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# SUBASSEMBLIES OF THE PARACHUTE CONTAINER WITH IMPROVED GEOMETRY BASED ON DIGITAL SOLUTIONS

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***Abstract:*** *The recovery system used in the aeronautic field have, as a main element, the whole set of parachutes, that represents a very complex system for which a thorough knowledge of the performance characteristics of the component materials is required, as well as the technologies, taking into account that they represent decisional elements in design and manufacture. The harness / container assembly represents the parachutist's safety system because controls the unfolding and opening of the parachutes and includes all the subassemblies necessary to make a parachute suitable for safe usage. Any constructive form of the canopy can be connected to the container in the specific compartments, which control the opening, the harness ensuring the parachutist's connection with them. The basic harness / container assembly is what remains when all detachable subassemblies are to be removed.*
*The paper presents the digitized design solutions used for the improvement of the textile parts used in the construction of the harness-container assembly used for the sports parachutes. The requirements underlying the design were related to: compliance with the dimensions of the container compartments for both the main and the reserve parachute, in order to avoid premature openings caused by unstable opening pins; the use of raw materials and materials with physical-mechanical characteristics similar to those used to make the prototype, following the same price / quality ratio; eliminating the wavy areas both at the strip and at the base layer, on the portions that have different rounded shapes and are difficult to align.*

***Key words:*** *sports parachuting, safety system, harness/container assembly, CAD/CAM, einfas, parts.*

## 1. INTRODUCTION

The parachute is an complex equipment, with a role in increasing the drag resistance of a body moving in a fluid environment. [1, 2]. Because this fluid is air, a parachute can be considered a particular case of "air brake". In most applications, the force that propels the body is its own weight, so the weight of the device that provides resistance must be very small. From this point of view, the parachute can ensure a high drag resistance, with a very low weight gain (8–12%) [3, 4]. The parachute is an assembly which consists of elements that, working together, ensure conditions of controlled descent, braking and stabilization as well as: automatic opening, deployment, load support and drag resistance for a given mass.

The first reports of parachute applications appeared in the 14th and 15th centuries in Siam and China, when animals were parachuted during fairs and carnivals. The development of parachutes in Europe and the USA did not appear until the 18th century, and they were also meant for entertainment. The first application of parachutes appeared during the First World War, when aviators were rescued from aircrafts with the help of parachutes. [2,4] Subsequent developments have led to the conclusion that parachute recovery systems can also be used for:

**-** Aerial launch of military personnel, equipment and military technique in the final phase of transport to the theater of operations (**Fig. 1**). Under these conditions, the personnel must be unharmed and ready for action, and the equipment must be intact and ready for use. [1,3]

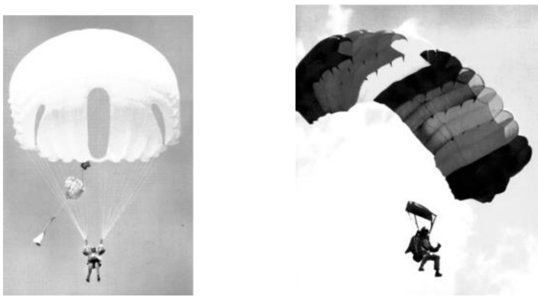


***Fig. 1****: Military parachutes for aerial launch*
*Courtesy SC CONDOR SA Bucharest – Manufacturer of parachutes and flight equiment*

**-** Stabilization and braking of the aircraft during military operations (**Fig. 2**). The parachutes used as brakes must be very stable, as they must not disturb the control of the aircraft. They must be very strong, but they must develop a reduced shock load at opening. [3]

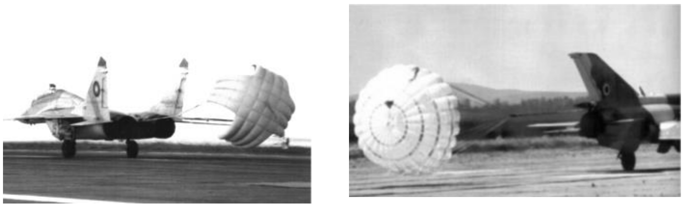


***Fig. 2****: Parachutes for landing and deceleration of the supersonic aircraft*
*Courtesy SC CONDOR SA Bucharest – Manufacturer of parachutes and flight equiment*

-Armament delay to enable the aircraft to adjust its firing, to stabilize the artillery ammunition before entering the water, to obtain the desired angle of impact and an orderly distribution of shrapnel.

The modern parachutes can be used for supersonic applications, others for gliding (paragliding). [4] However, superior aerodynamic performance cannot be guaranteed with just one type of parachute. The most important parachutes known today are differentiated in terms of stability, drag resistance, opening behavior, speed or design.

## 2. HARNESS/CONTAINER ASSEMBLY FOR SPORTS PARACHUTE

### 2.1 Requirements for the design and execution of a harness-container assembly

The main subassemblies of the container are specific to the type of parachutes connected to the container [5,6]. The containers for sports parachutes have two compartments, one for each parachute (**Fig. 3**)

The harness-container assembly represents the parachutist's safety system and contains all the parts necessary to make a parachute suitable for flight. The assembly allows the control and opening of the parachutes. The role of the container is to keep the canopy of the folded parachutes (main and reserve pilot chutes), together with the suspensions, the opening device (if used), and the opening parachute. The container is closes by locking with pins or ripcord cables through one or more cones or curls and stitches.

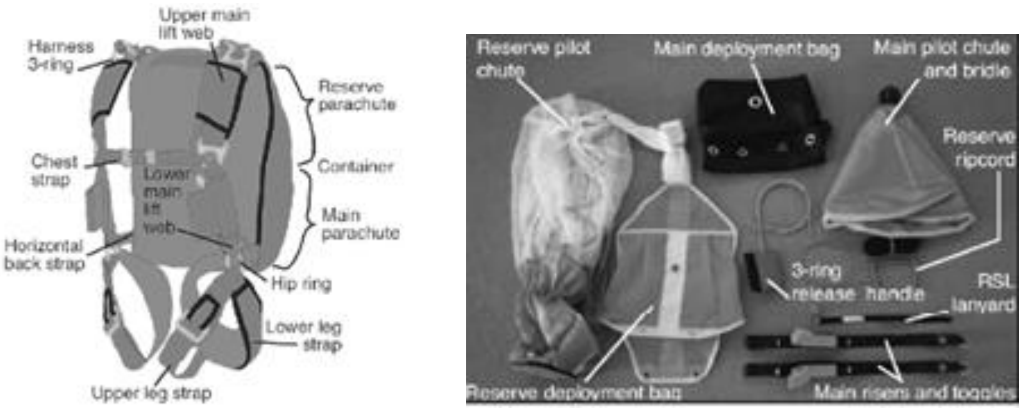



***Fig. 3****: Harness/container equipment for parachutes [5,6]*

The purpose of the parachute harness is to transmit the opening forces to the parachutist so that there is no possibility of injuring them during the jump. It is made of metal straps and buckles.

The main requirements imposed for design and accomplishment of the ham-container ensemble are respectively:

- for container
  - to ensure the correct opening in extreme conditions, when: the flexible metal cable, the cord attached to the aircraft and the extractor parachute that initiates the deployment of the main parachute at the aircraft jump (AAD) are activated and to enable the uninterrupted deployment of the canopy.
  - reducing the stiffening ribs to reduce the weight, the wear points and increase the wearing comfort.
- for harness (suspension system)
  - to ensure simple, visible and minimal adjustments made by the parachutist both from sitting and standing positions;
  - to be designed with a safety factor of at least 1.5;
  - to be safe and to avoid the contact of the mechanical devices with the parachutist body, mainly with the head and back zones;
  - to ensure the compliance with the requirements imposed by the standards of the aviation industry related to the position and color of the control handle that must be in contrast with that of the harness;
  - to limit the force required for the fast and safe operation of the trigger device to max. 10daN.
- for stitches - to comply with the requirements of the SR ISO 4915: 2001
- for assembly - to comply with the requirements of the SR ISO 4916: 1999 in designing of the component parts.

**2.2. Solutions for accomplishing the container subassemblies**

Requirements:

i) compliance with the calculated dimensions of the compartments of the container for:

- main parachute with a volume of 5733 $cm^3$ and 6880 $cm^3$ corresponding to areas of the main parachute of about 12.3 sqm and 16.6 sqm;
- reserve parachute with a volume of 4914 $cm^3$ and 6224 $cm^3$ corresponding to areas of the reserve parachute of about 11.9 sqm and 15.6 sqm.

ii) the use of the container for parachutes of different volumes, respectively:
- adjusting the volume of the reserve parachute compartment depending on the volume of the parachute, in the folded state, by adjusting the length of the closing loop;
- adjusting the volume of the main parachute compartment depending on the volume, in the folded state, of the parachute by building an additional compartment, which can be loaded with a ballast for parachutes with a smaller volume.

iii) narrow fabric used to make the container to have physical-mechanical characteristics similar or superior to those used to make the prototype (with emphasis on abrasion resistance).

***Table 1:*** *Technical characteristics for narrow fabrics*

| Nr. crt. | Characteristics | Tape Campina Kaki according with BA 65T/2017 |
|---|---|---|
| 1 | Raw material | 100% PA6 |
| 2 | Pattern | R2/2 |
| 3 | Thickness, mm | 0.61 |
| 4 | Tensile strength, daN | 380 |
| 5 | Elongation at break, % | 6.0 |

iv) lack of intervention on the technical characteristics of the fabrics [5,6] used to make the container, respectively:

***Table 2****: Technical characteristics for woven fabrics used for ham/container assembly (prototype)*

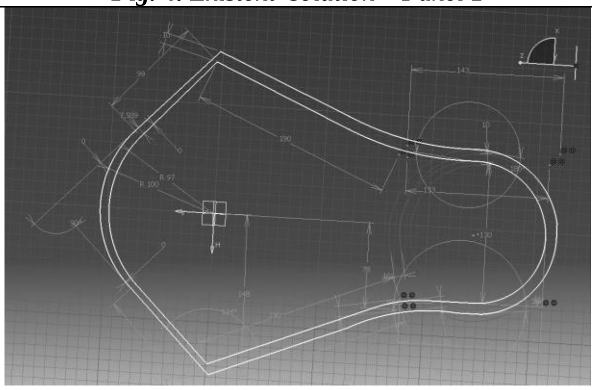
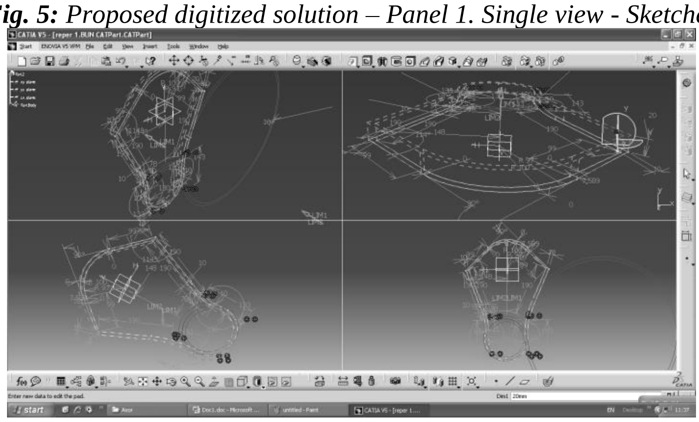
| Nr crt | Characteristic | Cordura 1000 Cf. BA 65T/2017 | Cordura 500 Cf.BA143T/2016 si BA 65/2016 |
|---|---|---|---|
| 1 | Raw material | 100% PA6.6 | 100% PA6.6 |
| 2 | Pattern | 1/1 | 1/1 |
| 3 | Mass, g/sqm | 322 | 239 |
| 4 | Tensile strength, daN, warp/weft | 305/230 | 224/209 |
| 5 | Tear strength, daN, warp/weft | 39/41 | 10/10 |
| 6 | Resistance to hydrostatic pressure, min., mm col. $H_2O$ | 412 | 395 |
| 7 | Abrasion resistance (Martindale), no. cycles | 100 000 without wear | 100 000 without wear |

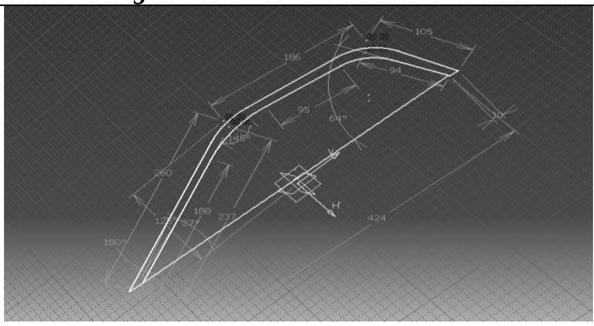
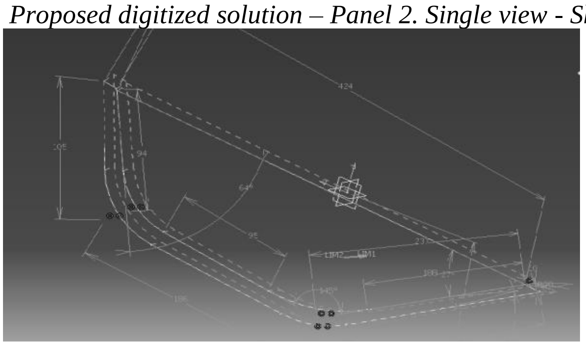
v) elimination of the wavy areas at the narrow fabric and at the base layer, on the zones that have a different shape than the linear one.

The analog data resulting from the design, realization and experimentation of the harness / container assembly prototype made by INCDTP specialists were processed with the help of software that allows, through the included modules, the realization of the sketch, and of the 3D visualizations.

The constructive solutions proposed for two subassemblies of the container (panel no.1 and no.2) are presented in table 3.

***Table 3:*** *Proposed solutions – pattern measurements, shapes and einface subassemblies*

| | |
|---|---|
| <br>***Fig. 4.*** *Existent solution – Panel 1* | Narrow fabric: einface (grosgrain)<br>Physical-mechanical characteristics:<br>- raw material 100%PA6<br>- tip legatura: R2/2<br>- thickness: 0.61 mm<br>- tensile strength: 380daN<br>- elongation at break: 6%<br>Seam type: 2x301 |
| <br>***Fig. 5:*** *Proposed digitized solution – Panel 1. Single view - Sketcher*<br><br>***Fig. 6:*** *Multiple view - Panel 1. Part Design* | Narrow fabric: einface with scalloped edge -width 2.2 cm<br>Physical-mechanical characteristics:<br>- raw material 100%PA6.6<br>- pattern: 1/1<br>- thickness: 0.76 mm<br>- tensile strength: min. 500daN<br>- elongation at break: 18%<br>Seam type: 2x301 |
|  | Narrow fabric: einface (grosgrain)<br>Physical-mechanical characteristics:<br>- raw material 100%PA6<br>- tip legatura: rips<br>- thickness: 0.61 mm<br>- tensile strength: 380daN<br>- elongation at break: 6%<br>Seam type: 2x301 |

| ***Fig. 7.*** *Existent solution – Panel 2* | |
|---|---|
| <br>***Fig. 8:*** *Proposed digitized solution – Panel 2. Single view - Sketcher*<br><br>***Fig. 9:*** *Single view - Panel 2. Part Design* | Narrow fabric: einface with scalloped edge – width 2.2 cm<br>Physical-mechanical characteristics:<br>- raw material 100%PA6.6<br>- pattern: 1/1<br>- thickness: 0.76 mm<br>- tensile strength: min. 500daN<br>- elongation at break: 18%<br>Seam type: 2x301 |

## 5. CONCLUSIONS

By adopting the new shapes of the patterns, it is expected to increase the technical resource of the narrow band fabric, especially in relation to the abrasion resistance, by eliminating wrinkles for the hardening band and by eliminating the corrugations on the surface of the part.

The rigorous calculation of the geometric elements of the band routing and their correct location within the container assembly will ensure continuity in the variation of the requirements in conditions of use and implicitly an increase of the safety in operation.

The proposed solutions could be used to transform the dedicated textile technology in real opportunities for efficiencies and increased revenue.

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