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Flight Experience, Risk Taking, and Hazardous Attitudes in Glider Instructors

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Abstract

Crew members' hazardous attitudes (including invulnerability to stressors) have been identified as possible contributing factors to many aviation accidents, and a great deal of research in this area thus far has been directed toward developing effective training programs to modify such attitudes to reflect realistic and positive attitudes towards flight safety. Yet little research has explored the role of flight experience and risk-taking attitudes in explaining hazardous attitudes, especially outside the context of general aviation. The current work extends existing research by examining the hazardous attitudes of glider instructors. It also investigates the role played by flight experience and risk-taking attitudes in predicting the instructors' hazardous attitudes, considering both the linear and curvilinear relationships between flight experience and hazardous attitudes. These cross-sectional data, originating from 144 current and past glider instructors from five Regional Gliding Centres across Canada, provided partial support for the hypotheses relating flight experience, prior involvement in accidents/incidents, and risk-taking attitudes to hazardous attitudes. Of note were the significant quadratic components of the overall main effect of flight experience on hazardous attitudes. As well, greater risk-taking attitudes and a basic knowledge of human factors were significantly related to greater negative attitudes toward human factors. I summarize the findings and present limitations of the study as well as suggestions for future research.

Résumé

Il a été établi que l'attitude dangereuse des membres d'équipage (y compris une invulnérabilité face aux facteurs de stress) était probablement un facteur contributif dans de nombreux accidents d'aviation. D'importantes recherches effectuées dans ce domaine ont jusqu'à maintenant été axées sur l'élaboration de programmes de formation efficaces visant à modifier ces attitudes afin d'encourager des comportements réalistes et positifs envers la sécurité en vol. Pourtant, il y a eu très peu de recherches sur le rôle que joue l'expérience de vol et la propension à prendre des risques des membres d'équipage pour expliquer les attitudes dangereuses, surtout en dehors du contexte de l'aviation générale. L'étude en cours a été élargie pour inclure les attitudes dangereuses des instructeurs de vol sur planeur. On a également examiné le rôle que jouent l'expérience de vol et la propension à prendre des risques dans le but d'anticiper les attitudes dangereuses des instructeurs, en tenant compte des relations linéaires et curvilignes entre l'expérience de vol et les attitudes dangereuses. Ces données transversales, obtenues par l'observation de 144 instructeurs de vol sur planeur, en activité ou non, œuvrant dans cinq centres de vol à voile régionaux répartis dans tout le Canada, corroborent en partie nos hypothèses. Parmi les éléments remarquables, il y a les composantes quadratiques marquées de l'ensemble de l'incidence principale de l'expérience de vol sur les attitudes dangereuses. De plus, on a pu établir un lien direct marqué entre la propension à prendre des risques et une attitude plus négative envers les facteurs humains, tout comme dans le cas d'une connaissance de base des facteurs humains. Je présente ici un résumé des faits établis et les limites de l'étude et propose des sujets pour de futures recherches.

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Executive summary

Flight Experience, Risk Taking, and Hazardous Attitudes in Glider Instructors

Ann-Renee Blais; Megan Thompson DRDC Toronto TR 2010-137; Defence R&D Canada – Toronto; August 2010.

Background: Crew members' hazardous attitudes (including invulnerability to stressors) have been identified as possible contributing factors to many aviation accidents, and a great deal of research in this area thus far has been directed toward developing effective training programs to modify such attitudes to reflect realistic and positive attitudes towards flight safety. Yet little research has explored the role of flight experience and risk-taking attitudes in explaining hazardous attitudes, especially outside the context of general aviation. The current work extends existing research by examining the hazardous attitudes of glider instructors. It also investigates the role played by flight experience and risk-taking attitudes in predicting the instructors' hazardous attitudes, considering both the linear and curvilinear relationships between flight experience and hazardous attitudes.

Results: These cross-sectional data, originating from 144 current and past glider instructors from five Regional Gliding Centres across Canada, provided partial support for the hypotheses relating flight experience, prior involvement in accidents/incidents, and risk-taking attitudes to hazardous attitudes. Of note were the significant quadratic components of the overall main effect of flight experience on hazardous attitudes. Specifically, the relationship between flight experience and negative attitudes toward human factors was negative for instructors with low levels of experience, its magnitude decreasing with increasing experience; the relationship became positive after 19.95 years in aviation, its magnitude increasing with increasing experience. Conversely, the relationship between experience and perceived invulnerability to stressors was positive for instructors with low levels of experience, its magnitude decreasing with increasing experience; the relationship became negative after 27.13 years in aviation, its magnitude increasing with increasing experience. As well, greater risk-taking attitudes and a basic knowledge of human factors were significantly related to greater negative attitudes toward human factors.

Significance: This work suggests that the relationship between flight experience and hazardous attitudes may not be linear in the glider instructor population. It also alludes to a positive relationship between risk-taking and hazardous attitudes, at least as far as negative attitudes towards human factors are concerned.

Future plans: In the short term, of great importance is the refinement of the scale items or the adaptation of an established instrument to the gliding context. After the reliability and validity of their scores have been established, items should be administered to a large representative sample of gliders in order to provide a normative base for future comparisons. Future research could then investigate whether or not the results of the current study are stable and reproducible. Ideally, such an endeavour would include a longitudinal study of change over the career cycle of gliders as well as simple experiments to establish causality. Additional work could eventually consider the role of social and peer influences on hazardous attitudes and/or evaluate more complex predictive models of hazardous attitudes aiming to explain mediating or moderating relationships.

Sommaire

Expérience de vol, prise de risque et attitudes dangereuses des instructeurs de vol sur planeur

Ann-Renee Blais; Megan Thompson DRDC Toronto TR 2010-137; Recherche et développement pour la défense Canada - Toronto; Aout 2010.

Contexte : Il a été établi que l'attitude dangereuse des membres d'équipage (y compris une invulnérabilité face aux facteurs de stress) était probablement un facteur contributif dans de nombreux accidents d'aviation. D'importantes recherches effectuées dans ce domaine ont jusqu'à maintenant été axées sur l'élaboration de programmes de formation efficaces visant à modifier ces attitudes afin d'encourager des comportements réalistes et positifs envers la sécurité en vol. Pourtant, il y a eu très peu de recherches sur le rôle que joue l'expérience de vol et la propension à prendre des risques des membres d'équipage pour expliquer les attitudes dangereuses, surtout en dehors du contexte de l'aviation générale. L'étude en cours a été élargie pour inclure les attitudes dangereuses des instructeurs de vol sur planeur. On a également examiné le rôle que jouent l'expérience de vol et la propension à prendre des risques dans le but d'anticiper les attitudes dangereuses des instructeurs, en tenant compte des relations linéaires et curvilignes entre l'expérience de vol et les attitudes dangereuses.

Résultats : Ces données transversales, obtenues par l'observation de 144 instructeurs de vol sur planeur, en activité ou non, œuvrant dans cinq centres de vol à voile régionaux répartis dans tout le Canada, corroborent en partie nos hypothèses. Parmi les éléments remarquables, il y a les composantes quadratiques marquées de l'ensemble de l'incidence principale de l'expérience de vol sur les attitudes dangereuses. On a notamment remarqué que dans le cas des instructeurs qui avaient moins d'expérience, il y avait une relation négative entre l'expérience de vol et les attitudes négatives envers les facteurs humains. L'importance de cette relation était inversement proportionnelle au niveau d'expérience, devenait positive après environ 19,95 années d'expérience en aviation puis augmentait en proportion avec l'expérience acquise. Par contre, la relation entre l'expérience et la perception d'invulnérabilité aux facteurs de stress était positive pour les instructeurs qui avaient moins d'expérience. L'importance de cette relation augmentait de façon inversement proportionnelle à l'expérience acquise pour devenir négative après environ 27,13 années d'expérience en aviation, puis augmentait en proportion avec l'expérience. De plus, on a pu établir un lien direct marqué entre la propension à prendre des risques et une attitude plus négative envers les facteurs humains, tout comme dans le cas d'une connaissance de base des facteurs humains.

Importance : Selon les résultats de cette étude, la relation entre l'expérience de vol et les attitudes dangereuses n'est peut-être pas linéaire chez les instructeurs de vol sur planeur. Ces résultats suggèrent également qu'il y a une relation positive entre la propension au risque et les attitudes dangereuses, au moins en ce qui concerne les attitudes négatives envers les facteurs humains.

Perspectives : À court terme, il est très important de mieux définir les éléments de l'échelle ou encore d'adapter un instrument bien établi au contexte du vol à voile. Après confirmation de la fiabilité et de la validité des résultats, les éléments de l'échelle devraient être appliqués à un échantillon représentatif important de la population d'instructeurs de vol sur planeur afin d'établir une base de comparaison normative pour les études à venir. Les prochaines recherches pourraient

alors porter sur la stabilité et la reproductibilité des résultats de l'étude actuellement en cours. L'idéal serait d'inclure une étude longitudinale des changements qui se produisent tout au long de la carrière des instructeurs de vol sur planeur ainsi que de simples expériences visant à établir la causalité. D'autres études pourraient éventuellement porter sur l'incidence de l'influence des pairs et du milieu social sur les attitudes dangereuses, ou encore sur l'évaluation de modélisations prédictives plus complexes des attitudes dangereuses afin d'expliquer les relations médiatrices ou modératrices.

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Acknowledgements

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1 Introduction

1.1 Hazardous Attitudes

In the early 1980s, Berlin, Gruber, Holmes, Jensen, Lau, Mills, and O'Kane (1982, as cited in Hunter, 2005) developed a program to improve the in-flight decision making of pilots that focused primarily on their attitudes, or *hazardous thought patterns*. The Federal Aviation Administration (1991, as cited in Hunter) then published a series of documents touching upon these hazardous attitudes (i.e., *anti-authority*, *impulsivity*, *invulnerability*, *macho*, and *resignation*), among other things. The documents included a self-report scale (designed mainly for pedagogic use) identifying characteristic attitudes and providing guidance on how to manage them (Hunter). On the other hand, even though Lester and Bombaci's (1984) and Lester and Connelly's (1987) work with pilots found invulnerability to be the most prominent hazardous attitude, they questioned the legitimacy of the concept altogether and pushed on for additional validation work.

The origins of a strong professional culture among pilots are clear, according to Helmreich, Wilhelm, Klinect, and Merritt (2001): Early aviation was an extremely risky mission for those in combat, flying for air show audiences, or carrying the mail. As Helmreich et al. mentioned, committing to such an undertaking required a well-established sense of personal invulnerability. Indeed, in their systematic and extensive assessment of pilots' attitudes, Helmreich and colleagues (e.g., Helmreich & Merritt, 1998) noted their unrealistic perceptions of their invulnerability to stressors. The pilots also reported perceiving their decision making as impervious to in-flight emergency situations and indicated that a "true professional can leave behind personal problems on entering the cockpit" (Helmreich et al., p. 308). Supportive of the findings of Lester and Bombaci (1984), Lester and Connelly (1987), and Helmreich et al., Wetmore and Lu (2006), in their investigation of 50 fatal general aviation accidents, also found invulnerability to be the most common hazardous attitude.

Even though it remains unclear whether hazardous attitudes precede behavior or result from direct experience (Dutcher, 2001), such attitudes have been identified as possible contributing factors to many accidents (Helmreich, Foushee, Benson, & Russini, 1986, as cited in Helmreich, 1992), and a great deal of research in this area thus far has been directed toward developing effective training programs in order to modify crew attitudes to reflect realistic and positive attitudes towards flight safety (Dutcher; see Helmreich & Merritt [1998] for an example of attitude change related to the effects of fatigue on performance).

In the current work, I will examine/describe the hazardous attitudes of glider instructors, thereby extending research that has mostly been investigated in the context of general or commercial aviation pilots to a novel environment.

1.2 Positive Illusions in Aviation

Numerous studies have demonstrated the existence of *self-aggrandizing self-perceptions* in individuals. Self-perceptions are generally positive, that is, individuals believe positive attributes are more characteristic of themselves than are negative traits; they also perceive themselves as superior to their peers (Taylor & Armor, 1996). O'Hare (1990) found such positive self-perceptions among general aviation pilots who rated their skill and judgment as greater than those of their peers.

Not only do individuals generally hold enhanced self-perceptions, but they also believe that they have a great degree of *personal control* in many life situations (Taylor & Armor, 1996). For example, numerous field and laboratory studies have shown that individuals think that they have greater control over traumatic health events than is objectively the case (Taylor & Armor, 1996). Anecdotal evidence suggests that pilots often overestimate their degree of control over the environment (Stewart, 2006).

Further, there exists a well-documented general tendency for individuals to view themselves as less vulnerable to a range of threatening events and as more likely to experience a greater number of positive events (i.e., *unrealistic optimism* or *optimistic bias*) than are their peers (Taylor & Armor, 1996). Indeed, O'Hare (1990) reported unrealistic optimism among general aviation pilots: Almost half of the participants in his study perceived their personal likelihood of being involved in a general aviation accident in the next 10 years of flying as 1 in 100,000, whereas the objective risk for United States of America (USA) pilots is very close to 1 in 10 (O'Hare).

A number of studies have associated *prior experience* with less optimistic bias (e.g., Weinstein, 1980, as cited in Helweg-Larsen & Shepperd, 2001). Several possible reasons exist that may explain why this is the case, including the notion that prior experience with a negative event may decrease perception of control over outcomes, leading to reduced optimistic bias because of increased estimates of personal risk (Helweg-Larsen & Shepperd, 2001).

Given that it is not uncommon for skilled and experienced pilots to have accidents, Stewart (2006) asked whether or not there exists a "…critical point in a pilot's career progression where the cumulative effects of thousands of hours of flight experience can lead to an illusion of invulnerability?" (Stewart, 2006, p. 11). Indeed, he suggested that there might be a point where she or he acquires increased status and responsibilities (e.g., aircraft commander, pilot in command, etc.) and thus experiences a greater illusion of personal control. Past that point, however, she or he may come to realize (through experience, including, for example, being involved in an accident/incident) that one is not invulnerable after all (Stewart, 2006).

In the present research, after examining/describing the hazardous attitudes of glider instructors, I will investigate the role played by flight experience and prior involvement in accidents/incidents in predicting instructors' attitudes. In order to test Stewart's hypothesis I will consider both the linear and curvilinear relationships between experience and perceived invulnerability.

1.3 Risk Taking

The notion that risk taking (i.e., ranging from risk aversion to risk seeking) is a stable personality trait has largely governed the psychology literature (see Weber, Blais, & Betz, 2002, for a review). More recently, however, decision researchers have increasingly come to consider the notion of an interaction between person-centered and situational characteristics in explaining existing results about the domain specificity of risk taking (Weber & Johnson, 2009).

As noted in Weber et al., situational characteristics include the domain (i.e., recreational, financial, etc.) of the decision as well as contextual variables such as outcome framing (e.g., when outcomes are phrased positively, i.e., lives saved, vs. negatively, i.e., lives lost). Person-centered characteristics comprise, for example, gender, age, and personality (e.g., sensation seeking, extraversion, etc.). Weber et al. suggested that both sets of characteristic influence risk taking primarily by affecting individuals' perceptions of the benefits and riskiness of decision alternatives rather than by impacting individuals' risk taking per se.

Hanoch, Johnson, and Wilke (2006) recruited individuals known to be risk takers (e.g., sky divers, smokers, and gamblers) or avoiders (e.g., gym members) in a specific domain. They found that, among other results, not only were the sky divers significantly more likely to engage in risky recreational activities than were the other individuals, but they also viewed these activities as significantly more beneficial than did individuals from other subsamples.

In addition to investigating the role of flight experience and prior involvement in accidents/incidents in predicting instructors' attitudes, another goal of the present study is to examine/describe the health/safety and recreational risk attitudes of glider instructors. I chose these particular risk domains, especially the recreational risk domain, as they appear to be the most relevant to hazardous attitudes in aviation. I will also explore the role of these risk attitudes in predicting the instructors' attitudes.

1.4 Hypotheses

I proposed the following hypotheses as far as the predictive model is concerned:

1. Flight experience will be a predictor of hazardous attitudes, yet the relationship between flight experience and perceived invulnerability to stressors will level off or decrease after a certain point;

2. prior involvement in accidents/incidents will be a negative predictor of hazardous attitudes; and;

3. risk-taking attitudes will be positively related to hazardous attitudes.

2 Method

2.1 Participants

Febbraro, Gill, Holton, and Hendriks (2008) recruited 144 current and former glider instructors from five Regional Gliding Centres across Canada. Age ranged from 18 to 70 years, with a mean of 27.8 years (*N* = 137; *SD* = 10.6). The number of years of experience in aviation varied from 2 to 51, with a mean of 11.3 (*N* = 142, *SD* = 9.7). As displayed in Table 1, most respondents were English-speaking (77.5%) single (56.6%) males (76.4%) with at least a college- or university-level education (56.3%). Almost all of them had an active flight status (95.8%); more than half of them had received human factors training as part of the glider syllabus (64.6%) if not elsewhere as well, and considered themselves moderately knowledgeable about human factors (55.7%). Less than half of them (38.7%) had been involved in a glider accident/incident.

Table 1: Individual Characteristics (N = 144)

Characteristic	*f*
Sex	
Female	34
Male	110
Primary language	
English	110
French	20
Bilingual	12
Highest level of education completed	
Less than high school	7
High school	56
College/university	67
More than undergraduate	14
Geographical region	
Atlantic	26
Eastern	35
Central	48
Prairie	15
Pacific	18
Marital status	
Common law	11
Divorced	2
Married	49
Single	81
Flight status active	
Yes	137
No	6

Involvement in accident/incident	
Yes	55
No	87
Human factors training	
Glider syllabus	93
Department of National Defence	56
Transport Canada	51
Other company/organization	26
Human factors knowledge	
Basic	51
Intermediate	78
Advanced	11

2.2 Measures

2.2.1 The Attitudes Towards Unsafe Acts Scale

This scale originates from the work of Simpson and Wiggins (1999) and includes 25 statements rated on 5-point Likert-type rating scales ranging from *strongly disagree* to *strongly agree*. Sample items include: "I have no time for human factors in critical situations" and "I can always deal with my stress." Simpson and Wiggins built the instrument so that it would reflect "two distinct behavioral features presumed to reflect the commission of *un*safe acts in complex [aeronautical] environments" (p. 339), *violations* and *active failures*. Violations refer to deliberate deviations from those rules, procedures, and practices in place to create and support a safe operative environment. Active failures represent those errors with immediate consequences (e.g., failure to extend the undercarriage prior to landing, misjudgement of weather conditions).

Despite having explicitly alluded to these two sets of behaviors, Simpson and Wiggins (1999) treated the data as being unidimensional and reported an internal consistency reliability estimate (i.e., Cronbach's alpha) of .83 across the 25 items. Febbraro et al. (2008), based on Dutcher (2001), included 19 out of the 25 original Simpson and Wiggins items in their questionnaire.

2.2.2 The Domain-Specific Risk-Taking Scale

The Domain-Specific Risk-Taking (DOSPERT) Scale (Weber et al., 2002) has recently undergone a major revision (Blais & Weber, 2009). Knowing this, items from its most recent version were used (Blais & Weber, 2009). However, the factor structure of this scale still needs to be replicated (see Blais & Weber, 2009, for more detail). Further, to my knowledge, this version of the DOSPERT Scale had not yet been used with aviation personnel.

Febbraro et al. (2008) included two (of the six) subscales of the revised DOSPERT Scale in their questionnaire, the six-item *Health/Safety* and the six-item *Recreational* subscales. Respondents rated their likelihood of engaging in the described risky activities/behaviors using 7-point Likert-type rating scales ranging from *extremely unlikely* to *extremely likely*. In the health and safety domain, sample items are "Engaging in unprotected sex," and "Driving a car without wearing a seatbelt." In the recreational domain, sample items are "Bungee jumping off a tall bridge," and "Taking a skydiving class." Blais and Weber (2009) reported internal consistency reliability estimates (i.e., Cronbach's alphas) of .77 and .85, respectively, for the Health/Safety and Recreational scores. Only 5 (of the 6) recreational items were included in Febbraro et al.'s questionnaire due to a clerical error.

2.3 Procedure

Febbraro et al. (2008) administered their survey in two forms, paper- and web-based. They posted their web-based survey on-line and made it available to participants via their respective regional gliding centre-school starting in June 2008. Ninety-four participants completed the survey this way. See Febbraro et al. for more detail with respect to the web-based data collection.

Febbraro et al. (2008) also mailed out copies of the paper-based survey to five regional gliding centres/schools and gave instructions for administering it to the instructors participating in the air cadet glider summer program (i.e., the Glider Pilot Scholarship course) in 2008. Fifty participants completed the survey this way. Again, for more information regarding the paper-based data collection, see Febbraro et al.

In accordance with the guidelines of the Defence Research and Development Canada (DRDC) Human Research Ethics Committee, all participants received an Information Letter and a Voluntary Consent Form prior to completing a demographic questionnaire, and a survey questionnaire package. They completed the survey on a voluntary basis in approximately 30 minutes.

3 Results

3.1 Data Preparation and Screening

Twelve participants had failed to complete the web-based questionnaire beyond the biographical data form, and 6 participants had not completed the risk items. The risk data originating from 19 additional participants (all from the same Centre) who had received the paper-based version of the questionnaire were also missing. Technical problems (e.g., computer glitches, missing questionnaires pages) may have contributed to those missing data.

In the end, only 107 (out of the 144 distributed) usable questionnaires remained. There were a few (i.e., .56%) missing observations that did not seem to occur for any particular set of variables throughout the questionnaire and were likely the result of those participants not responding to individual items. I used the Expectation Maximization (EM) algorithm available in the Structural Equation Modelling Software (EQS Version 6.1; Bentler, 2006) to impute these missing observations (Cohen, Cohen, West, & Aiken, 2003).

I converted a few (i.e., .25%) univariate outliers (i.e., $z > |3.29|$, $p < .001$, two-tailed; Tabachnick & Fidell, 2007) to the next most extreme rating, a remedial measure commonly suggested to deal with outlying data points (e.g., Kline, 1998). I assessed univariate normality by looking for univariate skewness greater than (approximately) 2 in absolute value and univariate kurtosis greater than (approximately) 7 in absolute value. These cutoff values for univariate skewness and kurtosis are recommended based on evidence showing that larger values may bias standard errors and fit indices in normal theory methods such as maximum likelihood (ML) in exploratory factor analysis (e.g., West, Finch, & Curran, 1995). For all but one of the risk variables (i.e., "Piloting a small airplane."), the univariate skewness and kurtosis values fell below their cutoffs, suggesting univariate normality.

3.1.1 The Attitudes Towards Unsafe Acts Scale

Given the uncertainty associated with the structure of this scale, I conducted two exploratory factor analyses, evaluating a one-factor (i.e., a general Hazardous Attitudes factor) model versus a two-factor (i.e., Violations and Active Failures factors) model on the 19 available items. I submitted the matrix of correlations (available upon request) to Comprehensive Exploratory Factor Analysis (CEFA Version 2.00; Browne, Cudeck, Tateneni, & Mels, 1998) for estimation with a ML procedure. I selected an oblique (i.e., direct oblimin) rotation, which allows factors to be correlated. I summarize the findings below, but the complete solutions are available upon request.

Fabrigar, Wegener, MacCallum, and Strahan (1999) encouraged the use of descriptive indices of fit such as the Root Mean Square Error of Approximation (RMSEA; Browne & Cudeck, 1993) in ML factor analysis. One can obtain a sequence of ML solutions for a range of number of factors and then assess the fit of these models using the RMSEA and other fit measures, choosing the number of factors that provides optimal fit to the data without overfitting (Preacher & MacCallum, 2003). RMSEA values less than .05 indicate a good fit to the data, values between .05 and .08, an acceptable fit, values between .08 and .10, a marginal fit, and values greater than .10, a poor fit (Browne & Cudeck, 1993). Thus, in addition to the likelihood ratio statistic, I report the RMSEA (and its 90% confidence interval [CI] in parentheses) as indices of goodness-of-fit of the model to the data.

At the item level, factor loadings greater than or equal to .35 (in absolute value) typically indicate a salient loading (Clark & Watson, 1995). "Good" candidate items are those that have a salient loading on their a priori assigned factor and minimal loadings on other factors, whereas "bad" items are those that load weakly on the hypothesized factor or cross-load on one or more factors (Simms & Watson, 2007).

The RMSEA associated with the one-factor model alluded to a poor fit to the data, .11(.09, .12), $\chi^2(152) = 332.11$. It resulted in only eight salient loadings. The RMSEA for the two-factor model suggested a marginal fit to the data, .09(.07, .11), $\chi^2(134) = 249.64$. The factor inter-correlation, significantly different from 0, was -.25. The two-factor solution resulted in 13 salient loadings, five on the first factor and eight on the second factor.[1]

Close inspection of the loadings revealed factors reflecting a disregard for human factors (e.g., "I have no time for human factors in critical situations" and "In a critical situation, most people forget human factors training and revert back to old, well-practiced ways") and a perceived immunity to stress in the face of situational adversity (e.g., "In critical situations, I find it easy to formulate opinions and choose between them" and "I can always deal with my stress"). The latter factor was consistent with a set of items (completed by commercial pilots) Sexton, Helmreich, Wilhelm, and Merritt (2001) denoted as representing "the extent to which individuals acknowledge personal vulnerabilities to stressors such as fatigue, personal problems, and emergency situations" (p. 8). I will refer to these two factors as, respectively, the *Neglect of Human Factors* (HF) and *Perceived Invulnerability* (to stress) factors.

Given the greater interpretability associated with the two-factor solution, I computed the resulting scores' internal consistency reliability estimates and obtained Cronbach' alphas of .66 and .88, respectively. However, deletion of one of the Neglect of HF items, which had a relatively low correlation (i.e., below .30) with the corrected total scale score (i.e., the total score except for the item of interest) (see Nunnally & Bernstein, 1994, for more detail), resulted in an increased alpha of .68, which is still slightly lower than the recommended cut-off value of .70, however.

3.1.2 The Domain-Specific Risk-Taking Scale

Due to the uncertainty associated with the DOSPERT Scale's structure (especially within the current sample), I conducted exploratory factor analyses on the 11 available risk items assuming, respectively, one (i.e., a general Risk factor), and two (i.e., a Health/Safety factor and a Recreational factor) factors. I submitted the matrix of correlations (available upon request) to CEFA (Browne et al., 1998) for estimation with an ordinary least squares (OLS) procedure this time. OLS estimation does not assume multivariate normality, and given that one of the variables ("Piloting a small airplane") exhibited marked skewness and kurtosis values, I favored this estimation procedure over ML (which, however, has the advantage of providing fit indices) and its assumption of multivariate normality. Once more, I selected an oblique rotation. Again, the complete solutions are available upon request.

The one-factor solution indicated 9 out of the 11 items with salient loadings on a general Risk factor. The two-factor solution resulted in only two items with salient loadings on the Recreational factor. The Health/Safety items all loaded as expected onto the Heath/Safety factor, however. The factor intercorrelation, significantly different from 0, was .26. Because of the parsimony associated with the one-factor solution, I decided to consider those 9 items as all loading onto a broad Risk factor. I computed the resulting score's internal consistency reliability

[1] I also examined the three-factor solution, .082(.062, .101), $\chi^2(117) = 199.93$. It yielded only two salient loadings on the third factor, however, which is suggestive of under-factoring.

estimate and obtained a Cronbach' alpha of .74. Further, all of the items showed sizable (i.e., greater than .30) correlations with the corrected total scale score.

3.1.3 Descriptive Statistics

I added the ratings on the four Neglect of HF and eight Perceived Invulnerability items and divided these sums by 4 and 8, respectively, resulting in minimal and maximal subscale scores of 1 and 5. Greater scores are suggestive of greater hazardous attitudes. The mean Neglect of HF and Perceived Invulnerability scores were, respectively, 2.80 (SD = 0.71) and 3.39 (SD = 0.88). I summed the nine Risk ratings and divided the resulting total by 9, leading to minimal and maximal scale scores of 1 and 7 and a mean score of 3.16 (SD = 1.04). Greater scores allude to greater risk-taking attitudes.

3.2 Additional Variables of Interest

I used the following variables included in the questionnaire of Febbraro et al. (2008) that asked the respondents: (a) their number of years in aviation (as a proxy for flight experience); (b) whether or not they had ever been involved in a glider accident or incident (*Yes* or *No*); (c) whether or not they had completed training in human factors as part of the glider syllabus (*Yes* or *No*), with the Department of National Defence (*Yes* or *No*), with Transport Canada (*Yes* or *No*), and with any other company or organization (*Yes* or *No*); and (d) their assessment of their current knowledge of human factors (*Basic*, *Intermediate*, or *Advanced*). I added the latter two sets of variables to the analyses for exploratory purposes (vs. the hypotheses listed in Section **1.4**), expecting greater training in (and knowledge of) human factors to lead to lower hazardous attitudes.

I recoded each *Yes* as a 1 and each *No* as a 0. If a participant had answered *Yes* to any of the human factors training items, I considered that she or he had completed human factors training (irrespective of its origin) and assigned her or him a value of 1. If a participant had responded *No* to all of these items, I considered that she or he had not completed human factors training and assigned her or him a value of 0. I recoded the Basic, Intermediate, and Advanced responses as 1, 2, and 3, respectively.

Flight experience varied from 2 to 45 years, with a mean of 12.56 years (N = 107, SD = 9.90). The majority (62%) of the participants had not been involved in a glider accident or incident, $\chi^2(1, N = 107) = 5.84$, $p = .016$. Only a few (16%) participants had not completed training in human factors, $\chi^2(1; N = 104) = 47.12$, $p < .001$. The majority (54%) of the participants viewed themselves as having an intermediate knowledge of human factors (vs. a basic [36%] or an advanced knowledge [9%]), $\chi^2(2; N = 107) = 32.77$, $p < .001$.

3.3 Regression Analyses

I conducted a hierarchical multiple regression analysis on the Neglect of HF score, regressing four sets of predictor variables on the outcome variable. The first set of predictors included centered flight experience (see Cohen et al., 2003, for more detail regarding centering predictors in polynomial regression) and the Risk score; the second set, the involvement in accidents/incidents and training in human factors variables; the third set, two dummy-coded knowledge of human factors variables;[2] and the fourth set, the quadratic term associated with centered flight experience. Based upon Cohen et al's recommendations, I entered the predictors in such an order as to reflect a causal/temporal sequence, with individual-differences variables entered first, followed by situational/contextual variables and by the quadratic term last in order to gauge whether or not its presence was contributing significantly to the model above and beyond the contribution of the other predictors.

The models met the assumptions of regression analysis (see Cohen et al., 2003, for more detail regarding these assumptions). Neither multicollinearity nor the presence of multivariate outliers was an issue based on Cohen et al.'s proposed minimum cutoffs for multicollinearity and diagnostic statistics.[3]

3.3.1 Neglect of Human Factors Score

Regarding Table 2, the model was neither significant at Step 1 nor at Step 2. At Step 3, adding the dummy-coded knowledge of human factors variables to the model explained a significant proportion (9.74%) of the variance in the Neglect of HF score above and beyond the contribution of the first and second sets of predictors, $F(2, 100) = 5.86$, $p = .004$. At Step 4, and in line with Hypothesis (1), adding the quadratic term to the regression equation resulted in a significant change in the proportion of variance accounted for, R^2, of 3.97%, $F(1, 99) = 4.97$, $p = .028$.

The overall linear trend in the data was not significantly different from 0, $b(SE) = -0.016(0.009)$, $t(99) = -1.72$, $p = .089$, $\beta = -.23$. The curve was u-shaped, $b(SE) = 0.001(0.000)$, $t(99) = 2.23$, $p = .028$, $\beta = .28$. It reached its minimum when centered flight experience was 7.39 (or 19.95 in raw score units). Table 2 displays the complete set of unstandardized regression coefficients and their associated standard errors as well as the standardized regression coefficients.

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[2] I created two dummy-coded variables, *Basic* (i.e., *Yes* = 1, *No* = 0) and *Intermediate* (i.e., *Yes* = 1, *No* = 0), with an advanced knowledge being the reference category.

[3] Three cases displayed extremity on the independent variables, yet they did not have undue global and specific influence on the regression equation, thus I decided to retain them in the analyses.

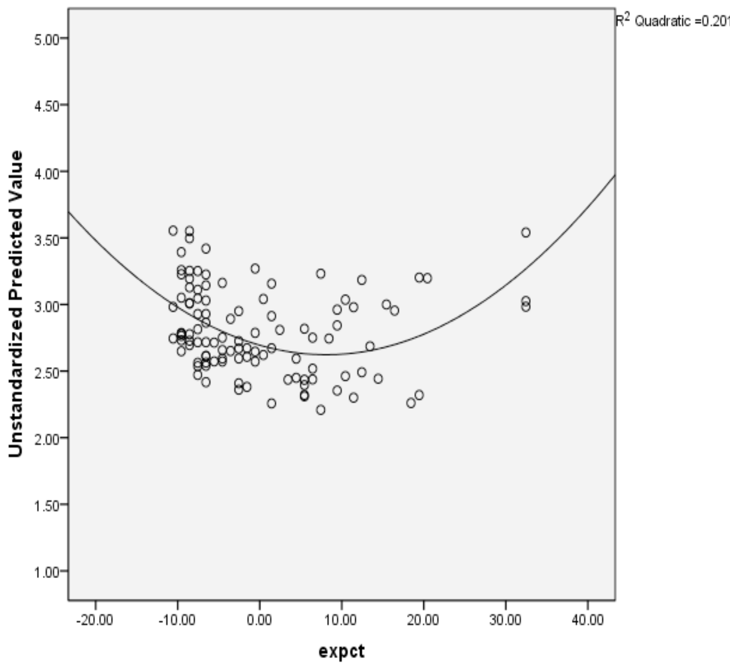
Table 2: Hierarchical Multiple Regression Analyses Predicting Neglect of Human Factors Scores (N = 107)

Predictor	ΔR^2	*b*	*SE b*	β
Step 1	.04			
Flight experience		0.001	0.007	.01
Risk score		0.138*	0.069	.20
Step 2	.03			
Flight experience		-0.001	0.007	-.01
Risk score		0.138*	0.069	.20
Involvement in accident/incident		0.072	0.142	.05
Human factors training		-0.357	0.190	-.19
Step 3	.10*			
Flight experience		-0.002	0.007	-.03
Risk score		0.152*	0.067	.22
Involvement in accident/incident		0.040	0.137	.03
Human factors training		-0.160	0.190	-.08
Basic human factors knowledge		0.539*	0.244	.37
Intermediate human factors knowledge		0.069	0.231	.05
Step 4	.04*			
Flight experience		-0.016	0.009	-.23
Risk score		0.147*	0.066	.22
Involvement in accident/incident		0.043	0.134	.03
Human factors training		-0.195	0.187	-.10
Basic human factors knowledge		0.483*	0.241	.33
Intermediate human factors knowledge		0.007	0.228	.01
Experience squared		0.001*	0.000	.28

*$p < .05$.

As shown in Figure 1, below a centered flight experience of 7.39, there was a negative relationship between flight experience and the Neglect of HF score that increased with decreasing flight experience, whereas above that point, there was a positive relationship between the two variables that increased with increasing flight experience.

Figure 1: Scatterplot of the unstandardized predicted values of the Neglect of Human Factors scores against centered flight experience (N = 107).



The hypothesis that prior involvement in accidents/incidents would be a negative predictor of hazardous attitudes was not supported, $b(SE) = 0.043(0.134)$, $t(99) = 0.32$, $p = .752$, $\beta = .03$. However, a greater risk-attitude score was significantly related to a greater Neglect of HF score, providing evidence for Hypothesis (3), $b(SE) = 0.147(0.066)$, $t(99) = 2.23$, $p = .028$, $\beta = .22$. In addition, a basic (vs. an advanced) knowledge of human factors was significantly related to a greater Neglect of HF score, $b(SE) = 0.483(0.241)$, $t(99) = 2.01$, $p = .047$, $\beta = .33$.

3.3.2 Perceived Invulnerability Score

At Step 1, the model explained 18.80% of the variance in the outcome variable above and beyond that explained by the null model, $F(2, 104) = 12.04$, $MSE = 0.64$, $p < .001$. At Step 4, and in line with Hypothesis (1), adding the quadratic term to the regression equation resulted in a significant change in R^2 (10.81%), $F(1, 99) = 15.90$, $p < .001$.

The overall linear trend in the data was positive, $b(SE) = 0.066(0.011)$, $t(99) = 6.07$, $p < .001$, $\beta = .75$. The curve was concave downward, $b(SE) = -0.002(0.001)$, $t(99) = -3.99$, $p < .001$, $\beta = -.45$. It reached its maximum when centered flight experience was 14.57 (or 27.13 in raw score units). Table 4 displays the complete set of unstandardized regression coefficients and their associated standard errors (SEs) as well as the standardized regression coefficients.

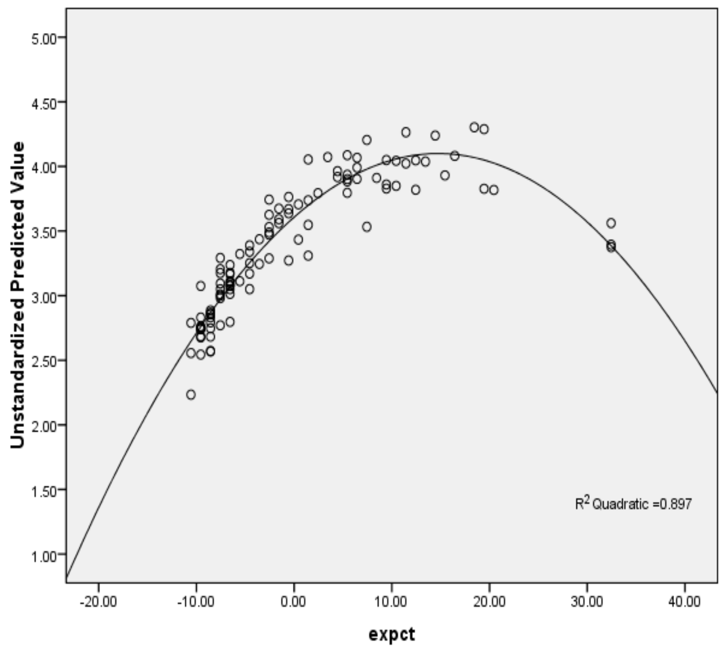
Table 3: Hierarchical Multiple Regression Analyses Predicting Perceived Invulnerability Scores (N = 107)

Predictor	ΔR^2	*b*	*SE b*	β
Step 1	.19*			
Experience		0.035*	0.008	.40
Risk score		-0.071	0.079	-.08
Step 2	.02			
Flight experience		0.035*	0.008	.40
Risk score		-0.081	0.080	-.10
Involvement in accident/incident		-0.186	0.164	-.10
Human factors training		0.231	0.218	.10
Step 3	.02			
Flight experience		0.036*	0.008	.41
Risk score		-0.076	0.081	-.09
Involvement in accident/incident		-0.162	0.165	-.09
Human factors training		0.145	0.229	.06
Basic human factors knowledge		-0.395	0.294	-.22
Intermediate human factors knowledge		-0.258	0.278	-.14
Step 4	.11*			
Flight experience		0.066*	0.011	.75
Risk score		-0.066	0.075	-.08
Involvement in accident/incident		-0.167	0.154	.09
Human factors training		0.216	0.214	.09
Basic human factors knowledge		-0.281	0.276	-.16
Intermediate human factors knowledge		-0.131	0.261	-.08
Experience squared		-0.002*	0.001	.47

*p < .05.

As shown in Figure 2, below a centered flight experience of 14.57, there was a positive relationship between flight experience and the Perceived Invulnerability score that decreased with increasing flight experience, whereas above that point, there was a negative relationship between the two variables that increased with increasing flight experience.

Figure 2: Scatterplot of the unstandardized predicted values of the Perceived Invulnerabilities scores against centered flight experience (N = 107).



Neither Hypothesis (2) nor Hypothesis (3) was supported, $b(SE) = -0.167(0.154)$, $t(99) = -1.08$, $p = .281$, $\beta = -.09$, and $b(SE) = -0.066(0.075)$, $t(99) = -0.88$, $p = .381$, $\beta = -.08$, respectively.

4 Discussion

4.1 Summary

A successful pilot needs to feel confident in her or his ability to control one's aircraft. Unfortunately, an offshoot of training may be overconfidence in one's judgment and skill as well as an unrealistic optimism about one's chances of avoiding harm via personal control (O'Hare, 1990). The current study supports this notion, while also carefully considering the complex relationship between flight experience and hazardous attitudes (as well as between involvement in accidents/incidents, risk-taking attitudes, and hazardous attitudes).

With regards to the first hypothesis, there was a significant quadratic component of the overall effect of flight experience on negative attitudes toward human factors, which had not been anticipated. Specifically, the relationship between experience and negative attitudes was negative for instructors with low levels of experience, its magnitude decreasing with increasing experience; the relationship became *positive* after 19.95 years in aviation, its magnitude increasing with increasing experience. In other words, the "protective effect" of experience on this hazardous attitude was active only for those instructors in the early stages of their career. This result is in line with the findings of Thomson, Onkal, Avcioglu, and Goodwin (2004) that human factors tend to guide novice pilots.

This protective effect of flight experience may be related to training in and knowledge of human factors. Indeed, experience was negatively (albeit only marginally so) related to training. That is, those instructors who had attended human factors training had fewer years of experience in aviation than did those who had not. Thus, novice instructors may be more likely to take part in training (i.e., perhaps because of the curriculum), which may in turn increase their knowledge of human factors and lower their negative attitudes toward them.

Also with respect to the first hypothesis, there were significant linear and quadratic components of the overall effect of flight experience on perceived invulnerability to stress, supporting the hypothesis of Stewart (2006). That is, the relationship between experience and perceived invulnerability was positive for instructors with low levels of experience, its magnitude decreasing with increasing experience; the relationship became negative after 27.13 years in aviation, its magnitude increasing with increasing experience. This result alludes to a complex relationship between flight experience and perceived invulnerability: The protective effect of experience on this hazardous attitude only kicked in after nearly three decades of experience in aviation. This result supports the conclusion of Thomson et al. (2004) that task-oriented factors (e.g., controllability) appear to influence the perceptions of experienced pilots.

Whether this relationship originates from first-hand negative experiences, or from observing the misfortunes of others, remains unclear: Involvement in accidents/incidents was not a significant predictor of hazardous attitudes. However, there was a marginally significant negative correlation between involvements in accidents/incidents and perceived invulnerability, with those instructors who had been involved in accidents/incidents reporting lower invulnerability to stress.

Hypothesis (3) was partially supported, with greater risk-taking attitudes being significantly related to greater negative attitudes toward human factors (but not to a greater perceived invulnerability to stress). The relationship between risk taking and invulnerability may be more complex than originally expected given their significant negative correlation in the current study. That is, as experience increased, risk taking decreased. This linear relationship between the two variables alludes to the presence of a curvilinear relationship between risk taking and invulnerability: Indeed, an inspection of the scatterplot of risk taking and invulnerability suggests a negative concave downward curve. In other words, the relationship between risk taking and invulnerability became increasingly negative as risk taking increased.

4.2 Limitations

The measurement model associated with the hazardous attitudes did not replicate that of Simpson and Wiggins (1999), yet I identified two constructs underlying the set of available items: negative attitudes toward human factors and perceived invulnerability to stress (consistent with the work of Sexton et al., 2001). However, the two scores lack reliability, and their validity remains unknown. The same thing can be said of the risk-taking score; that is, its reliability and validity need to be further explored.

Another limitation of the current work is the exclusive use of self-report measures, which lowers its internal validity (Cook & Campbell, 1976), as does its non-experimental nature. Many other causal models may be consistent with the models tested here: For example, although I assumed risk taking attitudes to be relatively stable (at least in a given risk domain) and to covary with flight experience, experience may predict recreational/safety risk taking (via, for example, personal control).

Similarly concerning is the sparseness of the data at high values of flight experience, as polynomial equations can be highly unstable and grossly affected by individual outliers (Cohen et al., 2003). Cohen et al. suggest cases may be sampled systematically to increase the stability of regression equations.

Lastly, the findings may not generalize to the population of gliders, as the data originated from glider instructors only.

4.3 Recommendations

To suggest detailed applications for the results would be premature given the uncertainty associated with the reliability and validity of the scores and the exploratory nature (at least in part) of the study. Arguably, the findings are exciting as far as the complex relationship between flight experience and hazardous attitudes is concerned. However, before making recommendations, additional research is needed.

In the long term, reliable and valid scores could find application in the measurement of negative attitudes toward human factors and perceived invulnerability to stressors as a mean of evaluating the effectiveness of programs aimed at improving safety attitudes. These programs could include, for example, training or self-awareness interventions aimed at developing and maintaining positive attitudes toward human factors or reasonable levels of perceived invulnerability to stress (Hunter & Stewart, 2009).

4.4 Suggestions for Future Research

In the short term, of great importance is the refinement of the scale items or the adaptation of an established instrument such as the New Hazardous Attitude Scale of Hunter (2005) to the gliding context. After the reliability and validity of their scores have been established, items should be administered to a large representative sample of glider pilots in order to provide a normative base for future comparisons. Even better, the results from this administration, particularly participants' feedback, could serve as a basis for further scale development work.

Future research could then investigate whether or not the results of the current study are stable and reproducible. Ideally, such an endeavour would include a longitudinal study of change over the career cycle of glider pilots as well as simple experiments to establish causality. Additional work could eventually consider the role of social and peer influences (e.g., disapproval) on hazardous attitudes (Goh & Wiegmann, 2001) and/or evaluate more complex predictive models of hazardous attitudes aiming to explain mediating or moderating relationships.

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List of acronyms

CEFA	Comprehensive Exploratory Factor Analysis
CI	Confidence Interval
DOSPERT	Domain-Specific Risk-Taking Scale
DRDC	Defence Research & Development Canada
EM	Expectation Maximization
EQS	Structural Equation Modeling Software
HF	Human Factors
ML	Maximum Likelihood
N	Number
OLS	Ordinary Least Squares
RMSEA	Root Mean Square Error of Approximation
SD	Standard Deviation
SE	Standard Error

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(U) Crew members' hazardous attitudes (including invulnerability to stressors) have been identified as possible contributing factors to many aviation accidents, and a great deal of research in this area thus far has been directed toward developing effective training programs to modify them to reflect realistic and positive attitudes towards flight safety. Yet little research has explored the role of flight experience and risk−taking attitudes in explaining hazardous attitudes, especially outside the context of general aviation. The current work extends existing research by examining the hazardous attitudes of glider instructors. It also investigates the role played by flight experience and risk−taking attitudes in predicting the instructors' hazardous attitudes, considering both the linear and curvilinear relationships between flight experience and hazardous attitudes. These cross−sectional data, originating from 144 current and past glider instructors from five Regional Gliding Centres across Canada, provided partial support for the hypotheses. Of note were the significant quadratic components of the overall main effect of flight experience on hazardous attitudes. As well, greater risk−taking attitudes were significantly related to greater negative attitudes toward human factors, as was a basic knowledge of human factors. I summarize the findings and present limitations of the study as well as suggestions for future research.

(U) Il a été établi que l'attitude dangereuse des membres d'équipage (y compris une invulnérabilité face aux facteurs de stress) était probablement un facteur contributif dans de nombreux accidents d'aviation. D'importantes recherches effectuées dans ce domaine ont jusqu'à maintenant été axées sur l'élaboration de programmes de formation efficaces visant à modifier ces attitudes afin d'encourager des comportements réalistes et positifs envers la sécurité en vol. Pourtant, il y a eu très peu de recherches sur le rôle que joue l'expérience de vol et la propension à prendre des risques des membres d'équipage pour expliquer les attitudes dangereuses, surtout en dehors du contexte de l'aviation générale. L'étude en cours a été élargie pour inclure les attitudes dangereuses des instructeurs de vol sur planeur. On a également examiné le rôle que jouent l'expérience de vol et la propension à prendre des risques dans le but d'anticiper les attitudes dangereuses des instructeurs, en tenant compte des relations linéaires et curvilignes entre l'expérience de vol et les attitudes dangereuses. Ces données transversales, obtenues par l'observation de 144 instructeurs de vol sur planeur, en activité ou non, œuvrant dans cinq centres de vol à voile régionaux répartis dans tout le Canada, corroborent en partie nos hypothèses. Parmi les éléments remarquables, il y a les composantes quadratiques marquées de l'ensemble de l'incidence principale de l'expérience de vol sur les attitudes dangereuses. De plus, on a pu établir un lien direct marqué entre la propension à prendre des risques et une attitude plus négative envers les facteurs humains, tout comme dans le cas d'une connaissance de base des facteurs humains. Je présente ici un résumé des faits établis et les limites de l'étude et propose des sujets pour de futures recherches.

14. KEYWORDS, DESCRIPTORS or IDENTIFIERS (Technically meaningful terms or short phrases that characterize a document and could be helpful in cataloguing the document. They should be selected so that no security classification is required. Identifiers, such as equipment model designation, trade name, military project code name, geographic location may also be included. If possible keywords should be selected from a published thesaurus, e.g. Thesaurus of Engineering and Scientific Terms (TEST) and that thesaurus identified. If it is not possible to select indexing terms which are Unclassified, the classification of each should be indicated as with the title.)

(U) Flight; Risk Taking; Hazardous Attitudes; Glider; instructor