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MODELLING OF LOADING COMMAND SYSTEM VEHICLES ON THE TRANSPORT AIRCRAFT C-130

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Abstract:

The article presents modeling of loading platforms for the automated command system of a field artillery battalion mounted on the light wheeled chassis. According to the operational requirements, the field battalion should be tailored to be transported by the transport aircraft C-130E Hercules, which requires limiting the weight and dimensions of vehicles. Since a vehicle cab height is equal with the exact centimeter precise to the aircraft cargo bay height, it is necessary to reduce the relevant vehicle height by lowering the tire pressures in order to obtain an adequate margin.

Keywords:

command system vehicles, air transport of vehicles

INTRODUCTION

Requirements for obtaining high mobility of military equipment and supplies necessitate adaptation of certain vehicles to be carried by transport aircrafts. The aircraft Lockheed C130 Hercules can be used in the conditions of the Polish Armed Forces. Its both capacity and dimensions of the cargo area allow the realization of a flight with a loaded truck weighing up to 20t.

The maximum cargo area of the aircraft has been determined on the basis of the document XX1C TO-130A-9 TECHNICAL MANUAL, CARGO LOADING MANUAL. This space is respectively [1,2]:

- 12,49m long;
- 3,12m wide;
- 2,74m high.

These dimensions may vary slightly in different versions. This depends on the distribution of equipment and built-in elements of some aircraft systems, e.g. wiring or hydraulic ones. The critical dimensions in terms of transporting military vehicles are: the width of the cargo bay and, above all, the height - 2.74 m, which is exactly the same as the height of the Jelcz 442 truck planned for carrying. As in the upper part of the fuselage there is placed a suspended rail for installations, it is necessary to reduce the air pressure in the tires in order to lower the Jelcz by a few centimeters and, as a result, obtain the safety height margin so as to load the vehicle securely.

Fig.1. The Polish aircraft C-130 Hercules landing in Alaska
Source: Altair Aviation Agency

The length of the cargo bay of almost 12.5 m must be taken into account when taking long items, trucks and trailers. The tilt angle of a ramp affects the maximum height and length of the load transported. The vehicle ground clearance is a key factor, because when entering on the ramp, the lower surface of the frame or any of components of the drive train can collide with the top of the ramp. In such a situation, loading of the vehicle may be conducted only from the ramp with the height similar to the height of the loading part of the aircraft.

1. THE MODEL OF THE CARGO BAY OF THE AIRCRAFT

Testing the possibility of loading the truck Jelcz required the development of models of the aircraft cargo area and the vehicle itself. The C-130 aircraft interior model was made through 3D optical scanning [4, 5, 6]. Reference points were applied on the surfaces of the interior of the cargo bay, and then in the course of the scanning process they were transferred to the scanning program with information about the location in space and the position of adjacent surfaces. This made it possible to create the model of the interior while saving dimensional relations. The scanning accuracy allows measurement of the position of points inside the aircraft with the precision up to tenths of a millimeter [3].

a) b)

Fig.2. The view of the loading ramp (a) and the cargo area (b) of the aircraft C-130 Hercules.

Source: Own study

a)

b)

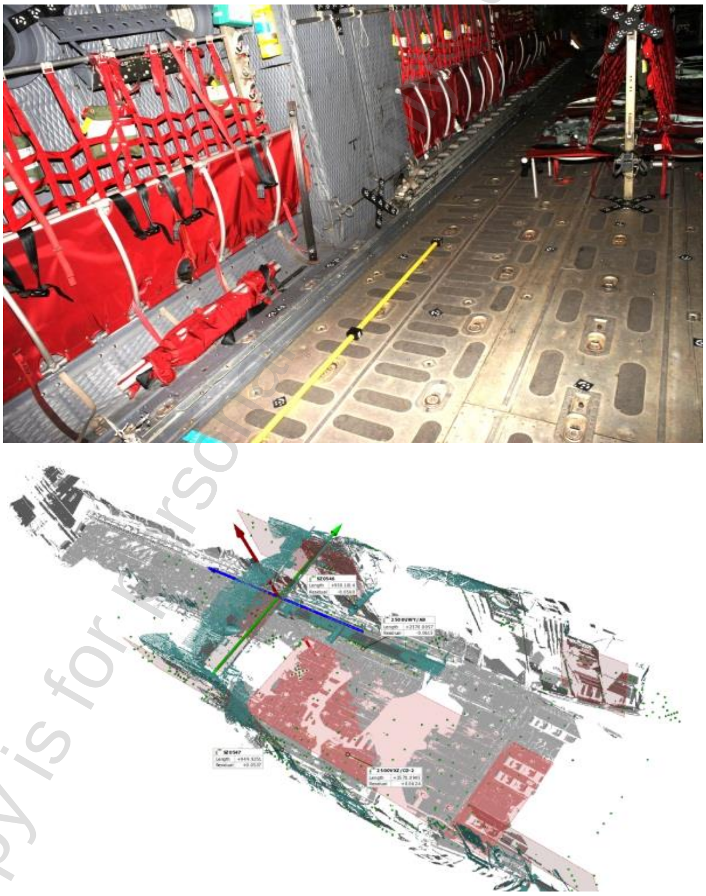
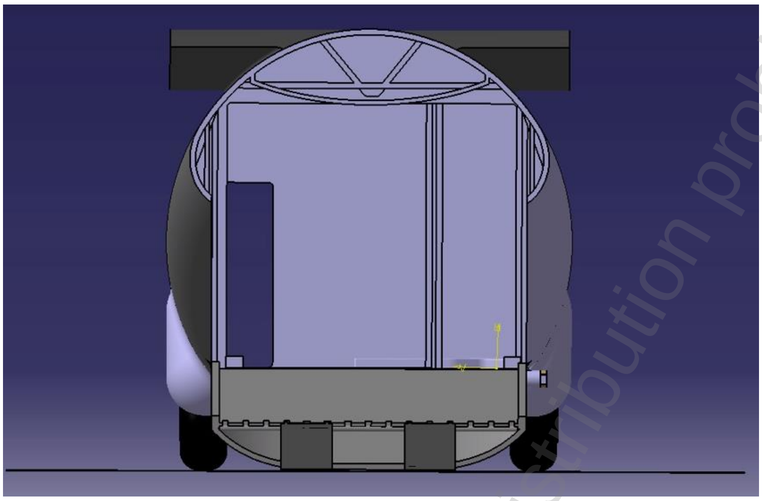


Fig.3. The cargo area of the C-130 transport aircraft, a) the real view, b) the scanned view of the aircraft interior

Source: own study

Measurements obtained during the scanning were used to model the cargo bay of the aircraft. Overall dimensions of the cargo bay are respectively: the length - 624 inches (15850 mm), the width - 123.2 inches (3130 mm) [119.5 inches (3035 mm) in place of attaching blades of wings], the height - 106 inches (2692 mm).

a)



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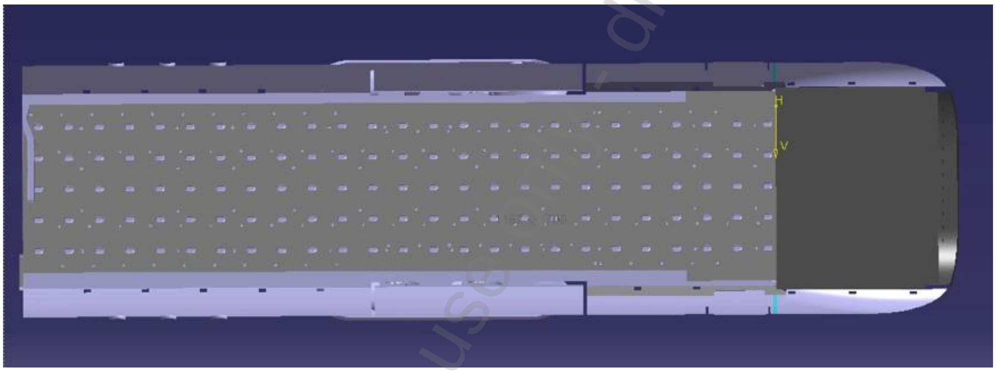


Fig.4. The geometry of the C-130 aircraft a) the cargo bay cross-section, b) the view of the floor

Source: own study

The usable area of the cargo bay is 597x106 inches (15164 x 2692 mm), and its height is 102 inches (2,590 mm), provided that the dimensions of the cargo bay also include a part of the loading ramp, the surface of which is adapted for the transport of loads (the weight of the load placed on the ramp cannot exceed 4664 lbs / 2115 kg). The usable length of the cargo bay floor is 485 inches (12320 mm). The floor is equipped with 125 evenly distributed catches to attach a load (25 points in five rows). In addition, it contains points for mounting seats.

The cargo bay floor is located at the height of 1100 mm in relation to the airstrip. The loading ramp is approximately 3100 mm long and with the total opening the angle between the level of the cargo area and the surface of the ramp is 10,5º. Additional drives are applied between the ramp and the ground level. They are 1820 mm long and 533 mm wide (produced by ITB, the USA). The angle between drives and the ground level is approximately 15º.

a)

b)

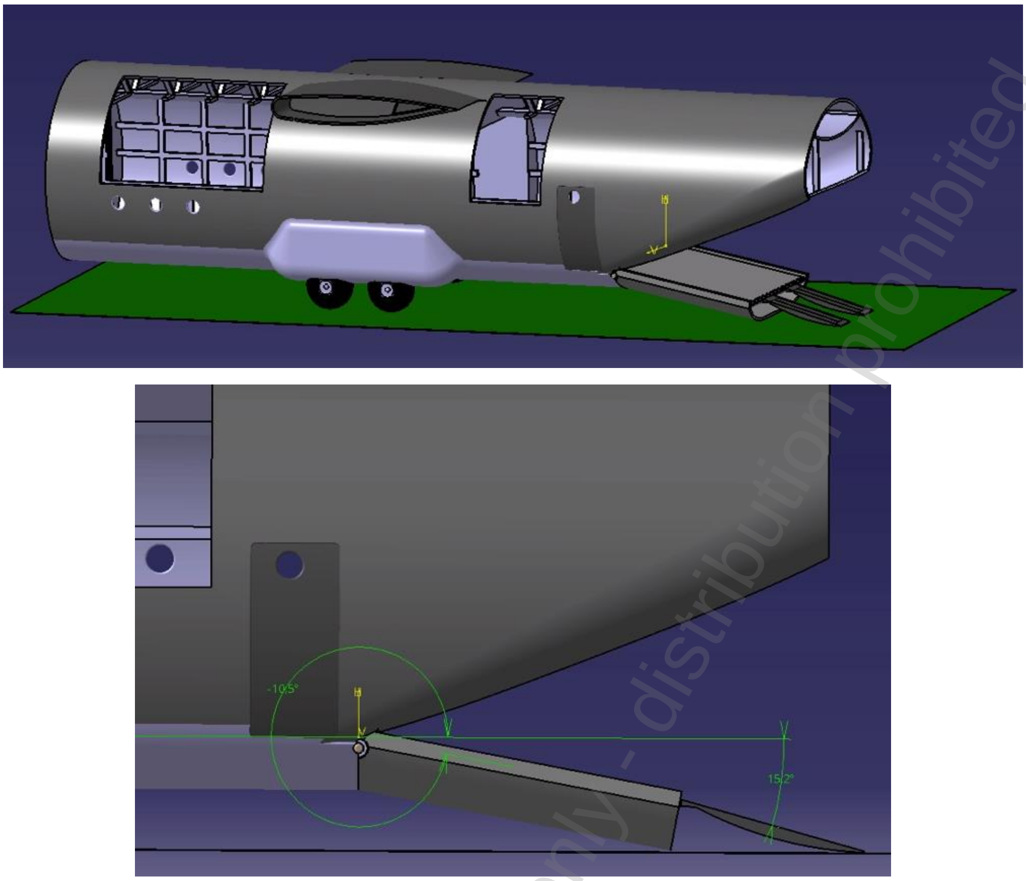


Fig. 5. The geometry of the C-130 aircraft, a) the view of the open cargo bay together with the skin, b) the ramp angle and the approach angle

Source: own study

2. COMMAND SYSTEM VEHICLES TRANSPORTED BY AIR

The developed concept of the system of command of artillery troops includes the use of several solutions of the vehicle specialist body. Such a vehicle may have a body integrated with a chassis or a body in the form of a container, which can be dismantled from a chassis for the duration of the air transportation. Both approaches have their advantages and drawbacks. In the first one a vehicle is loaded quickly so no time is wasted on the removal of the body, and when on board it takes up less space. Because a body is mounted on the chassis of an off-road vehicle, the integrated specialist body requires the limitation of the body height to approximately 140 cm. This does not allow the upright position inside the vehicle and makes it difficult to move around inside. Increasing the height of the body space requires the use of separate components of the command system, which, in turn, forces the removal of the body before loading on the aircraft, but the height inside the body can be up to 170 cm. Both components of the command vehicle are also possible to be transported in one aircraft using the correct order of loading [5].

a)

b)

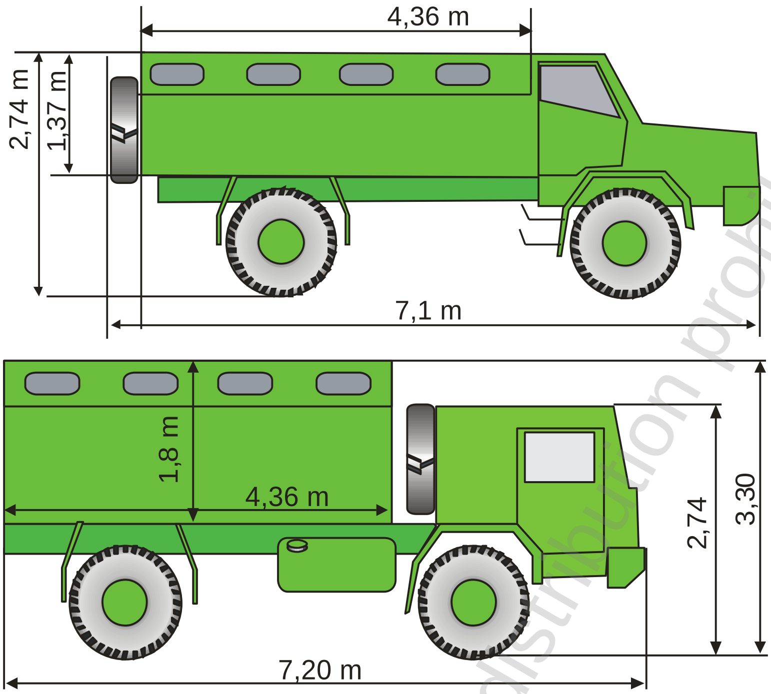


Fig. 6. The comparison of vehicles of the same length with the box trailer integrated with the driver's compartment (a) and the box trailer separated from the compartment (b)

Source: own study

a)

b)

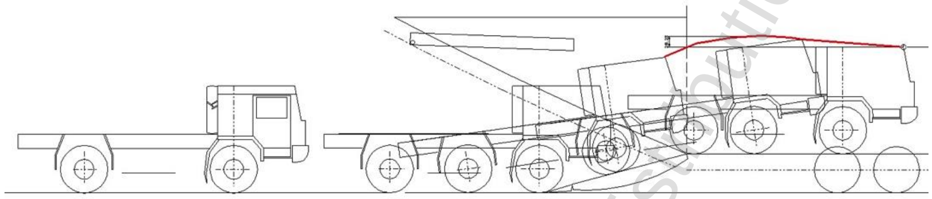
Fig. 7. Command system vehicles loaded on board of the aircraft C-130 Hercules: a) a vehicle box trailer separated from the compartment, b) the integrated vehicle

Source: own study

3. MODELLING OF LOADING THE COMMAND SYSTEM VEHICLES ON THE TRANSPORT AIRCRAFT

While loading command system vehicles large problems appear and are associated with the almost identical height of the driver's compartment and the aircraft cargo area - 2.74 m. This means that during the load the tire pressure must be reduced to obtain at least a few-centimeter margin. Unfortunately, using a loading ramp that the aircraft is equipped with poses a risk of collision between the vehicle components with the height greater than 2.4 m if they are in front of the axle of the vehicle, which is first loaded on the board of the aircraft. Figures 8 and 9 represent graphic simulations carried out.

a)



b)

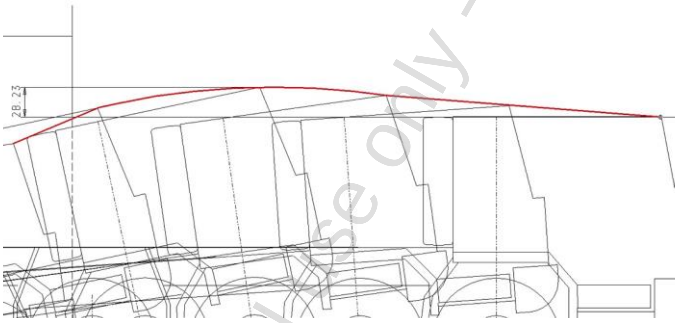


Fig. 8. a) forward-drive loading of the command system vehicle, b) the line of collision between the elements of the driver's compartment and elements of the aircraft equipment

Source: own study

The line of collision represented in Figure 8 shows that the highest point of the driver's compartment when driving forwards surpasses the position of the interior of the aircraft of almost 30 cm, which makes loading with the use of this method impossible. Likewise, when driving backwards for loading the vehicle integrated with the body, which is shown in Figure 9a. In this case, the line of collision rises to almost 20 cm above the position of the aircraft interior elements [7,8].

No collision between elements of the vehicles and equipment of the aircraft occurs only while loading a vehicle with separated elements – backwards (Fig. 9b) and a vehicle with the body and chassis integrated - forwards (Fig. 9c).

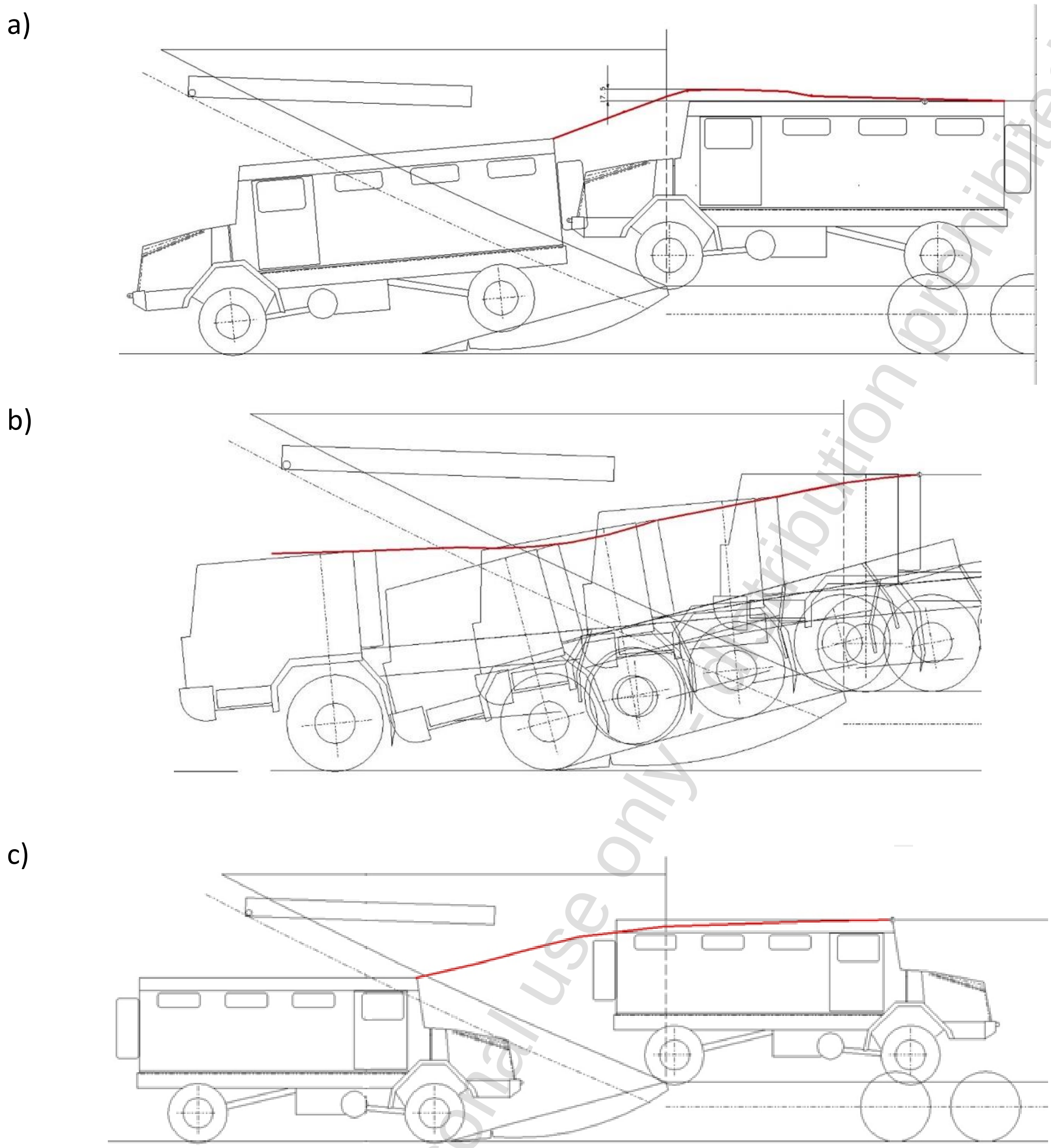


Fig. 9. Backward-drive loading of the vehicle, a) a command system vehicle integrated with the body loaded backwards, b) the line of collisions during backward loading of the truck Jelcz 442 (no collisions), c) forward-drive loading a command system vehicle integrated with the body (no collision).

Source: own study

4. SECURING A LOAD IN THE CARGO BAY

Inertial forces affect a load carried in the cargo bay of an aircraft. Therefore, it should be properly immobilized by means of guy-wires (ropes, chains) at the points in the aircraft floor. This will ensure stability and prevent movement during a flight. The layout and size of overloads affecting a load located in the cargo bay of an aircraft is shown in Figure 10.

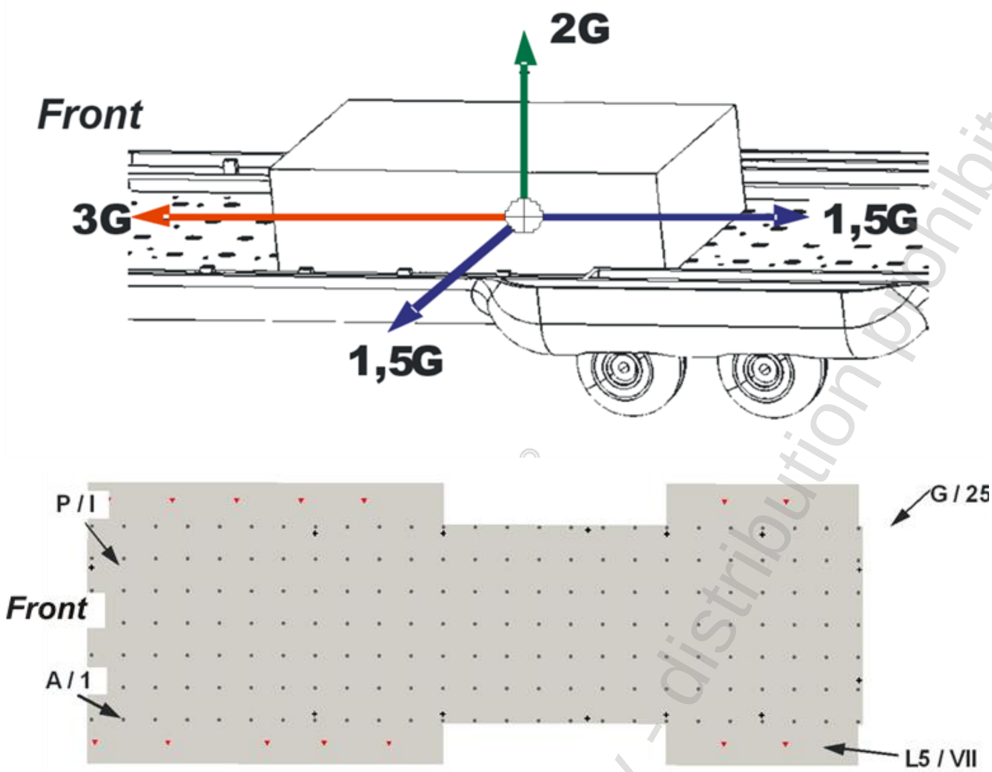


Fig. 10. a) Overloads impacting on a load, b) the arrangement of attachment points in the floor of a cargo bay [2]

Source: own study

Points for mounting guy-wires capable of transmitting three ranges of load are distributed in the floor of the cargo bay of the aircraft C 130 [1,2]. Figure 10 shows the arrangement and marking: black crosses - 25 000 pounds (11340 kg), grey points - 10 000 pounds (4530 kg) and red triangles - 5 000 pounds (2265 kg). Points capable of carrying loads of 5 000 lbs are at the height of 25.5 inches (approximately 648 mm) above the floor of the cargo compartment and on the floor of the ramp (not shown here).

Marking of attachment points:

- attachment points 10 000 - across the cargo bay A-B-C-D-E-F-G /from 01 to 25, for example C/2;
- attachment points 25 000 - across the cargo bay L-P /from I to VII, for example P/IV;
- attachment points 5 000 - across the cargo bay L5-P5 /from I to VII, for example L5/V;

Given dimensions of a vehicle and a body as well as the distribution of attachment points in the cargo bay of the aircraft C-130, the calculations were carried out aiming at the determination of the system of tendons securing a load, ensuring its immobility and at the same time non-exceeded permissible loads of holders at maximum overloads. Securing a vehicle superstructure in the cargo bay of the aircraft C-130 will be conducted by means of the system of 14 tendons according to the scheme presented in Figure 11. The vehicle chassis will be attached to holders located on the floor of the cargo compartment.

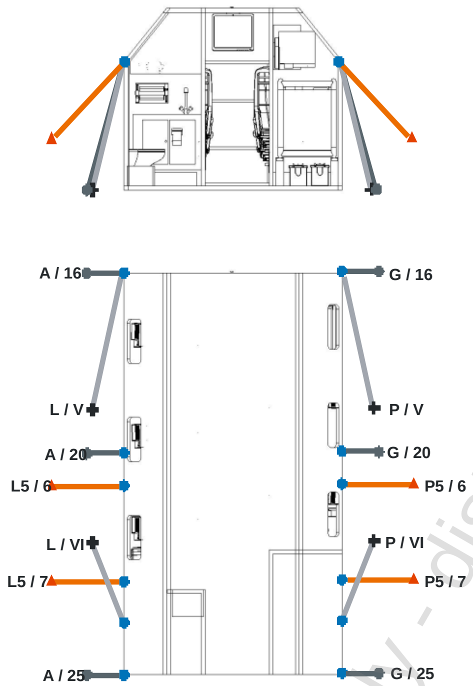


Fig. 11. The system of tendons securing a body

Source: own study

CONCLUSIONS

1. The transport aircraft C-130E Hercules due to its payload and overall dimensions of the cargo area is suitable for the transport of trucks, including the self-propelled artillery command system vehicles.
2. Depending on the weight of a load only one vehicle can be transported per flight. Due to the possible height of a load, a body should be removed or such a vehicle created, which, as an integrated structure, will not exceed the height of 2.72 m.
3. Loading must be well thought out so that there is no collision between the vehicle and the aircraft elements. If the front engine part of the vehicle is extended forward of the front axle and does not exceed the height of 2.40 m the forward-drive loading should be applied. If a vehicle has a body removed it is better to conduct loading backwards. If both parts of the vehicle (front and back) are high the loading should be led from a horizontal loading ramp, which will have to be developed for this purpose.
4. The vehicle and its body must be properly secured inside the aircraft cargo compartment. This includes the use of suitable attachment points with the required load. It is also important to provide the appropriate position of the center of gravity of a load.

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Mirosław KARCZEWSKI, PhD - currently works as a lecturer in the Division of Engines and Maintenance Engineering of Motor Vehicles at the Military University of Technology. The author and co-author of over 80 articles and scientific and technical papers. He deals with controlling the diesel engine working processes, the use of alternative fuels to power diesel engines, methods of measurement of exhaust gaseous components and solid particles, reverse engineering in automotive applications.

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