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DUAL SQUARE REPORT

In early 1992 the U.S. Army Parachute Team, in conjunction with PIA, conducted a series of test jumps on the flight characteristics of two square parachutes (main and reserve) in flight at the same time. The study was undertaken in an effort to evaluate the ram-air canopy as main and reserve for student use. The Army was interested, also, because some of their troops use square main/square reserve equipment.

The Army had planned on making about 50 jumps but was only able to do about 10. The canopies used were 288 sq. ft. Mantas with Raven III (249 sq ft.) and Raven IV (282 sq ft.) reserves. On the jumps conducted, the reserve was deployed manually while under a fully inflated and flying main.
In late 1992 and into 1993, Scott Smith made an additional 21 jumps using Crickets (147 sq ft.), Fury (220 sq ft.), and Sharpchuter (244 sq ft.). The jumps were performed along the same lines as the Army tests with basically the same results and conclusions.

Both of these studies, while encouraging, were felt to be inconclusive by the PIA technical committee. Chairman of the committee, Sandy Reid, said that "In order to do a complete study, other canopy combinations need to be jumped such as: large main/small reserve, large reserve/small main, and small main/small reserve." "In addition, we need to consider factors such as line lengths, zero porosity fabric, and wing loading."

In 1994 Performance Designs Inc. proposed to the technical committee a series of test jumps designed to fulfill these unanswered questions. While realizing it would be an impossible task to test every conceivable canopy combination and situation, the tests were an effort to get a good cross section of possibilities.

Both the Army Parachute Team and Scott Smith came up with conclusions that still stand true. Our test jumps allowed us to verify much of what they submitted and give additional input.

The following is the report on those test jumps:

DUAL SQUARE TEST EQUIPMENT

The equipment used in the dual square test jumps was extensively thought through and planned. Every jump was conducted using a three or four parachute system. When deploying a canopy while under its fully deployed mate, the appropriate container and pack tray were used as well as normal riser lengths, and deployment systems. This was done to gather the most accurate data possible.

Note: During the 12 intentional cutaways from a biplane, the reserve was deployed using a hand deploy pilot chute with a main d-bag modified as a free bag. This was done to save on the loss of expensive spring loaded pilot chutes and free bags. The cutaway was being evaluated in these scenarios, not the deployment.

In all except the simultaneous/near simultaneous tests jumps both the main and reserve were on risers that had the capability to be cutaway. A chest mounted back up reserve was worn that was not capable of being cut away.

During the simultaneous/near simultaneous deployments a special system was assembled that would house 4 canopies. Two would be deployed from their normal locations. One of these could be cut away separately or they could both be cutaway together. The third parachute if needed could also be cutaway, and the fourth was on risers that could not be cutaway.

Great care was used to assemble this equipment in such a manner that the sequence of deployment and breakaway would be in as much a normal sequence as possible.

Common Results of a Dual Square Deployment

The most likely canopy configuration from a simultaneous or near simultaneous deployment is a ***biplane*** with the main canopy in front and the reserve in the rear.

A ***biplane*** *is both canopies flying in the same direction with one behind the other. Excluding extremes, the shorter rear canopy's leading edge rests against the steering lines below the trailing edge of the taller front canopy.*

The next most common configuration is a ***side-by-side*** with the main risers behind the reserve risers.

A ***side-by-side*** *is both canopies flying side by side in the same direction. They are usually touching end cell to end cell, or the end cell of the shorter canopy resting against the outside lines of the taller canopy.*

Another fairly common configuration would be a fully inflated canopy (either main or reserve) with a ***trailing pilot chute, p.c. and bag, or trailing uninflated second canopy*** behind the jumper. This scenario if left unattended would sometimes remain as it is, or result in one of the other configurations.

A less frequently occurring configuration is a ***downplane.***

A downplane *is both canopies flying away from each other and toward the ground.*

Another infrequent configuration is an ***entanglement*** of the two canopies.

Note: Some people have always believed that you must choose a reserve that is smaller than the main. While this is probably a safe thing to do it is not an entirely accurate gauge. For example: a PD-143R has shorter lines than a STILETTO 135. This combination flew well in a biplane with the main in front. 7 cell canopies typically have shorter lines than equally sized 9 cells.

Conclusion: *Use great care to choose proper equipment. Choose a reserve that is similar in size to the main canopy.*

THE BIPLANE

From looking at the simultaneous/near simultaneous deployment results, as well as numerous reports from the field, the biplane with the taller main canopy in front and the shorter reserve in the rear, is the most common result of both canopies deploying. This personal biplane seems to be stable and easy to control.

Several combinations of canopies were used in the test jumps with some being greatly mismatched. Canopies with a difference of 100 sq ft. or more could cause results out of the norm. We consider this type of combination to be extreme and not advisable.

The most commonly preferred method of flying the personal biplane is to leave the brakes stowed on the rear canopy and fly the front canopy using smooth, gentle toggle input. A few canopy combinations were reported to be slightly more solid with the brakes released on both canopies, but the majority seemed to be most solid with brakes set on the rear canopy.

With the canopies in a compatible biplane it did not seem necessary or wise to attempt to move the configuration into a side by side to cut away the main canopy. In moving one canopy or the other to a side by side it always seemed necessary to maintain outside input to one canopy or the other, or both, to keep them in that configuration. They seemed to always want to return to a biplane. Cutting away while the canopies are returning to a biplane could be dangerous.

In addition while maneuvering canopies back and forth between side-by-sides and biplanes there were times when the two canopies tried to foul with each other or did in fact foul with each other. It does not make any sense to take a docile, maneuverable, and landable biplane configuration and try to change it.

Landing a personal biplane proved to be easy with large canopies, small canopies, heavily loaded canopies, and lightly loaded canopies. Flaring the front canopy seemed to be the preferred method of landing. However it must be noted that flaring the front canopy, or both, did not produce a significant effect in the landing. The canopy would pitch in attitude, but it did not plane out or slow in descent rate much if at all. The descent rate on all canopy combinations was very slow, even in full flight.

Recognizing the student and novice jumper's propensity to flare high, combined with the noneffectiveness of a dual square flare, leads us to believe that not flaring at all is the best way to land a dual square.

Conclusion: *If a biplane is present and the jumper has directional control, leave the brakes stowed on the rear canopy and fly the biplane using gentle toggle input on the front canopy. Do not flare either canopy for landing. Be prepared to do a PLF.*

THE SIDE-BY-SIDE

The personal side-by-side was the result of the taller of the two canopies deploying behind the shorter of the two. Whether this was the result of mismatched canopies where the reserve was the taller and deployed second, or the taller main canopy deployed second, the result was always the same during our tests, except for the downplanes that are noted later.

The reference to ***taller*** and ***shorter*** canopies is to indicate which canopy, when two are inflated together, is longer from the common connecting point on the harness to the very topskin of the canopies.

Line length alone doesn't seem to be an exact indicator as to which canopy is taller due to differences from manufacturers, harness/container sizes, and personal preferences in riser lengths. Different canopies will also have a variance in leading edge heights. At this time there doesn't seem to be an all inclusive formula readily available for determining heights when suspended from a common point on the harness under a fully inflated canopy.

What seems consistent at this time is: *If the top of the **leading edge** of the rear canopy is below the **trailing edge** of the front canopy the likely result will be a biplane. If the top of the **leading edge** of the rear canopy is at or above the **trailing edge** of the front canopy the likely result will be a side by side.*

For the most part side-by-sides formed in this manner seemed to be a configuration that was easy to fly with gentle toggle input from the dominant (usually the larger) canopy. It is not recommended to fly this configuration with all four toggles. On one such test jump a flare was tried with all four toggles which immediately turned the two canopies into a nose to nose fighting match. This was not a desirable result.

In addition, flaring with the outside toggle of each canopy will turn the dual square into a downplane. This also is not a desirable result. It must be stressed to only fly the front, or larger/dominant canopy in a dual square scenario.

The side by side seemed to be more susceptible to instability than the biplane when faced with mismatched sizing and shape. Sometimes with mismatched sizes, the larger canopy wanted to out fly the smaller canopy. The result would be a twisted-up, partial biplane with the smaller canopy partially in back. The stability of the mismatched combination is marginal in this twisted-up partial biplane, and requires very cautious control input.

Cutting away from a side-by-side that does not want to return to a biplane seems to be a safe action as long as no equipment problems exist, and the canopies are not entangled. It must be noted that RSL's were not used in any of these tests. Great caution must be used when cutting away in that scenario due to the varied styles and applications of RSL's.

The jumpers also did not feel comfortable landing heavily loaded side by sides, especially when a highly elliptical canopy is involved.

Both the personal biplane and the personal side-by-side seemed fairly docile and easy to control, the biplane especially so. It should be emphasized that while this is certainly true, complacency should not take place in this situation. During all of these test jumps the canopies were really put through the works and at times were caused to foul with one another. It should be noted that strong or erratic control input could cause undesirable results.

Conclusion: *If a side-by-side is present and the jumper has directional control, fly the side-by-side using smooth, gentle toggle input of the larger/dominant canopy. If the canopies do not seem controllable, and are not entangled with each other, disconnect any RSL, if time/altitude permits, and cut away the main canopy*

THE DOWNPLANE

The personal downplane was a rare but valid and possible result of a dual square deployment. It always involved line twists due to a tumbling bag on deployment of the main canopy when it was the second canopy deployed. While we did see an occasional flip in a reserve bag, it happened when the deploying lines reached the locking stows. The result in that case would be one, or maybe one half twist, which would untwist as the canopy inflated.

In most cases what started out as a downplane would quickly evolve into a side-by-side with no input from the jumper.

In the cases where the downplane did not recover on its own and the jumper did not feel like it was recoverable, there is question as to whether working the controls of the reserve canopy could have brought the downplane into a side-by-side configuration. The fact remains that this side-by-side would very likely result in a canopy with line twists remaining. This is probably not a configuration that one would want to land, and might still call for a cutaway.

The fact also remains that the reason a person is probably in this position to begin with is that their AAD fired. If their AAD fired, they are already low. If they are already low there isn't a lot of time to be playing around trying to undo things when that time could be used cutting away and sorting out the best place to land.

Being in a dual square situation calls for quick evaluation and quick action. A downplane plummets out of the sky at a high rate of speed. The best thing to do in a downplane situation is to disconnect any RSL and cutaway the main canopy.

Conclusion: *If a downplane is present, disconnect any RSL, if time /altitude permits, and cutaway the main canopy.*

TRAILING EQUIPMENT

In some cases the jumper found himself under one fully inflated parachute with a partially deployed second parachute trailing behind.

It was found to be easy to pull in a trailing pilot chute, or even a pilot chute, bag and lines. Great caution must be used however in doing this. If the canopy should get out into the airstream it could inflate or partially inflate quite rapidly and get out of control. **We do not recommend trying to pull in an inflated or partially inflated canopy.**

Even a bagged canopy is dangerous to carry around due to the possibility of it getting away from the jumper and inflating. This happened on one jump just as the test jumper was making a turn into final for landing. The result was a late developing personal downplane that caused bodily injury.

It might be wise when possible to cut away any canopy that is going to be pulled in and carried to the ground. The very act of trying to pull in a partially deployed parachute can aid in its deployment with undesirable results.

Conclusion: *If the main canopy deploys and the reserve is in a stage of deployment it might be best to aid the deployment of the reserve by shaking the risers. Then be prepared to take action on the resulting configuration.*

If the reserve opens and the main is in a stage of deployment, it might be best to remove the RSL and cut away the main.

MAIN/RESERVE ENTANGLEMENT

We did have one simultaneous deployment that resulted in a spinning entanglement. The reserve deployed directly into the deploying main, trapping the main slider which choked off the main canopy's inflation. The test jumper tried pulling risers, but due to the spinning situation elected not to stay with it past 6 or 7 revolutions and cut away both canopies.

We felt after evaluating the situation that if the jumper had cut away the main canopy only there was a chance it would have cleared. This is however, only speculation.

Conclusion: *If a main reserve entanglement should occur, do everything possible to clear the two canopies by pulling on risers and/or toggles. Be cautious about immediately cutting away the main canopy as this may accentuate the problem.*

FINAL CONCLUSIONS OF THE DUAL SQUARE STUDY

1. ***Conclusion:*** *The best way to handle any Dual Square Scenario is to* ***avoid*** *the situation.* Use appropriate and available altitude reporting devices to help maintain good altitude awareness. Follow safety regulations on proper opening altitudes. Insure that AAD's are properly maintained and used. Use properly maintained equipment and gear checks.

2. ***Conclusion:*** *Use great care to* ***choose proper equipment****.* Choose canopies that are not drastically different in size. A general rule of thumb is to choose a reserve that is similar in size to the main canopy.

3. ***Conclusion:*** *If a* ***biplane*** *is present and the jumper has directional control, leave the brakes stowed on the rear canopy and fly the biplane using gentle toggle input on the front canopy. Do not flare either canopy for landing, and be prepared to do a PLF.*

4. ***Conclusion:*** *If a* ***side by side*** *is present and the jumper has directional control, fly the side-by-side using smooth, gentle toggle input of the larger/dominant canopy. Do not flare either canopy for landing, and be prepared to do a PLF. If the canopies do not seem controllable, and they are not entangled with each other, disconnect any RSL, if time/altitude permits and cut away the main canopy.*

5. ***Conclusion:*** *If a* ***downplane*** *is present, disconnect any RSL, if time /altitude permits, and cutaway the main canopy.*

6. ***Conclusion:*** *If the main canopy deploys and the reserve is in a stage of deployment it might be best to aid the deployment of the reserve by shaking the risers. Then be prepared to take action on the resulting configuration.*

   If the reserve opens and the main is in a stage of deployment, it might be best to remove the RSL and cut away the main.

7. ***Conclusion:*** *If a main reserve* ***entanglement*** *should occur, do everything possible to clear the two canopies by pulling on risers and/or toggles. Be cautious about immediately cutting away the main canopy as this may accentuate the problem.*

8. ***Conclusion:*** Additional safety devices, such as AAD's & RSL's, may cause standard emergency procedures to change. Analyze the release recommendations and be sure they coincide with your equipment manufacturers guidelines. Practice these new emergency procedures prior to every jump.

Final note:

During the study we were besieged with requests from DZ owner operators and press wanting information on the tests. Indeed at the onset of the study we intended to release information as we went along.

Yet it did not take long to realize this might not be a good idea. As we were preparing the equipment for the tests we reread the information that had been printed in regards to the Army's tests.

There was one glaring error that bothered us. In the Army's summary, they reported a split decision between releasing the RSL and cutting away, or landing the side by side. A publication reported the Army as saying, "If the two canopies form a side-by-side, jettison the main."

Even still we did release some information to another publication because we thought it was safe to do so, and felt it was important. We released the statement: "Intentional cutaways from biplanes showed that the main had the possibility of entangling with the reserve 11 out of 11 times, with 1 actual entanglement resulting in a cutaway of the reserve." What was written: "All of these (11 jumps) showed at least a probability of canopy entanglement, or a brief entanglement that cleared."

We were told at times that the public has a right to know what we are finding, and that the information could save a life. We realize that information put out in a timely manner could save a life. We also realize that information which is incomplete, misquoted, or taken out of context can cause the loss of life.

We feel that it was an appropriate decision to wait until all the tests were complete and the information carefully researched before releasing the results in a proper format.

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