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## “THE ODD ONE OUT”. THE MAIN PARACHUTE OF T-11 PARACHUTE SYSTEM

*Two years ago as a member of the NTA AA SAD’s official delegation visiting the industrial centre of the Airborne Systems North America (ASNA), Santa Ana, California State. During a meeting on the wall of the ASNA’s Management’s building I noticed the Award of the Congress of the United States of America in a framed picture. In the picture there was a spectacular canopied airborne troop main parachute. It was my „first rendezvous” with the T-11. I was so impressed that I started further researches on this parachute. My study presents type T-11 system’s main parachute’s „unusual” deployment system and the structure of canopy are responsible for paratrooper’s safe landing. Apart from its characteristics and specifications, the study describes those technical solutions based on aerodynamical principles concisely which was intended to increase the safety level of the T-11’s in military implementation.*

**Keywords:** parachute system, airborne, mass dropping, controlled deployment system, parachute canopy

### INTRODUCTION

Nevertheless my study is focused on the T-11’s main parachute, an explanation why designing a new type of troop parachute was necessary. Therefore I am going to introduce not only those reasons which had lead to start the innovation process and in addition those elementary aerodynamic principles which determined the essential characteristics of „the new-born”.

### PRESENTATION OF THE ANCESTOR: THE T-10

The T-10 (Figure 1) conventional shaped parachute was first seen in 1952 [1] after the World War II. laying the ground for the basis of modern American personnel airborne troop parachute systems. This non-maneuverable type is undoubtedly one of the best known conventional canopy-shaped military parachutes: not only „the basic” but newer, modifiable versions of T-10 have been introduced at several armies of the world (Figure 2).



Figure 1. „The old”: T-10 system’s main parachute in the air [2]



Figure 2. Pakistani paratrooper woman with a newer version of T-10 dropped from a Russian made Mi-17 transport helicopter [3]

The system - consists of a main (back) and a reserve (chest) parachute – provides a guarantee for its appliers as stated in the table below (Table 1).

Type	T-10	T-10R
Design:	10% extended skirt	solid flat
Diameter ( $D_0$ ) [ft (m)]:	35.0 (10.668)	24.0 (7.315)
Number of gores [ea]:	30	24
Length of suspensions lines ( $L_s$ ) [ft (m)]:	25.5 (7.772)	20 (6.096)
Strength of suspensions lines [lbf (N)]:	375 (1668.681)	550 (2447.398)
Effective $L_s/D_0$ :	0.728	0.833
Canopy material:	1.1 oz/yd <sup>2</sup> nylon	1.1 oz/yd <sup>2</sup> nylon
Parachute weight [lb (kg)]:	13.85 (6.282)	10.4 (4.717)
Maximum drop speed [KIAS <sup>1</sup> (km/h)]:	150 (277.8)	

Table 1. Basic parameters of T-10 parachute system's main parts [4]

During decades of the „Cold War” the United States of America started several parachute innovations [5] in order to correct those problems<sup>2</sup> occurred many times during deployment and landing-phase of „the basic” T-10's usage<sup>3</sup>.

The next „three main areas” were included in the scope of „the old” – „the basic” version of T-10 - investigation:

- the safety of deployment,
- the stability of descent,
- the safety of landing [6].

Innovation programmes based on T-10, generated a „family tree” with these members: T-10, T-10A, T-10B (Figure 3), T-10C, T-10C(2), T-10D, MC<sup>4</sup>-1, MC1-1, MC1-1B (Figure 4), MC1-1C, MC1-1D, MC1-2, MC-2, MC-3 (Para-Commander) [7].

Among the useful technical innovations we must underline the application of anti-inversion net placed on the edge of the lower lateral band of round canopy assembly (see: Figure 3) to avoid the above mentioned canopy malfunction. The special slot-system was designed on the surface by extension of the air-permeability of canopy's fabric to decrease the level of deployment forces. This lead to recognition that canopy slots can be used direct the canopy and the result of this the first maneuverable versions of „the ancestor” emerged.

<sup>1</sup> British/American official abbreviation of the Knots (measured) Instrument Air Speed. – remark of the Author.

<sup>2</sup> The first and undoubtedly the most typical partial canopy malfunction problem is the „Mae West” (see: Figure 10) (nickname given by the airborne soldiers of the United States Army). – remark of the Author.

<sup>3</sup> These activities could be seen not only in the western but in the eastern part of the world as well: the Soviet parachute-designers made a decision to update their well-known D-1 airborne troop parachute. This type was commonly used in the Warsaw Pact's armies in 1970s and in 1980s. „D”-letter refers to the possible application areas of it: Airborne Troop Parachute („Десантный” – in Russian). - remark of the Author.

<sup>4</sup> „MC”-letters refer to one of the main characteristics of parachute: Maneuverable Canopy. – remark of the Author.

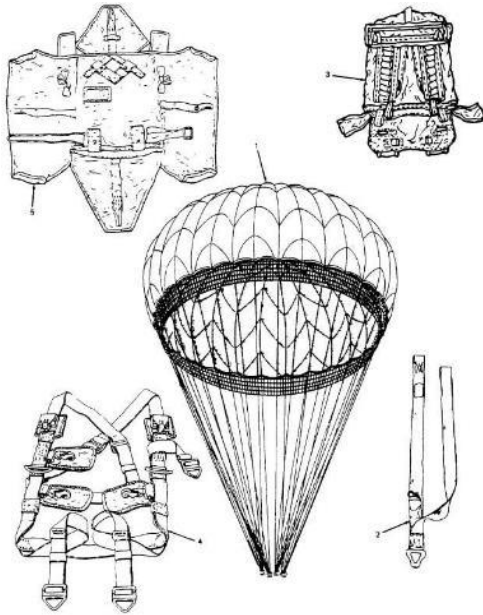


Figure 3. The components of main T-10B Personnel Troop Parachute: pack tray-, deployment bag-, harness-, canopy- (with anti-inversion net) and riser assemblies [8]



Figure 4. The MC1-1B Maneuverable Troop Parachute. The paratrooper can control the accidental drift above the planned Drop Zone [9]

These technical inventions modified „the basic” T-10 and resulted new versions -, but these new improvements may not be suitable for the continuously increasing level of war challenges [10] which determined the necessity for creation small special operation units. Nevertheless vision of the western military theoretics for mass dropping units (Figure 5) has yet been future-proof.



Figure 5. Paratroopers equipped with T-10D personnel troop parachute system over a Drop Zone during a mass dropping airborne exercise, these days [11]

Therefore new types of personnel parachute system must be designed for the airborne troops of the United States Army to extend the following criterias achieved by T-10: mass dropping with

individual weapon systems and equipment<sup>5</sup> from transport aircraft flies max. 150<sup>6</sup> KIAS (277.8 km/h) at low level altitude<sup>7</sup> [12]. And – of course – the primary requirement have not been changed: **paratroopers must land uninjured to start his/her mission.**

## THE NEW INNOVATION PROGRAMMES OF PERSONNEL AIRBORNE PARACHUTE SYSTEMS

Two main programmes were initialized in the middle of 1990s: the SOFTAPS<sup>8</sup> and the ATPS<sup>9</sup>. These names would refer to future applicants of parachute systems: the first new type would be designed for the Special Operation Forces only and the second one for the „conventional” airborne units of the United States Army.

The number ones of these programmes – the steerable MC-6 and the **non steerable T-11**<sup>10</sup> (Figure 6) **airborne troop parachute system**, including the same reserve parachute type: T-11R – were designed by engineer-teams of the Para-Flite, Inc.: the predecessor of the ASNA.



Figure 6. T-11 airborne parachute system. The main parts of it: T-11R (reserve) parachute on chest (left) and T-11 (main) non steerable parachute on back of the airborne soldier (right). The shapes of canopies can be seen in the background [14]

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<sup>5</sup> Meaning that the new parachute can be used maximum all up weight was 400 lb (181.44 kg) contrary to the T-10C's 360 lb (163.296 kg). – remark of the Author.

<sup>6</sup> In this context it should be stressed the above mentioned canopy malfunction occurs over 130 KIAS (240.76 km/h). – remark of the Author.

<sup>7</sup> It means that the planned minimum drop altitude was 500 ft (152.4 m). These requirements were based on the experiences of airborne operation „Retribution” in Panama, 1989 [13]. – remark of the Author.

<sup>8</sup> British/American official abbreviation of Special Operation Forces Tactical Assault Parachute System. – remark of the Author.

<sup>9</sup> British/American official abbreviation of Advanced Tactical Parachute System. – remark of the Author.

<sup>10</sup> Its sign was XT-11 during the innovation-process and the practical tests in the ATPS programme. The letter „X” referred to the „Experimental” status of the parachute. – remark of the Author.

According to the subject of this study I am going to focus on marginally introducing the main military requirements what the winner type of the ATPS programme has to meet. Moreover I am going to mention the several technical solutions partly based on the aerodynamic principles of parachute's deployment and the shape of canopy. I am also going to cover finally the achieved performance of the new type in connection with the above-mentioned „three main areas” of parachute's investigation.

## THE BORN OF THE NEW CANOPY-SHAPED AIRBORNE TROOP PARACHUTE

### The main requirements the new type had to meet

The primary characteristics of the new main parachute were determined as follows:

1. the deployment system must be the widely-known static line system, although partial modification had to be made to avoid the partial or total canopy malfunctions,
2. the shape of canopy must be conventional or similar structure.

### The new main components of „the new born”

#### *The deployment system*

The static line deployment system<sup>11</sup> (Figure 7) of T-10 has an effective method: the canopy, covered by the deployment bag is pulled out from the pack tray assembly (parachute pack). After stretching of suspension lines the canopy is pulled out from the main deployment bag to the air-flow and it starts filling up by air-mass.

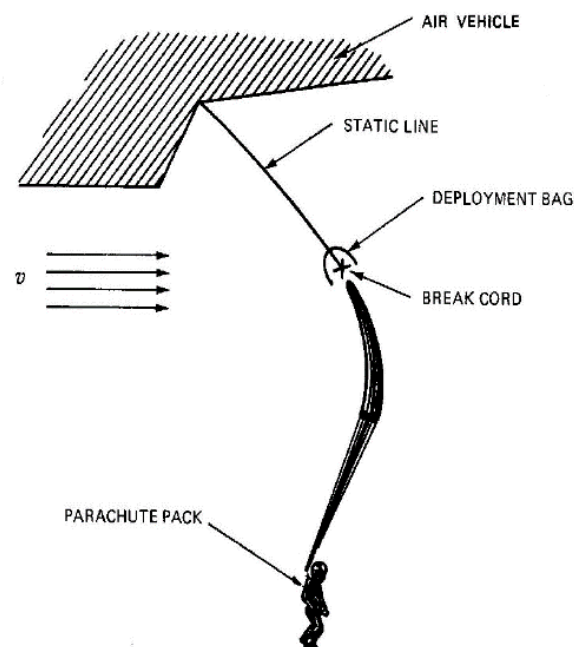


Figure 7. The scheme of uncontrolled deployment system of T-10 [15]

<sup>11</sup> In several parachute bibliographies this system is named as Heinecke-system. – remark of the Author.



Observing „the ancestor” of „the new born” we can see the lack of ripcord handle assembly, which is a general characteristic of the American-made airborne troop parachutes. That is why the static line assembly is the only one<sup>12</sup> which starts the deployment of parachute system. And in the foreseen future the main operator – the United States Army – has not, and – perhaps - will not want to change it.

Therefore designers had to partially change the T-10’s uncontrolled deployment system and equip it with new elements.

The new parachute deployment system must be fulfil the following requirements:

1. To minimize the parachute **snatch force**<sup>13</sup> by controlling incrementally the deployment of the parachute, and by keeping the parachute canopy closed until line stretch occurs. The main contributing factor to high snatch loads before line stretch is the acceleration of the air-mass in a partially inflated canopy.
2. To keep tension on all parts of deploying parachute. Tension prevents the „sailing-effect” (Figures 8 and 9) of the canopy.



Figure 8. T-10D static line parachute dropping from a C-130 „Hercules” heavy transport aircraft [17]



Figure 9. T-10D static line parachute dropping from a C-130 „Hercules” heavy transport aircraft [18]

The canopy’s fluttering movement can cause several canopy malfunctions: entanglement, canopy damage, line-overs, and canopy – partial or complete – inversions. The development of these malfunctions is a negative result of the non-symmetrical canopy’s filling-up (Figure 10).

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<sup>12</sup> It is interesting to know: this practice has never been applied on Soviet/Russian-made parachutes. Not only the military, but every type of personnel parachute system have been equipped with a ripcord assembly: parachutists must be able to start the parachute’s deployment during falling. Pulling out the ripcord handle assembly simultaneously with static line assembly can duplicate the effectiveness of canopy’s deployment. This is very essential for the safety of canopy’s deployment. – remark of the Author.

<sup>13</sup> The snatch force means a shock produced on the load, it is generated when the canopy assembly „escapes” from its deployment bag and becomes suddenly accelerated (towed) and takes the same speed of airflow. It comes just prior to opening shock [16]. Snatch force is the peak value of the forces produced on the parachute (see: Figures 11 and 12) during the deployment-process prior to canopy inflation. - remark of the Author.

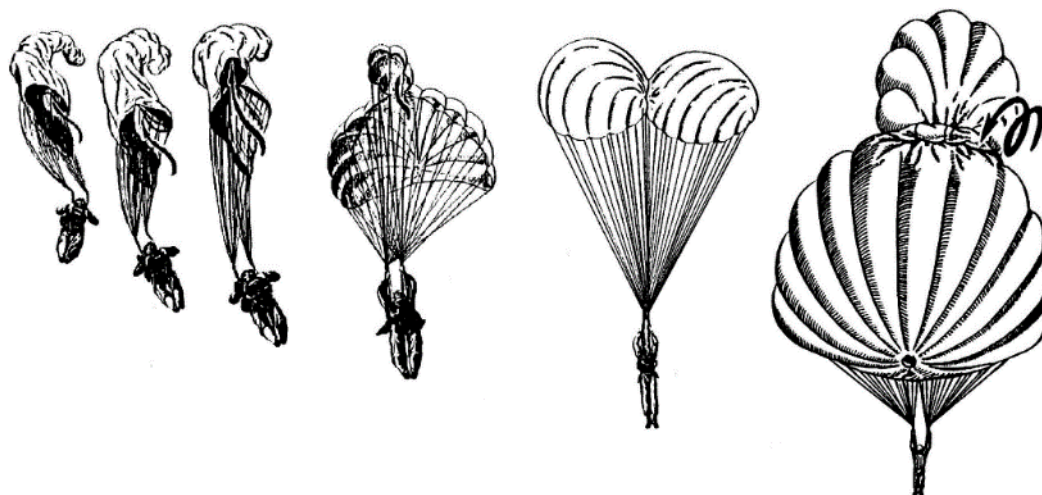


Figure 10. Forming of the partial inversion of the canopy – the so called „Mae West” – and its result: the parachute with its divided canopy [18]

3. To minimize opening time and opening force<sup>14</sup> which – in certain cases – lead to irregularities and delayed action during parachute deployment and inflation [19].

Although engineers continuously improved the canopy's design of „the old” version and equipped with supplementary components of its deployment system (Figures 11 and 12), those had not yet been enough to support the new requirements concerning maximum all up weight.

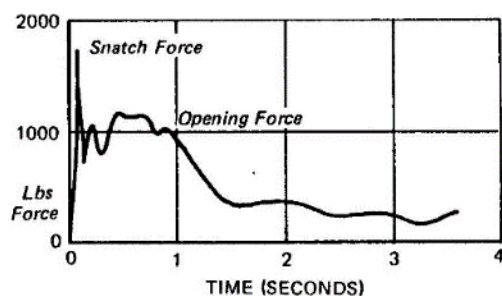


Figure 11. Deployment forces of a 28” flat circular canopy without deployment device [18]

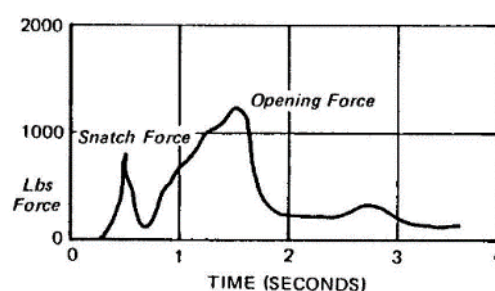


Figure 12. Deployment forces of a 28” flat circular canopy with deployment bag [18]

It was obvious that a special device of deployment system must be designed for the canopy's low lateral band. The task was not only to delay the dynamic deployment of canopy – similar to the **reefing-cord** (Figure 13) – but to secure the separation of the riser assemblies. The technical solution was based on the **slider**<sup>15</sup> (Figure 14): a device which can glide along the suspension lines at an appropriate speed to the harness assembly during canopy inflation.

<sup>14</sup> The opening force means that decelerating force exerted on the load during canopy inflation, following the snatch force (see: Figures 11 and 12). It caused by the acceleration of the opening canopy in connection with the air-mass. This process is determined by the canopy's filling rate depends on its porosity, size and shape. – remark of the Author.

<sup>15</sup> The original slider was patented by J. Floyd Smith in 1948. – remark of the Author.

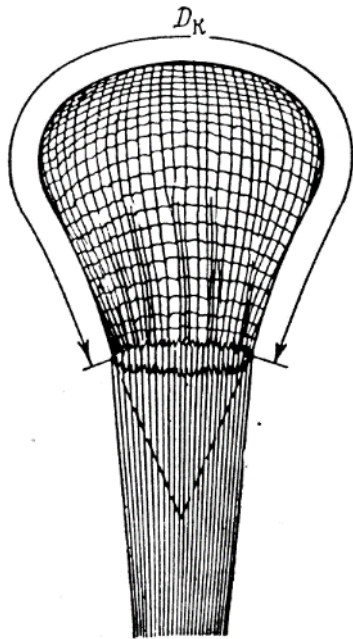


Figure 13. The scheme of reefing-cord placed at the canopy's low lateral band [20]

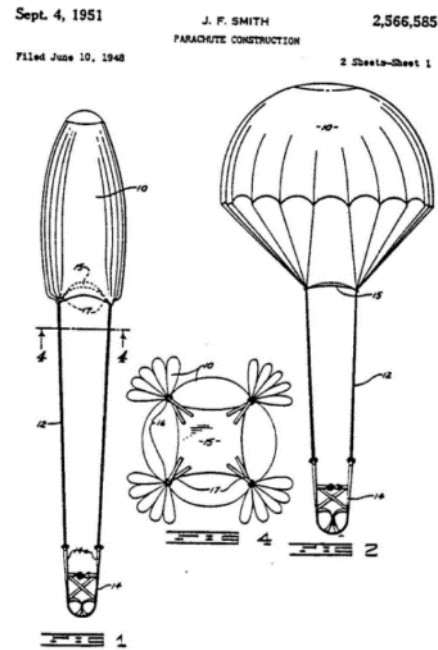


Figure 14. The patent drawing of the original Smith slider from 1951 [21]

The designed, new deployment bag (Figure 15) of the „new-born” was mainly same like „the ancestor's”, but the slider made of a special web fabric (Figure 16) which secures the optimal level of air-mass to the inner part of the new parachute's canopy.



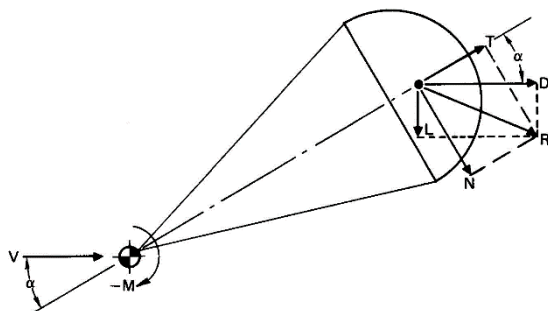
Figure 15. The front and the back side of the T-11's deployment bag and static line [22]

Figure 16. The T-11's special formed slider made from web fabric [23]

The undisturbed air intake and the avoidance of canopy malfunctions are secured by steadily strengthened assemblies of parachute system. Therefore it had to be equipped by a pilot chute<sup>16</sup>, similar to the ram-air parachutes. The aerodynamic forces generated on the parachute system during its deployment (Figure 17) verify the usefulness of the pilot chute's application (Figure 18).

<sup>16</sup> There are many pilot chutes in several areas of parachuting, which are initialized by the force of the built-in spring. The T-11's pilot chute liberates from the main deployment bag after break cord between the static line and the main parachute canopy brakes (see: Figure 19). – remark of the Author.





Where:

- $v$  – velocity at a point of undisturbed flow [ft/s (m/s)]
- $\alpha$  – angle of attack [deg]
- $M$  – moment [lbf·ft (N·m)]
- $R$  – resultant force [lbf (N)]
- $L$  – lift [lbf (N)]
- $D$  – drag [lbf (N)]
- $N$  – normal force [lbf (N)]
- $T$  – tangential force [lbf (N)]

Figure 17. Aerodynamic forces acting on the parachute canopy during its deployment [24]



Figure 18. A snapshot about the deployment of T-11 system's main parachute. The pilot chute can be seen on the top of the parachute canopy [25]

At the moment of dropping the paratrooper-parachute complex has not got vertical speed, but its horizontal speed is equivalent to the KIAS of the aircraft. Then the air-mass's drogue effect is reducing its horizontal speed to zero continuously and the gravity is increasing its vertical speed during the fall. Under real life conditions the direction of air intake's velocity into canopy<sup>17</sup> is very important connected to the angle of attack during deployment (see: Figure 17).

During the fall after the brake cord brakes (see: Figure 7) the specially designed pilot chute holds the parachute's canopy and suspension lines in strengthened position<sup>18</sup> parallel with the direction of the velocity at a point of undisturbed flow. (see: Figure 17).

According to engineer calculations: after dropping, within cc. 2 seconds from aircraft horizontal speed the parachute brakes to zero speed. This phenomenon is caused by the drogue force of the pilot chute created by the large amount of undisturbed flow. The drogue pulls out the canopy and its suspension lines and risers, but these are thrown back by the pilot chute horizontally, opposite the flight direction. Therefore canopy starts opening when the paratrooper-parachute complex lays on the flow horizontally (Figure 19), then starts turning into vertical direction (see: Figures 17 and 18).

<sup>17</sup> The air intake velocity is the vectorial amount of vertical and horizontal velocities. During experimental phase parachute canopies are mostly examined and tested in wind-tunnel. (Note: While during the wind-tunnel tests the air intake is always parallel with the symmetrical axle of the parachute, among real situations the angle of attack is not concentered to zero, mainly.) - remark of the Author.

<sup>18</sup> Similar aerodynamic effects act on the pilot chute as on the main parachute canopy but these amount of forces are not equivalent. These forces on the pilot chute will reduce to zero after the total inflation of the main canopy. - remark of the Author.

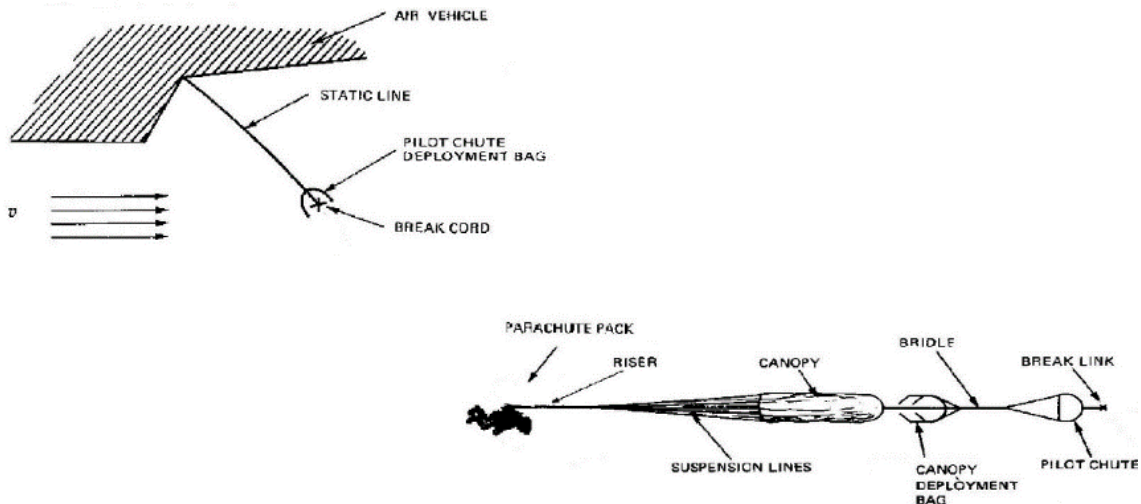


Figure 19. The scheme of controlled deployment system of T-11 [26]

Unfortunately the aftermath of „sailing-effect” is remained in part, so had to be add a special shaped deployment bag<sup>19</sup> to the canopy (Figures 20 and 21) to cover and save it from the air intake’s velocity up to that moment when the air-intake direction comes parallel to the symmetrical axle of the parachute. It is necessary to eliminate the above mentioned types of canopy malfunctions based on the „sailing-effect” (see: Figures 8 and 9).



Figure 20. The T-11’s pilot chute, connector link and deployment bag of its main canopy [27]



Figure 21. The identification signs on the deployment bag of T-11 canopy [28]

Besides the engineer calculations of deployment, real life tests validated the reliability of this controlled deployment system (Figure 22).

<sup>19</sup> This subsystem is named as deployment sleeve or canopy sleeve by several parachute bibliographies. – remark of the Author.



Figure 22. After brake cord's braking the resultant force acting on the pilot chute has started stretching the suspension lines and the sleeve covered canopy of T-11 system's main parachute [29]

Comparing the deployment process of T-10 (Figure 23) and T-11 (Figure 24) main parachutes the difference is very spectacular: the „sailing-effect” can be observed just at the canopies of the newer version of „the old” system (see: the two T-10D main parachutes are under-behind the transport aircraft's fuselage, in Figure 23).



Figure 23. Paratroopers equipped with T-10D static line parachutes dropping from C-17 „Globemaster III” heavy transport aircraft [30]



Figure 24. Paratroopers equipped with T-11 static line parachutes dropping from C-130 „Hercules” heavy transport aircraft [31]

In conclusion, for the reasons set out above: these accessories could modify the uncontrolled static line deployment system of „the old” to become a more reliable, controlled deployment, reserving the characteristic of its original static line initialization.

The practical tests demonstrated the in about 6 seconds inflation [32] of the T-11 main parachute canopy, so the opening shock is reduced significantly. The tests undoubtedly proved that the unique canopy sleeve-equipped and special shaped slider-controlled deployment subsystems fulfilled the expectations, together with its new shape of canopy, the deployment of the airborne troop parachute became safer.

The first from „the three objectives of the investigation” was achieved (the safety of deployment).

#### *The shape of main parachute’s canopy*

The new shape of canopy contributes to the safety of deployment of the airborne troop parachute but it plays a fundamental role in the remaining two of „the three main objectives of the investigation”. The airborne troop parachutes’ stability of descent and the safety of landing are exclusively depending on it.

The designers implemented a highly modified and refined version of cross/cruciform shaped canopy for the role of the main parachute’s canopy. The shape of the new canopy (Figure 25) were based on the cross/cruciform canopy but the physical dimensions (see: Table 2) were similar to the so called box-typed pilot chute<sup>20</sup> (Figure 26) canopy.

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<sup>20</sup> Note: This canopy was not a new product in the parachute industry, it was used as a very reliable pilot chute. And using as a main airborne troop parachute system canopy was not a unique idea: the former Soviet parachute designers had made several experiments in this subject in 1940s and 1950s. - remark of the Author.



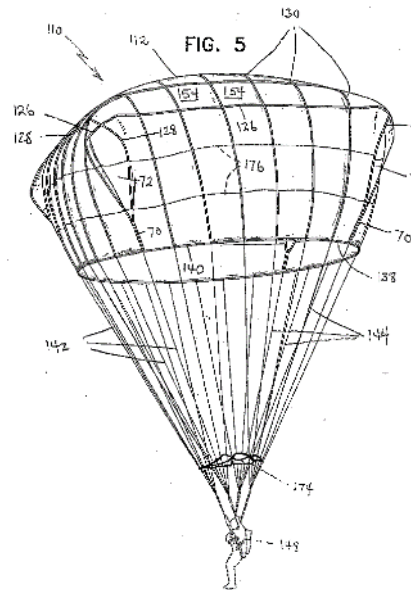


Figure 25. The designed shape of main parachute by Jean C. Berland from Para-Flite Inc. [33]

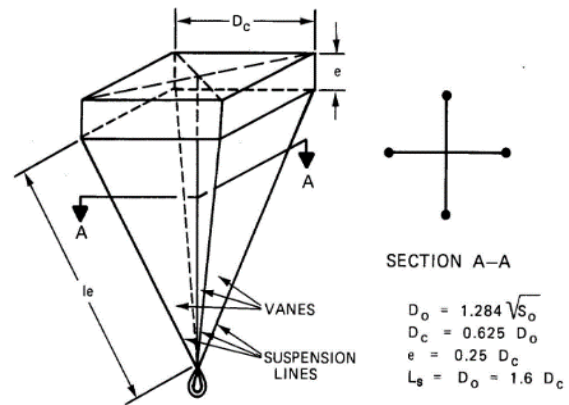


Figure 26. The scheme and the main dimensions of box-type pilot chute [34]

The parameters and the shape of canopy – based on the planned maximum all up weight of paratrooper-individual equipments-parachute system combination – insures secure slower rates of descent<sup>21</sup> and decreased oscillation<sup>22</sup> under canopy (Figure 27).

Any mid-air collisions of paratroopers during descending phase may occur, fortunately these (Figure 28) have not had a direct effect on safe landings.



Figure 27. Descending paratrooper under the canopy of T-11 main parachute. On the upper part of canopy surface can be seen the pilot chute and the deployment sleeve [37]



Figure 28. Bad experience: the landing paratrooper slipped through the corner's hole of his comrade's T-11 main canopy during the descent phase. Fortunately the landing ended without injury [38]

<sup>21</sup> The T-10D's rate of descent is 22 ft/s (6.705 m/s) [40], the T-11 guarantees a lower rate of descent (see: Table 2). The T-11's canopy is 28 percent larger than the T-10's. - remark of the Author.

<sup>22</sup> The rate of oscillation angle less than 5 degrees [36].

According to the manufacturer’s official data, the special canopy shape has resulted remarkable reduction in landing injuries: greater than 75% over 3,000 jumps [39].

The second and the third from „the three objectives of the investigation” were achieved (stability of descent and safety of landing).

## THE RESULT: T-11 PERSONNEL AIRBORNE PARACHUTE SYSTEMS

The total T-11 system – consisted of a main and a reserve parachute parts as well – guarantees similar characteristics of its „ancestor” (Table 2):

Type	T-11 [40]	T-11R [41]
Design:	cross/cruciform	aeroconical
Hem diameter (D <sub>0</sub> ) [ft (m)]:	28.6 (8.717)	20.3 (6.187)
Number of gores [ea]:	28	20
Length of suspensions lines (L <sub>s</sub> ) [ft (m)]:	20.78 (6.333)	20.3 (6.187)
Strength of suspensions lines [lbf (N)]:	unknown by the Author	650 (294.84)
Effective L <sub>s</sub> /D <sub>0</sub> :	0.84	1
Canopy material:	unknown by the Author	IV Type, low porosity FG 504 (MIL/PIA-C-44378 T4) nylon
Parachute weight [lb (kg)]:	36.8 (16.692)	14.9 (6.758)
Rate of descent [ft/s (m/s)]:	18 (5.486)	27 (8.229)
Maximum drop speed [KIAS (km/h)]:	150 (277.8)	
Maximum deployment altitude [ft (m)]:	7500 (2286)	
Minimum deployment altitude [ft (m)]:	500 (152.4)	150 (45.72)

Table 2. Basic parameters of T-11 parachute system’s main parts

These parameters seemed to be very attractive based on the requirements of the whole ATPS programme: the winner type was chosen from a five-parachute systems-groups after a display dropping-process above the shooting range and Drop Zone „Yuma” on 7–8 June 2004. (87 drops with torso in total). Then on 3 August 2004 and on May 2005 (with test-jumpers only with the later winner type: the T-11) [42]. From this time the letter „X” - the sign of experimental version of parachute type’s - was not visible anymore on the assemblies of the system.

The T-11 was introduced to the United States Army in 2010. After the preliminary success a decision was made to replace more than 52,000 T-10 parachute systems of the United States Army with the new T-11 [43]. But this triumph was overshadowed by deaths of American paratroopers: four parachute-comrades [51] died in training with T-11. The application of T-11 was suspended for the time of investigations. These days the introduction process re-started, so remember: the usage of this special shaped canopy-type as main airborne troop parachute has just started (Figure 29) its military carrier...



Figure 29. Descending American and Indonesian paratroopers equipped with M1950 Weapons Case and Parachute Drop Bag (PDB) cuddled by the harness assemblies of their T-11 parachute systems, after mass dropping during airborne exercise „Garuda shield” on 18 June 2013 [44]

## CONCLUSION

As mentioned: the proliferation of using these special parachute systems is witnessed nowadays, but it does not mean that „the T-10 family” will disappear. „The ancient” and its „descendants” have been still used and I am sure it will be in service for a long period, traditionally in basic airborne training courses for the new – and perhaps not only American – paratrooper-generations (Figure 30).



Figure 30. Nigerian paratroopers are ready to static line jump with MC1-1B parachute from a G222 „Alenia” transport aircraft [45]



To write this study I was inspired by the picture of the Award of the Congress of the United States of America (Figure 31) and I got the opportunity to collect a huge amount of information in the birth place (Figure 32) of T-10 and T-11 parachute systems.



Figure 31. The picture of descending T-11 main parachute on the Award of the Congress of the United States of America [46]



Figure 32. The Author of this study during the official visit in front of the picture of Mr. Elek Puskas, the Founder-President of the Para-Flite Inc. [47]

Therefore these pictures and technical parameters are from the official brochure of the manufacturer have been supplemented other useful parameters from the official publications of the United States Army for this study.

However I think it is just „one side of the coin”. The theoretical knowledge is just a small part of the preparation for parachute dropping, gaining practical experience is most important. Fortunately I got a chance to jump with T-11 parachute system more than one year after „the first rendezvous” so that I could extend my theoretical knowledge with my own practical experiences as well.

That real life experience has successfully managed to crown my study on T-11 parachute system.

In my next study I will publish the circumstances of that parachute dropping and my approximate, preliminary aerodynamical calculations about:

- the time of canopy's deployment,
- the values of snatch and opening forces,
- the total time from dropping to landing.

### REFERENCES

- [1] GlobalSecurity.org: T-10 Parachute (e-doc) url: <http://www.globalsecurity.org/military/systems/aircraft/systems/t-10.htm> (24.11.2012.)
- [2] BalckFive: (e-doc), url: <http://www.blackfive.net/.a/6a00d8341bfadb53ef019104c58172970c-pi> (18.10.2015)
- [3] The News Tribe: (e-doc), url: <http://www.thenewstribes.com/wp-content/uploads/2013/07/pk-2.jpg> (19.02.2015)
- [4] T. W. KNACKE: Parachute Recovery Systems Design Manual. NWC TP 6575 Para Publishing, Santa Barbara, California, 1992. ISBN 0-915516-85-3, p. 8-47.



- [5] Katonai ejtőernyőzés Magyarországon. Egyetemi jegyzet, Zrínyi Miklós Nemzetvédelmi Egyetem, Budapest, 2005. p. 99.
- [6] D. R. DENNIS: Legújabb fejlemények az ejtőernyő technológiában. Ejtőernyős Tájékoztató 1984/2 (Aeronautical Journal November, 1983.) KM LRI Repüléstudományi és Tájékoztató Központ Kiadványa, Budapest, 1984. pp. 8.
- [7] T. W. KNACKE: Parachute Recovery Systems Design Manual. NWC TP 6575 Para Publishing, Santa Barbara, California, 1992. ISBN 0-915516-85-3, p. 8-46.
- [8] Integrated publishing: (e-doc), url: [http://www.parachutemanuals.tpub.com/TM-10-1670-271-23P/css/TM-10-1670-271-23P\\_227.htm](http://www.parachutemanuals.tpub.com/TM-10-1670-271-23P/css/TM-10-1670-271-23P_227.htm) (11.10.2015)
- [9] url: <http://cfile235.uf.daum.net/image/173F8F3F4F2C7B061C6282> (10.11.2015)
- [10] Defence Update: (e-doc), url: [http://defense-update.com/20140605\\_parachuting-accident-puts-t-11-parachute-safety-in-question.html](http://defense-update.com/20140605_parachuting-accident-puts-t-11-parachute-safety-in-question.html). ViQA77mhfIU (18.10.2015)
- [11] Wikimedia Commons: (e-doc), url: [https://commons.wikimedia.org/wiki/File:Defense.gov\\_News\\_Photo\\_110910-GO452-406-U.\\_S.\\_Army\\_paratroopers\\_from\\_the\\_82nd\\_Airborne\\_Division\\_descend\\_to\\_the\\_ground\\_after\\_jumping\\_out\\_of\\_a\\_C-17\\_Globemaster\\_III\\_aircraft\\_over\\_drop\\_zone.jpg](https://commons.wikimedia.org/wiki/File:Defense.gov_News_Photo_110910-GO452-406-U._S._Army_paratroopers_from_the_82nd_Airborne_Division_descend_to_the_ground_after_jumping_out_of_a_C-17_Globemaster_III_aircraft_over_drop_zone.jpg) (18.10.2015)
- [12] Where technology takes flight, Airborne Mission Ready Products, Parachute Aerial Delivery Systems. (Official brochure of Airborne Systems North America, 2011.), p. 7.
- [13] Капитан 2 ранга С. ПРОКОФЬЕВ: АМЕРИКАНСКАЯ ДЕСАНТНАЯ ПАРАШЮТНАЯ СИСТЕМА Т-11, Зарубежное военное обозрение №10 2007 г. pp. 56-59. (e-doc) url: [http://publ.lib.ru/ARCHIVES/Z/Zarubejnoe\\_voennoe\\_obozrenie/\\_Zarubejnoe\\_voennoe\\_obozrenie.html#2007](http://publ.lib.ru/ARCHIVES/Z/Zarubejnoe_voennoe_obozrenie/_Zarubejnoe_voennoe_obozrenie.html#2007) (25.11.2015.)
- [14] Combat Reform: (e-doc), url: <http://www.combatreform.org/ATPSarmyambasscontinues.jpg> (21.11.2015)
- [15] T. W. KNACKE: Parachute Recovery Systems Design Manual. NWC TP 6575 Para Publishing, Santa Barbara, California, 1992. ISBN 0-915516-85-3, p. 6-5.
- [16] DAN POYNTER: The Parachute Manual. A Technical Treatise on Aerodynamic Decelerators. Santa Barbara, CA 93140-4232, USA, 1991. ISBN 0-915516-80-2, p. 310.
- [17] Wikimedia Commons: (e-doc), url: [https://upload.wikimedia.org/wikipedia/commons/thumb/d/d4/SCIE\\_T10\\_image1.jpg/300px-SCIET10\\_image1.jpg](https://upload.wikimedia.org/wikipedia/commons/thumb/d/d4/SCIE_T10_image1.jpg/300px-SCIET10_image1.jpg) (23.08.2014)
- [18] DAN POYNTER: The Parachute Manual. A Technical Treatise on Aerodynamic Decelerators. Santa Barbara, CA 93140-4232, USA, 1991. ISBN 0-915516-80-2, pp. 311-312, 314.
- [19] T. W. KNACKE: Parachute Recovery Systems Design Manual. NWC TP 6575 Para Publishing, Santa Barbara, California, 1992. ISBN 0-915516-85-3, p. 6-2.
- [20] Н. А. ЛОБАНОВ: Основы расчёта и конструирования парашютов. Москва, Издательство Машиностроение, 1965. Г-27188. p. 170.
- [21] DAN POYNTER: The Parachute Manual. A Technical Treatise on Aerodynamic Decelerators. Santa Barbara, CA 93140-4232, USA, 1991. ISBN 0-915516-80-2, p. 242.
- [22] Photo is from the Author's collection. It was taken in Papa Air Base, 25.02.2015. by the Author.
- [23] Photo is from the Author's collection. It was taken in Papa Air Base, 25.02.2015. by the Author.
- [24] T. W. KNACKE: Parachute Recovery Systems Design Manual. NWC TP 6575 Para Publishing, Santa Barbara, California, 1992. ISBN 0-915516-85-3, p. 4-13.
- [25] Farmaroc: (e-doc), url: <http://far-maroc.forumpro.fr/t2019p585-us-army> (04.01.2015)
- [26] Figure is made by the Author based on Figure 6-3, 6-4. from T. W. KNACKE: Parachute Recovery Systems Design Manual. NWC TP 6575 Para Publishing, Santa Barbara, California, 1992. ISBN 0-915516-85-3, pp. 6-5, 6-6.
- [27] Photo is from the Author's collection. It was taken in Papa Air Base, 25.02.2015 by the Author.
- [28] Photo is from the Author's collection. It was taken in Papa Air Base, 25.02.2015 by the Author.
- [29] Полковник О. Мартьянов: ПАРАШЮТИСТЫ ИЗ "ФОРТ-БЕННИНГ" url: <http://www.liveinternet.ru/users/657082/post183488623/page1.html> (02.12.2015)
- [30] Flickr: (e-doc), url: <https://www.flickr.com/photos/usairforce/8674235229/in/photostream/lightbox/> (04.10.2015)
- [31] U.S. Department of Defense: (e-doc), url: <http://archive.defense.gov/photoessays/photoessaySS.aspx?id=5557&cachebuster=463> (04.10.2015)
- [32] T-11 Non-Steerable Troop Parachute System. Airborne Systems Dedicated To Preserving The Safety Of The Mission And Its People. (Official brochure of Airborne Systems Family of Brands: GQ Parachutes, Irvin Aerospace, Para-Flite, Aircraft Materials (AML), 2013.)
- [33] Cruciform parachute with arms attached (EP 1317374 B1), (e-doc), url: <http://www.google.com/patents/EP1317374B1?cl=en> (29.03.2015)

- [34] T. W. KNACKE: Parachute Recovery Systems Design Manual. NWC TP 6575 Para Publishing, Santa Barbara, California, 1992. ISBN 0-915516-85-3, p. 6-45.
- [35] fayobserver.com: (e-doc), url: <http://www.fayobserver.com/>18th Airborne Corps suspends jumps following death - Fayetteville Observer Military & Fort Bragg News (25.11.2015)
- [36] T-11 Non-Steerable Troop Parachute System. Where technology takes flight, Airborne Mission Ready Products, Parachute Aerial Delivery Systems. (Official brochure of Airborne Systems North America, 2013.)
- [37] Where technology takes flight, Airborne Mission Ready Products, Parachute Aerial Delivery Systems. (Official brochure of Airborne Systems North America, 2011.), p. 6.
- [38] Photo is from the Author's collection. It was taken in Papa Air Base, 19. 06. 2014. by the Flight Safety Officer of the Joint Command of the Hungarian Defence Forces.
- [39] T-11 Non-Steerable Troop Parachute System. Airborne Systems Dedicated To Preserving The Safety Of The Mission And Its People. (Official brochure of Airborne Systems Family of Brands: GQ Parachutes, Irvin Aerospace, Para-Flite, Aircraft Materials (AML), 2013.)
- [40] T-11 Non-Steerable Troop Parachute System. Airborne Systems Dedicated To Preserving The Safety Of The Mission And Its People. (Official brochure of Airborne Systems Family of Brands: GQ Parachutes, Irvin Aerospace, Para-Flite, Aircraft Materials (AML), 2013.)
- [41] Data Sheet of T-11R attached to the Hungarian Military Type Certificate of MC-6 Airborne Troop Parachute System (Official edition of NTA AA SAD, 2013.)
- [42] ABC11: 82nd Airborne Division Paratrooper Dies in Airborne Training Incident (e-doc) url: <http://abc11.com/news/fort-bragg-paratrooper-dies-in-jump-exercise-/88809/> (02.12.2015)
- [43] T-11 Non-Steerable Troop Parachute System. Airborne Systems Dedicated To Preserving The Safety Of The Mission And Its People. (Official brochure of Airborne Systems Family of Brands: GQ Parachutes, Irvin Aerospace, Para-Flite, Aircraft Materials (AML), 2013.), p. 6.
- [44] U.S. Department of Defense: (e-doc), url: <http://archive.defense.gov/photoessays/PhotoEssaySS.aspx?ID=4025> (02.12.2015)
- [45] Beegeagle's Blog: (e-doc), url: <https://beegeagle.wordpress.com/2012/11/02/nigerian-army-paratroopers/> (05.08.2015)
- [46] Photo is from the Author's collection. It was taken in the building of the ASNA's Management, Santa Ana, California, 11.10.2013. by the Author
- [47] Photo is from the Author's collection. It was taken in the building of the ASNA's Management, Santa Ana, California, 11.10.2013. by Ms. Yvonne Wade from the ASNA
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### **„A KAKUKKTOJÁS”.A T-11 EJTŐERNYŐRENDSZER FŐ EJTŐERNYŐJE**

*Két évvel ezelőtt a NKH LH ÁLF hivatalos delegációja tagjaként látogatást tettem az Airborne Systems North America (ASNA) Kalifornia állambeli, Santa Anában települt ipari létesítményében. Ennek során az ASNA Igazgatótanácsa épületében észrevettem az Amerikai Egyesült Államok Kongresszusának fényképkamerájában foglalt, hivatalos elismerő oklevelét. A fénykép egy rendkívül látványos kupolával ellátott légideszant fő ejtőernyőt ábrázolt. Ez volt „az első találkozásom” a T-11-essel. Olyan módon a hatása alá kerültem, hogy tudományos kutatásokat kezdtem az ejtőernyővel kapcsolatban. Tanulmányom a később T-11 típusjelzést kapott rendszer fő ejtőernyőjének „szokásostól eltérő” nyitási rendszerét és kupolaszerkezetét mutatja be, ezek felelnek az ejtőernyős sérülésmentes földetéréséért. A technikai jellemzők és adatok mellett azokat az aerodinamikai törvényszerűségeken alapuló műszaki megoldásokat is leírja röviden, amelyek a T-11 katonai alkalmazását biztonságosabbá teszik.*

**Kulcsszavak:** *ejtőernyő rendszer, légideszant, tömeges dobás, szabályozott nyitási rendszer, ejtőernyő kupola*

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