CHAPTER 8

MILITARY FREE-FALL JUMP TRAINING FOR RAM-AIR PARACHUTE

This chapter describes the RAPS' canopy and its components. Also covered is the ram-air parachute deployment sequence, its theory of flight, and its flight characteristics. Finally, canopy control procedures are explained.

Characteristics

The ram-air parachute canopy's design is similar to an aircraft's wings, with curved upper surfaces (top skin) and flat lower surfaces (bottom skin). Support ribs maintain the airfoil shape of the canopy (Figure 8-1).

Reinforced, load-bearing support ribs serve as attaching points for the suspension lines, and non-load-bearing ribs separate a cell into two compartments. Cross-port vent holes in the support ribs equalize the internal air pressure in a canopy (Figure 8-2).

Nose, tail, chord, and span are terms of reference applied to ram-air parachutes. The open portion at the front is called the nose, with the rear being the tail. The distance from left to right is the span, and from nose to tail is the chord (Figure 8-3).

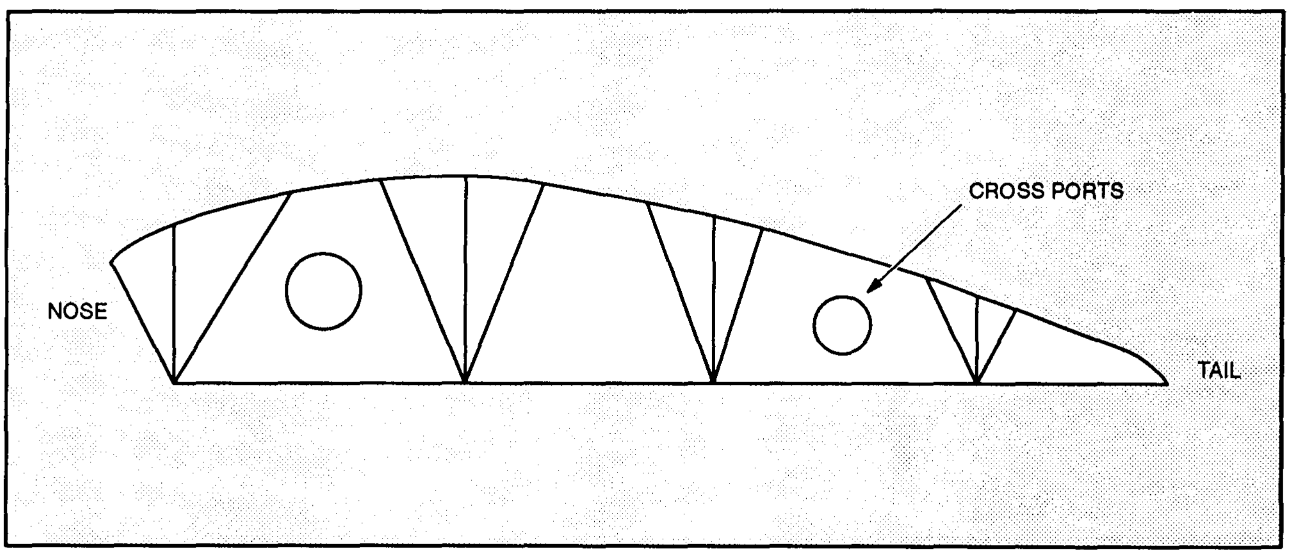

Figure 8-1. Shape of the ram-air parachute canopy.

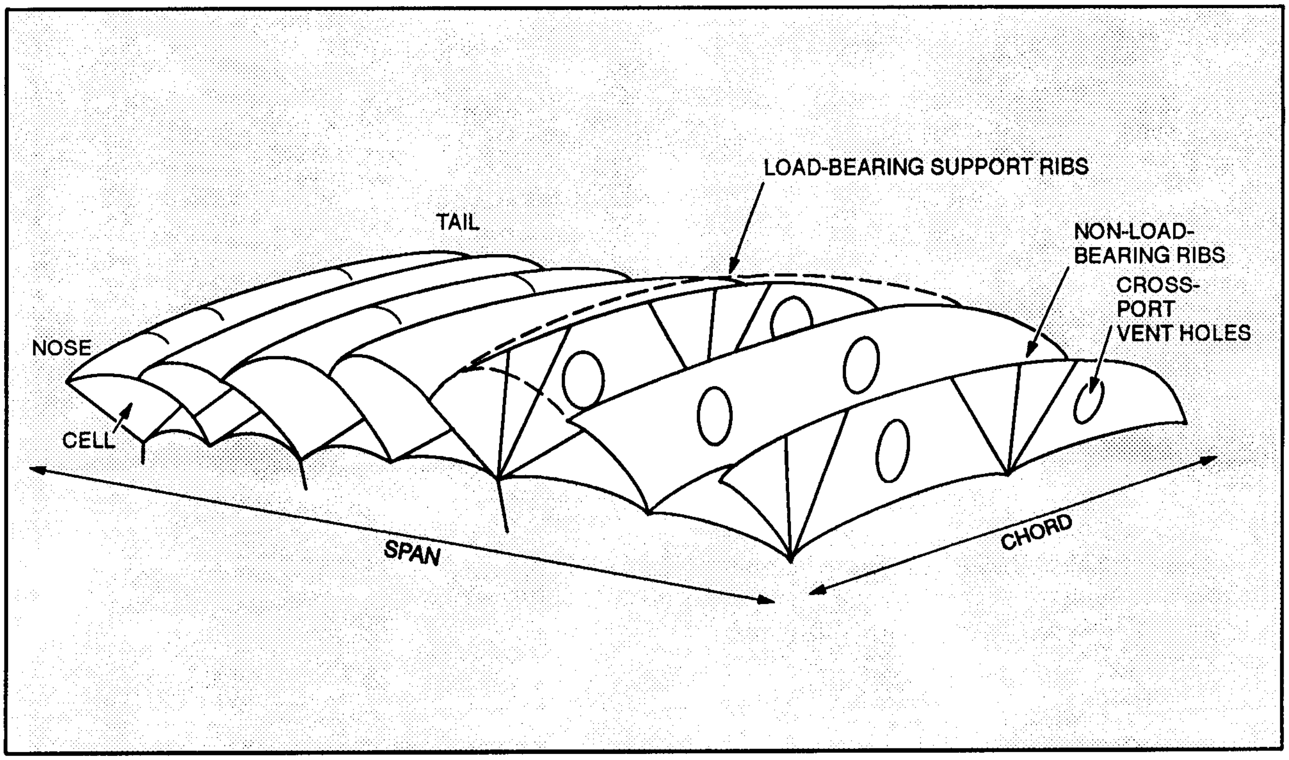

Figure 8-2. Structure of the ram-air parachute canopy.

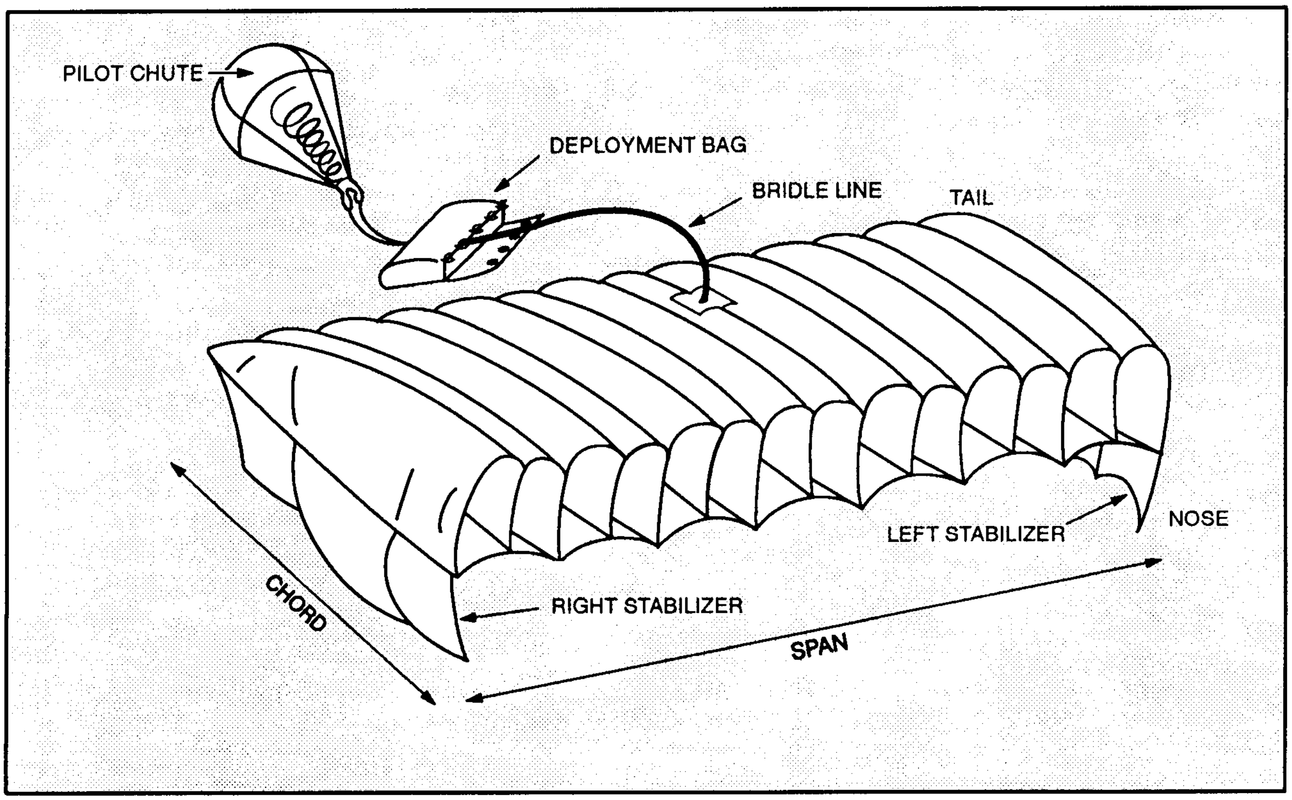

Figure 8-3. Components and nomenclature of the ram-air parachute.

The stabilizers are single-layered extensions of the canopy on the left and right sides of the parachute, They channelize the airflow across the chord and help to maintain straight and stable flight.

The military ram-air canopy has four suspension line groups. They are identified from nose to tail as A, A CASCADE, B, and B CASCADE. They become cascaded line groups when A and A CASCADE and B and B CASCADE are joined at a point below the parachute's bottom skin and connected at the riser in a single line. A continuous line group is a line attached to the parachute's bottom skin that runs directly in the connector link without having another line attached to it. The suspension lines distribute a suspended load under the canopy without distorting the canopy's airfoil shape (Figure 8-4).

Upper control lines converge from points of attachment on the left and right trailing edges of the tail, respectively, to common connection points with the lower control lines. The lower control lines are attached to the upper control lines and have a steering toggle secured to the lower end. Deployment brake loops sewn into the lower control lines set the canopy brakes for deployment.

The sail slider is a rectangular piece of reinforced fabric with a large grommet in each corner. The sail slider is a deployment device that retards the opening of a ram-air parachute (Figure 8-5).

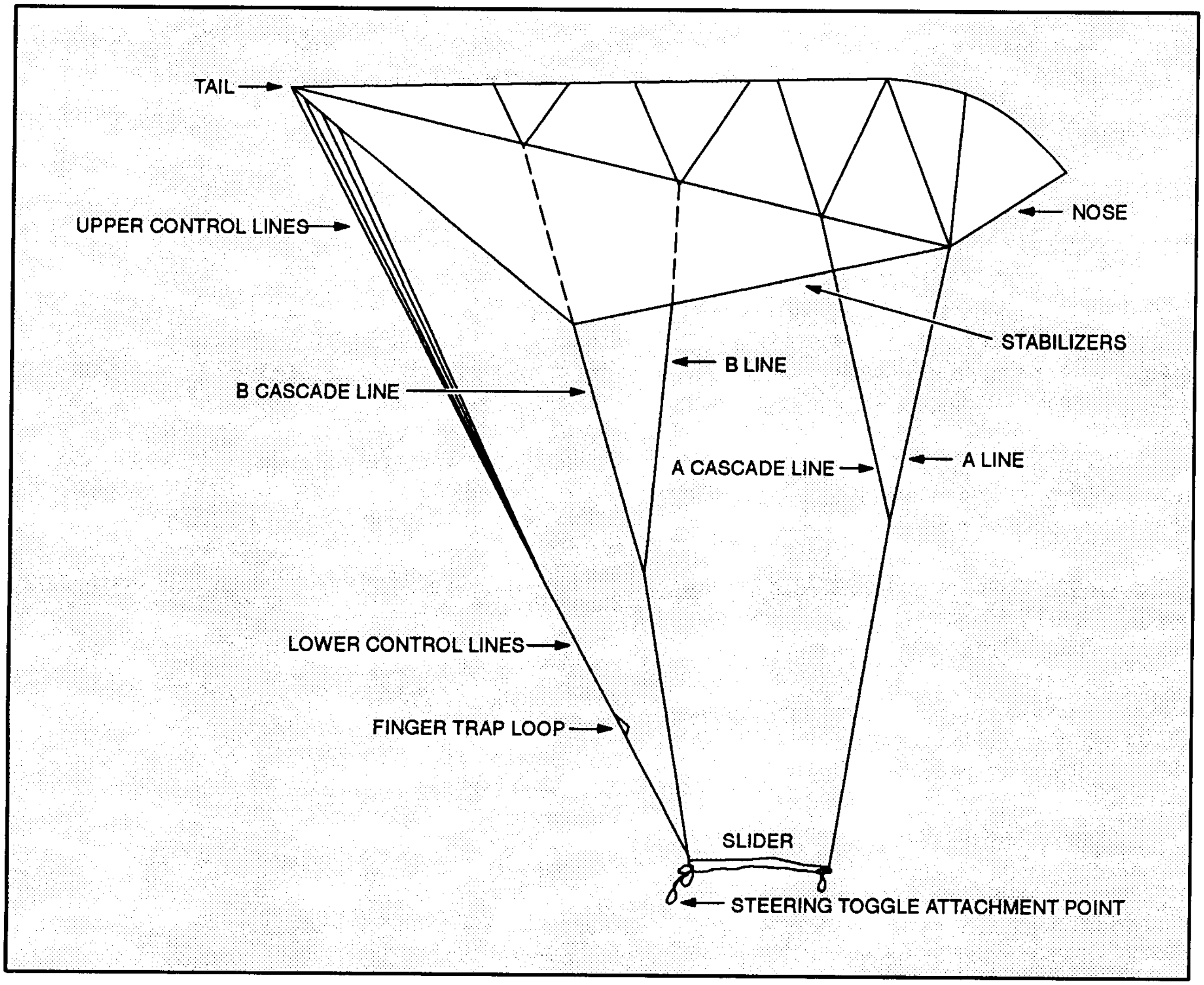

Figure 8-4. Location of components of the ram-air parachute.

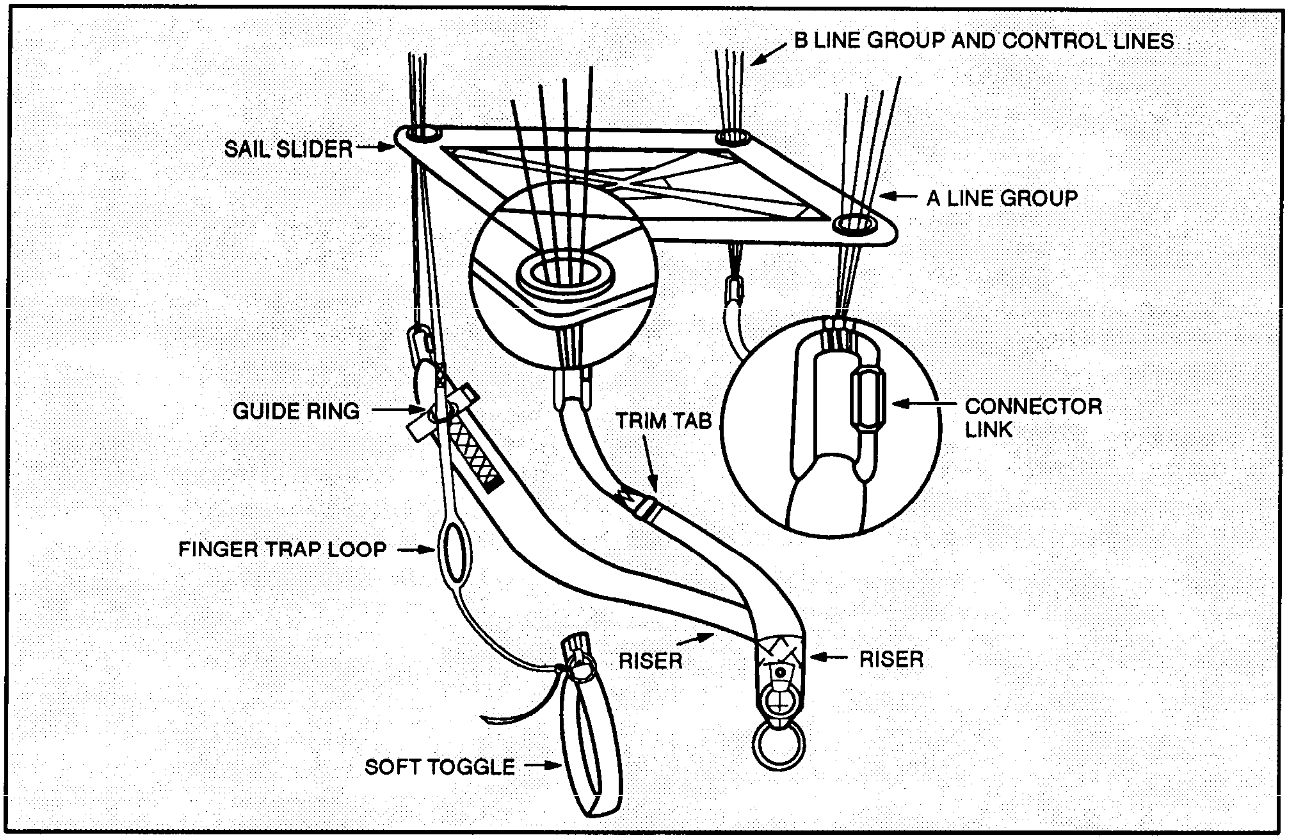

Figure 8-5. Detailed lower portion of the ram-air parachute.

Plastic disks called slider stops are sewn to the stabilizers at suspension line attachment points. These slider stops limit the upward travel of the sail slider.

The suspension lines are attached to a connector link on each riser (Figure 8-5).

Trim tabs on the main parachute's front risers shorten the risers to create an artificial decrease in the canopy's angle of attack into the wind.

Guide rings sewn to the rear risers function as anchor points for the deployment brakes and guides for the lower control lines (Figure 8-5).

Deployment Sequence

At the prescribed parachute deployment altitude, the parachutist manually activates his parachute. He grabs and unseats the main rip cord handle in his right hand and fully extends his arm (Figure 8-6).

When the main rip cord pin clears the closing loop, the main pilot chute opens the closing flaps, launches from the main parachute container, and extends the pilot chute bridle. The bridle extracts the deployment bag from the main container, and the suspension lines unstow from their retainer bands. When the lines are filly extended, they pull the main parachute from the deployment bag, and the canopy begins to inflate (Figure 8-7). The sail slider retards the canopy's deployment. As the canopy inflates, it forces the sail slider down toward the risers as the suspension lines spread apart. After complete canopy deployment, the parachutist pulls the steering toggles from the deployment brake loops to release the control lines from the deployment brakes setting to the full flight setting.

Should the parachutist encounter an uncontrollable situation requiring the initiation of emergency procedures, he discards the main rip cord handle.

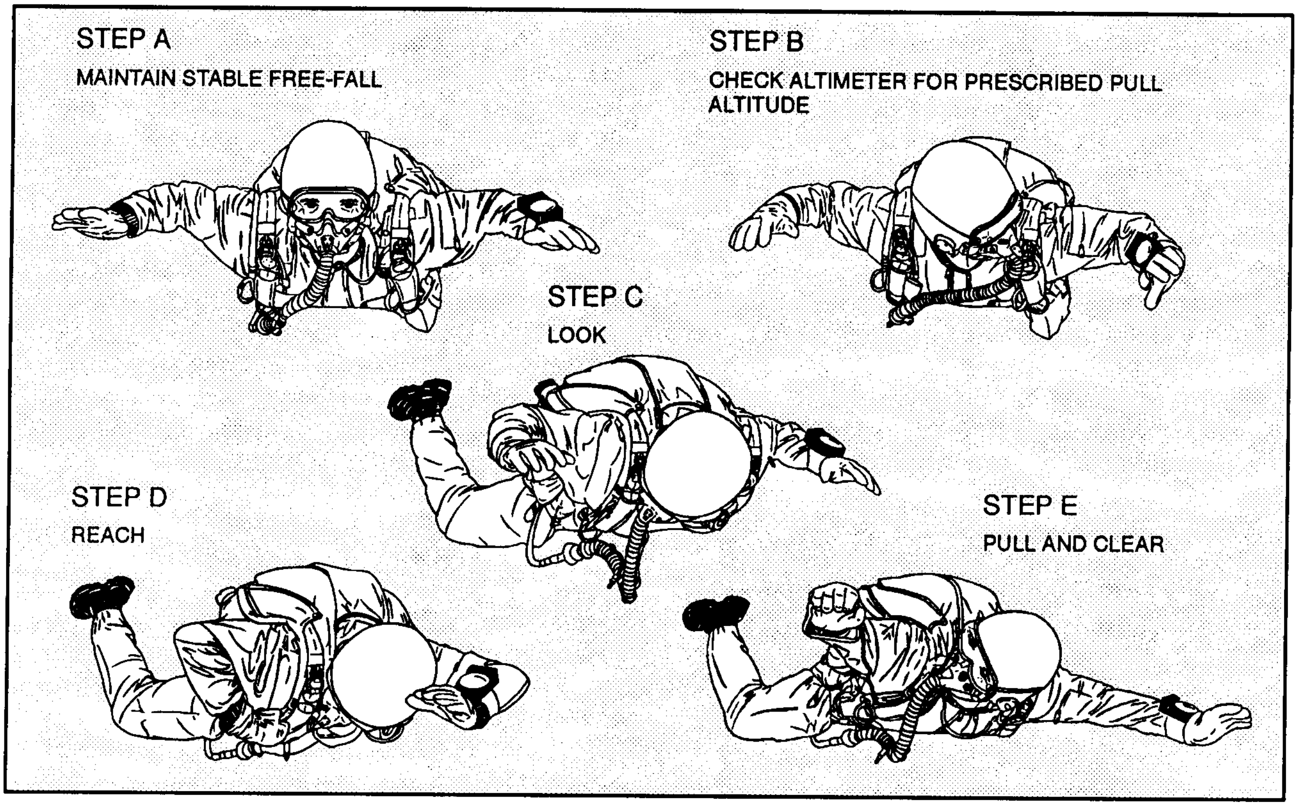

Figure 8-6. Activating the ram-air parachute.

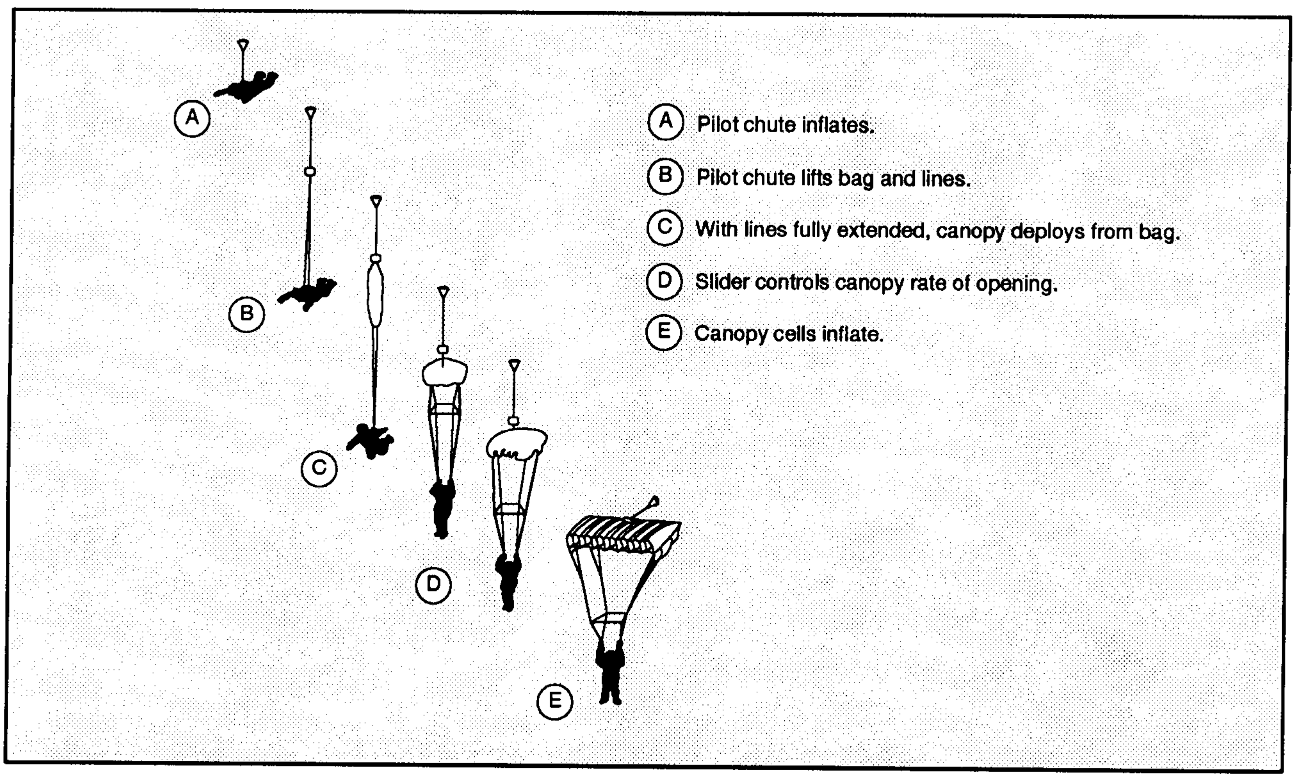

Figure 8-7. Deployment sequence.

He then looks at and secures the cutaway handle with his right hand and the reserve rip cord handle with his left hand and then arches vigorously. He pulls the cutaway handle to full arm extension. He then immediately pulls the reserve rip cord handle to full arm extension. Then he discards both these handles. This action allows the cutaway cables to clear the release loops threaded through the small rings of the canopy release assembly. The three-ring system activates the right side a moment before the left side to prevent an entanglement.

As the left riser set is jettisoned, it pulls the reserve static line, usually deploying the reserve before manual activation of the reserve rip cord (Figure 8-8).

WARNING

The parachutist must first pull the cutaway handle AND THEN the reserve rip cord handle to full arm extension and discard them to ensure complete emergency procedures are followed.

As the reserve rip cord pins clear the closing loops, the pilot chute opens the closing flaps. The pilot chute deploys from the reserve parachute container and, as it catches air, extends the 2-inch-wide high-drag bridle. Upon extraction of the reserve free bag from the container, the free-stowed suspension lines deploy from a pocket on the free bag and extract the reserve parachute from the free bag. The free bag then completely separates from the reserve parachute. As the canopy deploys, it forces the sail slider down the suspension lines. When the parachutist releases the toggles from the deployment brake loops, he releases the control lines from the deployment brake setting to the full flight setting.

Theory of Flight

The ram-air parachute is an inflated and pressurized fabric airfoil that generates lift by moving forward through the air. The relative lengths of the suspension lines maintain the airfoil's angle of attack. In flight, the parachutist keeps the wing's leading edge at a slightly lower angle than the trailing edge.

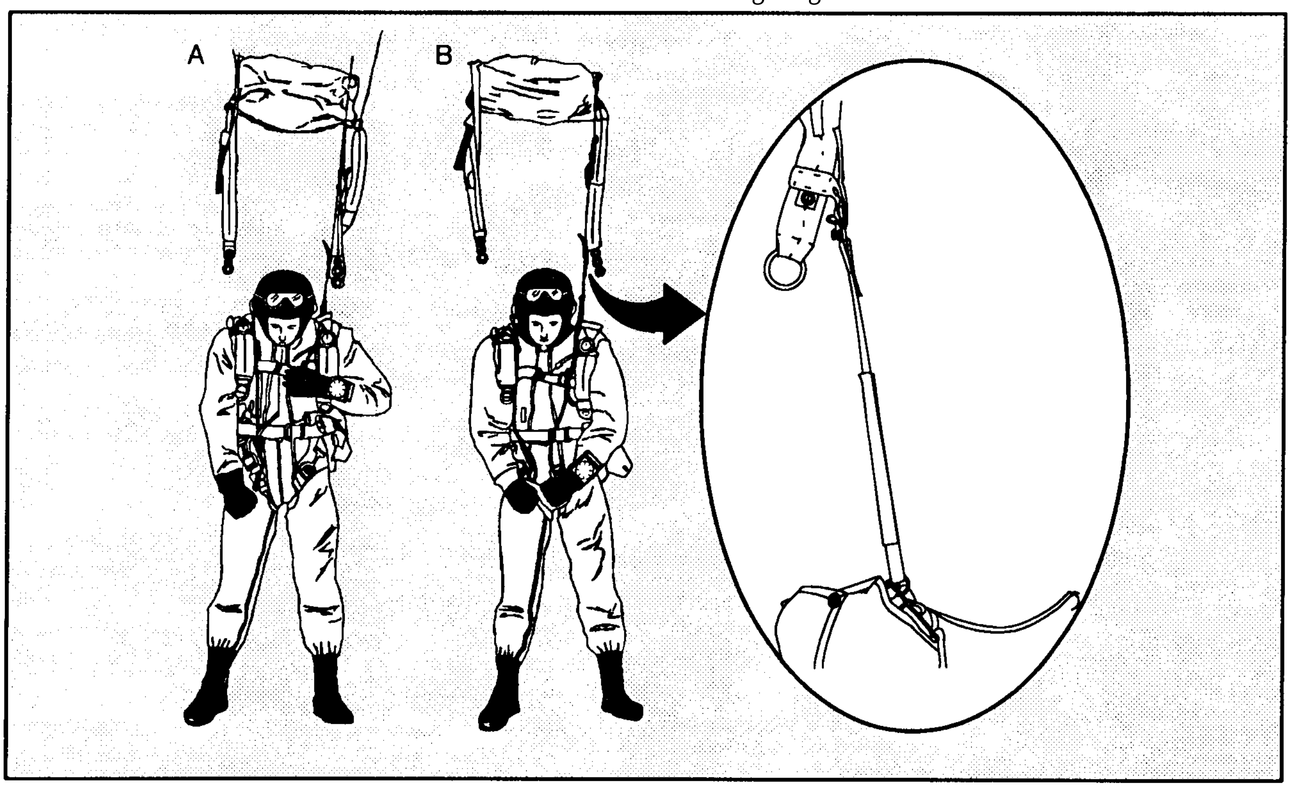

Figure 8-8. Cutaway sequence and deployment of the reserve.

Thus this angle forces the canopy's airfoil-shaped surface to glide or plane through the air, very much like a glider in descending flight. The wing-shaped ram-air parachute generates lift caused by the reduced pressure of the airflow over the curved upper surface.

The ram-air parachute's leading edge is open or physically missing, forming intakes that allow the cells to be ram-air inflated. Internal air pressure pushes a small amount of stagnant air ahead of the airfoil, forming an artificial leading edge. The focal point of this stagnant air acts as a true leading edge, deflecting the relative air above and below. Drag is the only force that retards the wing's forward motion through the air. It is created by the friction of air passing over the canopy fabric, the suspension lines, and the parachutist and his equipment. Gravity, plus the resultant sum of these aerodynamic forces on the upper surface, acts to pull the ram-air parachute through the air and contribute to the flat glide angle of the canopy (Figure 8-9).

Applying brakes on the ram-air parachute causes the trailing edge to deflect downward, creating additional drag (Figure 8-10). This drag produces a proportionate loss of airspeed but generates lift for a short time. Prolonged application of brakes results in a loss of airspeed and generated lift and a steeper approach angle. As full brakes are reached, the wing ceases to generate dynamic lift, resulting in an increased rate of descent at an almost vertical descent angle. Depressing the toggles beyond full brakes causes the parachute to cease flying and enter a stall.

Differential application of brakes (one side only, or one side more than the other) produces an unbalanced drag force at the trailing edge. This drag results in a yaw-type turn toward the side with the highest drag.

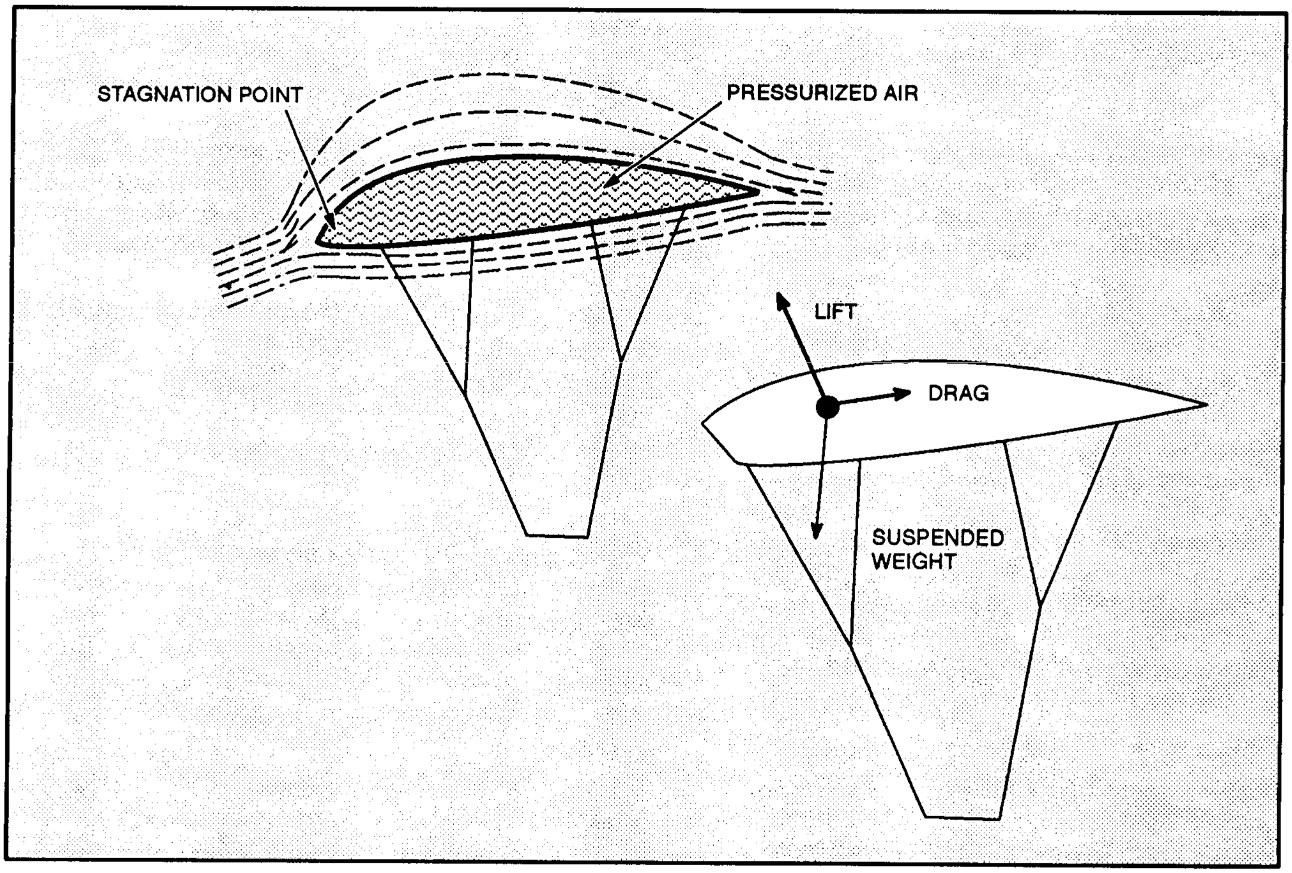

Figure 8-9. Ram-air parachute theory of flight.

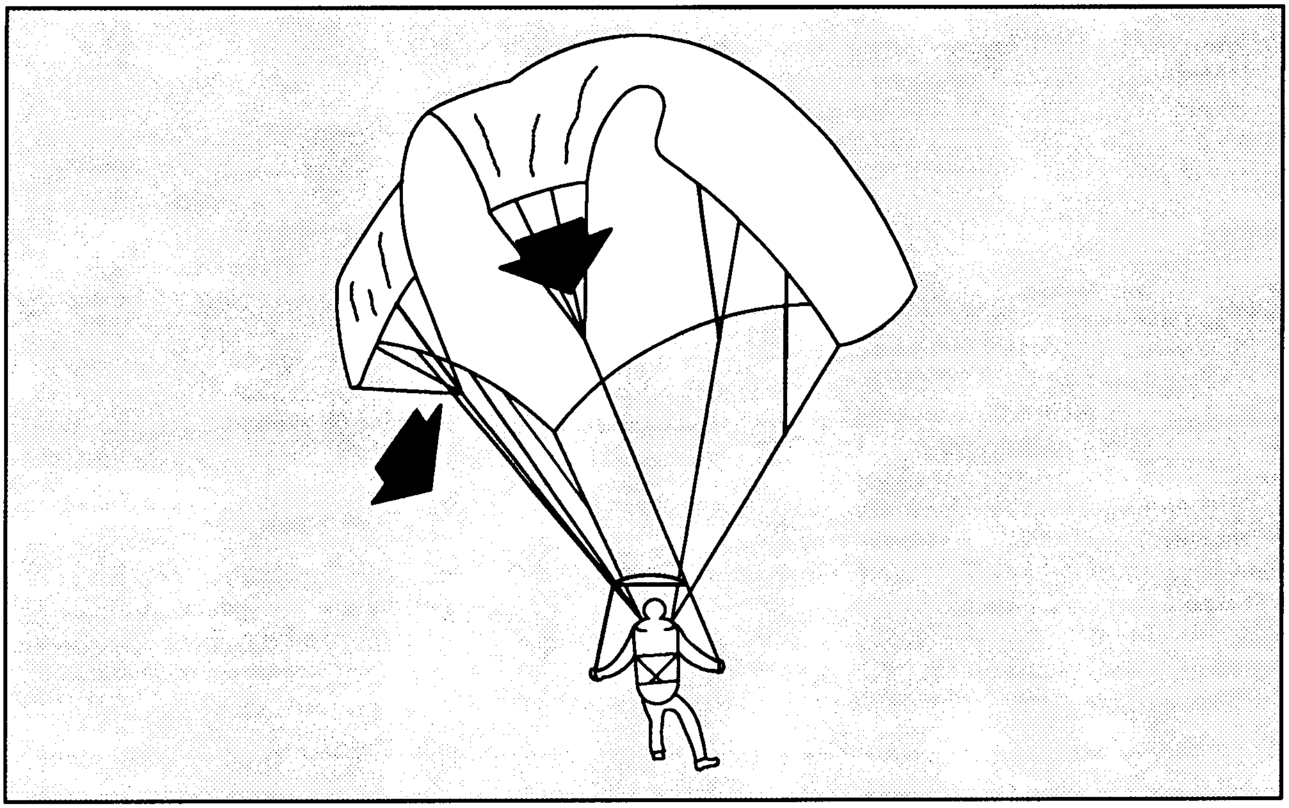

Figure 8-10. Applying brakes on the ram-air parachute.

Because the slow side generates less lift, it tends to drop slightly in a shallow banking motion, much like an airplane. This bank angle increases as differential toggle displacement increases.

Flight Characteristics

Although the ram-air parachute is a very docile and forgiving canopy, ***the parachutist must remember that it is a high peformance gliding system.*** In the hands of an inexperienced parachutist or one ignorant of proper handling techniques, it is, by virtue of its high performance, potentially dangerous. The parachutist must possess a working knowledge of its flight capabilities and limitations and fully understand the canopy control techniques.

The ram-air parachute is not overly complicated. It is basically a fabric wing section. The parachutist must have a very basic knowledge of aerodynamics to better understand its flight and handling characteristics.

The ram-air parachute planes or glides through the air at about 20 to 30 miles per hour (mph). It always flies at this speed regardless of wind conditions, except when the parachutist applies brakes.

The flying speed is called AIRSPEED and remains constant regardless of whether the parachute is headed upwind, downwind, or crosswind. The only variation in flying upwind or downwind is a change in GROUND SPEED, which is often mistaken for a change in airspeed.

Wind affects ground speed only and has no effect on airspeed. Brakes applied with conventional control lines and toggles control the ram-air parachute's airspeed. The parachutist must remember that 50 percent of toggle travel on a ram-air parachute will cause a speed reduction of close to 12 mph.

There is almost no surge on deployment, and there is no wind noise at all until after releasing the brakes. A parachutist who has not been previously exposed to the ram-air parachute's flight characteristics can use the wind noise created by forward speed as a rough airspeed indicator. A reduction in the wind noise level can provide a stall warning.

After the parachutist becomes accustomed to the canopy, he will not notice the wind noise. By this time he will have learned to fly the canopy by feel, and he will have ample stall warning. A parachutist will feel the canopy shudder as it loses lift and begins to stall.

The parachutist must remember that in controlling the canopy's flight, how fast he moves the toggles from one position to another is as critical as the relative position of the toggles. As a rule, rapid and generous (more than 30 percent) application of both toggles will cause a rapid decrease in airspeed, decelerating into the stall range at about 0 to 3 mph. (Depending on the wind speed, the ground speed could still be very high.)

Due to the penetrating ability of the ram-air parachute, it is often difficult to determine wind direction without the aid of a wind sock, streamer, or smoke on the ground. All landings should be made facing into the wind.

The ram-air parachute has a constant airspeed of 20 to 30 mph. If the parachutist points the ram-air parachute downwind with a 10 mph wind, the ground speed will be 30 to 40 mph. If he turns the ram-air parachute into the wind and the winds are 10 mph, the airspeed remains the same but the ground speed reduces by 10 mph. If the ram-air parachute faces into 20 mph winds, the ground speed will be O mph (Figure 8-11).

Canopy Control

The overall objective of MFF parachuting is to land personnel and equipment intact to accomplish the assigned mission. The free-fall parachutist must know and employ the principles of canopy control as they relate to the use of the ram-air parachute.

Wind action, direction of canopy flight, and manipulation of the control toggles primarily control the movement of the ram-air parachute.

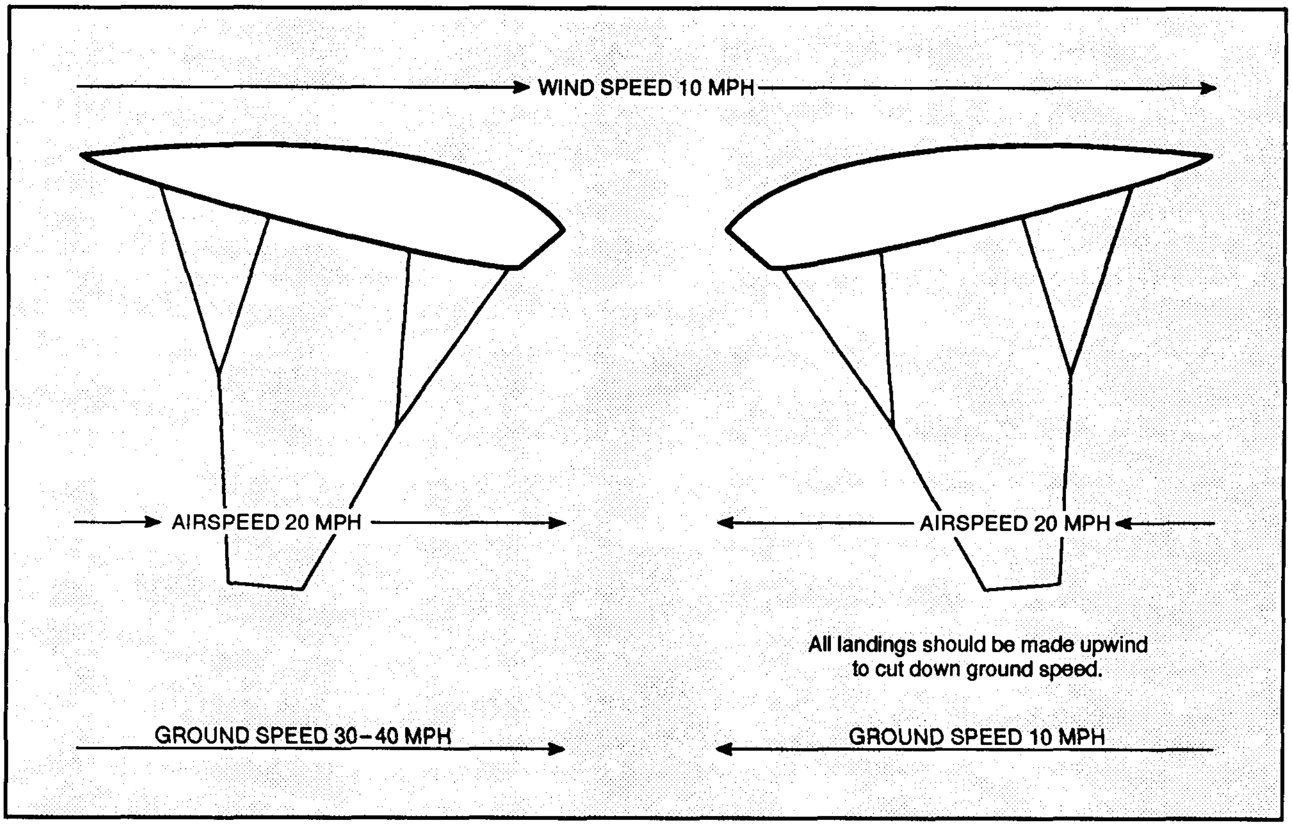

Figure 8-11. Controlling ground speed.

Upon canopy deployment the parachutist grabs the control toggles and performs a controllability check of the parachute. The purpose of this check is to ensure he has control of the canopy using no more than 50 percent toggle travel.

The parachutist must first know wind direction and approximate speed since the direction of his canopy's flight, as determined by his toggle manipulation, is in relation to wind action. The canopy's shape, design, span, and chord generate the ram-air parachute's 20- to 30-mph glide. The flow of air over and under the canopy's wing shape provides the lift and forward flight of the parachute. By specific manipulation of the toggles, the parachutist may distort the trailing edge and cause the canopy to turn, to vary forward speed, and to increase the rate of descent.

Canopy control involves the coordination of wind direction and speed, canopy fright and penetration, and the parachutist's own selective manipulation and distortion of the canopy. Maneuvering the parachute requires more than simply turning the canopy. A properly executed parachute maneuver requires correct canopy manipulation to combine the wind's force and the canopy's flight to move the parachute in a given direction. The parachutist may have to hold into the wind, run with the wind, or crab to the left or right while holding or running. Figure 8-12 contains a condensed guide to good canopy control.

Holding Maneuver. Pointing the canopy into the wind, or "holding," aims the canopy flight directly into the wind (Figure 8-13). This maneuver increases lift has the same effect as reduced wind speed, and slows the canopy's forward movement. The parachutist manipulates the toggles to maintain the position. To crab to either direction while holding, he turns the canopy slightly in the direction in which he wants to move. Turning the canopy too far may cause it to become windcocked and move with the wind. As the parachutist's canopy begins to move in the desired direction, he manipulates the toggles to keep it in position until he completes the maneuver.

Running Maneuver. If the parachutist points the canopy with the wind, the combined glide speed and the wind speed produce an increased canopy movement speed called "running" (Figure 8-14). He manipulates the toggles to maintain the canopy in position. To crab while running, he turns the canopy slightly in the desired direction and maintains the position until he completes the maneuver.

Crabbing Maneuver The parachutist performs a "crabbing" movement by pointing the canopy at any given angle to the wind direction (Figure 8-15). The force of the wind from one direction and the flight of the canopy at an angle to it moves the canopy at an angle to the direction of flight. The direction of flight varies with the wind speed and the angle at which the parachutist points the canopy. A canopy pointed at a downwind angle makes a sharper angle than one pointed upwind.

- ☐ Check canopy and ground position after opening.
- ☐ Keep a sharp lookout for other parachutists.
- ☐ Check your altitude and your first ground reference point.
- ☐ Pick out intermediate ground references between you and the target.
- ☐ Determine wind direction (on the ground and at altitude).
- ☐ Check the holding pattern and penetration of your canopy.
- ☐ Use the upwind toggle to turn your canopy.
- ☐ Locate the wind line and determine the direction in which you want to move.
- ☐ Always maneuver toward the wind line.
- ☐ Check your progress at halfway and three-quarter-way points and make necessary adjustments.
- ☐ Turn into the wind at a minimum altitude of 500 feet.
- ☐ Control your canopy all the way to the ground.
- ☐ Always land facing into the wind.

Figure 8-12. Sample canopy control and movement accuracy checklist.

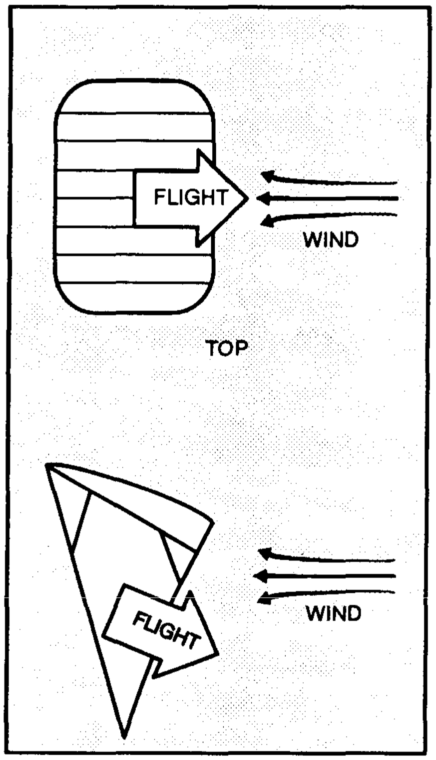

Figure 8-13. Holding maneuver.

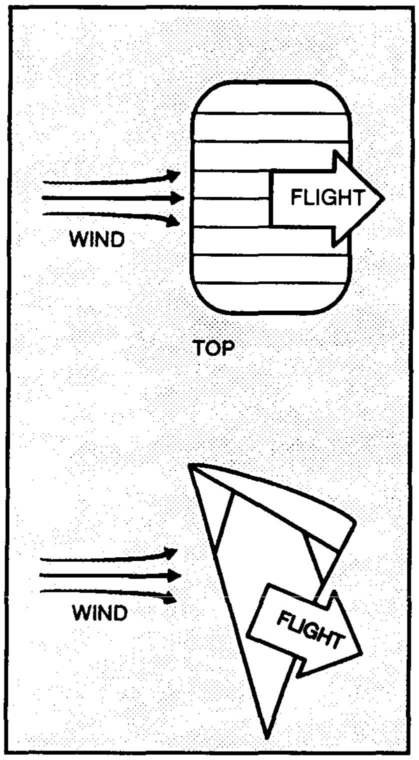

Figure 8-14. Running maneuver.

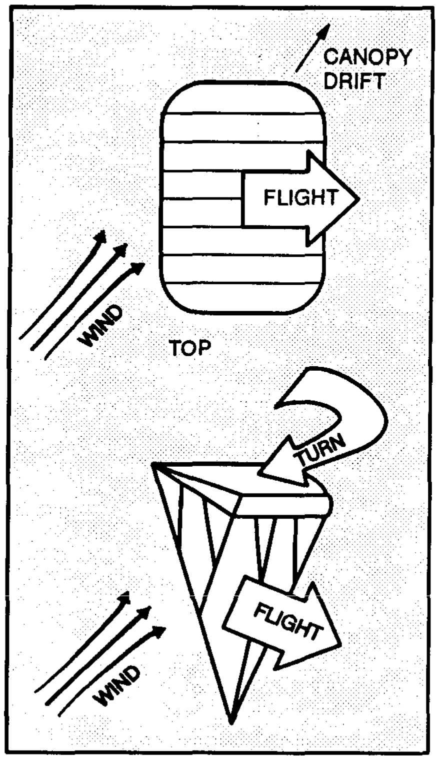

Figure 8-15. Crabbing maneuver.

The effective canopy range and the wind line determine the course (direction of movement) the parachutist follows in maneuvering toward the target area. The effective canopy range is the maximum distance from which the parachutist can maneuver the canopy into the target area from a given altitude. It is greater at high altitudes and decreases proportionately at lower altitudes, forming a cone- or funnel-shaped area (Figure 8-16). Changes in wind direction and conditions may cause this range to shift in any direction.

A wind line is an imaginary line extending upwind from the target area to the opening point and can be marked by ground references. Accurate reference points are essential to effective parachute maneuver.

The parachutist checks his movement in relation to the ground. Winds at altitude maybe from different directions than those at the desired impact point.

The parachutist picks a ground reference point on the wind line, halfway between the opening point and the target area. This point is the first checkpoint that he can reach in half the opening altitude with correct canopy manipulation. The second checkpoint is a reference point halfway between the first checkpoint and the target area that he should reach in half the remaining altitude.

The parachutist always tries to maintain the “upwind advantage.” This advantage is a margin in his canopy range where he will not be blown behind his target area from which he cannot recover and land with his group.

The ram-air parachute is a highly maneuverable canopy capable of 360-degree turns in 3 to 5 seconds under normal conditions. Its maneuverability comes from the parachutist's use of its capabilities to vary forward speed, rate of descent, turn, and crosswind movement.

Under normal conditions, the parachutist varies his forward speed and rate of descent by using the canopy’s toggles. Immediately upon canopy deployment he clears the toggles from the deployment brakes setting and performs a controllability check. His toggle position at the stall point will be at a different position as wind speed increases and when carrying heavy equipment loads.

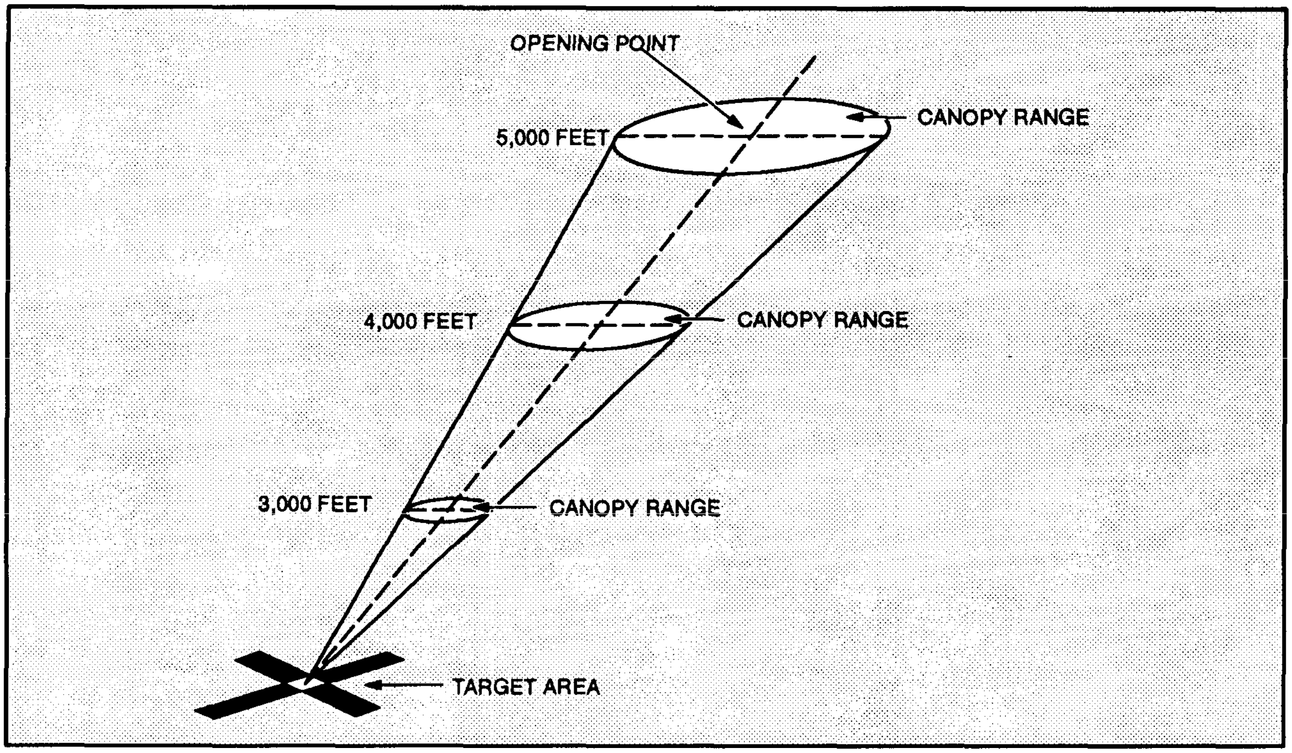

Figure 8-16. Effective canopy range.

WARNING

Before attempting any maneuvers or turns, the parachutist must be alert to prevent collisions with other parachutists. This maneuver is especially critical below 500 feet AGL.

Fu// Flight (No Brakes). The maximum canopy flight and penetration for maneuvering is obtained using full flight. The toggles are in the up position behind the rear risers (Figure 8-17).

Half Brakes. The parachutist grasps the toggles and pulls them down to about shoulder or chest level for the halfbrakes position (Figure 8-18). The canopy speed will decrease to about a 9- to 12-mph flight, and the rate of descent will increase.

Fu// Brakes. The parachutist pulls the toggles to about waist level for full brakes (Figure 8-19). The canopy stops moving forward and the rate of descent increases. In the full brakes position, the canopy is actually on the verge of a stall.

Stall. A stall occurs when the parachutist pulls the toggles below the full brakes position (Figure 8-20). The angle of attack of the parachute's nose and wing change produce a very great amount of lift for a short time. As the parachute loses forward airspeed and because the parachutist pulled the tail down lower than the nose, the canopy will attempt to fly backward and the rate of descent will increase to a hazardous degree. To regain forward airspeed and flight, the parachutist slowly raises the toggles to the half brakes position to raise the tail.

WARNING

The parachutist does not move the toggles quickly from the stall to the full flight position, as the canopy will surge forward with an increased rate of descent. The parachutist must avoid stalling the ram-air parachute below 500 feet AGL.

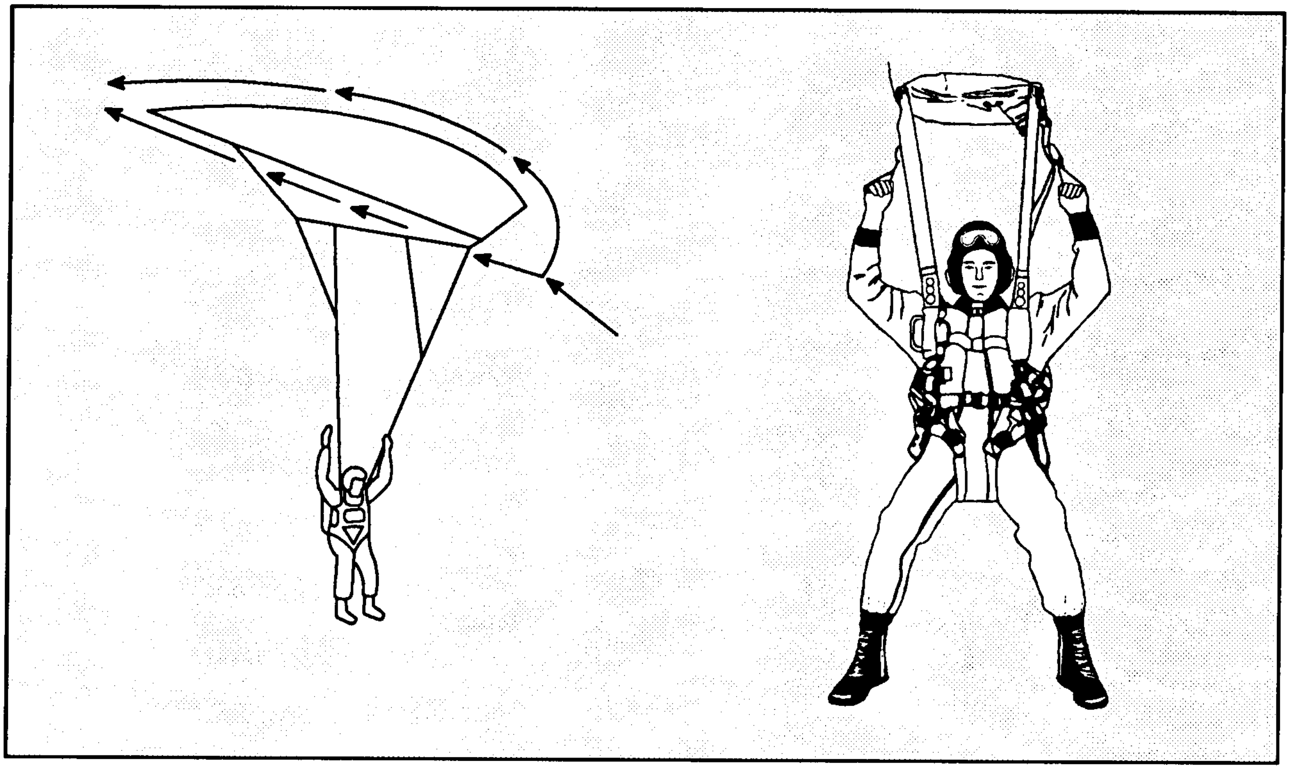

Figure 8-17. Full flight.

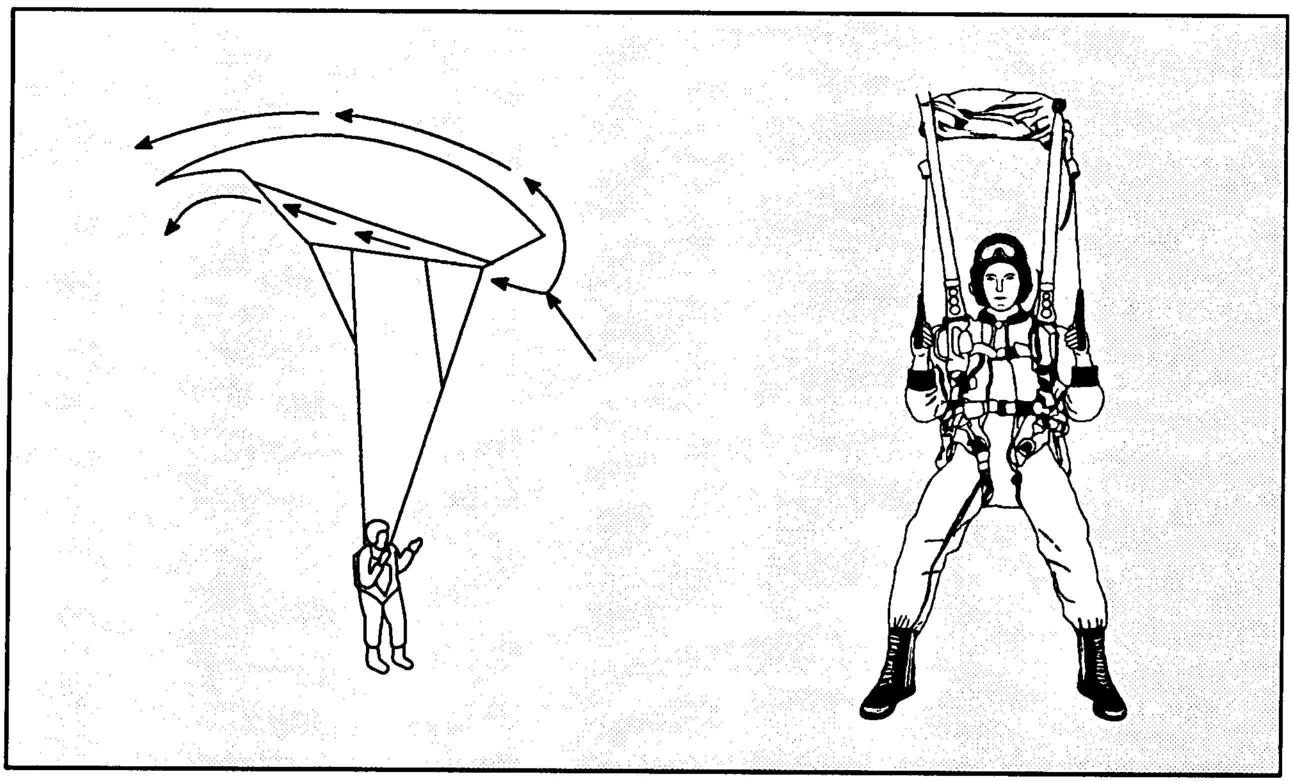

Figure 8-18. Half brakes.

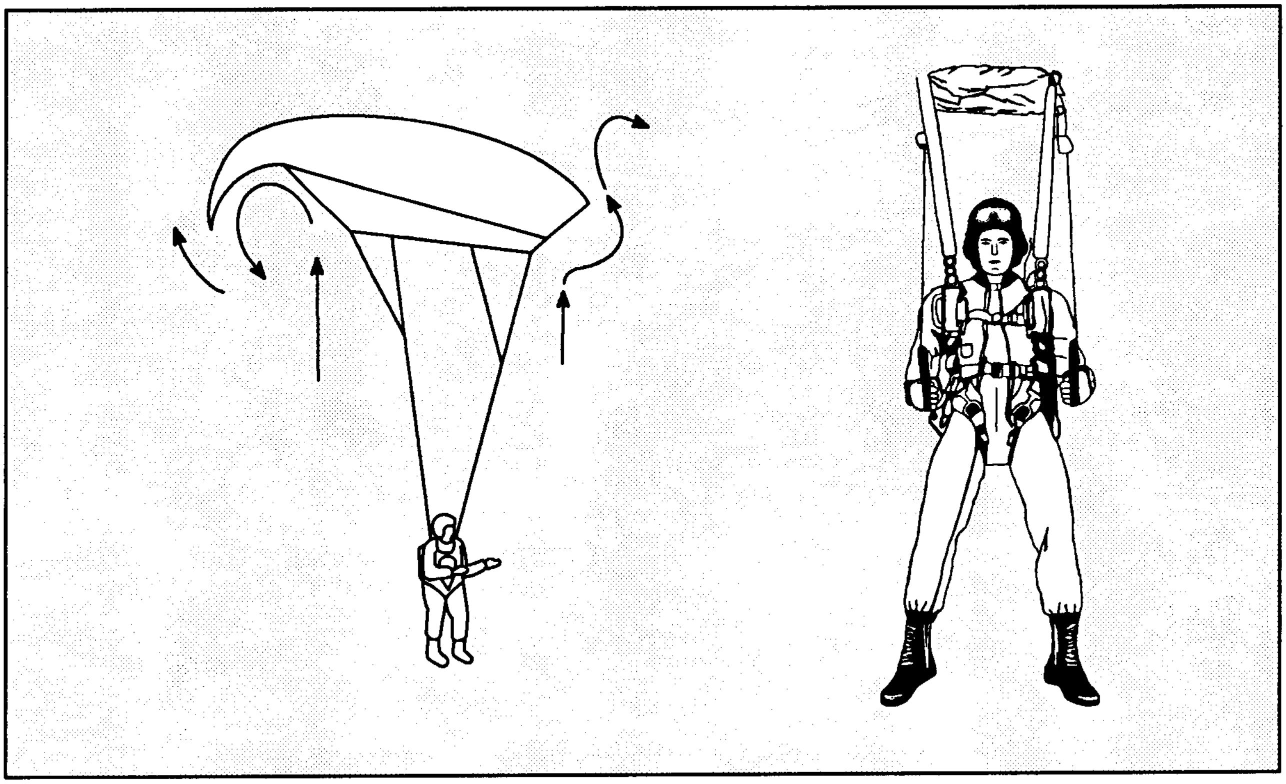

Figure 8-19. Full brakes.

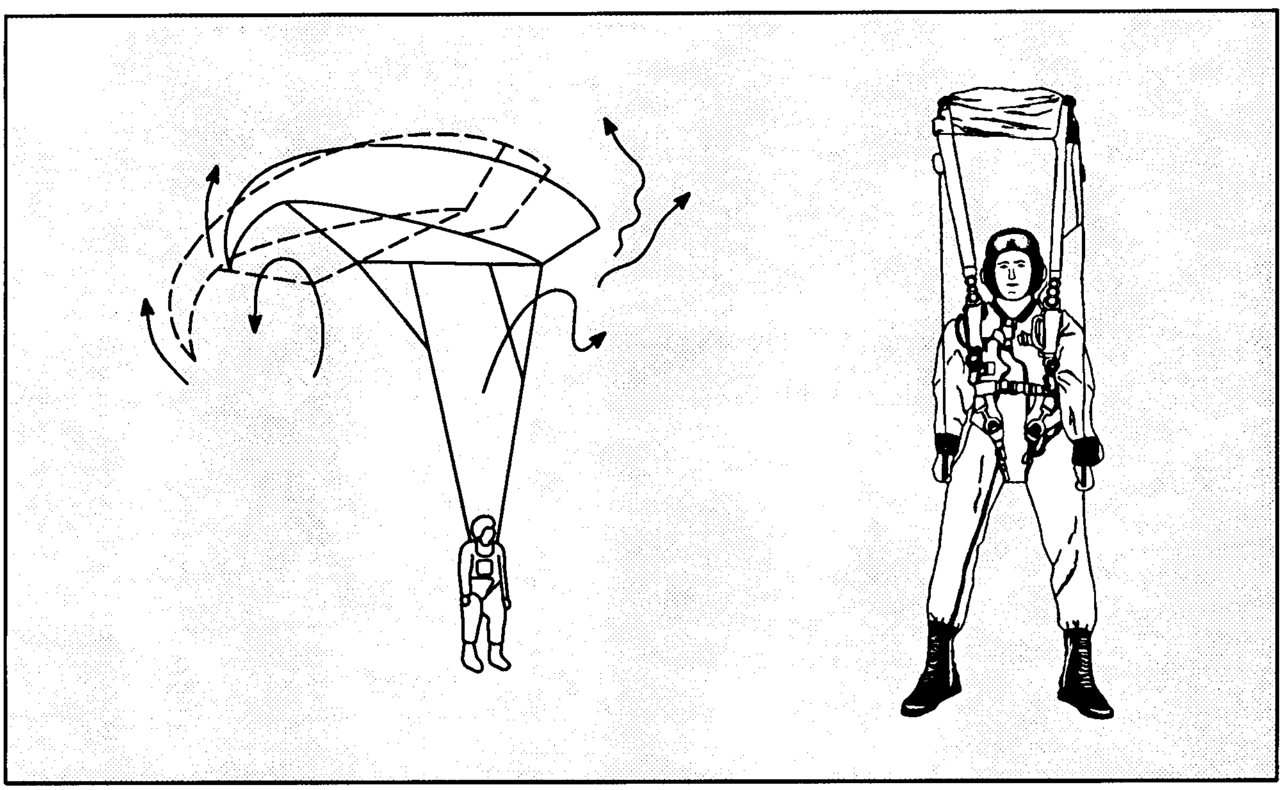

Figure 8-20. Stall.

The parachutist can make turns from the full flight, halfbrakes, and full brakes positions. Turns from full flight are very responsive, but due to the high forward speed, the turns will cover a wide arc. The parachutist makes these turns by depressing either toggle, leaving the other one at the guide ring. In this type of turn, the parachute will bank and actually dive, causing the parachute to lose altitude quickly. The farther the parachutist depresses the toggle, the steeper the bank angle.

Spiral turns are basically turns from full flight but maintained for more than 360 degrees of rotation. The parachute will begin diving in a spiral. The first turn will be fairly slow, with shallow bank angles, but the turn speed and bank angle will increase rapidly while the parachutist maintains the spiral. The parachutist should use trim tabs located on the front risers to lose altitude, if required.

WARNING

Spiral turns are NOT recommended. They will cause excessively fast diving speed with a rapid loss of canopy control. If the parachutist makes a spiral turn, he should be aware of other parachutists and wind direction. He must NEVER make a spiral turn below 500 feet AGL.

Turns from the half brakes position result in almost flat turns. These turns are desirable when flying the target approach legs.

Turns from full brakes are extremely fast, and heading changes are quick and flat. To prevent the canopy from stalling, the parachutist makes these turns by raising the opposite toggle.

The parachutist makes flared landings into the wind. He starts them at an altitude of 10 to 15 feet, with room ahead for the actual touchdown. At *200* feet, he eases both toggles to the full flight position, allowing airspeed to build. At about 10 feet above the ground (depending on wind conditions), he slowly pulls both toggles downward, timing the movement to coincide with the full brakes position at touchdown. The flared landing, when properly executed, practically eliminates forward and vertical speed for a short period. If the parachutist slows down the ram-air parachute prior to the flare point, depressing the toggles will result in a "sink."

WARNING

On a misjudged flare attempt, if the parachute enters a stall, the parachutist initiates recovery procedures by slowly raising the toggles about 6 inches. He must be prepared to perform a parachute landing fall (PLF).

NOTE: In turbulent wind conditions, the parachutist maintains about 25 percent to half brakes to help keep the ram-air parachute inflated and stable.

NOTE: The parachutist can safely land the ram-air parachute in the half brakes position. This procedure is especially useful during night or limited visibility operations when he cannot see the ground or if recovering from a stall. He must be prepared to perform a PLF upon ground contact.

The ram-air parachute landing approaches similar to standard aircraft practice consisting of a downwind leg, a base leg, and a final approach upwind into the target (Figure 8-21). The parachutist uses his altimeter to assist his visual altitude determination.

Downwind Leg. The parachutist flies the downwind leg along the wind line, passing the target area at an altitude between 1,500 and 1,000 feet (depending on winds), about 300 feet to the side of the target. He continues the downwind leg about 300 to 400 feet downwind of the target (again, depending on winds),

Base Leg. When 300 to 400 feet past the target, the parachutist begins a gentle 90-degree turn to fly the base (crosswind) leg across the wind line. He usually flies this leg at 30 to 60 percent brakes, depending on the wind conditions. He may either shorten or extend the base leg to reach the turning altitude. Under low wind conditions, he flies the base leg to a turning point about 500 feet directly downwind of the target and at an altitude of 500 feet.

Final Approach. Under light wind conditions (0 to 5 knots) and 500 feet directly downwind of the target, the parachutist makes a braked turn to turn toward the target. He completes the final turn at approximately 500 feet and no lower than 200 feet. On the final approach, braking techniques control descent and flight. The parachutist performs any major control corrections immediately while there is enough altitude and distance to the target. He lowers his equipment at 200 feet.

WARNING

The parachutist avoids the turbulent air directly behind and above a ram-air parachute by flying offset to a parachute to his front or a minimum of 25 meters to the rear and above. He does not make sharp or hook turns on the final approach or attempt a 360-degree turn.

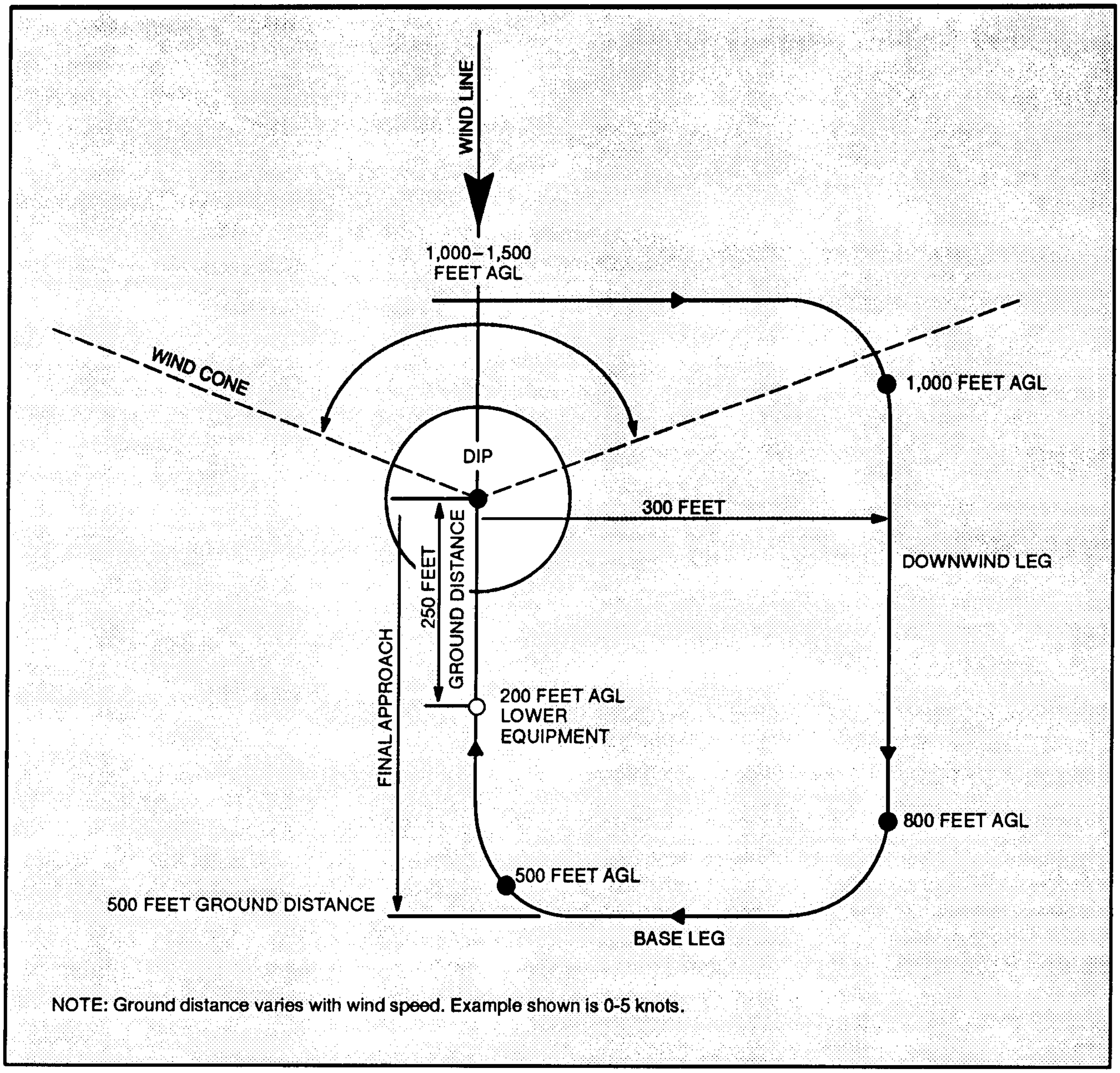

Figure 8-21. Landing approaches.

WARNING

Landing while facing in a direction other than into the wind results in higher lateral movement and increased rate of descent, increasing the probability of injury on impact.

WARNING

The parachutist maintains a sharp lookout for fellow parachutists at 500 feet and below to avoid canopy collisions and entanglements. The lower parachutist has the right-of-way.

Turbulence

Turbulence is the result of an air mass (wind) flowing over obstructions on the earth's surface. Common obstructions are irregular terrain (bluffs, hills, mountains), man-made features (buildings, elevated roadways, overpasses), or natural ones such as tree lines. A disturbance of the normal horizontal wind flow causes turbulence. As the air mass moves around and over the obstruction, it transforms into a complicated pattern of eddies and other irregular air movements. Turbulence generally affects the flight of the parachute at the most critical time for the parachutist, the last 200 feet of canopy flight.

In general, with ground wind speeds less than 10 knots, both the windward and leeward sides of an obstruction cause small eddies 10 to 50 feet in depth. When wind speeds are between 10 and 20 knots, obstructions can cause currents that are several hundred feet in depth. Additionally, there will still be eddies on the windward and leeward side near the obstruction. At wind speeds greater than 20 knots, currents formed on the leeward side are carried considerable distances beyond the object that created them. Only minor eddies and currents form over smooth water surfaces. Turbulence over choppy swells is worse closer to the surface of the water due to the wind flow over a constantly changing surface configuration. Over mountains, even light winds (moving air masses) pushed up mountainsides or redirected down valleys can form major eddies and air currents that have violent, abrupt characteristics. Additionally, in HAHO operations in mountains or around hilly terrain, unstable air masses form currents that continue to grow in size and complexity. The resultant turbulence can extend up to thousands of feet AGL.

An example of turbulence is the vortex created by aircraft taking off or landing. The turbulence created by these aircraft can invert smaller aircraft landing too closely behind them. bother example is the turbulence behind another parachutist's canopy, The parachutist who finds himself behind this canopy will feel the turbulence it creates. Turbulence can exist around any cloud mass. Individual clouds probably will not create turbulence. Clouds that mark the leading edge of an air mass probably will contain strong downdrafts. Cloud decks capping mountain ridges will contain very strong downdrafts and abrupt turbulence. Those type cloud formations will contain rapid pressure differentials. Altimeter readings should be suspect because the parachutist could be 1,000 feet lower than the indicated altitude on the altimeter.

The parachutist should avoid at all costs clouds that contain thunderhead activity due to the violent turbulence associated with those formations.

Land and Sea Breezes

The thermal differences of air masses associated with the interface along shorelines cause land and sea breezes. In the daytime, coastal land masses warm up faster than water. The air above the land rises, causing a lower air density than over the water. The air flows from the water over the land to replace the lower air density there. This phenomena creates an "onshore" breeze known as a "sea breeze." It is most evident on clear, summer days in lower latitudes. The same phenomena occurs in reverse in the evening due to the more rapid cooling of the landmass. The reversed process creates a "land breeze." The air flow over obstacles in the vicinity of shoreline DZs creates turbulence, when farther away from the coast, turbulence might not exist.

Valley and Mountain Breezes

Winds generally flow upslope on warm days in mountainous terrain. They flow downslope in the evening as the air masses cool. During the day, the winds create “valley breezes;" at night, the reverse process creates “mountain breezes.” These breezes, coupled with the air flow over obstacles, can cause strong and unpredictable turbulence.