A PILOT RESTRAINT SYSTEM FOR THE MOBA 2C GLIDER

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INTRODUCTION

The MOBA 2 pilot compartment was designed to optimize comfort, performance, and safety.

These considerations are not in conflict and for all three reasons a low profile supine seating postion is adopted. In this paper I shall be dealing with only the safety aspect.

BASIC LAYOUT

In the absence of design information and accurate accident analysis data, it is necessary to base the design of the glider cockpit on engineering judgement.

From many years experience, we know that the upright seating position has resulted in a high proportion of severe back or spinal injuries from hard landings. This is one reason why the supine position has been adopted in modern sailplanes. For MOBA 2, a backrest angle of 20-30° from the horizontal datum is adopted.

Of equal importance is the need to protect the pilot within the nose structure and, hopefully, prevent it breaking up or being penetrated by exterior objects. Many modern sailplanes with "shell" structures are liable to split or burst apart at the joint line under a nose impact, depositing the unfortunate pilot among the rocks and thistles.

In MOBA 2, the pilot is seated between two triangular side beams of rivetted aluminium alloy capable of absorbing a nose load of more than 9g. The pilot is seated on a plywood, rigid foam and fiberglass seat attached to the aluminum floor. Below this there is a space and then the nose cone itself, a fiberglass-plywood-fiberglass sandwich. Thus, the pilot is well protected, even in a "wheel-up" landing.

Finally, there is a need to protect the pilot against injury from hard objects within the cockpit. In MOBA 2 the controls are removed from between the pilots' legs and relocated in each arm rest.

The purpose of the pilot restraint system is to restrain the pilot in these protective side beams and against the shock absorbing seat structure.

DESIGN DATA

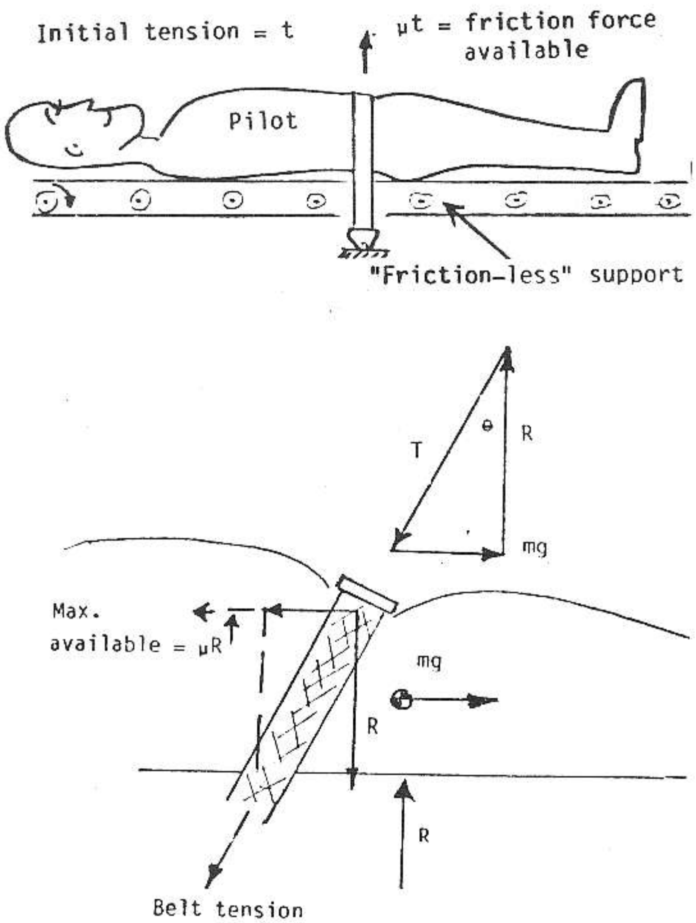
There is a great deal of data available on restraint systems for normal "upright" seating postions. The glider design requirements also appear to assume that the pilot is seated substantially upright. Most modern sailplanes feature a backrest angle of 45° or less. Gliders with extremely supine seating position, similar to MOBA 2, are the Polish Foka, Swiss Diamant, German Ventus and British Sigma. All of these adopt a normal four-point harness system except the Sigma. As will be shown, the normal harness is not ideal in these circumstances.

An experienced gliding instructor and test pilot, Mr. Bob Rowe, has observed that several unexplained fatal accidents may have been caused by the pilot "submarining" underneath the seat harness and bodily pushing the control column hard forward. It is thus worth considering this possibility if the seat back is at less than a 45° slope, although it can easily be seen that certain load combinations could produce the same effect, even for a full upright seating position.

ANALYSIS

It is difficult to resolve the loads for seating positions between fully upright and fully supine. To simplify the argument, we will assume that the pilot is lying flat on his back, restrained only by a seat belt over the loins. He is also lying on a bed of ball bearings so that all the restraint is provided by the seat belt.

As can be readily seen, if the belt has an initial tension, this will produce a friction force to move the belt if the pilot is moved under a forward load. As the "free" end of the belt moves forward, it tightens across the hips. Figure 1 shows that static equilibrium may be established under these conditions and the seat belt tension can be calculated. This is "self locking" up to $\theta = \mu$, the angle of friction.



If free to move, lap belt rotates until it locks.

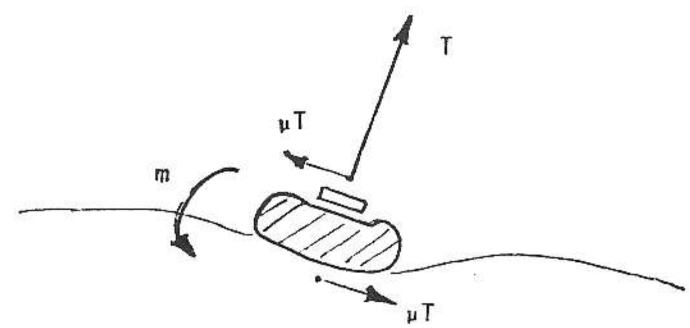
If θ is known, loads can be calculated.
Belt locks until θ = friction angle.

Fig. 1

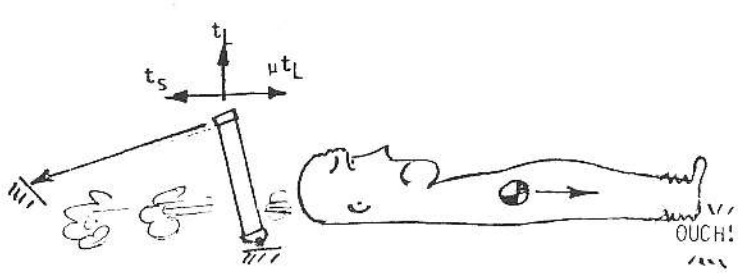
In a practical test, the author was seated in the MOBA with the lap belt comfortably firm. With one person pulling forwards at each arm and leg, there was absolutely no tendency to move forwards at any load up to the threshold of pain. The seat belt "locks-in" to anchor the pilot using the same principle of operation as the "walking washer" type of car jack, or the lumberjack climbing a tree with a rope loop.

Figure 2 shows how a seat belt with bulky padding will rotate, rather than act to restrain the pilot. Thus belts such as the "Q-type" and Irvin with bulky padding should not be used when the seat back is at 45° or less.

Next, we should consider the best type of upper body restraint to install. Figure 2 shows that the upper straps of a four-point harness can destroy the "self locking" capability of the lower seat belt. This will not occur if the upper straps are left suitably loose, but, if the upper straps are tight, this tension will overcome the friction force of the lower strap allowing the pilot to slide forward out of the harness.



Padded belt will rotate due to couple.



Shoulder strap tension greater than initial friction = no restraint.

Fig. 2

It is normal to expect the pilot to tighten his seat belts as much as possible in an emergency situation. In the cockpit the mechanical advantage available is such that it is usually much easier to tighten the upper straps rather than the lower straps and the pilot will probably not notice that the latter are being pulled up. Thus, we have the possibility of good intentions leading to an opposite result than that intended.

Assuming that the pilot is clever enough to leave the upper straps relatively loose, we still have less than optimum restraint sideways.

In MOBA 2 both problems are overcome by fitting two TSO-C22 seat belts: one at the normal lap position, the second across the chest under the arm pits. Note that this chest belt does not act to restrain the pilot forwards, but mainly upwards and sideways. With no danger of fire in an accident, the two release features are acceptable.

A five-point "Christian 820" harness was also examined as an alternative to the selected configuration. This has many of the problems of a four-point harness in operation with an added possibility of injury between the legs. It was found that if the center strap tightens before the lap straps, the buckle assembly will rotate down into the pilots' groin.

CONCLUSION

The two belt system used in the MOBA 2C design produces a reliable restraint system. Four-point harnesses, normally used in sailplanes, exhibit serious design faults when the pilot is not seated fully upright. Harnesses with bulky padding may be particularly dangerous. In flight, these problems may not be obvious because the hump normally found at the front of the seat holds the pilot in position. Under emergency alighting loads, this hump may not prevent the pilot sliding forward if the lap straps are rendered ineffective by any of the reasons mentioned.