IN THE UNITED STATES COURT OF APPEALS
FOR THE ARMED FORCES

U N I T E D S T A T E S,	)	FINAL BRIEF ON BEHALF OF
Appellee	)	APPELLANT
	)	
v.	)	Crim. App. Dkt. No. 20131064
	)	
	)	USCA Dkt. No. 16-0599/AR
Sergeant (E-5)	)	
JARED D. HERRMANN,	)	
United States Army,	)	
Appellant	)	

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v.	)	Crim. App. Dkt. No. 20131064
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Sergeant (E-5) **JARED D. HERRMANN**, United States Army, Appellant	)	

TO THE JUDGES OF THE UNITED STATES COURT OF APPEALS
FOR THE ARMED FORCES:

Issue Presented

WHETHER THE EVIDENCE IS LEGALLY SUFFICIENT TO FIND APPELLANT COMMITTED RECKLESS ENDANGERMENT, WHICH REQUIRES PROOF THE CONDUCT WAS LIKELY TO PRODUCE DEATH OR GRIEVOUS BODILY HARM.

Statement of Statutory Jurisdiction

The Army Court of Criminal Appeals (Army Court) had jurisdiction over this matter pursuant to Article 66, Uniform Code of Military Justice, 10 U.S.C. § 866 (2012) [hereinafter UCMJ]. This Honorable Court has jurisdiction over this matter pursuant to Article 67(a)(3), UCMJ, 10 U.S.C. § 867(a)(3).

Statement of the Case

On September 18 and December 16–17, 2013, a military judge sitting as a general court-martial convicted Sergeant (SGT) Jared D. Herrmann, contrary to his pleas, of one specification of willful dereliction in the performance of his duties and one specification of reckless endangerment, in violation of Articles 92 and 134, Uniform Code of Military Justice, 10 U.S.C. §§ 892, 934 (2012) [hereinafter UCMJ].[1] The military judge sentenced appellant to a bad conduct discharge, confinement for ten months, forfeiture of all pay and allowances, and reduction to the grade of E-1. (JA 28). The convening authority approved the sentence as adjudged. (JA 17–18).

On April 18, 2016, the Army Court affirmed the findings of guilty and the approved sentence. (JA 1-15). Sergeant Herrmann was notified of the Army Court's decision and, in accordance with Rule 19 of this Court's Rules of Practice and Procedure, appellate defense counsel filed a Petition for Grant of Review on June 15, 2016, and a Supplement to the Petition for Grant of Review on July 5, 2016. This Honorable Court granted appellant's petition for review on October 20, 2016.

[1] The military judge acquitted appellant of solicitation to commit an offense, false official statement (two specifications), and obstruction of justice.

Statement of Facts

During February 2013, appellant worked as a parachute rigger and "In-Process Inspector" (IP) in the 10th Special Forces Group (Airborne) at Fort Carson, Colorado. (JA 41). Appellant's job was to ensure rigger checks were completed and parachutes were packed in accordance with the appropriate training manuals (TM), and then sign the parachute log record book to confirm the parachute is "airworthy in accordance with the TM." (JA 34, 41, 49-50).

For every airborne operation, jumpers "are required to have a reserve parachute in the event of an emergency." (JA 30). The T-11 Reserve (T11R) parachute is the designated reserve parachute for the MC6 parachute typically jumped at Fort Carson. (JA 30). Training manuals require these T11R parachutes to be opened and re-packed every 365 days if not used. (JA 35, 136, 165, 167–168). The term "pencil packing" describes personnel failing to properly pack or inspect a parachute, yet still verifying the proper procedures were followed by signing the appropriate forms. (JA 52–53, 272–273).

Prior to the date of the charged offenses, Fort Carson held a jumpmaster certification course. (JA 464). To assist with this course, Sergeant First Class (SFC) David Doris, the Non-Commissioned Officer In-Charge (NCOIC) of the parachute packing facility, issued some of the T11R parachutes to the course as training aids. (JA 46–47). These parachuted were near the 365-day mark at which they had to be re-packed, and SFC Doris further explained "by the time the Jumpmaster course was over they would have been out of the 365 date." (JA 47). During the jumpmaster course, trainers "rigged" deficiencies into these T11R parachutes in order to train the trainees on proper Jump Master Pre-Inspections (JMPI). (JA 47). The JMPIs are "a very specific sequence of events that has to happen [prior to a jump] and [the jumpmasters] have to inspect that parachute from top to bottom to ensure that is a safe parachute to jump externally and make sure that there are no deficiencies. . . ." (JA 47). Essentially, during the course, trainees learn to inspect prospective jumpers and find defects in the main and reserve parachutes. (JA 45). When the February class was complete, instructors collected the T11R parachutes used in the course and placed them with the other T11R parachutes that needed re-packing. (JA 47).

On February 19, 2013, SGT Herrmann was an IP for three parachute riggers: then-Specialists Elizabeth Martinez-Mojica, Tristan Brown, and Johnny Arrington. (JA 180). That day, SGT Elizabeth Escobar, a NCO working with SGT Herrmann, was spot-checking the pack sheets of numerous riggers. (JA 270). When she checked SPC Arrington's sheet, she noticed he had packed more parachutes than she thought was possible for him. (JA 270–271). Sergeant Escobar took her concerns to Chief Warrant Officer 2 (CW2) Franklin Fowler, the officer in charge (OIC) of the packing facility. (JA 272).

While investigating the situation, CW2 Fowler pulled the sixteen parachutes packed by SPC Arrington. (JA 133-135). Chief Warrant Officer 2 Fowler then determined some were pencil packed. (JA 133). Next, CW2 Fowler questioned both SPC Arrington and SGT Herrmann who both denied pencil packing. (JA 133-135). Eventually, CW2 Fowler and SFC Doris inspected between two hundred and four hundred parachutes, determining a total of 14 had been pencil packed. (JA 64–65, 135–137). These 14 parachutes were all pencil packed by SPC Arrington and SPC Brown with SGT Herrmann as their IP. (JA 138). Each of the fourteen parachutes determined to be pencil packed had knots in the closing loops and two of the fourteen did not have springs. (JA 135). The specifics of this are unclear though. According to CW2 Fowler, "[d]uring the Static Line Jumpmaster Course they popped [the parachutes] and the spring came out and in order to reclose a parachute or the T-11R to make it the same amount of tautness, you have to put knots in the closing loops or it's not going to stay closed." (JA 137). Notably, CW2 Fowler explained they discovered these deficiencies "based on outside visual" inspections. (JA 138). Eventually, two of the fourteen parachutes were opened for a "full pull down," and the other twelve were locked in a cage without being opened. (JA 68).

Another reason CW2 Fowler believed the parachutes were pencil packed was that "once you repack a T-11R, and . . .[if] the spreader bar ties . . . are dirty, frayed, or look like they've been abused then you know that they were never changed." (JA. 137). Also, after the pencil packed parachutes were opened, they were not as "fluffy" as they should have been. (JA 137). Had they been recently re-packed they should be fluffy, but if they had been packed over a year earlier and been sitting in a bin, they would be compact. (JA 137). Each parachute with deficiencies (and every other parachute in the shack) was re-packed. (JA 139).

In outlining the potential for harm from pencil packing, SFC Doris testified, "if they weren't packed as they were supposed to be, lives are *potentially* in danger. If they weren't inspected as they were supposed to be, lives are *potentially* in danger." (JA 57)(emphasis added). When trial counsel asked SFC Doris "what can happen" with these flawed parachutes, SFC Doris responded "[i]f a Soldier jumps [with] a piece of equipment that hasn't been inspected properly or is missing a component, death; that is a *plausible* outcome." (JA 75–76)(emphasis added).

When asked about the potential for harm if a spring is missing, CW2 Fowler said the jumper could "*potentially* die or get seriously hurt." (JA 140)(emphasis added). During direct examination, trial counsel asked CW2 Fowler, a sixteen veteran of parachute rigging:

> Q. When you were talking about deficiencies in a reserve parachute or a parachute of any kind and that it can potentially cause death, how do you know that?

> A. [Crying] If you stay in the field long enough then you see it.
>
> Q. And what have you seen?
>
> A. I've seen a daughter lose a dad.

(JA 123, 142–143).

The government presented additional testimony about the potential harm caused by closing loops having "premature" or "unintended" deployments (JA 168–169), missing or flawed ejector springs delaying the opening of a reserve parachute (JA 76–77, 140, 169–170), and degraded connector ties (JA 169–170). However, during all of the testimony regarding deficiencies, witnesses interjected numerous qualifying terms like "could have," "could be," "could get," "can cause," "potentially," "may not," and "if." (JA 76–77, 140, 168–171).

The government called Mr. Gordon Whiteman, an expert in "research and development of static line parachutes, specifically the T-11 Reserve." (JA 161, 163). He testified that, if a T11R did not have a spring, "the parachute *may* not open quick enough in a total malfunction scenario and *can potentially cause* serious injury or death to the paratrooper if there is a total malfunction." (JA 170)(emphasis added). In regards to cotton ties, Mr. Whiteman testified they may fray and fail, and "the opening shock *can* be pretty violent if they are not there and *maybe causing* a--*maybe* the parachute *may not* be able to fully open properly." (JA 171) (emphasis added).

During closing argument, trial counsel described the possibilities as:

> [Appellant's] actions *could and may* have likely produced death or serious bodily harm. Sergeant First Class Doris, Chief Fowler, and Chief Jimenez all testified that if a reserve were to fail to deploy the result *could be* death, at best injury. As Chief Fowler put it, he has seen children (*sic*) lose their father.

(JA 295) (emphasis added).

In response, the defense highlighted the weakness of the government's case:

> The government has provided you no statistics with regard to how often a reserve chute needs to be . . . deployed. The reserve chute is typically deployed . . . when somebody's air speed is to fast or when the main chute doesn't deploy properly and they have to cut away and that's when you get the reserve chute, but *they have produced no evidence that because of these inadequacies that is a likelihood. . . .* As a matter of fact through Mr. Whiteman what you heard was that even without that spring, the experts said that chute will still deploy and somebody could land safely. . . . *So the government hadn't shown that if these deficiencies weren't corrected that the chute would fail. All they said is that this is a possibility.*
>
> . . .
>
> Everything they have produced is speculative, well, it could happen, but *they have not produced any evidence that if those things failed – those deficiencies failed that this is a likely result.*

(JA 315) (emphasis added).

Summary of Argument

While the evidence demonstrated the potential for harm from a T11R parachute malfunction, the government did not demonstrate the likelihood of such an event happening in the first place. More specifically, the government did not demonstrate the likelihood of failure because of the pencil packing or the likelihood of any condition that must occur prior to a jumper needing his reserve occurring. The government put on either no or insufficient evidence regarding the likelihood of: 1) the reserve parachute making it through in-house checks; 2) the reserve parachute getting onto a prospective jumper; 3) JMPI not catching the deficiency; 4) the prospective jumper making it onto an aircraft; 5) the prospective jumper exiting the aircraft; 6) the main parachute failing to the point a reserve parachute is needed; 7) the jumper activating the reserve parachute; and 8) the reserve parachute failing because it was not re-packed. Not only was the government required to demonstrate that the totality of each step would make it likely the reserve parachute would be needed and fail, but they did not demonstrate it would happen within the following 365 days. At the 365-day point, the pencil packed parachutes would be repacked.

Argument

WHETHER THE EVIDENCE IS LEGALLY SUFFICIENT TO FIND APPELLANT COMMITTED RECKLESS ENDANGERMENT, WHICH REQUIRES PROOF THE CONDUCT WAS LIKELY TO PRODUCE DEATH OR GRIEVOUS BODILY HARM.

Standard of Review

This court reviews questions of legal sufficiency de novo. *United States v. Ashby*, 68 M.J. 108 (C.A.A.F. 2009) (citing *United States v. Chatfield*, 67 M.J. 432, 442 (C.A.A.F. 2009)).

> [I]n reviewing for legal sufficiency of the evidence, the relevant question an appellate court must answer is whether, after viewing the evidence in the light most favorable to the prosecution, any rational trier of fact could have found the essential elements of the crime beyond a reasonable doubt.

United States v. Oliver, 70 M.J. 64, 68 (C.A.A.F. 2011) (quoting *Jackson v. Virginia*, 443 U.S. 307, 319 (1979)(internal quotations omitted). "Further, in resolving questions of legal sufficiency, [appellate courts] are bound to draw every reasonable inference from the evidence of record in favor of the prosecution." *United States v. Barner*, 56 M.J. 131, 134 (C.A.A.F. 2001) (citations omitted).

Law

As delineated by the President, the four elements for reckless endangerment under Article 134, UCMJ, are:

> 1) That the accused did engage in conduct;
>
> 2) That the conduct was wrongful and reckless or wanton;
>
> 3) That the conduct was likely to produce death or grievous bodily harm to another person; and
>
> 4) That, under the circumstances, the conduct of the accused was to the prejudice of good order and discipline in the armed forces or was of a nature to bring discredit upon the armed forces.

Manual for Courts-Martial, *United States*, pt. IV ¶ 100a.b. (2012) [hereinafter MCM].

The explanatory text clarified the phrase "likely to produce":

> When the natural or probable consequence of particular conduct would be death or grievous bodily harm, it may be inferred that the conduct is 'likely' to produce that result. *See paragraph 54(c)(4)(a)(ii).*

MCM, pt. IV, ¶ 100a.c.(5)(emphasis added).

Paragraph 54(c)(4)(a)(ii) is the explanatory language for aggravated assault under Article 128, UCMJ, stating that, if the natural and probable consequences of the act would be death or grievous bodily harm, the conduct is likely to bring about that result. *MCM*, pt. IV, ¶ 54.c.(4)(a)(ii). This definitional link between aggravated assault and reckless endangerment makes sense. As this court recently explained, aggravated assault also includes "the element that the assault was committed with 'a dangerous weapon or other means or force likely to produce death or grievous bodily harm.'" *Gutierrez*, 74 M.J. at 63 (quoting Article

128(b)(1), UCMJ). *Gutierrez* now stands for the premise that both the events, the vent leading to the harm and the magnitude of that harm must both be likely. *Id*. at 68.

In *Gutierrez*, this court analyzed this element of aggravated assault during a legal sufficiency review. The offense in *Gutierrez* related to the appellant's "failure to disclose that he had human immunodeficiency virus (HIV) prior to engaging in otherwise consensual sexual activity with multiple partners." *Id*. at 63. When framing the key issues in *Gutierrez*, this court noted "the question in this case is not whether HIV, if contracted, is likely to inflict grievous bodily harm . . . . The infliction of such a disease meets any reasonable definition of 'likely' to inflict grievous bodily harm." *Id*. at 65. Instead, "the critical question . . . is whether exposure to the risk of HIV transmission is 'likely' to produce death or grievous bodily harm. Put another way, '[h]ow likely is 'likely?''" *Id*. (quoting *United States v. Johnson*, 30 M.J. 53, 57 (C.M.A. 1990)) (citation omitted).

In answering this question, this court stated, "[t]he ultimate standard . . . remains whether – in plain English – the charged conduct was 'likely' to bring about grievous bodily harm." *Id*. When applying this standard, this court found "testimony that the means used to commit the assault had a 1-in-500 chance of producing death or grievous bodily harm is not legally sufficient to meet the element of 'likely to produce death or grievous bodily harm.'" *Id*. at 63. This court also specifically discussed how the use of a condom during sexual intercourse impacts likelihood of contracting HIV in the first place. *Id*. at 66.

Argument

Contrary to the Army Court's decision, the evidence here remains legally insufficient for reckless endangerment. More specifically, as in *Gutierrez*, the government did not prove appellant's actions were "likely to produce death or grievous bodily harm." While the potential harm from a T11R failure is great, the government demonstrated neither the likelihood of such a malfunction occurring because of appellant's actions, nor the likelihood a jumper would need the reserve parachute in the first place.

As demonstrated by the condom analysis in *Gutierrez*, the totality of the conduct must be considered when coming to a decision on likelihood. The court specifically discussed the use of a condom during sexual intercourse when one partner is HIV positive and how that affects likelihood. *Id*. at 66. In *Gutierrez*, this Court reasoned that a condom's success at preventing exposure in the first place, at a rate between ninety-seven to ninety-eight percent, is a factor to weigh in determining if appellant's conduct was likely to cause death or grievous bodily harm. *Id*. While not discussed specifically, a condition precedent to exposure is condom failure; or, in other words, condom failure is a conditional probability of the later exposure. *See also Eubanks v. Pickens-Bond Constr. Co.*, 635 F.2d 1341, 1355 n.2 (8th Cir. 1980)(citing J. Freund, Modern Elementary Statistics 143–140 (1973); T. Wonnacott & R. Wonnacott, Introductory Statistics 40-41 (1969)). Another court simplified the premise as "if one event occurs, how likely is it that another event will occur?" *United States v. Prandy-Binett*, 995 F.2d 1069, 1070-1071 (D.C. Cir. 1993).

Similarly, a D.C. District court recently discussed issues related to 'probability' in conducting an analysis of damages related to a large oil drilling station. *Oceana v. Bureau of Ocean Energy Mgmt.*, 37 F. Supp. 147 (D.C. Dist. Ct. 2014). The court noted the logical flaw in the determination of damages resulting from a drilling well having a catastrophic failure, as this determination presupposed the failure itself. The court ultimately reasoned the estimated damages were excessive because, while a catastrophic failure would cause immense damage, the possibility of the condition precedent – the failure of the well – was low. *Id*. In this case, while the damage caused by a catastrophic failure of a T11R parachute may be substantial, getting to the point of needing the T11R in the first place is unknown or, at best, very low.

In appellant's case, the government failed to demonstrate the likelihood of each condition precedent within the 365-day pack cycle:

1) the reserve parachute making it through in house checks;

2) the reserve parachute getting onto a prospective jumper in the next 365 days;

3) the reserve parachute making it through jumpmaster inspections without any deficiencies being caught;

4) the jumper making it onto the aircraft;

5) the jumper exiting the aircraft;

6) the main parachute failing to the point a reserve parachute is needed;

7) the jumper activating the reserve parachute; and

8) the reserve parachute failing because it had been pencil packed.

The government had to demonstrate that each was likely. However, the government put on no evidence that *every one* of these events was likely.

First, the government would have to demonstrate that Soldiers in the rigger shack would not catch the deficiencies in the regular course of business. If, at this stage, the deficiencies were discovered and corrected, the likelihood of T11R failure due to pencil packing would be zero. What was actually shown was that each and every deficient parachute was discovered during regular checks and the deficiencies were corrected. (JA 133-139, 270-272). Furthermore, routine inspections and in-storage inspections are regular obligations in a rigger shed. (JA 427) ("[E]mergency-type personnel parachutes packed for use will be inspected every 30 calendar days or at more frequent intervals as prescribed by the local unit commander.")("Airdrop equipment which is in storage will be inspected at least semiannually and at more frequent intervals if prescribed by the local parachute maintenance officer.")

Second, there is no evidence of the likelihood that any of the fourteen suspect parachutes would be placed on a jumper. This would have to occur before the parachute was re-packed 365 days later. The government could have had CW2 Fowler or SFC Doris testify how often the T11Rs were placed on a jumper, if ever, but they did not. (JA 44-45, 134). Basically, during the previous year, these parachutes were never deployed by a jumper hence requiring re-packing. The government did not present any evidence to show the use of these parachutes would be any more (or less) likely during their upcoming pack cycle.

Third, the evidence shows that every parachute must make it through JMPI prior to the jumper boarding the aircraft. (JA 47-48, 136). The government failed to show the likelihood that these pencil-packed parachutes would make it through this inspection. Again, JMPI includes a "very specific sequence of events that has to happen and they have to inspect that parachute from top to bottom to ensure that [it] is a safe parachute to jump externally and make sure that there are no deficiencies." (JA 45). However, the government did show that each of the fourteen pencil packed parachutes did have knots in the closing loops (JA 135) and those knots may be specific checks during JMPI. (JA 135-137). The record does show that a simple visual inspection demonstrated the parachutes were deficient. (JA 137). These deficiencies were in effect, made to be caught.

Fourth and fifth, the government did not demonstrate the likelihood that, once through JMPI, the jumper would get onto the aircraft and, later, exit the aircraft. It is unclear from the record if every scheduled flight takes off and every jumper jumps. Common experience dictates that some planes have mechanical trouble before and during flight and weather conditions change necessitating canceling certain flights. Furthermore, there is no evidence of a jumper failing to exit the aircraft out of fear. The government, again, could have called CW2 Fowler or SFC Doris to explain the rate at which jumpers, who get on an aircraft, also exit the aircraft, but they did not.

Sixth, the main condition precedent to needing a reserve parachute is the main parachute failing. The record includes no discussion of the failure rate of main parachutes and instead indicates that each of the pencil-packed reserve parachutes were not used during their 365-day pack cycle. It would be hard to imagine airborne operations being a realistic military endeavor if failure of main parachutes were likely in the first place. The government did call Gordon Whiteman, an employee of the Natick Research Development and Engineering Center, Aerial Delivery Directorate, who was recognized as an expert in "research and development of static line parachutes, specifically the T-11 Reserve." (JA 161, 165). The government needed only to ask Mr. Whiteman how many main parachutes fail or how often reserve parachutes are deployed, but it did not.

Seventh, even assuming a main parachute fails, the government did not explain how likely it would be for a jumper to pull his reserve parachute. Again, Mr. Whitman could very well have testified as to how many jumpers pull their reserve parachute when needed. He did not.

Finally, the government failed to show that each of these conditions precedent and the final failure of the reserve due to pencil packing was, as a whole, likely. In *Gutierrez*, the government had to show not only that exposure to HIV was likely (factoring in the efficacy of the condom) and, after exposure, contraction was likely, but all of the conditions, taken as a whole, were likely. The government's evidence did not address the "critical question." Instead, the critical question is whether the risks associated with pencil packing were "likely" to produce death or grievous bodily harm. For this "critical question," the defense counsel accurately summarized the government's evidence: "[e]verything they have produced is speculative, well it could happen. . . ." (JA 315).

The weakness of this type of evidence is clearly demonstrated when analogized to other events. For example, multiple people would testify they have experienced events associated with great success (winning the lottery, landing a royal flush in poker, making a hole-in-one in golf), or with great harm (being attacked by an animal, being struck by lightning, or even the issue in *Gutierrez* (contracting HIV through sexual intercourse)). Just because these events *have* occurred does not prove they are, in any given scenario, *likely* to occur.

Overall, the likelihood of death from airborne operations is extremely low. In a study of United States Army static-line jumps, scientists found that parachute malfunctions were extremely uncommon. Joseph J. Knapik et al., Preliminary Comparison of the T-11 Advanced Tactical Parachute System with the T-10D Parachute, Fort Bragg, North Carolina, June 2010-November 2011, United States Public Health Command Report 12-HF-27G0ED-11, December 2011 (Appendix A). This report covered 63,487 total jumps and found one fatality from a parachute malfunction. *Id*. at ES-2, 16. In the one fatality, the main parachute had a total malfunction and the jumper did not activate his reserve parachute. *Id*. at 1. A crude injury rate (not grievous bodily harm but any injury) inherent in jumping out of military aircraft is about 10.7 per 1000 jumps or 1.05%. *Id*. at ES-2. However, it seems from the Knapik study, *supra*, the chance of a catastrophic failure of a main parachute is astronomically small.

Similar statistics are presented annually for skydiving. *See* Basics-The 2014 Fatality Summary, Parachutist Online, http://parachutistonline.com/feature/basics (April 2015)(Appendix B). In 3,600,000 civilian parachute jumps in 2014, there were twenty-four fatalities. (0.000066%). The average number of jumps before a fatality is 1,920 with a mean of 901. *Id*.

From anecdotal evidence found in the Knapik and Parachutists Online study, malfunctions and fatalities are extremely rare. Therefore, no matter what SGT Herrmann did to the T11R parachutes, the likelihood that death or grievous bodily harm would be the result is minuscule.

Conclusion

Appellant requests this court dismiss the reckless endangerment specification and return the record to the Army Court for a determination on sentencing. The maximum punishment will decrease from eighteen months confinement and a bad-conduct discharge to six months confinement and a bad-conduct discharge. Sergeant Herrmann was sentenced to ten months confinement and a bad-conduct discharge.

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CERTIFICATE OF FILING AND SERVICE

I certify that a copy of the forgoing in the case of United States v. Herrmann, Crim. App. Dkt. No. 20131064, USCA Dkt. No. 16-0599/AR, was electronically filed with the Court and Government Appellate Division on November 21, 2016.

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Appendix A

Military Parachuting Injuries, Associated Events, and Injury Risk Factors

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Knapik JJ, Steelman R, Grier T, Graham B, Hoedebecke K, Rankin S, Klug K, Proctor S, Jones BH. *Military parachuting injuries, associated events, and injury risk factors.* **Aviat Space Environ Med 2011; 82:797–804.**

Introduction: The purpose of this investigation was to examine injury incidence, events associated with injury, and injury risk factors during parachuting in an Army airborne infantry unit. ***Methods:*** Injury data were obtained by the investigators on the drop zone and confirmed by a physician. Operational data (potential injury risk factors) were obtained from routine reports published by the infantry unit. Weather data were obtained using a Kestrel® Model 4500 pocket weather tracker. ***Results:*** There were a total of 23,031 jumps resulting in 242 injured soldiers for a crude injury incidence of 10.5 per 1000 jumps. Parachute entanglement incidence was 0.5 per 1000 jumps. Where an event associated with the injury could be determined (67% of cases), these included ground impact (75%), static line problems (11%), tree landings (4%), entanglements (4%), and aircraft exits (3%). Univariate analysis showed that higher injury risk was associated with night jumps (versus day jumps), combat loads (versus unloaded jumps), higher wind speeds, higher dry bulb temperatures, higher humidity, C17 Globemaster or C130 Hercules aircrafts (compared to the other aircraft), exits through aircraft side doors (versus tailgates), and entanglements. Multivariate analysis indicated that independent risk factors for injuries included night jumps, combat loads, higher wind speeds, higher dry bulb temperatures, and entanglements. ***Discussion:*** This investigation provided injury incidence, events associated with injury, and quantitative assessments of injury risk factors and their interactions during military parachuting. An appreciation of these subjects can assist medical and operational planners in further reducing the incidence of injury during airborne operations.

Keywords: wind speed, night, combat loads, temperature, aircraft, drop zone, entanglements.

SINCE MILITARY airborne training operations were initiated in the U.S. Army shortly before World War II, physicians and scientists have worked with the operational community to enhance safety and increase the likelihood that airborne soldiers arrive on the ground ready for their operational missions. These efforts, coupled with continuous improvements in parachute technology, aircraft exit procedures, and ground-landing techniques, have substantially reduced the number of injuries over time. Early estimates of military parachuting injury rates in the World War II era were 21 to 27 per 1000 descents (10,35). A summary of studies conducted after this time (up to 1998) indicated that airborne injuries averaged about 6 per 1000 jumps (4). Nonetheless, different injury definitions, dissimilar methods of data collection, and diverse operational conditions can result in widely different injury rates (7,22,34).

Earlier studies on military airborne training identified a number of factors that elevated injury risk. These included high wind speeds, night jumps, heavy loads, and rough landing zones (10,13). Later studies identified such extrinsic risk factors as smaller diameter canopies (30), fixed-wing aircraft (verses rotary-wing) (24), extra equipment (22,24,30), more jumpers in the air (24), and higher temperatures (30); intrinsic risk factors included female gender, greater body weight, older age (1,5,29), less upper body muscular endurance, lower aerobic fitness, and prior injuries (22). Most studies only analyzed risk factors in isolation (e.g., in a univariate manner) and few (21,22,24) performed multivariate analysis that would allow identification of independent risk factors and determine how risk factors might interact. The purpose of this paper is to examine injury rates, events associated with injury, and injury risk factors during parachute training in an operational airborne unit in the U.S. Army. We consider risk factors that previous studies have explored, but also expand the knowledge base by examining some new factors; in addition, we analyze these risk factors in a multivariate manner.

METHODS

The 82nd Airborne Division of the XVIII Airborne Corps is an airborne infantry unit garrisoned at Fort Bragg, NC. Its mission is to, within 18 h of notification, strategically deploy, conduct parachute assaults, and secure key objectives for follow-on military operations in support of U.S. national interests. The division regularly conducts jump operations to keep soldiers trained for airborne missions. From 17 June to 3 December 2010, injury and operational data were systematically collected by the investigators on all jump operations performed by the 82nd Airborne Division. The project plan was approved as a public health field investigation (15) by the

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Human Subjects Protection Administrator at the U.S. Army Public Health Command.

Procedures

For all airborne training jumps, soldiers donned T-10D parachutes. Prior to soldiers loading onto fixed wing or rotary aircraft, a jump manifest was created. The jump manifest contained information on the soldiers' rank, jump order (order in which the soldiers exited the aircraft), door side (right, left, tailgate), aircraft type, and the type of jump. Type of jump could be administrative/non-tactical or combat loaded. For an administrative/non-tactical jump operation, soldiers were dressed in Army combat uniforms, advanced combat helmets, and T-10D parachutes with attached reserve parachutes. For combat-loaded jumps, the soldiers additionally wore weapons containers (for rifles) and rucksacks. The rucksacks and weapons containers were attached to the jumpers' harnesses by quick release straps and a lowering line. The lowering line served to drop the rucksack and container about 15 feet below the soldier's body while remaining attached to the soldier. The quick release strap was activated before ground contact.

After the soldiers were completely seated in the aircraft, the aircraft departed for the drop zone (the area over which the soldiers jumped and landed). Once the aircraft reached its specified release point, the jumpers exited the aircraft in quick succession. As each jumper exited, the static line took about 3 to 4 s to pull open the main parachute and provide the canopy that slowed the jumper's descent. On contact with the ground, the jumpers executed a parachute landing fall (PLF) to break the impact of the landing (4,14). After landing and while lying on the ground, the jumper collapsed the parachute canopy using a quick release device on the parachute harness. The jumper then stood up, bundled the parachute, and prepared for the follow-on operation.

Depending on the number of soldiers involved in the airborne operation, there were from one to six ambulances located on the drop zone near the point where the first jumper was scheduled to land. Each ambulance had two to four Army-trained medics and, for larger operations, a physician's assistant (PA) was present. Once all soldiers who had jumped were on the ground, the ambulances drove across the drop zone and provided medical care to injured jumpers. They returned injured jumpers to a central collection point.

For each jump operation, one or more investigators were present on the drop zone. Once an injured soldier was brought to the collection point, the investigators recorded the soldier's initial injury diagnosis, anatomical location of the injury, and how the injury occurred. The initial diagnosis was provided by the medic or PA. If the injury was minor, the soldier could be released on the drop zone by the medic or PA, but usually soldiers were taken to a hospital or clinic for follow-up care. Once in the hospital, the medical care provider who saw the soldier generated a record in the Armed Forces Health Longitudinal Technology Application (AHLTA) that included a more detailed diagnosis and anatomical location. A physician examined the AHLTA record and provided a final diagnosis and anatomical location for the injury. If the soldier was released on the drop zone, the final diagnosis and anatomical location were those obtained on the drop zone. If the soldier was evacuated to the hospital, the final diagnosis and anatomical location were those determined by the physician from the AHLTA record. An injury was defined as any physical damage to the body, seen by the medic or PA on the drop zone, from the time the soldier was seated in the aircraft until the time the soldier completed the parachute landing and removed the parachute harness on the ground.

After the jump operation was completed, a standard report was issued that contained information on the actual time of the jump, unit, drop zone, entanglements, and some data on injured jumpers. From the time of day and visual operations of the drop zone, investigators could determine if the jump had occurred in daylight (day) or after dark (night). Information on entanglements was obtained from a narrative section on the report. Entanglements involved physical contact between two or more jumpers that interfered with a normal parachute descent. From the narrative description on the report, it was possible to determine if the jumpers were able to disentangle before ground contact or if they remained entangled to the ground. Injury data on the report were used to enhance injury information obtained on the drop zone and to further ensure that all injuries were captured.

Weather data were obtained by the on-site investigators using a calibrated Kestrel® Model 4500 (Kestrel Meters, Sylvan Lake, MI) pocket weather tracker. As each aircraft came over the drop zone, investigators recorded the ground dry bulb temperature, humidity, and wind speed. The lowest and highest wind speeds were obtained from 3 min prior to the aircraft passing over the drop zone until all jumpers had landed.

Statistical Analysis

A de-identified database was created that had one jump on each line along with operational data, weather, and any injury information. Cumulative injury incidence was calculated as soldiers with 1 or more injuries (numerator) divided by the total number of jumps (denominator) and multiplied by 1000 (injuries per 1000 jumps). The Chi-square test of proportions was used to assess the univariate association between the operation/weather data (covariates or injury risk factors) and all injuries. Risk ratios (RR) and 95% confidence intervals (95%CI) were calculated. Covariates (risk factors) that were significantly ($P < 0.10$) associated with injury incidence in the univariate analysis were included in a backward stepwise multivariate logistic regression (16).

RESULTS

A total of 23,031 jumps were made in the survey period and these resulted in 242 injured soldiers for a crude injury incidence of 10.5 per 1000 jumps. **Table I** shows the types of injuries and the anatomical locations. The most common injury/anatomical location combinations were

TABLE I. INJURIES BY TYPE AND ANATOMICAL LOCATION.

Injury Type	N	Proportion (%)
Closed Head Injury/Concussion	74	30.6
Fracture	36	14.9
Sprain	34	14.0
Contusion	31	12.8
Strain	28	11.6
Abrasion/Laceration	17	7.0
Pain (not otherwise specified)	14	5.8
Muscle/Tendon Rupture	4	1.7
Dislocation	4	1.7
Anatomical Location		
Head	81	33.5
Ankle	43	17.8
Lower Back	27	11.2
Upper Arm	18	7.4
Knee	14	5.8
Shoulder	12	5.0
Hip	8	3.3
Thigh	7	2.9
Foot	6	2.5
Pelvis	6	2.5
Neck	5	2.1
Chest	4	1.7
Lower Arm	2	0.8
Ear	2	0.8
Elbow	2	0.8
Hand	1	0.4
Toe	1	0.4
Wrist	1	0.4
Finger	1	0.4
Face	1	0.4

closed head injuries/concussions ($N = 74$), ankle fractures ($N = 21$), ankle sprains ($N = 20$), low back sprains ($N = 14$), hip contusions ($N = 8$), upper arm abrasions/lacerations ($N = 6$), and lower back fractures ($N = 4$).

There were 12 entanglements in the 23,031 jumps, resulting in an entanglement incidence of 0.52 per 1000 jumps. Eight were entanglements to the ground and four were freed before ground contact. There were eight injuries associated with these entanglements. Seven of the eight occurred among soldiers who were entangled to the ground and one occurred in a soldier who was freed before ground impact. Injuries among soldiers entangled to the ground included a low back fracture (L4), a pelvic fracture, a closed head injury, a knee sprain, a neck strain, a strain in the pelvic area, and a hip contusion. The injury in the entanglement that was freed before ground contact was a fracture of the hand.

Table II shows the events associated with the injuries experienced by the soldiers. In two-thirds of the injury cases ($N = 160$), it was possible to determine the event associated with the injury, but in one-third of the cases it was not. Early in the investigation, these data were not systematically collected, accounting for most of the missing events. When events could not be determined later in the investigation, it was because the soldier was not sure how the injury had happened, or due to an inability to adequately interview the soldier because they were evacuated too quickly. Most injuries were associated with ground impact and inability to execute a proper PLF. These included landing on uneven ground, on harder surfaces, because of drop zone obstructions (logs, rocks), or because of improper PLF procedures.

Table III shows the univariate associations between injury risk and the covariates. Higher injury risk was associated with night jumps, combat loads, higher wind speeds, higher dry bulb temperatures, higher humidity, C17 Globemaster or C130 Hercules aircraft (compared to the other aircraft), exits through doors (compared to tailgates), the Geronimo drop zone, and entanglements. **Table IV** shows the results of the backward stepwise multivariate logistic regression analysis. There were 20,481 jumps (89%) that had complete data and could be included in the analysis (logistic regression required complete data on all variables). Independent risk factors for injuries included night jumps, combat loads, higher wind speeds, higher dry bulb temperatures, and entanglements.

DISCUSSION

The present investigation found that the overall crude injury risk was 10.5 per 1000 jumps. The major events associated with injury were ground impacts, static line problems, tree landings, and entanglements. Support was provided for classic military airborne injury risk factors, including higher wind speeds (10,21,30), night jumps (13,21,24), and combat loads (21,24,30). The present investigation expanded the knowledge base of jump-related injury risk factors by examining factors that have received little or no attention, including temperature, humidity, aircraft type, aircraft exit door, jump order, military rank, drop zone, and entanglements.

The overall crude injury risk was similar to the incidence of 10.9 per 1000 jumps reported in a study of a

TABLE II. EVENTS ASSOCIATED WITH INJURIES.

	N	Proportion of All Categories (%)	Proportion (%) of Known Activities (unknown removed)
Ground Impact (PLF Problems)	120	49.6	75.0
Static Line	17	7.0	10.6
Tree Landing	6	2.5	3.8
Entanglement	6	2.5	3.8
Aircraft Exits	4	1.7	2.5
Landed on Equipment	2	0.8	1.3
Dragged by Parachute on Ground	2	0.8	1.3
Parachute Risers	2	0.8	1.3
Lowering Line	1	0.4	0.6
Unknown	82	33.9	—

TABLE III. UNIVARIATE ASSOCIATION BETWEEN INJURY RISK FACTORS AND AIRBORNE INJURY INCIDENCE.

Variable	Level of Variable	Jumps (*N*)	Injury Incidence (Cases per 1000 Jumps)	Risk Ratio (95%CI)	Chi-Square *P*-Value
Time of Day	Day	14,895	6.7	1.00	< 0.01
	Night	8020	17.5	2.60 (2.02-3.36)	
Jump Type	Administrative/non-tactical	14,791	5.9	1.00	< 0.01
	Combat load	8240	18.8	3.19 (2.46-4.15)	
Lowest Wind Speed	0-1 kn	10,784	7.8	1.00	0.01
	2-5 kn	8847	8.3	1.06 (0.76-1.45)	
	6-8 kn	1746	14.9	1.91 (1.24-2.96)	
Highest Wind Speed	0-1 kn	2512	10.0	1.00	< 0.01
	2-4 kn	4885	6.8	0.86 (0.40-1.14)	
	5-7 kn	8361	6.6	0.66 (0.41-1.06)	
	8-10 kn	5161	11.8	1.24 (0.77-1.98)	
	11-12 kn	458	22.4	2.19 (1.06-4.54)	
Dry Bulb Temperature	37-50°F	1917	1.6	1.00	< 0.01
	51-70°F	4184	8.4	5.35 (1.65-17.36)	
	71-90°F	9954	9.5	6.10 (1.93-19.23)	
	91-104°F	4542	9.7	6.19 (1.93-19.91)	
Humidity	20–40%	6447	7.4	1.00	0.09
	41–60%	5330	9.2	1.24 (0.83-1.84)	
	61–80%	6747	7.9	1.06 (0.72-1.57)	
	81–92%	2073	13.0	1.74 (1.10-2.80)	
Aircraft	C130 Hercules (fixed wing)	17,248	11.5	1.00	< 0.01
	C17 Globemaster (fixed wing)	2255	16.0	1.39 (0.98-1.98)	
	C23 Sherpa (fixed wing)	1011	1.0	0.09 (0.01-0.61)	
	C160 Transall (fixed wing)	784	7.7	0.67 (0.30-1.50)	
	CH47 Chinook (rotary wing)	1271	0.8	0.07 (0.01-0.49)	
	UH60 Blackhawk (rotary wing)	462	0.0	—	
Aircraft Exit Door	Left	9160	12.1	13.83 (3.42-55.93)	< 0.01
	Right	9181	10.5	11.93 (2.94-48.35)	
	Tailgate	2282	0.9	1.00	
Jump Order	1-5	4266	9.1	1.00	0.31
	6-10	3837	10.4	1.14 (0.74–1.77)	
	11-15	3825	10.2	1.12 (0.72–1.74)	
	16-20	3515	9.7	1.06 (0.67–1.67)	
	21-25	3147	12.4	1.36 (0.87–2.11)	
	26-30	2637	14.4	1.58 (1.01–2.46)	
	31-35	873	8.0	0.88 (0.39–1.95)	
	36-40	433	6.9	0.76 (0.23–2.44)	
	41-45	313	0.0	—	
	46-51	154	13.0	1.42 (0.35–5.82)	
Military Rank	Junior Enlisted (E1-E4)	11,853	10.1	1.00	0.79
	Senior Enlisted (E5-E9)	8030	11.1	1.10 (0.83–1.44)	
	Warrant Officer	198	10.1	1.00 (0.25–4.00)	
	Junior Officer (O1-O3)	2152	8.8	0.87 (0.54–1.41)	
	Field Grade Officer (O4-O8)	567	14.1	1.39 (0.68–2.84)	
Drop Zone	Sicily	11,898	8.7	1.00	< 0.01
	Luzon	4761	7.8	0.89 (0.61–1.29)	
	Geronimo	1654	35.7	4.08 (2.98–5.59)	
	Normandy	1598	9.4	1.07 (0.63–1.84)	
	Nijmegen	1255	8.0	0.91 (0.48–1.74)	
	Holland	974	10.3	1.18 (0.62–2.24)	
	Rock Air Force Base	700	8.6	0.98 (0.43–2.26)	
	Clute	115	0.0	—	
	Salerno	76	13.2	1.51 (0.21–10.65)	
Entanglement	No	23,019	10.2	1.00	< 0.01
	Yes	12	666.7	65.58 (43.10–99.80)	

British operational unit where the investigator defined and collected injuries in a manner almost identical to the present investigation (24). Another British study that collected data in a similar manner during World War II had a much higher injury incidence of 21.0 per 1000 jumps (10), but these data were obtained at a time when airborne techniques and equipment were in an early stage of development. In studies where more restrictive injury definitions were used (e.g., time loss injuries, hospital visits), incidences of 0.6 to 51 per 1000 jumps have been reported. When all injuries and jumps were combined in the studies with restrictive injury definitions (6408 injuries in 1,192,446 jumps) the incidence was 5.4 per 1000 jumps (5,6,11,12,14,23,28,32,33). Injury incidences in basic airborne training (post-1950) have ranged from 4 to 10 per 1000 jumps. When all jumps and injuries were combined in these basic training studies (2000 injuries in 300,589 jumps) the incidence was 6.7 per 1000 jumps (2,3,13,21,27,29,30). The variations in injury incidences may be attributed not only to differences in injury definitions and training experience, but also to the risk factors that likely differ in the different investigations.

TABLE IV. MULTIVARIATE ASSOCIATION BETWEEN INJURY RISK AND RISK FACTORS.

Variable	Level of Variable	Jumps (*N*)	Odds Ratio (95%CI)	Chi-Square *P*-Value
Time of Day	Day	14,115	1.00	Referent
	Night	6366	2.01 (1.06–3.83)	0.03
Jump Type	Admin/non-tactical	13,897	1.00	Referent
	Combat load	6584	2.38 (1.43–3.97)	< 0.01
Highest Wind Speed	0-1 kn	2512	1.00	Referent
	2-4 kn	4185	1.01 (0.57–1.80)	0.98
	5-7 kn	8281	1.66 (0.97–2.81)	0.06
	8-10 kn	5045	3.09 (1.73–5.52)	< 0.01
	11-12 kn	458	4.02 (1.40–11.54)	< 0.01
Dry Bulb Temperature	37-50°F	1917	1.00	Referent
	51-70°F	4184	3.45 (1.03–11.58)	0.05
	71-90°F	9954	3.03 (0.94–9.77)	0.06
	91-104°F	4426	5.50 (1.68–18.43)	< 0.01
Entanglement	No	20,469	1.00	Referent
	Yes	12	245.32 (68.22–882.21)	< 0.01

Three previous reports have involved soldiers and drop zones at Fort Bragg, NC (5–7). One study (7) reported an injury incidence of 24.6 per 1000 jumps for a single jump operation with troops jumping at night with combat loads. If only night jumps with combat loads were considered in the present study, the overall injury incidence was 18.7 per 1000 jumps, somewhat lower. Two other studies (5,6) surveyed parachute injuries at Fort Bragg from May 1993 to December 1994 and from May 1994 to April 1996. The crude injury incidences were 8.0 and 8.1 per 1000 jumps in the two periods, respectively. When only jumps onto Fort Bragg drop zones were considered in the present investigation, the injury incidence was 8.6 per 1000 jumps. However, the two previous studies at Fort Bragg (5,6) only obtained injuries that were seen in the emergency room at the Fort Bragg Womack Army Community Hospital. If only injuries evacuated to hospitals and clinics in the present investigation were considered ($N = 182$), the injury incidence was 7.9 per 1000 jumps, very similar to the two earlier studies (5,6).

Of note, there were a large proportion of closed head injuries/concussions, making up almost one-third of all injuries. In previous studies, closed head injuries made up 4–19% of all injuries (6,19,21,23). Jumpers wear advanced combat helmets during all jump operations, but these helmets were designed primarily for ballistic protection (fragmentation and bullets) and not specifically for protecting the head during ground impacts. It is possible that helmet design modifications could be implemented to improve head protection.

Only three studies have actually reported events associated with military parachuting injuries (5,11,28), although there is no shortage of speculation and anecdotal observations on how injuries might occur (8–10,18). When events were reported in these previous studies, the categories for the events differed from those in the present investigation. Nonetheless, these previous studies provide at least some basis for comparison. Neel (28) reported on 140 parachute injury cases within the 82nd Airborne Division at Fort Bragg in 1946. At least 61% of injuries were associated with ground impacts and 6% were associated with aircraft exits. Farrow (11) provided details on all 63 injuries experienced by the Australian Parachute Battalion Group from March 1987 to December 1988. The battalion jumped from C130 Hercules and C7 Caribou (tailgate exit) aircraft using T10 parachutes. Ground impacts, exit procedures, and tree landings accounted for 59%, 10%, and 6%, respectively, of activities associated with injury. This compares with 75%, 3%, and 4%, respectively, in the present investigation.

Craig and Lee (5) reported on altitude injuries at Fort Bragg from May 1994 to April 1996 (24 mo). Altitude injuries were defined as those occurring from aircraft exit to just before ground impact. They reported that 6% of all parachute injuries were of this type and that the incidence was 0.46 per 1000 jumps. In the present investigation, if injuries associated with static lines, exit procedures, and parachute riser injuries were combined, they would account for 14% of all injuries with a known event. However, Craig and Lee (5) only reported on injuries that were seen in the emergency room at the Fort Bragg Womack Army Medical Center. If only altitude injuries that were evacuated to the hospital were considered in the present investigation, these would be 5% of all injuries, for an incidence of 0.35 per 1000 jumps. Interestingly, the incidence of static line injury in Craig and Lee's study (5) was 0.15 per 1000 (37 in 242,949 jumps) while the incidence of static line injuries evacuated to the hospital in the present investigation was twice as high, 0.30 per 1000 jumps (7 in 22,981jumps).

By far, the event associated with the largest number of injuries in the present investigation was ground impact. PLFs were introduced into the U.S. Army in 1943. Weekly injury reports issued at the Fort Benning, GA, Parachute School in 1943 suggested that injuries were trending downward before the PLF became U.S. Army doctrine, but injuries were definitely reduced just after introduction of the PLF technique (25,26,31). PLFs as executed today require that, prior to ground contact, the soldier keep feet and knees together, with hips and knees slightly flexed. The soldier makes ground contact with the balls of the feet, then rapidly distributes the kinetic energy of the impact through the body by falling sideways and allowing the feet, calves, thighs, buttocks, and back to progressively make contact with the ground (4,14). This sequence of events can be made difficult or impossible if the ground is uneven or has obstructions; soldiers may not be able to keep their legs and knees together or to make the required rapid series of ground contacts across the body. Wind conditions can exacerbate problems by causing parachute oscillations that result in greater impact energy. Winds from the front of the soldiers can force them into a rear PLF, which is very difficult to properly execute.

Static line problems accounted for the second largest number of injuries in the present investigation. The 82nd Airborne Division requires that all static line problems be listed on a standard report. Static line injuries occur when the static line is not properly handed to safety personnel, if safety personnel do not properly clear the static line, or if the parachutist's arm is wrapped around the line on aircraft exit. Proper training in static line management and attention to detail when handing off the static line can reduce injuries of this type.

The entanglement incidence of 0.52 per 1000 jumps in the present study was lower than the incidence of 0.87 per 1000 jumps reported at the Airborne School training at Fort Benning, GA (21). The lower incidence may reflect the higher level of experience among the 82nd Airborne Division soldiers. The primary cause of high altitude entanglements is assumed to be weak and simultaneous exits from opposite sides of the aircraft such that the aircraft slip stream forces jumpers toward each other as their parachutes deploy. A previous study showed that a 1-s delay between jumpers exiting opposite sides of the aircraft reduced injury risk (12). In practice, jumpers have a difficult time maintaining the separation. If a soldier rushes the exit door or hesitates slightly, this can disrupt the timing and still result in simultaneous exits from both sides of the aircraft.

When an entanglement occurred there was a high probability of an injury. Of the 12 entangled jumpers, 8 were injured and all but 1 of the entanglement-related injuries occurred among jumpers who remained entangled to the ground. It should be remembered that the number of entanglements was small. Nonetheless, the large proportion of injuries among jumpers entangled to the ground supports the training practice of instructing soldiers to disentangle as soon as possible.

A number of previous studies have shown that higher wind speeds were associated with higher injury incidence (10,21,24,30) and higher wind speed was an independent risk factor in the present investigation. Winds increase the horizontal velocity vector of the jumper and increase ground impact velocity when added to the vertical velocity vector. Higher winds can also increase parachute oscillations, adding additional velocity and resulting in a less controlled landing. Winds can push a parachutist away from preplanned drop zones into obstacles, rougher terrain, or trees. Tree landings are especially hazardous since a collision with a tree can be followed by an uncontrolled ground impact if the parachutist falls from the tree. High winds can also drag soldiers on the ground after they land and before they have time to collapse their parachute canopies.

Previous studies have shown that combat loads increase injury risk (21,24,30) and this was an independent injury risk factor in the present investigation. Extra equipment increases descent velocity, resulting in greater impact energy. Since the extra equipment is lowered on a strap before ground impact and arrives on the ground before the jumper, the equipment may also create a landing zone hazard. It has been hypothesized that combat loads may increase the risk of entanglements (20). In the present investigation, there was some difference in entanglement incidence between administrative/non-tactical jumps and combat load jumps, but the small number of entanglements did not produce a definitive difference (0.41 per 1000 jumps and 0.73 per 1000 jumps, respectively, RR = 1.78, 95%CI = 0.58-5.56, $P = 0.30$).

Another classic injury risk factor is night jumps and this was an independent injury risk factor in the present study (13,21,24,30). During night jumps, there is less ability to see the ground, to perceive distance and depth, and to appreciate the direction of horizontal drift. These and other factors possibly contribute to less controlled landings, reduced ability to see obstacles on the drop zone, and higher injury rates.

Higher temperature was an independent risk factor for injury, but humidity alone had only a modest influence on injury incidence. These data are generally in consonance with those of a single previous investigation that examined the influence of temperature and humidity on injury rates during Belge Airborne training (30). Assuming a standard pressure of 1013.25 mbar and dry air (gas constant = 297 $J \cdot kg^{-1}*K$), the density of air would decrease about 11% as the temperature increased from 40 to 95°F (from 1.272 to 1.146 $kg \cdot m^{-3}$). The less dense air may result in faster descent velocities and this could influence injury rates.

The present study found that the C17 and C130 aircraft had higher injury incidences than the other aircraft examined. Jumps from C23, C160, CH47, and UH60 were all daytime administrative/non-tactical jumps, at least partly accounting for the lower injury rate in these aircraft. Jumps from the C17 and C130 aircraft were all conducted at 800 ft (244 m) above ground level, while jumps from the C23, CH47, and UH60 were conducted at 1250, 1500, and 1500 ft (381, 457, and 457 m), respectively. Higher jump altitudes may have allowed jumpers to achieve better canopy control and provide more time to prepare for landing. Further, CH47 and C23 jumps were conducted off the tailgate of the aircraft and not off of side doors like the C130 and C17. In tailgate exits, jumpers hooked their static lines to starboard-side anchor cables using a reverse or upside-down bite on the static-line with their left hand. This could have reduced potential static line injuries because it was less likely that a jumper's hand or arm could be routed around the static-line. The distance between where the jumper released grip on the static line and the point where his feet left the aircraft increased significantly with tailgate exits. In rotary-wing aircraft (CH47, UH60) jumpers have more space during exits and during descents, less probability of entanglements, and can better concentrate on landing procedures. Thus, some combination of higher jump altitudes, less probability of static line problems, and better jumper spacing during descents may explain the lower injury rates in the C23, CH47, and UH60 aircrafts.

One previous study (24) compared jump injury rates between fixed-wing and rotary-wing aircraft and found that fixed-wing aircraft had higher injury risk. As noted above, all jumps from rotary-wing aircraft in the present investigation were administrative/non-tactical daytime jumps. If only administrative/non-tactical daytime jumps were considered, injury rates in the present investigation were 6.5 per 1000 jumps with the fixed-wing aircraft and 0.6 per 1000 jumps for the rotary-wing aircraft [RR (fixed/rotary) = 11.3, 95%CI = 1.57–81.03], in consonance with Lillywhite (24).

In the univariate analysis, there was a higher injury incidence for the C17s compared to the C130s. This was largely due to the greater number of nighttime combat-loaded jumps conducted with the C17 aircraft. The proportion of jumps involving nighttime combat-loaded missions was 60% for the C17s and 34% for the C130. If only administrative/non-tactical daytime jumps were considered, injury incidences for the C-17s and C-130s were 6.2 per 1000 jumps and 7.0 per 1000 jumps, respectively [RR(C130/C17) = 1.11, 95%CI = 0.35-3.52, $P = 0.86$]. As noted above, all jumps from the C160 were daytime administrative/non-tactical jumps and the injury incidence was similar to the C17s and C-130s under these conditions (7.7 per 1000 jumps).

Previous literature had indicated that airborne drops onto sand were less hazardous than jumps onto rougher terrain (13), or onto dirt landing strips with uneven and unimproved areas around the landing area (23). Of jumps reported in the present investigation, 89% occurred at drop zones on Fort Bragg, NC. There were jumps at Sicily, Luzon, Normandy, Nijmegen, Holland, and Salerno drop zones. There was little difference in injury incidence among these areas. There were 11% of jumps that occurred at drop zones not located at Fort Bragg and these included jumps at Clute, Little Rock, and Geronimo. Jumps at Geronimo drop zone were part of an airborne insertion into the Joint Readiness Training Center (JRTC) at Fort Polk, LA. The single operation at Geronimo involved a night jump with combat loads from C130 and C17 aircraft. This was the first time an airborne brigade combat team had conducted an operation of this size into the JRTC and the unfamiliarity with the drop zone paired with the large number of jumpers involved may have contributed to the high casualty rate.

There are some limitations to this investigation. First, this investigation was ecological/observational in design and not a randomized intervention trial, the type that provides the strongest test of an intervention (17). Second, this investigation recorded only injuries that occurred on the drop zone and that were noted by medics there. There may have been incentive to delay treatment of minor injuries so service members could complete training missions with their units. However, the method of data collection used here was likely to obtain the more serious injuries, those most in need of acute medical care. Finally, some injuries (25%) were diagnosed only by medics on the drop zone and these diagnoses were likely not as accurate as those evacuated to the hospital for higher level diagnoses and care. An appreciation of injury incidence, events associated with injury, and factors increasing injury risk can assist medical and operational planners in further reducing the incidence of injury during airborne training operations.

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Appendix B

Basics - The 2014 Fatality Summary

Tag: Feature, April 2015

Don't run into anyone in freefall or under canopy, quickly release an uncontrollable spinning main parachute, wear a functioning automatic activation device and reserve static line, and make your final turn under canopy with plenty of altitude to complete it. If 20 of the 24 people who died skydiving in the U.S. in 2014 had done so, they would still be alive today. Compared to past years, 2014 could have been worse, but it's still a pity for our sport and our friends that so many of the deaths were so easily preventable.

Skydiving will always have a degree of risk. The purpose of the annual fatality summary is to remind us of the dangers that resulted in fatal accidents. Awareness should equal avoidance. The price our fellow skydivers paid is too high for us to ignore these lessons.

The incident reports in Parachutist, articles in other publications and online discussions allow a case-by-case analysis of what went wrong. We can learn from these personal disasters, and the details of each incident tell us a lot. On the other hand, the big picture we see by grouping a year of skydiving deaths into categories can often make danger areas even more obvious.

NO PULL/LOW PULL (3—13%)

The three people who died in this category in 2014 were experienced skydivers with an average age of 61. Each had decades in the sport and an average of 3,300 jumps. Two of the jumpers did not wear AADs, and investigators could not determine whether the third jumper had the installed AAD tuned on.

- Two jumpers did not open their main or reserve parachutes. Investigators determined that both incidents were suicides.
- Another skydiver had recently returned to skydiving after a long layoff. His recently purchased harness-and-container system was very small for his size and may have made locating the handles difficult. He never deployed his main canopy, and he did not have an AAD. He deployed his reserve just before impact, and it did not have enough time to inflate.

Safety Tips

When someone doesn't start an opening at all or starts it too low to survive, investigators can often only speculate as to the cause. Sometimes, the circumstances point to suicide. Prior to the widespread use of dependable AADs, the cause of many no- and low-pull incidents remained a mystery. However, many of these jumpers now survive after landing under AAD-deployed reserves and have shared stories of temporal and spatial disorientation (loss of time and altitude awareness), major distractions at main-deployment time and medical or physical problems that explained their failures to deploy their parachutes at the normal altitude. However, the bottom line is that in some instances we'll never know why a jumper didn't open a main or reserve canopy in a timely manner.

- For altitude-awareness or deployment problems, backup systems such as audible altimeters and AADs can be invaluable insurance policies.
- Altitude awareness is a critical survival skill. Jumpers should frequently reference their altimeters (their own or a teammate's) and practice awareness of how the ground looks at different altitudes. This is an ability that jumpers can easily fine-tune by practicing on the way to altitude.

CATEGORY DEFINITIONS

No Pull/Low Pull: Jumper did not initiate opening of the main or reserve parachute in time.

Malfunction: Jumper did not respond successfully to a main-parachute malfunction in time.

Reserve Problem: Within its normal operating envelope, the reserve system didn't save the skydiver.

Collision: The skydiver hit someone or something (including aircraft) in freefall or under canopy prior to landing.

Landing: The skydiver died while attempting to land a fully inflated main or reserve parachute.

Other: Deaths that don't fit into any of the other five categories.

CONTEXT

USPA membership at the end of 2014: **36,770**

Estimated U.S. skydives in 2014: **3,200,000**

Estimated tandem jumps during the year: **500,000**

Average annual skydiving deaths since 1963: **32**

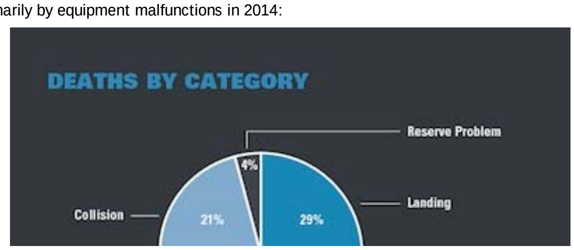
Average annual skydiving deaths in the last 10 years: **22.5**

Skydiving deaths in 2014: **24**

MALFUNCTION (8—33%)

Some jumpers experience their first malfunctions early in their skydiving careers and some after hundreds or even thousands of jumps, but all jumpers should have the mindset that a malfunction will happen on the very next jump so they'll be ready for it if it does. Here are some situations caused primarily by equipment malfunctions in 2014:

- While performing a diving exit from a small aircraft at 7,500 feet, a tandem instructor and his student experienced a horseshoe malfunction when a seatbelt snagged and stretched the drogue-release cable's housing, which opened the main container but left the drogue in its pouch. Either the instructor or the main bag's tension on the bridle pulled



MOST VIEWED RECENT COMMENTS

hearing protection
3 days 22 hours ago

Wrist mount
1 week 2 days ago

skydiving
1 week 5 days ago

Mary, Bringing in the
2 weeks 3 days ago

Flag Etiquette
3 weeks 18 hours ago

TK HAYES
5 weeks 5 days ago

Land needed?
5 weeks 6 days ago

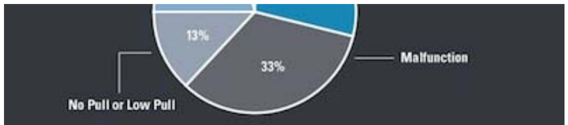
AAD cutter clamping on reserve closing loop
6 weeks 5 days ago

Back fly
7 weeks 1 day ago

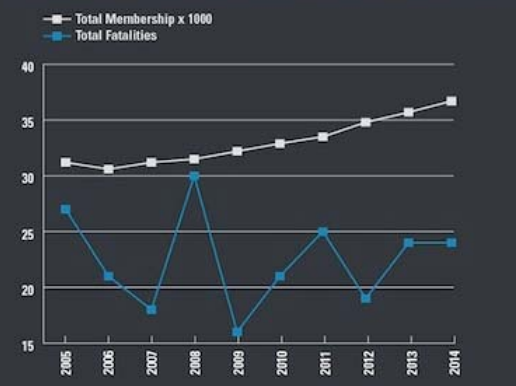
Make contact
7 weeks 5 days ago

the drogue from its pouch, but it entangled with the stretched housing. The instructor then deployed the reserve, but it did not clear the malfunctioned equipment. The tandem pair landed under a partially inflated main parachute, killing them both.

- In four cases, skydivers experienced spinning main parachutes and did not handle the emergencies in the time and altitude remaining:
    - One very experienced wingsuit jumper started his opening lower than the recommended altitude. His pilot chute apparently was not cocked (set properly for deployment), and although it still opened his main, the canopy deployed slowly and with line twists and began spinning. Because of the slow opening, he was still traveling quickly enough at a low altitude (about 750 feet) for his AAD to fire and initiate reserve deployment. The reserve bridle entangled with the main canopy, which stopped the reserve from deploying. He attempted to gain control of the spinning main parachute for the remainder of the jump but was not successful. Post-mortem toxicology tests showed that he had recently used marijuana and was likely under the influence of the drug at the time of the incident.
    - Another wingsuit skydiver opened his main canopy at approximately 5,000 feet. He then unzipped his arm wings and collapsed his slider. When he tried to unstow his steering toggles for full flight, one side didn't release and the canopy began to spiral. He tried to free the stuck toggle as the parachute continued to spin for the rest of the jump.
    - Two skydivers did cut away from their spinning mains, however:
        - One jumper, whose rig was not equipped with a reserve static line, cut away about 900 feet above the ground and did not open his reserve manually. His AAD had properly disarmed itself when he opened his main, and although it re-armed and fired after the cutaway, the reserve did not have enough time to fully deploy.
        - The other jumper experienced a brake release on one side of his main canopy during main deployment. The canopy spun itself into line twists as the jumper deployed his reserve canopy while still attached to the main. The jumper then pulled his cutaway handle but only far enough to release one of the main risers. He landed hard under the two canopies, with the reserve spinning and the main, which was in a streamer configuration, attached by just one riser.
    - A jumper, part of a group re-enacting a World War II airborne operation, experienced a line-over malfunction on his military-style round main parachute. He deployed his chest-mounted round reserve but then took no further action. For the rest of the canopy flight, observers saw him hanging limp in his harness under the fully inflated main canopy (which had a line-over) and fully inflated reserve canopy.



FATALITIES VS. TOTAL MEMBERSHIP x 1000



2014 DEMOGRAPHICS
(statistics on those who died)

	Average	Median
Age	47	49
Number of jumps	1,920	901
Years in the sport	12	6.5

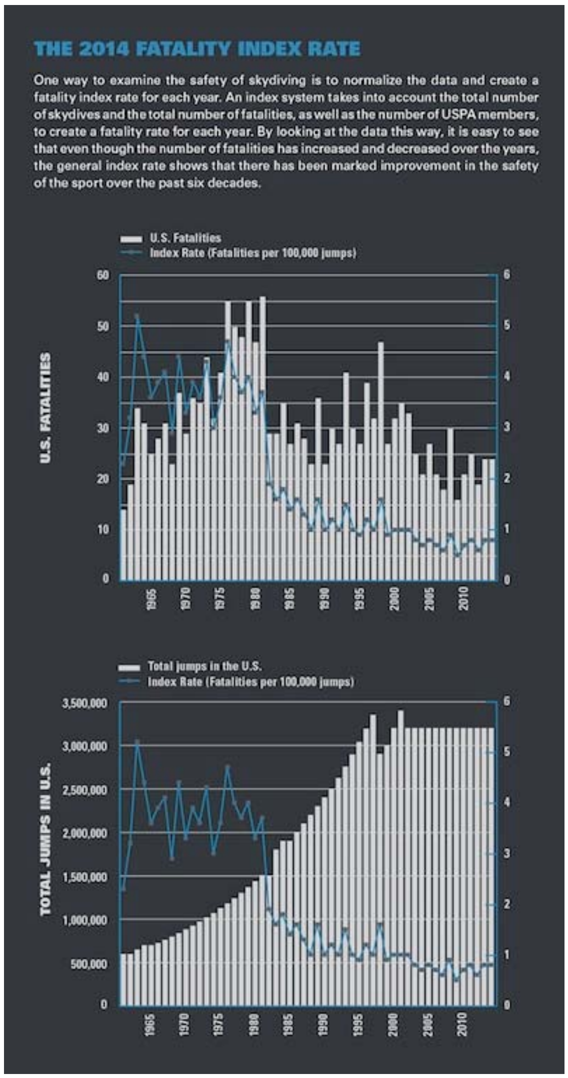
Average: the sum of a set of values divided by the number of values
Median: middle value of a set of values arranged in order of magnitude

Safety Tips

- Tandem instructors have challenging, complex and physically demanding jobs. The workload can be exhausting, especially when an instructor makes many jumps in a day. The complexities posed by the tandem equipment, as well the student up front, make it important for the instructor to follow a pattern of procedures—including handle checks—that will make the jump as safe as possible. Instructors should check their handles and touch them in the correct sequence on the ground, in the aircraft, before exiting and during the jump. This helps to build muscle memory, and it also helps to ensure that the equipment is configured properly and the handles are unobstructed. A poised exit allows instructors a better opportunity to check their handles. Finally, exiting from higher altitudes gives instructors more time to deal with any problems.
- Under today's high-performance canopies, a slow turn can rapidly morph to an altitude-eating spin. Not only does a spin increase a canopy's descent rate, but it also builds centrifugal force, which increases a jumper's disorientation and makes emergency procedures more difficult to perform. Highly loaded canopies are particularly susceptible, but most canopies are designed for crisp performance, which means that turns often become spins under even lightly loaded canopies. However, a jumper can often slow or stop a turn by pulling down the steering toggle or the rear riser opposite the direction of turn. If the jumper can't control the turn, it is time to cut away and open the reserve parachute—the higher, the better.
- The prevalence of AAD use has greatly advanced skydiving safety, but AADs do have their limitations:
    - Jumpers must maintain a buffer between the AAD-activation altitude and the planned main-parachute-opening altitude, since it is hazardous when a reserve deploys while a main is deploying. One manufacturer recommends 1,000 feet between the AAD-activation altitude and the altitude at which the jumper plans to be under an open parachute (not the altitude at which he starts the opening). While jumpers can change an AAD's activation altitude, the default altitude on an experienced skydiver's AAD is 750 to 840 feet.
    - In a cutaway after a full main-parachute deployment, an AAD is not a substitute for an RSL or a manual pull of the

reserve ripcord. One of the beauties of a modern AAD is its ability to sense descent rate and disarm itself if the jumper is no longer falling near freefall speeds. This is why an expert AAD doesn't activate the reserve when a canopy pilot makes hard turns or spirals. However, for an AAD to work after a cutaway, that also means that if a jumper releases an opened main parachute, he must accelerate to near-normal freefall speeds, the AAD must sense this and re-arm itself, and enough altitude must remain for a normal reserve opening. This sequence takes several seconds, and that's time and altitude that may not exist after a cutaway.

- Wingsuit jumps add complexity to a skydive. USPA Skydiver's Information Manual Section 6-9 has recommendations about the use of wingsuits and the qualifications for skydivers who use them.
- Jumping while under the influence of any drug that affects ability and judgment greatly increases the risks for the jumper, as well as others in the air with him.
- Jumpers should practice their emergency procedures and decision-making skills frequently, not just during their student progressions. USPA Safety Day is a good time to review these skills, and SIM Section 5-1, Skydiving Emergencies, is a good resource any time of the year. In the event of an emergency, a fast and correct response to the situation at hand is critical. For example, it is appropriate to spend a moment after opening to make sure a canopy is controllable, but it is inappropriate to work with that same canopy for many spinning turns while the situation deteriorates. It is appropriate for students and A-license holders to release an uncontrollable canopy at 2,500 feet (or at least 1,800 feet for B-, C- and D-license holders), but it is inappropriate to release a main canopy at 200 feet.
- In recent years, some former military members (and even civilians) have taken part in military re-enactment static-line jumps using military surplus gear. Many participants are more than 60 years old. In one case this year, it appeared that a participant likely suffered a heart attack after dealing with a line-over malfunction. A regular medical check-up is a good idea for all skydivers, but especially for those over age 40.



RESERVE PROBLEMS (1—4%)

A reserve system is built for dependability, but there are few absolute guarantees in skydiving. In the one incident in this category, a very experienced camera flyer opened at a conservative altitude, jettisoned his malfunctioned main and deployed his reserve with plenty of altitude. However, he died after his reserve bridle snagged on his camera mount, creating a horseshoe malfunction and preventing his reserve canopy and freebag from clearing the container. He had disconnected his RSL prior to boarding the aircraft and experienced the entanglement after manually pulling his reserve while in a back-to-earth position. When the reserve bridle snagged on his camera mount, he spent the remainder of his time trying to clear it.

Safety Tips

- The jumper used his reserve appropriately but opened in the position most likely to create an entanglement. Bottom line: Skydiving is about risk management, and that risk is higher when using a camera on a skydive.
- For most jumps other than canopy formation skydives, using an RSL is advisable. Although some jumpers, camera flyers in particular, are concerned that an immediate reserve deployment via an RSL will create a reserve entanglement, the reality is this scenario is extremely rare, even for camera flyers. However, every year some of the people who died would have lived if they had an RSL.
- Cameras have become smaller and less expensive. The result is that almost anyone can jump with them. However, they are not risk free. As well as causing distractions that can lead to dangerous situations (such as forgetting to fasten a chest strap), they also can pose entanglement hazards during main or reserve deployment. Some camera helmets minimize this risk by using "no-snag" mounts. Additionally, some helmets come equipped with a quick-release mechanism for jettisoning the helmet if an entanglement does occur. SIM Section 6-8 contains camera-flying recommendations.
- In a horseshoe malfunction, part of the deployed parachute is entangled with the jumper or his equipment while the risers are still attached to the harness. This usually creates a loop of suspension line and twisted parachute material that flaps above the jumper. The jumper's rate of descent likely does not decrease much from freefall, so he has only a few seconds to react. The design of a reserve's freebag and long bridle maximizes the chance of its opening (even if the reserve pilot chute is trapped), but it still does not guarantee success.

WING LOADING

The jumper's exit weight divided by the area of the parachute, expressed in pounds per square foot.

For example, a 190-pound jumper with 20 pounds of equipment (a 210-pound exit weight) jumping a 120-square-foot canopy is loading his canopy at 1.75:1.

HOW THEY DIED

(Category Percentages, Previous Decade Versus 2014)

	2004-2013	2014
No/Low Pull	13%	13%
Malfunction	22%	33%
Reserve Problem	2%	4%
Collision	21%	22%
Landing	31%	29%
Other	9%	0%

Red indicates an increase from 10-year average. Blue indicates a decrease from 10-year average.

COLLISIONS (5—21%)

Speed represents energy, and when jumpers with a speed differential collide in freefall or under canopy, their bodies are likely to absorb the energy. Collisions almost always occur because one or both jumpers do not see the other, and often at least one of the jumpers is not in control.

- Two skydivers, neither wearing an AAD, died in separate tracking-dive incidents after striking the body of another tracker. In both cases, investigators were unable to determine whether the jumper died immediately from the collision or from striking the ground without a deployed canopy.
- A jumper shooting video struck a jumper who was deploying his parachute as planned. The video person exited directly above a pair of jumpers performing a Mr. Bill jump (in which two jumpers hold on to each other and one deploys a parachute). The videographer deployed his main parachute, apparently to avoid a collision, when he saw the deploying parachute below him, but he still struck the lower jumper hard enough to receive fatal injuries.
- In two separate instances, a jumper turning or spiraling under canopy entangled with another jumper below 1,000 feet.
  - In one of the incidents, both jumpers were focused on the landing area and not looking for other canopy traffic when they collided. One of the jumpers cut away his main about 200 feet above the ground, and although his RSL initiated reserve deployment, it did not have the time and altitude to fully open.
  - In the other situation, a spiraling jumper received deadly injuries after colliding body-to-body with another jumper.

Safety Tips

- Horizontal separation between opening jumpers is critical. Deploying above a lower jumper will not guarantee vertical separation. Although it's a good idea to grab the rear risers as the parachute opens to allow an immediate riser turn to avoid other jumpers, this only works if the canopy is inflated and there is horizontal space between the jumpers.
- Unless the collision is extremely close to the ground, there's seldom a reason to stay with an entanglement for more than a few seconds before at least one person cuts away. This will often clear the entanglement or at least slow things down. However, releasing the main with just a couple hundred feet remaining doesn't give most reserve systems time to open. Both of the entanglement incidents happened at the worst time, when the jumpers were preparing to land.
- Jumpers should set a hard deck—SIM Section 4 recommends 1,000 feet—below which they will not cut away.
- Jumpers must continually check their airspace and make sure the airspace in the direction they wish to turn is clear before starting a maneuver.
- Spirals (rapid, continuous steep turns) near landing-pattern altitudes are unsafe and needlessly endanger other jumpers. (No aircraft pilot would perform a maneuver like this anywhere near an aircraft traffic pattern, and neither should a canopy pilot.) It is not unusual at many drop zones to see a canopy spiraling, especially at altitudes above 1,000 feet. However, spiral turns require a very large area of clear airspace. When there is more than one canopy in the air, it can be very difficult to know with certainty that the airspace is clear enough for this type of maneuver.
- Tragically, one jumper had removed his AAD for servicing and then died in a freefall collision. AAD users should assess whether the absence of this potentially life-saving device is reason enough to delay skydiving until one is available.

LANDING (7—29%)

Over the years, the failure to safely land a parachute has been a leading cause of death, and it remains so today. In the last 10 years, 76 skydivers died landing properly functioning canopies. The seven incidents in 2014 are typical of those in past years:

- Four canopy pilots simply started their turns too low. Their experience levels ranged from 80 to 1,600 jumps, and their wing loadings from 1.1:1 to 2.8:1. A post-mortem toxicology report for one of the jumpers indicated that he had recently used marijuana and that he was likely under the influence of the drug during the skydive.
- Another jumper died when he landed during the last, incomplete turn in a series of turns. The landing, under a canopy loaded at 1.4:1, was not survivable. It appears that a tension knot in one of his steering lines caught on the guide ring and caused a series of hard turns as he prepared to land.
- A tandem student died and the tandem instructor was hospitalized when the pair encountered a dust devil that partially collapsed the main parachute at about 75 feet and then dragged them on the ground after landing.
- A canopy pilot stalled his highly loaded (2.27:1) canopy at 600-800 feet above the ground. The canopy came out of the stall in a spiraling turn. After three revolutions, the jumper landed while still in the turn.

Safety Tips

- A dust devil is a mini-tornado, a vertical column of swirling air formed by ground heating. Dust devils usually occur on low-wind days. The dust and debris drawn into the column is generally visible and canopy pilots should avoid them whenever possible. However, when a dust devil forms over a grass area, it can be difficult or impossible to see because it does not pick up much debris.

- Line wear and twisting of the brake lines causes tension knots. (To see how tension knots form, hold a piece of line between two hands and twist one side. The line will begin to coil in on itself.) A tension knot can involve a group of lines or just a single line but are most prone to form on brake lines since they are not attached to risers like the suspension lines. Because the toggle end of the brake line is free, it can be twisted to the point where a tension knot will form. Usually, it's just an inconvenience with some minor twisting that needs to be unwound by twisting the brake line in the opposite direction before packing the main canopy, but when it is not corrected over a longer period of jumps, a tension knot may develop.
- Jumpers can offset some turn problems by using the opposite steering line or riser to counter it.
- Any turn initiated close to the ground increases the risk of striking the ground at a high forward speed and descent rate. Trying to judge the height above ground while under the influence of drugs or alcohol is even more difficult and increases the risk to the canopy pilot and anyone else in the same airspace.

OTHER (NONE IN 2014)

This category includes deaths—commonly, medical incidents—that don't fit into any of the other five categories. Skydiving can lead to stress, which increases the chance that a jumper will experience a heart attack or other medical incident. Hard-opening parachutes and rapidly spinning main canopies can also apply excessive force to the head, neck and aorta. In at least three of the incidents in 2014, investigators strongly suspect that medical issues may have contributed to the jumpers failing to execute their emergency procedures properly. However, even though circumstances may point to a heart attack or other medical problem—for example, a jumper who hangs limp and unresponsive under canopy—if the evidence is not definitive (e.g., the autopsy report was unavailable or inconclusive), the death falls into another category. This was the case for all suspected medical incidents in 2014.

GENERAL COMMENTS

AADs, RSLs and Audible Altimeters

There's no question about it, a skydiver has the primary responsibility for ensuring safety on every jump. But the use of redundant safety devices adds additional layers of safety. Audible altimeters can provide an extra aid to altitude awareness on every jump. AADs and RSLs are situational backups that are invaluable when needed. Their functions are not overlapping: Using one does not eliminate the need for the other. An AAD initiates reserve activation when the jumper reaches a low altitude at or near freefall speeds. Any type of RSL system, including the SkyHook and similar main-assisted-reserve-deployment (MARD) devices, initiates reserve deployment after a cutaway. Both provide critical backup for the skydiver. Neither was in common use a few decades ago, and their use today is one of the reasons the sport is so much safer. In 2014, the use of AADs or RSLs would possibly have saved seven lives.

Landings

Over the last 20 years, deaths that occurred while jumpers landed properly functioning canopies comprised the single largest category of skydiving deaths. This category accounts for 33 percent (184 skydivers) of overall fatalities during the period. Although this year the landing category was the second-deadliest category, canopy selection and operation remain two of the most important factors that determine a skydiver's safety.

Experience

Experienced skydivers—those who averaged more than a decade in the sport—made up the largest concentration of fatalities. These experienced jumpers were most likely to use high-performance canopies and sophisticated equipment (e.g., wingsuits, cameras, tandem equipment) that required more complicated emergency procedures. In 2014, those who died averaged almost 2,000 jumps. The need for experienced skydivers to frequently review and practice emergency procedures is painfully obvious.

Health

Early in the history of skydiving, the physical demands on jumpers made it a young person's sport. That's changed. As equipment became more forgiving, it allowed jumpers to stay in the sport longer. It also allowed those with a wider variety of fitness levels to jump. But heart, brain and other medical ailments (both age-related and non-age-related) can be deadly on a skydive. Investigators suspected medical problems in at least three of the deaths last year. Tandem instructors must undergo Federal Aviation Administration Class III Physical Examinations before jumping with students, but a physical exam is a reasonable precaution for all skydivers to take, particularly older ones or those with known physical risk factors.

Gender

While women represent about 13 percent of U.S. skydivers, no women died skydiving during 2014.

Substance Abuse

Those who die suddenly are usually subject to medical examination. A routine part of a post-mortem examination is analysis of body fluids, in part to see if any perception-altering substances are present. Two of these examinations in 2014 showed that the skydivers had used marijuana within a few hours of their deaths.

From over-the-counter medications to recreational drugs and alcohol, any substance that affects a person's time sense or decision-making skills has no place in skydiving. Seconds count in our world. When what we do—or fail to do—can result in injury or death (our own or others'), reducing our capacity to make timely or correct decisions is just plain wrong.

Break the Chain

A skydiving mishap is often a chain of events rather than a single event. For example, a skydiver chooses to fly a canopy loaded higher than recommended for his skill level. He chooses not to equip himself with an AAD or RSL and doesn't review his emergency procedures frequently. He then jumps while taking cold medication, opens a little lower than normal and opens in a turn because a brake released due to poor packing. Rather than briefly attempting to control the turn, the jumper starts to cut away, fumbles for the cutaway pillow for a few revolutions and finds himself in a nearly horizontal spin. When he finally cuts away, he decides to get stable and face-to-earth before pulling his reserve and runs out of altitude. This fictional chain of events doesn't reflect any of this year's accidents, but elements of it absolutely do. A jumper can avoid potential disaster by breaking the chain.

CONCLUSION

We can never completely eliminate the risks in skydiving, but we can manage them. Basic mistakes cause the majority of deaths in parachuting. Use an AAD and a RSL. Watch where you are going in freefall and under canopy. Quickly respond to malfunctions. Don't turn near the ground. Do these things and you will have minimized much of the risk.

Skydiving-Related Aircraft Incidents

by **USPA Director of Government Relations Randy Ottinger**

The single fatal aircraft accident in 2014 involved the propeller of a Twin Otter. The National Transportation Safety Board (NTSB) determined the probable cause to be, "The skydiving operator employee's failure to see and avoid the rotating propeller blades when she walked toward the cockpit while the airplane's engines were running." All aircraft propellers pose a danger to pilots, skydivers and support staff. The Twin Otter's design requires all participants to be vigilant as they approach the aircraft.

Two other accidents resulted in minor injuries to pilots during forced landings:

- A Cessna 182 first showed signs of fuel exhaustion while on final approach, did not make the runway and sustained substantial damage in the crash. The post-accident investigation found a limited quantity of useable fuel in the left tank and none in the right tank. The safety board found the probable cause of the accident to be, "The pilot's mismanagement of the available fuel supply, which resulted in a loss of engine power due to fuel exhaustion." Aircraft operators and pilots must calculate the usable fuel necessary to complete each flight with the Federal Aviation Administration-required 30-minute fuel reserves.
- A Cessna 205 with five skydivers on board lost all engine power during its initial climb at approximately 900 feet above the ground and sustained substantial damage during the forced landing. None of the skydivers were injured. The safety board's preliminary report says, "The airplane's nose gear struck a ditch and the airplane nosed over before coming to a stop." The manufacturer's facility will perform a teardown examination of the engine before the safety board makes a determination of the accident's probable cause.

Five other incidents resulted in no injuries:

- A Cessna 182 lost engine power as it was on final approach for landing after dropping skydivers. The pilot initially applied carburetor heat as he started his descent from approximately 10,000 feet and then removed carburetor heat as he leveled the aircraft in preparation for lowering the flaps. When he added power to maintain airspeed, he noticed that engine power did not increase. The safety board determined the probable cause of the accident to be, "The pilot's improper use of the carburetor heat, which resulted in a total loss of engine power due to carburetor icing."
- A Pacific Aerospace Corporation 750XL experienced a left-main-landing-gear separation following a hard landing, and the pilot performed a go-around. According to the NTSB preliminary report, the aircraft then sustained substantial damage to its left wing as it landed for the second time.
- A Cessna 210 sustained substantial damage in a hard landing. In its narrative, the NTSB said, "During the landing, the airplane bounced three times down the runway. The pilot taxied to the hangar and without shutting down the engine boarded the second load of skydivers. Shortly thereafter, the pilot departed and during the initial climb, he attempted to retract the landing gear. The landing gear would not retract and the pilot decided to continue the flight with the landing gear extended. After the skydivers jumped, the pilot landed without incident. He taxied back to the hangar and shut down the engine. After exiting the airplane he noticed that the propeller tips were bent. As a result of the impact, the firewall was substantially damaged." The safety board determined the probable cause of the accident to be, "The pilot's inadequate landing flare, which resulted in a hard landing."
- A Cessna 182 crashed after its pilot bailed out due to flight-control problems caused by an exiting jumper's premature parachute deployment. The last jumper to exit the aircraft hit his container on the door, which caused his reserve pilot chute to deploy and damage the airplane's horizontal stabilizer. The jumper had an uneventful descent under his reserve parachute. While the pilot struggled to maintain control of the stricken aircraft, spotters in a chase plane confirmed the damage. After some discussion, the jump pilot agreed to guide his plane to unpopulated farmland east of the DZ. It was there that the pilot used his emergency parachute to make his first jump. In its finding of probable cause, the NTSB used the word "drogue" rather than "pilot chute" when it determined, "The inadvertent deployment of the skydiver's drogue chute when he exited the airplane" resulted in its "contacting and damaging the horizontal stabilizer."
- A bird strike damaged a deHavilland DHC-6 Twin Otter shortly after takeoff while conducting routine parachute operations. The NTSB said, "The hawk impacted the left wing, and the pilot elected to perform a precautionary landing. The airplane subsequently landed without incident." The safety board determined the probable cause of the accident to be, "An inadvertent collision with a bird, which resulted in substantial damage to the left wing."

Piloting a jump plane is among the most demanding of flying jobs, with multiple takeoffs and landings in a variety of conditions and with a variety of loads, along with the need to refuel often throughout a day. Pilots must plan and fly every flight professionally. The USPA Skydiving Aircraft Operations Manual, Jump Pilot Training Syllabus and Flight Operations Handbook are all available under the Group Members tab at uspa.org. Jump pilots and skydiving aircraft operators are encouraged to utilize these resources as part of a comprehensive and proactive safety-management system.

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Max Peck REPLY

Thu, 12/31/2015 - 19:05

This is all very thorough and I appreciate the time spent pouring over all this data. I am curious about how you estimate the number of skydives in a year (which seem to be constant over the last several years)? Do you survey USPA drop zones? It's nice that you estimate the number of tandems, but is there information on the composition of other skydivers? How many jumps were wingsuit, relative work, canopy formations, student jumps, etc? What's the average wing loading, experience level, AAD/RSL usage? Knowing some estimates of trends in the sport might help to give perspective or place emphasis on some of the risk factors that show up in these fatality summaries.

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