarity of their set of tasks, speed and height range it is worthwhile to examine the solutions used in helicopters. Out of the possible solutions I will analyse the potentials of catapulting, emergency parachuting, guided crash and escape crew capsule saving the whole of the aircraft as well.

My study is searching for optimal solutions for life defence, safety – both theoretical and practical – for military-civilian light multipurpose aircrafts.

CONSTRUCTIONAL SOLUTIONS

The necessity of rescue

The function of rescue equipment on board is to save the lives of the persons who are on board the aircraft and to increase their survival chances. The dangers connected to civilian flying stem from airspeed and height, the ones connected to military aviation originate in air defence counteractions, and the challenges of survival and rescue after landing. Since my study focuses on the category of military-civilian light multipurpose aircrafts, I am intentionally not discussing emergency situations stemming from dehermetisation and from high speed (supersonic emergencies). I am not examining the dangers resulting from the failures and shortcomings of organisational, air traffic control or passenger information systems.

The necessity of rescue equipment is justified by the permanent inability of aircrafts to fly. We can differentiate among technical failures and emergency situations arising from the pilot's or air traffic controllers' error, meteorological conditions or military counteractions. It is worthwhile to examine the details of emergency situations that can be attached to aviation, especially to military applications.

Our fast developing world ensures great opportunities for air travel since it has managed to enhance the level of safety to a required level. Accordingly, passive safety means are used in civilian aviation that fulfils their tasks directly, without intervention, by their sheer presence, or because of their special features, by prevention. In the case of emergency landing these include anti-sparkle materials, guided breaking-points, ergonomic formations protecting crew against crashes in cabins, anti-burn materials, notices informing passengers, et cetera. There are, however, devices serving safety actively, which block or reduce damage by means of intervention. Such are eject seats, parachutes, on board fire extinguisher systems, seat belts and air bags.

Let us examine which procedures and constructional solutions meet requirements, and what the strengths and weaknesses of implementation and operation are [1].

Guided crash

Guided crash is landing conducted by the pilot which emerges from the permanent inability of the aircraft to fly and demands an immediate solution. The aircraft unable to fly performs the landing stabilised in its motion on a designated area in a very short time. If the aircraft suffers a major damage the most important aspect is to save lives and reduce injuries.

This especially needs to be examined when flying at low altitudes, particularly for military aircrafts. It is a fact that there is no sufficient time left to reduce or restore immediate breakdowns as a result of technical or military counteractions or to make use of other rescue devices when lacking sufficient altitudes.

Military flying uses these zones that are dangerous for aviation due to tactical, reconnaissance and air defence security reasons. In these cases the first step is to examine the external circumstances of guided crash, emergency landing.

The use of passive means serves the function of absorbing the impact energy that comes from the power of the hit which is a result of the vertical sinking speed. Crews aim to achieve the smallest load multiple and the smallest retardation in order to avoid damaging the aircraft. In the majority of cases this can be achieved by increasing the travelling length and keeping retardation at a guided, regulated level. Tolerating the strain materialises in a flexible change of form at the beginning, then after a certain limit it realises in permanent guided changes. The landing gear – the strut and the tyre – absorbs the impact energy coming from the impact with the ground without permanent change of form. If the complete pit of the strut is not, enough the fixing of the crew's seat becomes deformed on a further 40–60 cm distance. (Figure 2.)

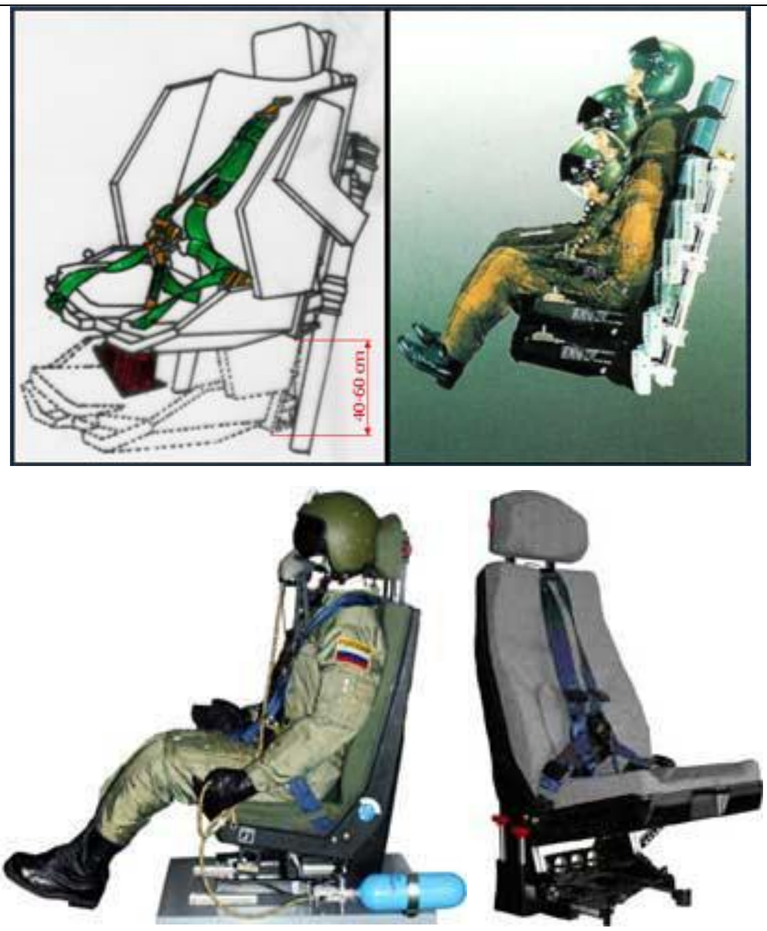


Figure 2. An AK-2000A pilot seat that absorbs impact energy, suffering a non-flexible change of form [2]

Further retardation is ensured by the guided deformation of the fuselage after the break of the landing gear. The parts bearing the load may be timed to deform by changing the strength of the bolt coupling, so the extent of retardation can be regulated [3].

In figure 3 we can see airbags built into airplanes. According to statistics, 50% of deaths are caused by head injuries which can be reduced this way significantly. Airbags protecting aircraft crews were introduced much later than those for car drivers. When we search for reasons we must size up the speed ranges used by the two industries as different. The operational speed of airbag systems installed into cars is strongly limited (10–50 milliseconds depending on size and approximately 300 km/h fast). The time to sense, make a decision and intervene and the retardation distance define a maximum speed which is usually a 60-80 km/h limit value, thus a 0-80 km/h speed range. This interval at the same time is a range not used by airplanes for flying. It can be used in the retardation period after landing or by helicopters. It is usually experienced that the full length of retardation time is considerably longer than in road traffic. That is why airbags used in airplanes remain inflated for longer, for nearly 3 seconds [4][5].

Figure 3. The Mooney airbag and the crash test of the Diamond Da-40 type aeroplane fitted with it [6][7]

Despite all the above airbags can serve as a device to avoid certain injuries when doing emergency landing and guided crash. Their structural formation is partly different from the ones in cars, the opening process starts at n_y=9 load multiple. The airbag fitted into the dashboard or the seatbelt protects the human body lashing forward helplessly from injuries like a cushion. (Figure 3)

Figure 4. The airbag system fitted externally on the MD-500 and the one fitted onto the seatbelt in Da-40 [8]

Another solution – which for the moment is in its experimental stage – can be airbags fitted onto the outside of the fuselage to decelerate crashes. (Figure 4) Advantages of this inflating balloon system are that they weigh a mere 1.5 kg and that the protection is activated regardless of the pilot's intention. Figure 1 shows that flying at low altitudes and at high speed the response time of the crew is not sufficient to solve an emergency situation. The drawback of this system is the speed limit which cannot offer real protection in some of the aviation incidents.

Guided, regulated crash is a passive means decreasing the amount of injuries among those protecting the crew. The limits of the results achieved by the modified fittings may be the limited nature of the descending speed, and the lack of guided emergency landing. If rudders become ineffective or are lost the supplements cannot protect the lives of the crew. Other disadvantages are the weight and cost increase of the structural modifications. Thus it is worthwhile to examine options that can be suitable to effectively save the lives of the crew at higher altitudes compared to what we have studied before, in case of the aircraft's total inability to fly.

Parachutes as rescue equipment

Using parachutes to rescue crews is a generally used, obvious and long standing solution. According to the cyclopaedia of flying parachutes are structures that can decelerate the dive of the body (load) attached to them during falling. They can only perform their unfolding and their braking effect as a result of drag, when in air. They reduce the 50 m/s speed of the falling human body to 5-8 m/s (or 0 m/s) vertical speed which is a condition to land safely, without injuries. (The 0 m/s in brackets refer to the so-called ram-air parachutes (that can be flared); the 5-8 m/s refer to traditional round parachutes.)

The idea of creating parachutes is probably as old as the wish to fly. Although the Chinese and Venetian constructions or those designed by Leonardo da Vinci had ensured the theoretical background, the appearance of hot air balloons and zeppelins – and later aeroplanes – have made the improvement of parachutes more important [9].

There are different types of rescue parachutes that have been and are used in Hungary. More popular ones are: S-3-3; S-4; S-5K; Pn-58; Re-5; PSM-3; PSM-4; PSU-36; developed in Hungary are: ZHM-1 and ZÜM-1.

Rescue parachutes that are popular abroad are: USA-B-12; B-4; NB-6; NB-8.

In civilian air traffic Security Safety-Chute, Pioneer Thinpack and Beta are popular.

Requirements for parachutes:

- they should operate and unfold safely;
- their structure should bear all strains as safely as indicated in their specifications;
- they should be sturdy but light, and small in volume;
- it should be easy to plan their lifetime – that is reduced by the fatigue caused by the repeated strain – through their practical formation, structure, and an excellent quality of material;
- after unfolding parachutes should be stable and easy to direct; they should equalise the harmful effects of wind;
- they should have a simple structure and should be easy to fold; the cost of their production and repair should be low.

The use of parachutes can be limited by the physical feature of the pilot which prevents or limits leaving the aircraft due to its high speed, complicated movements and the power impact resulting from these. (It is easy to see that if a helicopter has a torque effect trouble – which happens suddenly and usually ends in a catastrophe – beside the 180°/second turnover rate the radial force makes it impossible to leave the helicopter. In the case of a fighter plane a resistance at 600–700 km/h which is a result of convection changes leaving the plane safely without outside help into an impossible task.)

The descending speed of round rescue parachutes is formed in such a way due to size and mass economy that they are suitable for rescuing lives as opposed to sport parachutes which are expected to make landing possible without injuries. Mass and volume of rescue parachutes are in inverse ratio to descending speed. It has been an aim to reduce the mass of rescue parachutes through their size. As we can see from the formula of reaction force and strength (Formula 1) the product of mass (m) and gravitational acceleration (g) equals the product of the drag coefficient (C_x) characteristic of the shape of the dome, half of the density (ρ), square of the vertical speed (v) and the surface (A) of the dome. Depending on the mass of the pilot with the consistency of g, C_x, ρ, A descending speed changes and because of that the risk of injuries increases considerably. Limits of a rescue parachute's use are the mass of the pilot and flying height because of the change in the density of air.

$$m \cdot g = F_X = C_X \cdot \frac{\rho}{2} \cdot v^2 \cdot A \qquad [kg \cdot \frac{m}{s^2} = N = \frac{kg}{m^3} \cdot \frac{m^2}{s^2} \cdot m^2] \tag{1}$$

$$v = \sqrt{2gs} \Rightarrow s = \frac{v^2}{2g} \qquad \left[m = \frac{\frac{m^2}{s^2}}{\frac{m}{s^2}} \right] \tag{2}$$

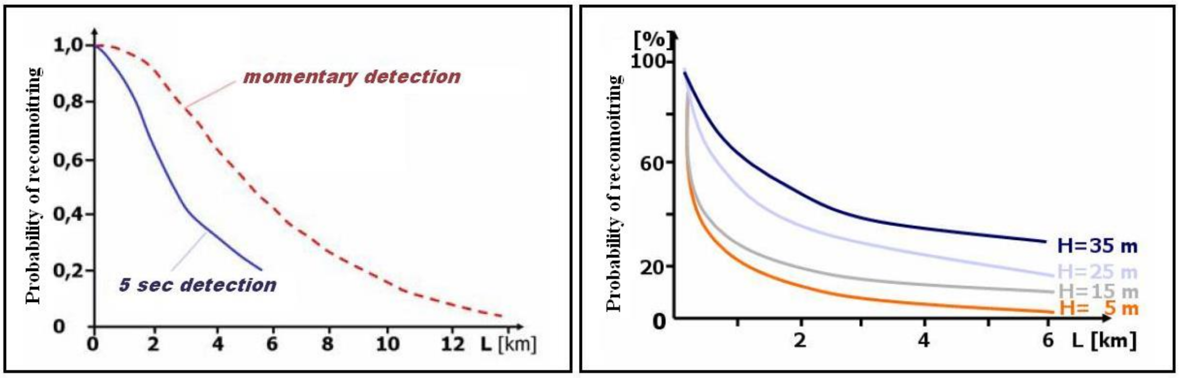
As an example, if we fit the 6 m/s descending speed of a parachutist into Formula 2 equals the landing speed of a person jumping from 1.8 meters. The density of air at 5500 meters is half of what can be measured at sea-level. [10] The v^2 doubles and the equal jump height without a parachute changes from 1.8 to 3.6 meters. Depending on the nature of the ground this can be dangerous. The example is extreme but because of its nature it shows that landing on high surfaces using a rescue parachute may mean further risks.

Although not generally used as rescue parachutes, it is worthwhile to examine the so-called ram-air parachutes that can reach 0 vertical speed at touch-down. Their small structural mass and low descending speed make them an obvious solution. However, this structural formation is rarely used as a pilot's rescue parachute since its unfolding procedure is slower than that of round parachutes so their minimal jump height is also higher. In practice the unfolding process requires a stable fall that can only be performed by experienced parachutists. High forward speed, selecting the appropriate moment to glide, and touching the ground are all important, sensitive parts of remaining accident-free so they make rescuing an unconscious person risky.

On the whole we can say that a pilot's high body mass or parachute landing performed at high altitudes in mountainous areas pose increased risks.

The application of parachutes can be limited by time required for leaving the aircraft and for unfolding the parachute, and through that the minimal flying height as well. A significant feature of parachutes is their minimal height to unfold from where beside the given flying speed the parachute can reduce the speed of its load to land safely. Thus we can conclude that in NOE (Nap Of the Earth) flying parachutes cannot be used on their own as rescue devices.

Light aircrafts have limits when in military use. Due to the low take-off weight, the option of armour-plating of an aeroplane, and installing missile defence in it is strongly limited. As a result of this, flying at low altitudes where landmarks and the curve of the Earth guarantee protection is an excellent way of reducing the chance of being reconnoitred. This protection, however, worsens flight security, increases the crew's stress level, and can require the installation of special soil tracking facilities, systems.



Destruction device	Flight altitude (H)				
	5 m	50 m	100 m	500 m	1000 m
	Survival chances [%]				
“Ground to air” missile	~100	90	80	40	10
Portable air defence missile	~100	95	90	85	90
Multiple pompom guns	~100	90	85	75	60
Airborne machine gun	~100	90	75	85	95
Infantry gun class firing	80	70	60	80	~100

Figure 5. Chances of being visually reconnoitred, destructed in accordance with distance and height

As we can see in Figure 5, the chances of being visually reconnoitred largely depends on flight altitudes; below 15 metres the chances of being reconnoitred are a mere 5% in 5 km, and in 1.5 km – which is the inducement distance for Sz-5 non-guided missiles – is only 15%. [3]

Based on this we can say that flying near ground level guarantees fair protection. Although parachutes alone are not sufficient to enhance the safety of pilots flying at low altitudes, a possible solution is to use catapult systems at the same time.

Catapulting

“Catapulting is when the pilot leaves – usually military – aircraft flying at a high speed using an ejection seat in cases when the aircraft gets damaged and impossible to control.” [11] Its development was necessitated by the increased speed of military flying. Flying over 400 km/h makes it impossible for the pilot to leave the aircraft without help because of the volume of strength from dynamic pressure. The first operable plan of the ejection seat was designed in Germany in 1939, and then came successful development in the UK, USA and the former Soviet Union. [12]

The constructional solution was that the pilot’s seat was formed in such a way that the gas piston in the cylinder attached to it is ejected by the gas produced during ignition and later landing is assisted by a parachute. The most powerful limit of the use of this system is the overload which is a result of the pilot’s acceleration. [13] (Figure 6)

$$n_y = \frac{F_y}{G} = \frac{\mathrm{m} \cdot a}{m \cdot g} \tag{3}$$

Since the overload can be as high as a $n_y = 16 - 20$, the endurance of the strain depends on the pilot’s fitness level, their build, the position of their body and the time of the overload.

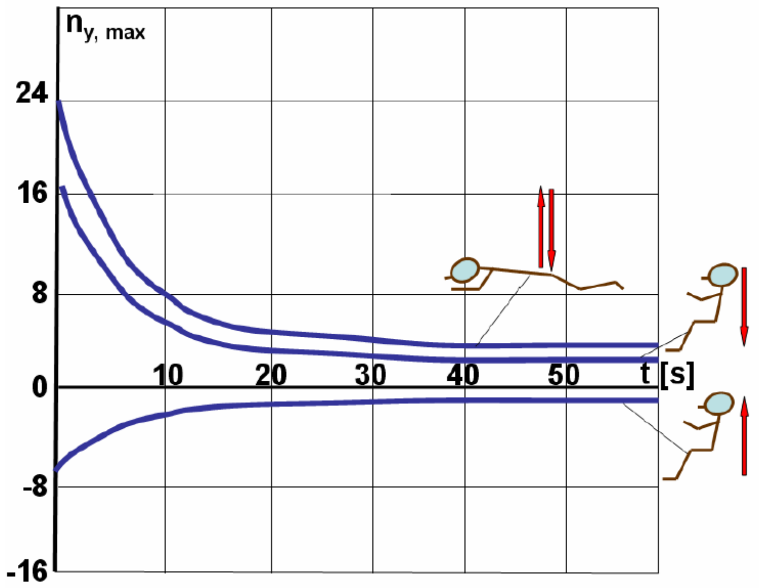


Figure 6. Tolerable overload in accordance with body positions and time [2]

When leaving the aircraft a pilot needs to do several tasks using technical devices. Let us see these in the order of using an ejection seat:

- Successful rescue of crew should be ensured in all possible **altitude and speed** ranges and spatial positions. As a result of developments now state-of-the-art ejection seats are able to do a so-called double 0 – at 0 km/h and from 0 meter high – successful rescue. The spatial position of the aeroplane is not crucial, since it is able to turn and direct the seat into a vertically ascending orbit, and eject it 50-150 meters higher than the aircraft, even if it is diving or flying upside down.
- Facilitating the pilot's decision to leave the aircraft, since the seconds, deciseconds before **decision** making can be crucial. Unambiguous warnings of instruments on board and clean-cut vocal instructions help in making this decision. On some aircraft there is an automatic system examining the elements of flying and in critical situations – such as stalling at low altitudes – it initiates ejection regardless of the pilot.
- Forcing the **pilot's special body position** that is necessary for ejection. The process begins with the use of pull handles. Positioning it in the cockpit makes ejection possible during considerable overload as well. The position of hands is defined and legs are typically put into safe position by a sling. Tolerating the overload, and protecting body parts the position of the spine, the head and the elbow is forced by side cushions.
- Escape hatches or **canopies are blown off** or broken through: these happen with the help of explosion, unhitching using blast, so there is no obstacle for ejection. In other cases the seat itself breaks the canopy.
- **Separating the pilot from the flight instruments**: joining the radio, oxygen and the g-suit has to be easily unloosened and if they are fitted into the seat then their further operation is ensured.
- Reaching the necessary **vertical speed** to leave the aircraft: the formation of the tail is dangerous for the crew. The airspeed of the aircraft determines the necessary ejection speed. High airspeed involves high ejection speed, which increases acceleration and overload.

- Another important aspect is to keep the head-to-pelvis overload tolerable, which is a result of the **acceleration** from ejection. In Figure 6 we can see that the acceleration value is limited by physiology. Different acceleration values of ejection are desirable but regulating these is a difficult matter.
- Dealing with the overload stemming from the convection from the opposite direction after ejection, from the **ram pressure** and deceleration. Specially designed helmets and masks are used against air pressure that suddenly affects the face and the body. Shock wave generators are made in front of the pilot with the body positioned in the flow, creating shock waves when ejection seat use above sound speed. This way the ram pressure on the pilot is reduced considerably. A never-failing solution when the ejection seat is used with high speed is making use of the cockpit canopy as protective sheathing.
- Elimination of the harming effects of **dehermetisation** as a result of the opening of the cockpit (sudden change of pressure): After leaving the pressurised aircraft, at higher altitudes pressure equalization means a considerable physical strain for the human body – its oxygen supply, circulation and eardrums. These harmful effects can be greatly reduced by using the helmet, the g-suit and the oxygen mask.
- **Stabilising the spatial position** of the seat after ejection: a balance is necessary in terms of dynamics and aerodynamics that can prevent the seat turning in the wrong direction after ejection. In practice this is provided by aero dynamical surfaces and stabilising canopies.
- In military use it is of high importance to **land on safe areas** after ejection. From the military point of view a good solution is to use ram-air parachutes that glide properly (as opposed to rescue parachutes) – these can take us 30–40 km from the boundaries of the stratosphere. (In this case the pilot's control is necessary. Currently the development of autogiros and Rogallo-wings is on the way. Using these could multiply this distance.
- **Hit-like** strains resulting from unfolding the parachutes and landing are necessary to be reduced: The aim is to reduce the strains to a minimum that stem from hitting the ground and from jerking when the parachute unfolds, since other injuries, unconsciousness of the crew can be expected thus further strains can cause serious injuries. Braking from airspeed can be done using the stabiliser canopy.
- **Radiating radio signals** for search and rescue units to help them find the crew: when unfolding the parachute the radio fitted into the seat starts radiating, using the internationally accepted 121.5, 243 or 406 frequencies.
- Making **survival devices** available after landing (on ground or water): different devices are placed in the life jacket or the pilot's equipment that are suitable for the scope of application. If landing on water can be expected, a life jacket and dinghy are provided to help the pilot stay above the water.
- Assisting **military camouflage**, survival: it is worthwhile to differentiate between equipment necessary to leave the aircraft and equipment used in warfare. Life jackets are usually orange attracting attention to help search and rescue actions. On enemy grounds these are hidden, buried immediately after landing. According to war application the pilot's self-defence gun is placed on their clothing. Their equipment is fitted with several small items like shark alarm, whistle, chocolate, torch, hook, knife.

Based on all of the above we can see the technical realisation of using the ejection seat needs a technical background. The light aircraft category – 2000–3000 kg maximal take-off weight and room for 800–1000 kg payload – makes it difficult to use a rescue system that weighs 100–110 kg for each seat. [14] Although the ejection seat as rescue equipment offers a defined safety level, due to its technical realisation it is necessary to search for other solutions in this category.

Although flying at low altitudes ensures excellent tactical and reconnaissance protection, it makes leaving the aircraft suddenly a difficult task. At low heights colliding with small landmarks is an increased risk which often leads to losing the aeroplane. The reaction time of the crew is reduced at failures because of low heights. The use of parachutes is limited, the solution with appropriate speed would be using an ejection seat but this cannot be applied realistically due to the extra mass of the aircraft. Company Zvezda has developed an in-between solution which is an ejection parachute with no seat as a rescue device for light aircrafts flying at low speed.

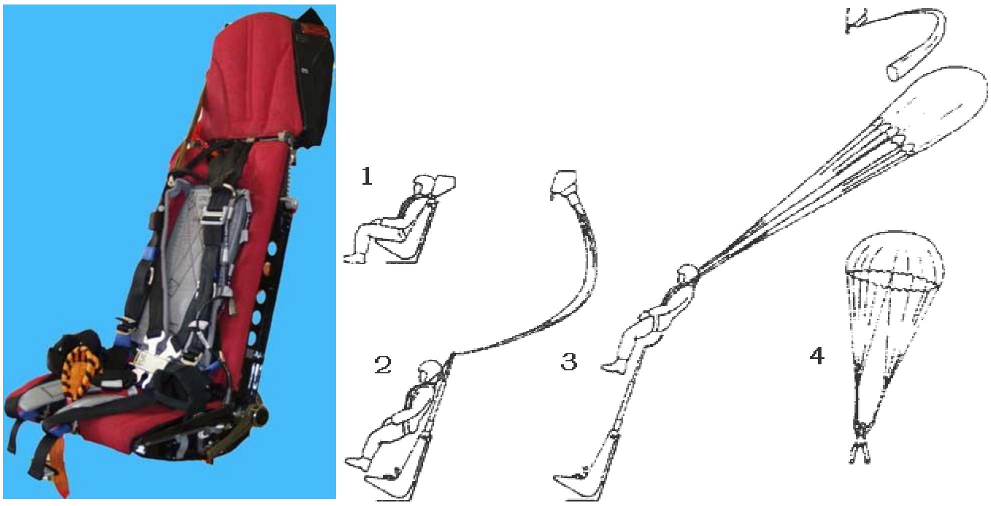


Figure 7. The CKC-94 type rocket operated rescue parachute [14]

The CKC-94 rescue system shown in Figure 7 helps the pilot leaving the aircraft by a jar-like eject system. This pulls out the parachute using a rocket, and then the flow of the air fills the dome. This makes leaving the aircraft considerably faster and the strain on the pilot is not more than the one originating in the pull of unfolding the parachute. The minimal application height is 7 meters flight altitude according to the factory data. The weight of the entire rescue device is 22–28 kg, depending on the variety. Thus the CKC-94 and other rescue devices analogous with these principles could be an alternative utilized by military-civilian light multipurpose aircrafts.

Table 1 shows the comparison of the technical data of some ejection seats.

Producer	***Type***	***Operational speed***	***Ignition height***	***Mass***	***Aeroplanes types using the device***
Zvezda	K-93	0–900 km/h	0–13 km	68 kg	L-39
Zvezda	K-36D	0–1400 km/h – M=2,5	0–20 km	103 kg	Mig-29
Zvezda	K-36L	0–1050 km/h – M=1	0–13 km	87 kg	
Zvezda	CKC-94	60–400 km/h	7–4000 m	28,5 kg	Su-26, Yak-52
	MK-17	60–300 knots	0–7,5 km		

Table 1. Technical data of ejection seats [12][14][15]

GRS (Galaxy Rescue System) is a special variety of rescue systems based on parachutes which makes landing injury- and damage-free for not only the crew but also for the entire aircraft. The GRS parachute is ejected in a sealed container to 15–18 meters from the aircraft which puts the complete pylon system into a strung position. The container only opens after this, so the dome avoids the components of the aircraft. The whole system is created in such a way that it enables the fastest opening adequate for the given circumstances, thus ensuring safe operation at the lowest height. The system starts by pulling a mechanical trigger – approximately 90 N-sized force – and the sear mechanism ignites the solid propellant of the rocket. The effusing gas is piped outside the fuselage of the aircraft so during ignition only a small amount of reactive force affects the aeroplane. [16]

Figure 8. Varieties of GRS 750, 840, 960 and 1200

When the dome opens 18 meters above the aeroplane, the rocket flies further using kinetic energy and it separates from the dome. Depending on the size of the dome and the airspeed, the rescue parachute system unfolds completely in 1.5-6 seconds. Thus a safe height for unfolding is above 30-150 meter, depending on the direction of ejection, the moves of the aircraft, and the fitting of the device. The rocket can be ejected into any direction but the most practical is to eject it at right angles with the centreline upward, or slightly backward. (Figure 9)

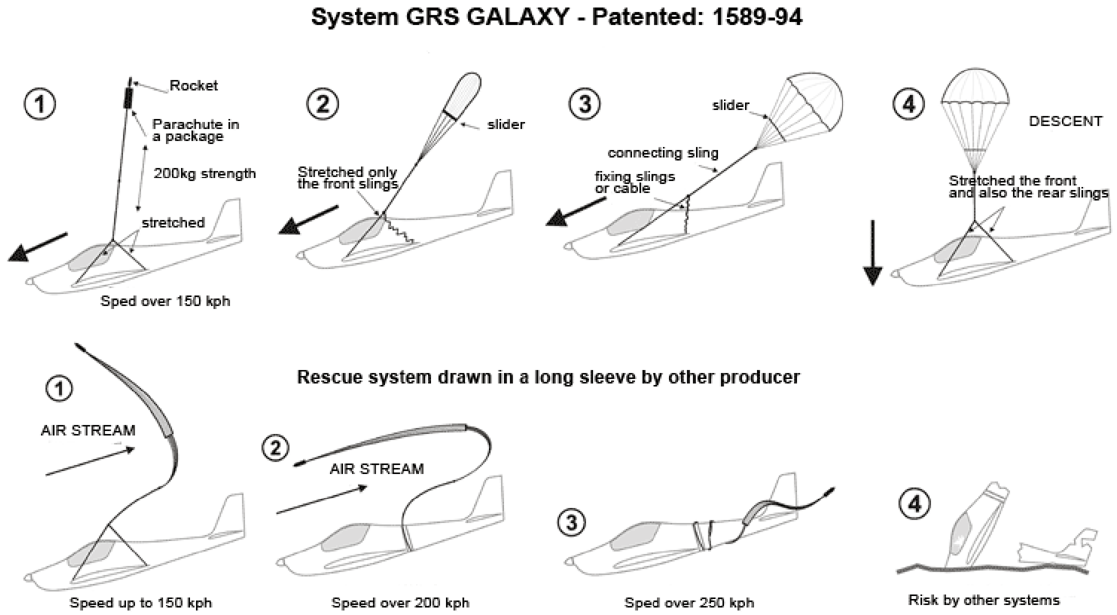


Figure 9. The operational draft of the GRS rescue system [17]

The GRS system can be used with ultra light, experimental, engine light or any other aircrafts whose maximal take-off weight is 250–2000 kg. The rocket system is designed in such a way that it is able to open the dome under extreme circumstances like between –40 and +60 Celsius outside temperatures. [17]

TYPES	safety coef.	GRS 6 750 SDS 140m^2	GRS 6 840 SDS 245m^2	GRS 6 960 DS 245m^2	GRS 6 1200 SDS 245m^2	GRS 6 1300 SDS 245m^2
Total safety coefficient of the canopy 1,25 x 1,21	K =	(● 1,08)	1,5	1,5	1,5	1,5
Allowed max. operational weight (MTOW)	K= 1,25	● 750 kg	840 kg	960 kg	1200 kg	1300 kg
Allowed never exceed speed for use (VNE)	K= 1,21	●250 km/h	268 km/h	250 km/h	250 km/h	250 km/h
Maximum test dive speed at MTOW + 25% load	K = 1	270 km/h	325 km/h	305 km/h	305 km/h	305 km/h
Measured tested figures						
Overall time of full canopy stretching at the speed of **95 km/h** and operational weight **MTOW**	sec.	6,3 sec.	6,4 sec.	6,4 sec	6,5 sec	6,6 sec
Overall time of full canopy stretching at the **MTOW** at **VNE**	sec. kg	5,3 sec. 750 kg	5,8 sec. 840 kg	5,9 sec. 960 kg	6,0 sec. 1200 kg	6,0 sec. 1300 kg
Maximum operational opening dynamic shock at VNE at MTOW	kN	28,8 kN 3,9 G	26,5 kN 3,2 G	28,7 kN 3,1 G	40,3 kN 3,4 G	45,7 kN 3,6 G
Maximum load at speed **250 km/h**	Kg	793kg	1200 kg	1500 kg	1730 kg	1820 kg
Descending recorded at Sea Level (AMSL) for **MTOW**	m/sec.	7,0 m/sec.	5,6 m/sec.	6,0 m/sec.	6,7 m/sec.	7,0 m/sec.
Canopy						
Area		140 m^2	245 m^2	245 m^2	245 m^2	245 m^2
Number of lines and panels		28	40	40	56	64
Nominal diameter		1x13,1 m	1 x 15,6m	1 x 15,6m	1 x 15,6m	1 x 15,6m
Ballistic device						
Igniter – mechanical ignition		Dual primer				
Stationary rocket engine pull		770 N/ sec. / 78 kg/sec.				
Maximum rocket engine pull		1400 N / 142 kg				
Ballistic and drawing device weight		2,62 kg				
Burn time (- 40 °C do + 60°C)		1 sec. ± 0,2 sec.				
Cycle Exchange **6 years**		lifetime 30 let				
Dimensions						
Soft pack B1	LxWxD	440x280x230	660x265x25	700x315x230	700x315x230	700x315x230
Soft pack B2	LxWxD	360x380x200	580x270x270	690x380x210	690x380x210	690x380x210
Weight unit – GRS						
Drawing sling	length weight	1 x 6 m 0,4 kg	1 x 8 m 1,2 kg	1 x 8 m 1,2 kg	2 x 8 m 1,7 kg	2 x 8 m 1,7 kg
GRS total weight Incl. the drawing sling	**Soft B** **Soft B2**	**14,8 kg** **---**	**26,9 kg** **---**	**---** **27,9 kg**	**---** **31,4 kg**	**---** **32,0 kg**

Table 2. Technical data of the GRS rescue parachute [17]

The parachute system rescuing the complete aircraft has several positive features. In this case we can speak about not only a personal rescue device but about a device that protects an entire valuable aircraft, its weaponry, airborne equipment and information. In the case of the maximum 1300 kg take-off weight category the entire system is a mere 32 kg.

In the category of light multipurpose aircrafts due to military uses the potentials of the GRS rescue parachutes is realistic but is to be treated with limitations.

The 7 m/s descending speed is critically high because of the sitting position of the pilot, but these values are for sea-level so a hit from high altitudes would worsen them. The intentions to rescue the aircraft do not seem to realise since this vertical speed brings about the damaging of the aircraft as well. The use of braking rockets before hitting the ground this value could be reduced to an acceptable level.

Escape crew capsule

Stanley Aviation Company has developed their B-58 escape crew capsule (Figure 10) for supersonic ejections and ejections at high altitudes. The airtight system has made it possible to safely leave an unserviceable aeroplane flying at 20000 meters at double the sound speed. The capsule sealing at the moment of ejection ensures the necessary survival conditions using its own pressurised and oxygen system. Naturally, it is fitted with a parachute to reduce descending speed but due to its formation it can float on water and act as a rescue raft.

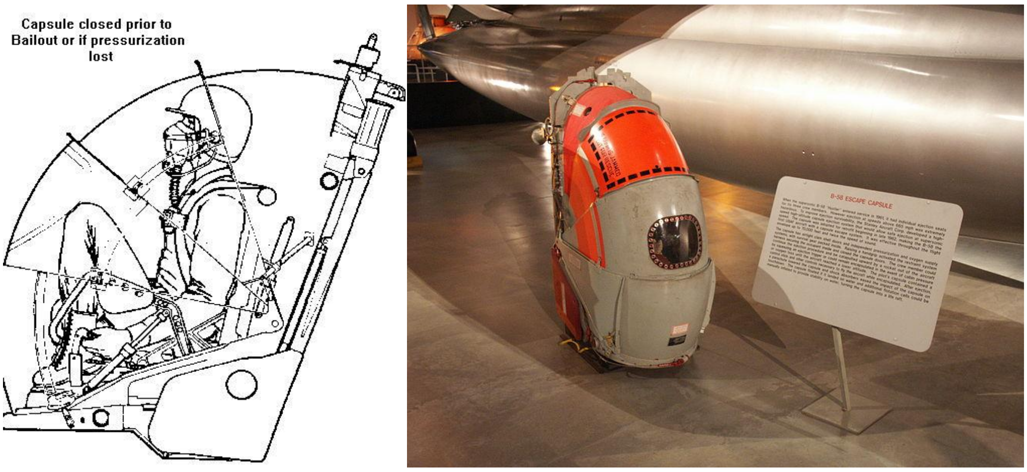


Figure 10. Escape crew capsule of B-58 bomber aircraft [18]

The lives of the two-man crew of the F-11 fighter-bomber aircraft were saved by a unit separating from the fuselage of the aircraft (Figure 11). Ejecting the entire capsule on the ground and in the stratosphere it guarantees safe landing even at double sound speed. The stability is ensured by the aero dynamical surfaces at the back of the capsule and after opening the same is done by the parachute. Safe landing on ground or water is assisted by inflating balloons that also help to stay above water. This solution is an interesting mixture of ejection and the GRS system that rescues the complete aircraft. The reduced mass of the rescue capsule results in a smaller parachute and lower descending speed.

Figure 11. The escape crew capsule of the F-11

The construction of the escape crew capsule that separates from the fuselage could be a possible rescue device for the aircraft category examined in this study. This way it is not only the crew but the passengers and the airborne load may be rescued. The parts that are not engaged in the rescue process – wings, engine, tail, fuel, weaponry – can be separated from the damaged aeroplane and this way the mass to be saved reduces to 10–30%. The remaining fuselage, landing gear unit can bring about successful landing and keeps crew, passengers and load away from potential dangers. The fuel, the operating hot engine, the weaponry may be the cause of several potential injuries damages after landing.

Summary

As opposed to civilian aviation the military operation of aircrafts involves greater risks. Keeping safety levels relatively high needs the use of special means, devices and systems. It is worthwhile to examine the details of technical solutions of rescue devices and procedures, and search for new constructional solutions and new directions for development. Military-civilian light multipurpose aircrafts need solutions that can function as rescue devices in a realistic and efficient way in the case of an aircraft serving a special function. That is why in my study I have examined the guided crash, parachutes, ejecting, GRS system and the escape crew capsule separating from the fuselage as active rescue devices. I have attempted to draw conclusions based on their structural, technical and practical features about the possible applications of these for military-civilian light multipurpose aircrafts.

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