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An Examination of Hangover Effects on Pilot Performance

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AN EXAMINATION OF HANGOVER EFFECTS
ON PILOT PERFORMANCE

by

JoAnne W. Bates
Master of Science, University of Tennessee at Chattanooga, 1994

A Dissertation
Submitted to the Graduate Faculty
of the
University of North Dakota
in partial fulfillment of the requirements
for the degree of
Doctor of Philosophy

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2001

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This dissertation, submitted by JoAnne W. Bates in partial fulfillment of the requirements for the Degree of Doctor of Philosophy from the University of North Dakota, has been read by the Faculty Advisory Committee under whom the work has been done and is hereby approved.

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This dissertation meets the standards for appearance, conforms to the style and format requirements of the Graduate School of the University of North Dakota, and is hereby approved.

Carl
Dean of the Graduate School

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Degree Doctor of Philosophy

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To Patrick Thor Bates

ABSTRACT

The present study investigated the influence of ethanol on aviation performance 10 hours after subjects finished drinking. The results of past studies concerning alcohol hangover effects are conflicting. Some studies have shown that alcohol hangovers affect complex cognitive performance, while other studies have not found effects.

One aim of the present study was to observe hangover effects after strong and medium doses of alcohol with an intervening night of sleep. Furthermore, previous research has found that use of ethanol increased variability in flying performance. This implies that hangover effects influence some pilots more than others. Therefore, this study also examined individual pilot characteristics that may modify the degree of hangover effects observed.

In the present study, subjects' performances were measured on several indices of information processing and optometric functioning that are theorized to be related to flying ability. The three groups of subjects were administered: (1) a placebo, (2) alcohol until their blood alcohol levels (BAL) reached 0.05% BAL, or (3) alcohol until their blood alcohol reached 0.1% BAL. Subjects were given overnight accommodations after the target BAL was reached. At 9 a.m. the following morning, the subjects piloted a Frasca 241 flight simulator. Effects of alcohol

hangover were found on two aspects of airplane pilot performance. There were significant differences on two flight performance measures: bank angle and rate of turn. These differences were seen only between the placebo group and the high dose group (3mg/kg; 0.1% BAL). There were no significant differences in performance between the placebo group and the moderate alcohol dose (0.05% BAL) group. The results of the present study support the notion that alcohol impairs performance at least 10 hours after reaching 0.10% BAL.

CHAPTER I

INTRODUCTION

Since the 1950's, the examination of the physiological and cognitive effects of alcohol use has taken place in the fields of medicine and behavioral science (Milam & Ketcham, 1981). This introduction to the present study serves to briefly review the physiological and cognitive effects of alcohol that have been examined. General facts about alcohol use and its physiological effects, studies of alcohol effects on cognition, alcohol hangover, and alcohol and aviation will be reviewed.

Alcohol

The use of alcohol by people all over the world is well documented by an assortment of texts that use the relationship of alcohol and people as an example of the way a substance alters the physical chemistry of humans (Austin, 1985; Blum, 1991; Fishman, 1987; Milam & Ketcham, 1981).

Even in early written records, such as the books of the Bible, essays by Aristotle, and plays by William Shakespeare there are references to alcohol use. For example, according to the book of Genesis, after Noah survived the great flood he started a vineyard and frequently drank wine to the point of intoxication (Fishman, 1987). Furthermore, avoiding intoxication, or drunkenness, was the topic of moralistic essays

by Aristotle (circa 300 BC). Likewise, in the 17th century, Shakespeare often portrayed his characters drinking alcohol in depicting social traditions and also he used drunken characters for comic relief.

The parallel conceptions of (1) the moderate use of alcohol as a traditional drink and (2) the contempt of drunkenness, or abusing alcohol, have both invariably been parts of the human endeavor (Austin, 1985; Blum, 1991; Fishman, 1987; Milam & Ketcham, 1981).

Along with the struggle to not drink too much comes the common negative after effect of drinking too much, otherwise known as a hangover. For as long as alcohol has been discussed in human history, so has the proverbial hangover (Fishman, 1987; Milam & Ketcham, 1981).

The medical and psychological details of hangovers will be discussed in a later section in this chapter. In short, a hangover is characterized by unpleasant physical symptoms that often occur after alcohol is ingested to the point of intoxication. Some of the more common hangover symptoms include headache, nausea, and fatigue. However, regardless of these negative effects related to hangover, the positive physical effects of alcohol tend to outweigh the potentiality of hangover for many people (Blum, 1991).

Alcohol ingested in small quantity (e.g., one drink) acts as an exhilarating stimulant on the human body. While on the other hand, alcohol ingested in larger quantity causes sedating, relaxing physical

consequences. Both of these effects, stimulation and relaxation, are desired by many people and have been throughout history. However, though alcohol produces desired effects, when used in excess it can be toxic. Also, when used in large amounts over long periods of time alcohol damages cells, tissues and organs of the body (Lieber, 1976; National Institute on Alcohol Abuse and Alcoholism, 1999).

To complicate the human-alcohol relationship further, alcohol is sometimes safer to drink than other liquids and humans must drink liquids. People often drank wine or other alcoholic beverages in place of water when water sources were contaminated. Fermented beverages such as wine kill the bacteria that may contaminate water. Also, alcohol is a carbohydrate-based drink, not just a drug. Alcohol is an unusual substance because it is considered a drug as well as a food. This is because alcoholic beverages are rich in calories and a potent source of energy for the body. However, though it is a food, alcohol is of little nutritious value, containing very few vitamins or minerals.

Alcohol is in fact a chemical called ethyl alcohol or ethanol. Alcohol is actually the excrement of yeast, which is a fungus with a ravenous appetite for sugar. When yeast encounters honey, fruits, or grains, for example, it releases an enzyme that converts sugar into carbon dioxide and alcohol. This process is known as fermentation (Austin, 1985; Milam & Ketcham, 1981).

Beers and wines are made through the fermentation process.

Fermentation was discovered by accident because it occurs naturally.

Distillation, however, is a manufacturing process designed to take over where the natural yeast fermentation stops and results in beverages with higher percentages of alcohol such as vodka, rum, whisky, bourbon, scotch, rye, and gin. Pure alcohol is a colorless, harsh liquid that is combined with water and various substances called congeners in order to make it palatable. Different congeners give alcoholic beverages distinct flavors.

Distilled, or hard, liquors, such as vodka, brandy, whisky or rum contain more alcohol than beer or wine. The higher the percentage of alcohol in a beverage, the less one has to consume to acquire the physical consequences of alcohol (Austin, 1985; Wiese, 2000).

When a human drinks alcohol, it travels rapidly to the stomach, where approximately 20 percent immediately pass through the stomach walls into the blood stream. The remaining 80 percent are transferred from the stomach to the small intestine, where is it then absorbed into the blood stream (Blum, 1991; Fishman, 1986; Milam & Ketcham, 1981).

The concentration of alcohol in the body is represented in terms of the blood alcohol level (BAL) (also termed blood alcohol concentration or BAC) which is a measure of the percentage of alcohol in the blood. A 0.05 BAL, for example, indicates approximately 5 parts alcohol to 10,000 parts other blood components. When more alcohol is ingested than the

human body can immediately eliminate (approximately 1 ounce of 100 proof whisky per hour), alcohol accumulates in the blood stream, and the BAL rises (Blum, 1991; Milam & Ketcham, 1981).

As the human body's BAL rises, behavior, thoughts and emotions are increasingly affected, with severe disruptions in behavior occurring at high BALs (Fillmore & Vogel-Sprott, 2000). For example, BALs of 0.10 and 0.08 (depending on the state) are considered high and used for specifying legal intoxication in most of the US. Moreover, when blood alcohol concentrations reach very high levels, the brain's control over the respiratory system may be paralyzed. A 0.40 BAL can cause a person to lapse into a coma. At 0.60 BAL death usually occurs (National Transportation Safety Board, 2000).

A number of factors can affect the rate at which the BAL rises and thus the rate at which behaviors are altered. Body weight is one factor. The more a person weighs, the more water there is in the body to dilute the alcohol and therefore lower the BAL. A 200-pound male will have an approximate 0.15 BAL after drinking eight cans of beer, whereas a 150-pound male, drinking at the same rate, will have an approximate 0.20 BAL with the same intake. The 150-pound male therefore would be more intoxicated. It is thus the BAL, not the amount of alcohol consumed, which determines the effect on behavior (National Institute on Alcohol Abuse and Alcoholism, 1999).

Gender is another factor that affects the BAL. Females reach higher BALs faster because their bodies contain less water and more fat tissue than males. Fat tissue is not easily penetrated by alcohol. Hormones may also affect the BAL. With the same intake of alcohol, women often experience the highest BALs premenstrually and the lowest on the first day of the menstrual cycle (Dubowski, 1976; Frezza, di Padova, Pozzato, Terpin, Baraona, & Lieber, 1990).

Correspondingly, food or lack of it can alter the BAL. An empty stomach does not have anything with which to dilute alcohol and slow down its absorption into the blood stream. As a result, the BAL rises more rapidly in those who drink alcohol on an empty stomach. Conversely, when food (particularly high protein foods, such as cheese, meat, and eggs) is in the stomach, the absorption rate is slowed down (National Institute on Alcohol Abuse and Alcoholism, 1999).

Two other factors that may influence alcohol absorption into the blood stream are the type of mixer used with the alcohol and the temperature of the drink. Water and fruit juices slow the absorption process by diluting the alcohol. On the other hand, drinks such as carbonated soda containing carbon dioxide speed up the absorption process by rushing through the stomach and intestinal walls and into the blood stream. Furthermore, warm alcohol is absorbed more rapidly than cold alcohol (Lieber, 1976).

Finally, the concentration of alcohol or proof of a beverage influences absorption into the blood stream. Ingesting liquors with higher concentrations of alcohol usually result in more rapid absorption. Pure alcohol (100 proof) is generally absorbed faster than diluted liquors (e.g., 86 proof gin) which are, in turn, absorbed faster than wine or beer. However, a contrary effect sometimes occurs when people drink high concentrations of alcohol, such as high proof liquors. The body may secrete a mucous into the stomach to protect the stomach lining from irritation. This extra mucous may delay the absorption of the alcohol into the blood stream. Each of these previously mentioned factors might influence both the processes of alcohol entering into the blood stream and the BAL rising (Blum, 1991; Institute of Alcohol Studies, 1991; Lieber, 1976; Milam & Ketcham, 1981).

When a person's BAL starts to rise, the effects of alcohol begin. Such feelings as exhilaration and relaxation are experienced with low blood alcohol levels (e.g., 0.01 - 0.03 BAL). As the BAL increases a person becomes intoxicated which causes impaired motor coordination and cognitive functions. As a result, intoxicated people are not fit to function normally or perform work efficiently (Blum, 1991; Fishman, 1986; Institute of Alcohol Studies, 1986; Milam & Ketcham, 1981; Paton, A., 1999). As well noted by traffic statistics, intoxicated people can be dangerous operating machinery such as automobiles (National Transportation Safety Board, 2000).

Coordination of motor skills, decision-making abilities, and vision are all impaired by drinking alcohol and this in turn affects activities such as driving or piloting. Consuming alcohol affects the human body and the human brain; thoughts and actions are altered by the consumption of alcohol. In other words, alcohol modifies cognition (Milam & Ketcham, 1981; Paton, A., 1999).

Cognition

Composite processes called cognition control both actions and thoughts. A simple definition of cognition is the acquisition of knowledge. However, both the acquisition and the use of knowledge involve numerous mental skills.

Human cognition includes such processes as pattern recognition, attention, memory, visual imagery, language, problem solving, and decision making. Some of the many cognitive processes that are carried out by humans are simple while some are more complex. In fact, it has been shown that cognitive tasks vary considerably in the amount of mental effort required to perform them. Some skills become so well practiced and routine that they require very minimal capacity. The term automatic processing is used to describe these routine skills.

Automatic processing is very useful because it allows people to perform routine activities without much concentration or mental effort. Some examples of skills that often become automatic for people are: typing, reading music and playing the proper keys on an instrument,

using a clutch and gear shift in an automobile, or walking a familiar route. However, automatic processing can also be a disadvantage because people may put so little thought into what they are doing that they make silly mistakes or fail to remember what they did. Nonetheless, in order to perform more complex tasks automatic processing of other tasks is necessary.

Automatic processes allow people to perform complicated skills that would otherwise overload limited human cognitive capacity. Piloting a plane, for instance, is a complex cognitive task because it requires many aspects of cognitive processing. For example, a pilot must use automatic skills such as reading flight instructions, maps and instrument dials as well as concentrating on specific novel information from Air Traffic Control (ATC) about a current flight. Therefore, a task such as piloting a plane is a complex cognitive task (Reed, 2000).

People perform complex cognitive tasks every day. Therefore, studying the effects of certain substances, such as alcohol, on human cognition has been an consequential topic in medical and psychological research (Austin, 1985; Lieber, 1976). The influence alcohol has on human performance falls into the category of transient cognitive impairment. Transient cognitive impairment refers to changes in mental state that occur with certain human conditions (Gevins & Smith, 1999).

Alcohol and Cognition

Some of the conditions that can cause transient cognitive impairment are: sleep deprivation, some illnesses (e.g., influenza, strep throat), use of common medications (e.g., antihistamines, narcotic pain relievers), alcohol intoxication, and alcohol hangover. These conditions may cause a person to be overly emotional, lack normal motor coordination, and have trouble concentrating. People suffering from transient cognitive impairment are not at full mental alertness and their reaction times are not up to speed. Individuals who are cognitively impaired (e.g., intoxicated or experiencing hangover symptoms) may have the ability to carry out rote functions sufficiently despite being intoxicated. Rote functions are repetitive behaviors that are performed without attention to meaning. However, due to transient cognitive impairment, these individuals may be inaccurate in situations that tax the limits of their attentional capacity, such as complex cognitive tasks (e.g., driving, piloting) (Gevins & Smith, 1999).

The effects of alcohol on cognition have been studied extensively in the fields of medicine (Kauhanen, Kaplan, Goldberg, Cohen, Lakka, & Salonen, 1997), physiology (Heikkonen, Ylikahri, Rone, Valimaki, Harkonen, & Salaspuro, 1998) and psychology (Harburg, Gunn, Gleiberman, DiFranceisco, & Schork, 1993). Numerous studies have shown that alcohol consumption alters cognitive functioning (Easdon & Vogel-Sprott, 2000; Fillmore, Vogel-Sprott, Gavrilesco, 1999; Howland,

Rohsenow, Cote, Siegel, & Mangione, 2000; Maylor & Rabbitt, 1993; Tzambazis & Stough, 2000; Usakov & Egorov, 1996). Alcohol changes cognitive processes by causing impaired motor coordination, blurred vision, alterations in thinking and decision making, and mental confusion (Delin, 1992; Milam & Ketcham, 1981).

Furthermore, effects of alcohol after blood alcohol level reaches zero (hangover effects) have also been studied in reference to physiological (Squier, 1999) and cognitive (Yesavage & Leirer, 1986) factors. However, the exact implications of hangover effects on performance of complex cognitive tasks have yet to be determined.

Wiese, Shlipak, and Browner (2000) state that there is no agreed upon definition of the medical condition termed *veisalgia* (alcohol hangover). Most medical studies on *veisalgia* or hangover have identified a set of common physical symptoms that occur with this condition and these include headache, diarrhea, trembling, fatigue, lack of appetite, and nausea. These authors define hangover as the presence of at least two of the aforementioned "symptoms occurring after the consumption and full metabolism of alcohol with sufficient severity to disrupt the performance of daily tasks and responsibilities" (p. 898).

Though hangover has often been considered unimportant as a medical condition, it has important economic consequences. This is due to the common occurrence of hangover. When surveyed, 29% of college students report losing school time because of hangover symptoms. Of

the general population surveyed, 15% of men and women report having hangovers at least monthly. Alcohol use in the U.S. is cited as costing \$148 billion annually in lost work days due to "decreased occupational productivity caused by hangover-like symptoms" (Wiese et al., 2000, p. 898).

Most of the lost-work costs are caused by light to moderate users of alcohol (0-3 drinks per day for men and 0-1 drinks per day for women). This is because they constitute most of the work force. However, actual chronic alcoholism causes only a small portion of economic losses of alcohol use in the work place (Blum & Payne, 1991; Wiese et al., 2000).

Hangover is a term often used to indicate the adverse after effects of consuming alcohol. Hangover may begin when a substantial blood alcohol level (BAL) starts to decline as the BAL approaches 0.0% (Lemon, Chesher, Fox, Greeley, & Nabke, 1993). Symptoms accompanying a hangover can continue for up to 24 hours. Physical symptoms of hangover may include headache, dizziness, fatigue, muscle aches, increased sensitivity to light and sound, thirst, and redness of the eyes. Increased systolic blood pressure, sweating and rapid heartbeat are signs of increased sympathetic nervous system function that can appear with a hangover. Other emotionally linked symptoms, including possible mood disturbances such as depression, anxiety and irritability, have also occurred with hangovers for some people (Swift & Davidson, 1998).

Alcohol intoxication causes blood pressure to increase. During the period when blood alcohol levels are decreasing, usually at night, both systolic and diastolic blood pressure levels fall to less than the basic level. These major and rapid changes in blood pressure might increase the likelihood of strokes (Seppa & Sillanaukee, 1999).

Not everyone experiences hangover symptoms and those who do vary in the degree of the severity of symptoms (Wall, Horn, Johnson, Smith & Carr, 2000). Circumstances that may add to the severity of hangover symptoms include insufficient food consumption, lack of quality or quantity of sleep, heightened physical activity while intoxicated, dehydration, and poor physical health (Tornros & Laurell, 1991; Yesavage, Dolhert, & Taylor, 1994).

Several medical studies have examined possible preventive methods and treatments for the physical symptoms of hangover. One study assessed the use of the high-blood pressure medication, propranolol, to treat hangover symptoms. This drug did not show sufficient results to relieve hangover symptoms (Bogin, Nostrant, & Young, 1987). The outcome of simple carbohydrates (glucose) on hangover severity has been shown to be ineffectual. Subjects were administered glucose and their hangover symptoms were not reduced (Seppala, Leino, Linnoila, Huttunen, & Yikarhri, 1976).

Yet, in another study, the administration of 1200 mg of vitamin B6

decreased the number of hangover symptoms in subjects (Khan, Jensen, & Krogh, 1973). In addition, sufficient hydration has been shown to reduce the unpleasant physical symptoms that occur with alcohol hangover (Squier, 1999).

Wiese et al. (2000) indicates that hangover is a pressing medical problem that deserves more research in order to find treatments. With a successful treatment, individuals might experience less physical discomfort with hangover. However, these authors state that even with overt hangover symptoms treated, individuals would continue to suffer the impairments in visual-spatial, cognitive, and cardiovascular systems due to hangover.

For moderate drinkers, approximately 5 to 6 drinks for men and 3 to 5 drinks for women will almost always lead to hangover. The type of alcohol consumed might also contribute to the severity of hangover symptoms. The byproducts of particular alcohol preparations, called congeners (which are found principally in dark liquors such as brandy, wine, tequila, and whiskey), increase the severity and frequency of hangover symptoms. Clear liquors, such as vodka, rum, and gin, tend to cause hangover symptoms less often (Chapman, 1970; Damrau & Liddy, 1960; Milam & Ketcham, 1981; Wiese et al., 2000).

Along with the physical symptoms, differences in cognitive performance linked to hangovers have been studied. The terminology “post intoxication effects” and “hangover effects” are used to denote

alterations in perception, cognition and performance due to the prior consumption of alcohol, occurring after the BAL has reached 0.0%. (Lemon et al., 1993).

Early studies on hangover effects showed high doses of alcohol bring about behavioral impairment up to 8 hours after drinking. Coordination of motor skills, decision-making abilities, and vision are all impaired several hours after drinking alcohol (Karvinen, Miettinen, & Ahlman, 1962; Myrsten, Post, & Franenhaeuser, 1971; Takala, Siro, & Toivaninen, 1958).

Unfortunately, the more recent results from the various studies that focus specifically on hangover effects upon cognitive performance are conflicting. Some studies show that hangover does effect motor and cognitive performance while other studies show no hangover effects on performance. It has yet to be clearly determined whether hangover effects on complex cognitive performance occur (Swift & Davidson, 1998). Performance on some difficult and complex tasks was shown to be adversely affected for some time after alcohol has been cleared from the system (Morrow, Yesavage, Leirer, Dolhert, Taylor, & Tinkleberg, 1993; Yesavage & Leirer, 1986). These two studies are discussed in greater detail in following sections on aviation. Morrow et al. (1993) found increased variability in cognitive and motor performance after drinking was present up to 8 hours after subjects finished drinking. Yesavage and Leirer (1986) found that subjects' cognitive and motor performance

declined and increased variability in performance was greater after drinking even when BAL level was 0.0%.

In contrast to the findings of the two previously mentioned studies, however, various studies found no evidence to support hangover effects on simple or complex cognitive performance (Bowden, Walton & Walsh, 1988; Finnigan, Hammersley & Cooper, 1998; Lemon et al., 1993; Streufert, Pogash, Braig, Gingrich, Kantner, Landis, Lonardi, Roache & Severs, 1995).

Bowden et al. (1988) attempted to predict cognitive performance from self-reports of alcohol consumed 24 hours prior to testing. They found no significant results to support the notion that alcohol ingestion produces a measurable toxic effect on brain function after the period of acute intoxication.

Finnigan et al. (1998) examined forty male subjects for hangover effects on psychomotor performance. Treatment group subjects were administered alcohol until 0.1% BAL was reached. The authors found no evidence for impaired performance the morning after ingestion.

Lemon et al. (1993) tested subjects on a simple reaction time task, a divided attention task, and a complex cognitive task the morning after drinking. Subjects were assigned to one of four alcohol dosage conditions: placebo, 0.0% BAL; low, 0.05% BAL; medium, 0.075%; and high 0.1% BAL. The authors found no evidence to support a hangover effect on cognitive performance.

Streufert et al. (1995) tested subjects on multiple decision-making tasks the morning after having a BAL of 0.1%. They found no impairment due to hangover effects on decision-making ability.

The findings from the research on hangover effects are uncertain at this time. More research needs to be conducted in the area to determine the implications of hangover effects on cognitive performance. This is an important topic because of the possible danger to drivers, pilots and passengers that may occur if people are not educated about the possible after effects of consuming alcoholic beverages (Swift & Davidson, 1998).

Alcohol and Aviation

Though the findings about hangover effects are equivocal, the data on alcohol intoxication effects on cognition are more apparent. Drinking alcohol in moderate to high doses (0.04% - 0.1% BAL and over) has been shown to impair cognitive and motor performance (Easdon & Vogel-Sprott, 2000; Fillmore, et al., 1999; Howland, et al., 2000; Maylor & Rabbitt, 1993; Tzambazis & Stough, 2000; Usakov & Egorov, 1996).

Alcohol use and aviation, as well as using other dangerous machinery, has been researched because of the possible risk factors involved when a pilot, or driver, uses alcohol and operates an aircraft or another dangerous machine. The implications of the aviation and alcohol research may be applied to use of any dangerous machine (Swift & Davidson, 1998; Wiese, 2000).

As stated previously, people have the tendency to drink alcohol (Blum, 1991; Fishman, 1987; Milam & Ketcham, 198). Pilots are certainly not exempt to the extensive use of alcohol in human culture. However, alcohol use by pilots is a concern due to the nature of their professional duties. Professional pilots have been found to be heavier drinkers than private pilots (Maxwell & Harris, 1999). The responsibilities and pressures involved with the professional airline pilot's job are very stressful. Often people drink more off duty when they have been or expect to be under stressful job related situations (Carney, Armeli, Tennen, Affleck, & O'Neil, 2000). Cuthbert (1997) has suggested that opportunities for alcohol consumption are higher amongst aircrew. He also referred to factors such as work pattern, time away from home, social custom and fatigue, which may all tend to increase alcohol consumption. This suggests a potentially worrying combination of both increased acceptability and increased availability of alcohol for this group in comparison with other pilots.

Alcohol abuse by airline pilots may threaten public safety. Intoxication has been implicated in some aviation accidents (Modell & Mountz, 1990). Monitoring DWI (driving while intoxicated) convictions and random preflight alcohol testing are two strategies that are used to prevent alcohol abuse by pilots (McFadden, 1997). The National Transportation Safety Board (NTSB) (1986) cited alcohol impairment as an important contributory factor to general aviation accidents in the

United States. These 1980-1986 records revealed that 5.3% of the fatally injured pilots tested positive for alcohol. In accordance, public law 100-591 was put into effect in 1988 and states that the Federal Aviation Authority (FAA) must conduct postmortem toxicology tests on aviators to try and determine the effects of drugs and alcohol on human performance. Furthermore, it was found that 8% of the aviators tested from accidents between 1989 and 1993 had a BAL at or above the legal limit of 0.04% (Canfield, Flemig, Hordinsky, & Birky, 1995).

Regulations regarding the use of alcohol and the piloting of aircraft differ. Certain armed services require a 12-hour abstinence from consuming alcohol before piloting. Alternatively, some scheduled carriers require as much as 24 hours of abstinence from drinking. Some authors suggest that alcohol/aviation regulations have been decided without the backing of satisfactory empirical investigation of the effects of alcohol or hangover on flying performance (Wick, 1992; Yesavage & Leirer, 1986).

However, the Federal Aviation Administration (FAA) is responsible for establishing guidelines that regulate alcohol consumption of pilots prior to acting as crewmembers on any civil aircraft. Current regulations (Federal Aviation Regulations & Airman Information Manual, 2001; Spence, 2001) mandate a maximum blood alcohol level (BAL) of 0.04% (less than 40 mg of alcohol per 100 ml of blood) and that aviators cease drinking a minimum of 8 hours before piloting a plane. This is

commonly known as the eight-hour “bottle to throttle” rule. This regulation was put into effect in 1985 (Widders & Harris, 1997).

In response to an alarmingly high rate of aviation accidents where alcohol was cited as a contributing factor, the FAA funded an in-flight study of alcohol effects on pilot performance in 1972. Wick, Billings, Gerke, and Chase (1972) conducted the study on which the current aviation regulations are based.

The Wick et al. (1972) experiment consisted of 16 instrument-rated pilots flying a series of instrument approaches after being administered a number of either placebo or alcohol drinks. They tested BAL of 0.0%, 0.04%, 0.08%, and 0.12%. As a scoring device, a Cessna 172 flight simulator was modified with on-board computers to monitor pilot performance on quantifiable parameters such as deviations from a glide slope (a unidirectional navigational signal which provides vertical course guidance on an instrument approach) and deviations from the localizer (a similar device which provides horizontal guidance). The safety pilot on board the aircraft hand-scored objective procedural-type errors such as failing to retract the landing gear on a missed approach. Performance deterioration was discovered at each of the BALs tested.

In a more recent article, Wick (1992) stated that when his research team did the study in 1972 that the FAA used to set the 0.04% BAL standard for pilots, they did not intend for that to be used as a concrete limit. Wick (1992) states that the study results were not meant to “serve

as any sort of regulatory benchmark” (p. 213). The researchers did not propose that 0.04% be used as a limit below which it was safe to fly. The author disclaimed any determination of a blood alcohol level below which there was no impairment. In other words, there is no proof that even a small amount of alcohol does not impair motor behavior or cognition. It is possible, depending on the person, that indeed a small amount of alcohol may alter human functioning.

Widders and Harris (1997) state that the United Kingdom (UK) Civil Aviation Authority proposed that a maximum BAL limit of 0.02% should be imposed on UK pilots. These authors found that a large percentage of the 477 pilots they surveyed could not calculate when their BAL was likely to fall below this level after consuming alcohol and could, therefore, possibly unintentionally violate the regulation. In 1999, the European Joint Aviation Authorities operations regulations were revised to prohibit airplane pilots from flying with a BAL greater than 0.02% (Maxwell & Harris, 1999).

Since the FAA’s 1985 decision to state the 0.04% BAL cutoff in their regulations, there have been studies conducted on the effect of alcohol on pilot performance. The role of alcohol on aviation performance has been examined by using slightly differing methodologies. One type of study administered alcohol to subjects until they achieved blood alcohol levels at or below 0.04% and immediately (within 1 to 5 minutes) examined flight performance under low BAL

(Davenport & Harris, 1992). Another type of study examined flying performance after subjects reached a 0.1% BAL and then 2, 4, 8, 24, and 48 hours after they stopped drinking (Morrow et al., 1993).

Davenport and Harris (1992) administered alcohol to aviator participants until they achieved blood alcohol levels of 0.04% and immediately examined flight performance. They tested 8 pilots with a mean age of 33 years and a mean flying experience of 3,109 hours. Four subjects were randomly assigned to the alcohol condition and four were assigned to the placebo condition. Subjects were required to perform four simulated approaches during the study; two performed visually and two performed using the instrument landing system (ILS). Within each type of approach, subjects made one approach with both engines operative and one approach in which one engine failed. Subjects given alcohol showed larger performance decrements (vertical and horizontal deviations from optimum flight path) in a high cognitive workload situation such as during an ILS (instrument landing system) approach and when one engine failed.

Morrow et al. (1993) reported a study where subjects performed the same flight scenario under an alcohol and placebo condition in two separate experimental sessions. Within each session, pilots flew after reaching a 0.1% BAL (in the placebo condition pilots flew at about the same time they would have reached 0.1% BAL) and then 2, 4, 8, 24, and 48 hours after they stopped drinking. Pilots flew in a Frasca 141 flight

simulator and the specific flight scenario involved a climb out (flight take off procedure), eight legs (procedures) assigned by air traffic control, and the approach and landing. The errors monitored included flying errors, communication errors, and failure to detect potential safety problems. A summary score, that was a combination of all the dependent measures, was computed each time the pilot flew. Results indicated a significant decrement in performance when tested at a 0.1% BAL and 2 hours after they stopped drinking, while non-significant decrements in performance were observed at 4 and 8 hours after subjects finished drinking.

Increased variability after drinking was present up to 8 hours after subjects finished drinking. Morrow et al. (1993) gave their subjects extensive practice in the simulator (over 8 hours) because only half of their subjects were instrument rated. In addition, subjects who flew in the placebo session first showed considerably less impairment from alcohol than subjects who flew the alcohol session first. Morrow et al. (1993) state that this is a possible problem with their study.

If subjects first perform a task as the control group and then as the treatment group (or vice versa) they may get practice at the task and this may misconstrue the data. This may occur when within-subjects research designs are used, such as in the previously discussed study performed by Morrow, et al. (1993). In order to avoid this problem of practice effects, subsequent work in this area needs to have alcohol level as a between subjects factor. Using alcohol as a between-subjects factor

allows different groups of subjects to perform the same tasks under alcohol conditions or placebo conditions. This permits the comparison of the groups without the possibility of confounding due to practice effects (Morrow, et al., 1993).

Mughni and Ross (1996) report that low BAL (0.04% or below) decreases the ability to detect acceleration and deceleration changes in angular motion and this effect persists after the BAL returns to zero. The authors attribute this shift in the ability to detect angular motion to changes in vestibular functioning from consuming alcohol. This is a concern in aviation because pilots need to detect deviations from straight and level flight if distracted from instruments in order to maintain altitude and airspeed conditions (Squier, 1999).

Ross, Yeazel, and Chau (1992) set out to exclusively study low BAL's (below 0.04%) on pilot performance. Thirty-six male pilots, all instrument rated and FAA current (pilots that have been tested and passed FAA guidelines for piloting), participated. Four separate experiments were run using four different flight scenarios. The first two scenarios included complicated departure instructions, a series of non-routine VOR navigation clearances, and at least one instrument approach. VOR (very high frequency omnirange station) is a ground based electronic navigation aid that transmits flight instructions given by ATC over very high frequencies. The remaining scenarios consisted of a series of instrument approaches under light, moderate and heavy

workload conditions. Varying amounts of turbulence, crosswind, and windshear were used to create the three difficulty levels. Each scenario was to be flown in instrument meteorological conditions (mock weather patterns such as turbulence, crosswind, and windshear) simulated by a Frasca 141 flight simulator. The first experiment included 12 pilots; the mean age of this group was 33.9 years. The remaining pilots were divided into three groups of eight with mean ages of 42.2, 43.75, and 41.3 years. Each subject flew a flight scenario under both alcohol conditions; each subject was administered enough alcohol to bring their BAL up to 0.04%. Subjects did not begin flying until their BAL's dropped to 0.03%. A significant correlation between alcohol and performance degradation was found but only under heavy workload conditions. It should be noted that generalizability of this study is limited due to the large age range (23-60 years) of the subjects and the fact that nothing was done to control for this potentially confounding variable. Age is a concern when testing cognitive impairment from alcohol because reaction time slows with age and this must be taken into account when comparing old and young pilots' performances (Morrow, Leirer, & Yesavage, 1990).

It has been shown that moderate to high alcohol intake (0.04% - 0.1% and above) effects motor and cognitive performance (Easdon & Vogel-Sprott, 2000; Fillmore, et al., 1999; Howland, et al., 2000; Maylor & Rabbitt, 1993; Tzambazis & Stough, 2000; Usakov & Egorov, 1996).

With this in mind, it is reasonable to assume that alcohol use may impair some motor and cognitive abilities needed to pilot an aircraft. The public safety issue concerned with combining piloting and drinking alcohol is an important topic for research to make sure that highest safety measures are taken (McFadden, 1997; Wick, 1992).

Alcohol and aviation research is meaningful due to safety concerns. Correspondingly, alcohol hangover research is also important to fully understand the implications of alcohol effects on aviation performance (Swift & Davidson, 1998).

Hangover and Aviation

Alcohol hangover effects are not always detected in pilot performance (Taylor, Dolhert, Morrow, Friedman, & Yesavage, 1994). However, after assessing hangover effects on aviation performance, several authors state that pilots should be aware that their performance might be adversely affected by recent alcohol intake, even if their BAL is 0.0% (Mughni & Ross, 1996; Squier, 2000; Taylor, et al., 1994; Yesavage & Leirer, 1986).

A problem related to hangover and aviation is the possible alteration in the ability to detect angular motion. This inability is due to changes in vestibular functioning from consuming alcohol. Alcohol displaces part of the fluid in the inner ear, making the hair cells hypersensitive to any movement. Pilots using instruments to fly, rather than their senses, may become dizzy and nauseated in this situation. It

may take 24 to 48 hours for the alcohol in the inner ear to dissipate, in spite of a 0.0 BAL. This is important because pilots need the ability to detect angular motion when flying. Problems in angular motion detection may impair pilot performance. This is a concern in aviation because pilots need to detect deviations from straight and level flight if distracted from instruments in order to maintain altitude and airspeed conditions (Squier, 1999).

One type of alcohol hangover and aviation research study that has been performed entails administering alcohol to aviation subjects the night before they fly in a flight simulator. In this type of study, hangover, or aftereffects, of alcohol consumption are studied in relation to aviation performance. Yesavage and Leirer (1986) tested 10 pilots under the age of 32 with a group mean flight time of 1,115 hours in a Navy P-36 airplane. A repeated measures counterbalanced design was used such that every pilot flew two different flight scenarios in a P-3C flight simulator; one flown under hangover conditions, and the other flown under placebo conditions. Hangover conditions were achieved by administering sufficient quantities of 95% ethanol (1.0 g/kg), (diluted in a diet soda drink base) to bring each subject up to at least a BAL of 100 mg/dl (decaliters) (or 0.1%), then allowing 14 hours elapse prior to testing. During this lapse, subjects were allowed to sleep and eat as they normally would.

Data were obtained directly from the simulator in the form of six flight parameters and were collected each second of flight. The flight parameters measured were takeoff heading, landing heading, localizer, glide slope, yaw on takeoff, and yaw on landing. Heading is the direction on a compass that an aircraft is pointed, measured with respect to true north or magnetic north. Localizer is part of the Instrument Landing System (ILS) that provides lateral deviations from a preset course or bearing. ILS or Instrument Landing System is equipment determining glide slope, localizer (bearing), and distance (marker beacon) to a runway. ILS provides precision aiding for landing and is a basic guidance mode, providing lateral guidance, longitudinal guidance, and vertical guidance to approach a runway for landing. Glide slope is the angle of approach to the runway. Yaw is the angle of heading. Each of the flight scenarios included two crucial maneuvers; one takeoff and one instrument approach, both with a loss of two engines from one side of the aircraft.

Subjects scored worse in the hangover condition on almost every measure, although this difference was only significant for one of the performance measures, which was landing heading. Variability in performance was measured by standard deviation. Variance was greater in the hangover group on three of the six measures. These were takeoff heading, landing heading, and localizer. The authors reason that significant increases of variability under the hangover condition indicate individual differences in susceptibility to alcohol hangover effects. They

conclude that caution should be practiced when piloting an aircraft 14 hours or less after consuming enough alcohol to bring BAL to approximately 0.1%.

Yesavage and Leirer (1986) state that one limitation of their study was that Navy pilots may be more highly skilled and trained more extensively than civilian pilots. Therefore, Navy pilots may not be representative of the typical civilian pilot and thus the performance decrements may be underestimated. In addition, the authors state, the question remains as to whether there are hangover effects for smaller doses of alcohol that do not exceed the legal limit of 0.1% BAL. This is a research concern because many people, who plan to drive or pilot the next day, reach a lower than 0.1% BAL when drinking the previous night (Yesavage & Leirer, 1986).

Taylor et al. (1994) examined the acute (intoxication) and 8-hour effects (hangover) of alcohol at a target point BAL of 0.08% on pilot performance. 24 pilots were tested during an alcohol and placebo condition at three points in time: pre-drink, acute intoxication, and 8 hours after drinking. The performance measures used were takeoff (from the runway), course (of the flight), communication frequency (understanding how to receive and give ATC communication), traffic avoidance (in the air), cockpit monitoring (monitoring the airplane instruments), visual approach (using vision, not instruments to land), and two landing factors (vertical speed and runway alignment). Of the 8

performance measures, deficits in communication frequency errors were the only flight impairments observed 8 hours after the subjects finished drinking. The measures that comprised communication frequency errors were mistakes in setting radio frequencies and transponder codes (not using the communication equipment properly), along with delayed entry radios (not contacting ATC in a timely fashion).

Taylor et al., (1994) gave their subjects extensive practice in the simulator (7.5 hours) and subjects flew three flights in each of two testing sessions. With this extensive degree of practice, it is possible that the degree of hangover effects would be underestimated, as Morrow et al. stated in their 1993 study.

In summary, aviation and alcohol hangover research has delved into the subsequent effects of different BALs on pilot performance. These studies show impairment and variability in some aviation performance tasks (Taylor, et al., 1994; Yesavage & Leirer, 1986). The present study was also conducted to test hangover effects on pilot performance.

The Present Study

According to the FAA, there are over 700,000 pilots currently working in the United States. Clearly, flying a plane is not an obscure task. Still, piloting does require both complex cognitive and psychomotor skills (Wick, 1992).

There are significant reports that show that alcohol reduces many components of memory (Birnbaum, Parker, & Hartley, 1978; Mitchell,

1985; Ryback, 1971). If alcohol does reduce short-term memory capacity, then presumably the ability to divide attention between two or more mental tasks would be altered (Yesavage & Leirer, 1986). Divided attention deficits due to alcohol have been observed in previous research (Mills & Bisgrove, 1983; Misawa, Aikawa, & Shigeta, 1983). Pilot performance is contingent on the aspects of short-term memory and divided attention in human cognition. Pilots must retain and maintain an assortment of information in working memory during most aspects of flight. Specifically, during landings and takeoffs pilots have to be aware of air speed, altitude, rate of descent or climb and heading.

Consequently, pilots in circumstances of this kind may encounter an overload of processing demands if and when drinking has lessened their processing capacity. Alcohol lessens the capacity to execute behaviors that are not standard operation and has greater effects when it is necessary for individuals to respond with an inconsistent behavior (Landauer & Howat, 1982; Robinson & Peebles, 1974). For instance, in terms of pilot performance, this suggests that in emergency (i.e., not standard operation) situations the effects of alcohol may be more pronounced (Yesavage & Leirer, 1986). It has been shown that easier or more automatic tasks are less likely to be hindered by alcohol use than more complex tasks (Milam & Ketcham, 1981). More complex or unusual tasks such as in emergency situations are likely to require more complex cognition. Therefore, drinking alcohol prior to piloting may

increase the chance of a possible negative interplay between hangover effects and task difficulty when an emergency or non-standard situation occurs. Such circumstances may take place when pilots, who are assigned to especially stressful flights, drink to try to curb their stress (Yesavage & Leirer, 1986). Correspondingly, Cuthbert (1997) referred to factors such as work pattern, time away from home, social custom and fatigue, which may all tend to increase alcohol consumption.

Morrow et al., (1993) state that hangover effects are more likely to compromise aviation safety if pilots are unaware of the possible impairments due to hangover. These authors indicate that aviator subjects in their study were inappropriately confident in their ability to fly 8 hours after having a 0.10% BAL. In accordance with these conclusions, Ross and Ross (1988) found that 20% of the pilots they surveyed would still have measurable BAL's after waiting the time period they considered to be reliable. These reports suggest that pilots should not depend on their own judgement of hangover effects when determining whether they are qualified to fly.

The authors of several past alcohol and aviation research studies state that it is necessary to find a more accurate evaluation of the implications of hangover effect. They conclude this because of the safety concern of pilots using alcohol and assuming that their performance will not be affected if they wait 8 hours after drinking, as the FAA flight regulations state as proper procedure. These authors state that evidence

to support the FAA guidelines of pilot alcohol use is unclear (Morrow et al., 1993; Taylor et al., 1994; Yesavage & Leirer, 1986). The present study was conducted to add to the findings about alcohol hangover effects on cognition.

Additionally, the principal hypothesis of the present study is that the presence alcohol hangover is related to various performance decrements on complex cognitive tasks, such as aviation performance. Performance decrements that have been detected in previous studies (Yesavage & Leirer, 1986; Taylor et al., 1994) have been found in flight performance measures such as flight communication and heading (direction in which an aircraft points). In designing the present study, it was predicted that performance decrements would occur in all five flight performance measures used: altitude, bank, heading, airspeed and Rate of Turn (ROT). These five flight skills require complex cognition. For example, a pilot must use automatic skills such as reading flight instructions, maps and instrument dials as well as concentrating on specific novel information from Air Traffic Control (ATC) about a current flight. All five skills require a pilot to use automatic skills, working memory, and long-term memory, while processing new information coming from ATC ((Morrow et al., 1993; Taylor et al., 1994; Yesavage & Leirer, 1986).

There have been only a small number of studies that have addressed the question of specifically what are the possible hangover

effects on complex cognitive performance. The present study is an attempt to augment the research pertaining to hangover effects on cognition and aviation. The present study uses the Yesavage and Leirer (1986) methodology as a model. However in the present study, more subjects per treatment group are used and a moderate dose (0.05%) of alcohol is tested as well as a high dose (0.10% BAL), and the subjects were tested 10 hours instead of 14 hours after drinking. The possible findings of significant effects of hangover on complicated cognition would aid in a more comprehensive understanding of how alcohol intoxication alters human performance on various activities. Understanding how alcohol hangover may effect human performance on complex cognitive tasks would allow the potential to educate people who use dangerous machinery under hangover conditions. People have been shown to overestimate their performance abilities when under the influence of alcohol and after their BAL reached 0.0% (Widders & Harris, 1997). The public would benefit in knowing more about how aftereffects of alcohol may impair their performance on complex cognitive tasks.

The eight-hour "bottle to throttle" rule that pilots commonly use may be based on false assumptions. According to Wick (1992) there is not thorough empirical evidence to support the current FAA regulations regarding when an aviator is unaffected by recent alcohol intake and, therefore, competent to pilot a plane. This uncertainty about when a pilot is capable to perform his or her job is a dilemma for the public. It is

imperative that a more accurate assessment of cognitive ability and alcohol use be concluded. The public (as well as pilots and drivers) is trusting authorities such as the Federal Aviation Authority to establish regulations according to precise data. Unfortunately, there are few studies that show significant results to determine what the regulations should be about alcohol hangover and operating dangerous complicated machinery such as aircraft (Wick, 1992).

If a more thorough assessment of hangover effects on complex cognitive tasks can be established, it may be applied to many facets of human life (e.g., driving, working machinery, aviation, test performance, work performance). As stated previously, alcohol use is a very common human behavior and requires exhaustive examination. The influence of intoxication on human behavior has been extensively examined, but the effect of alcohol hangover has not been researched in an exhaustive manner (Fishman, 1986; Milam & Ketcham, 1986; Wiese et al., 2000).

The examination of hangover effects after achieving a moderate blood alcohol concentration may be a more accurate representation of the drinking habits of pilots that do drink prior to actual flight. It has been shown that people are more likely to reach a moderate BAL (approximately 0.05%) on average occasions of drinking than a high BAL (approximately 0.1%)(Stockwell, 1998). Therefore, one purpose of the present study was to examine hangover effects on pilot performance after subjects had reached a moderate (0.05%-0.07% BAL) level of

intoxication. This level is operationally defined as moderate; taking into account that 0.0% BAL the lowest level and 0.1% BAL is considered the legally intoxicated level in 32 U.S. states. There are 19 states now that consider 0.08% as legally intoxicated (National Institute on Alcohol Abuse and Alcoholism Congressional Report, 2000). It has been shown that the average drinker is a light to moderate drinker (Stockwell, 1998). Consequently, it is important to determine the hangover effects for moderate alcohol intake. Thus, one hypothesis of the present study is that, even with a moderate level of intoxication, hangover effects (i.e., decrements in performance) on cognitive performance will occur. However, it is assumed that the hangover effects are more severe as alcohol intake increases. Therefore, higher alcohol intake is assumed to lead to more severe hangover effects than moderate alcohol intake.

Research has determined that some significant impairment and fluctuations in performance among pilots does occur when testing for alcohol hangover effects. This indicates that some pilots are more vulnerable to low blood alcohol levels and hangover effects than others are. Previous work in this area has frequently reported that intoxication with alcohol results in heightened variability in flying performance, suggesting that some pilots were more sensitive than others to experience aviation performance deterioration after drinking. The present study measured subjects on a wide range of variables assumed to be related to flying performance. Spatial skills, verbal skills, short-

term memory, and visual contrast sensitivity were all assessed in the present study. The event of increased inter-individual variability of response elicits the question of what factors influence the amount of variability (e.g., practice, pilot intelligence, personality, etc.) (Yesavage, Taylor, Morrow, & Tinklenberg, 1992). A second purpose of our study was to ascertain the characteristics (e.g., spatial skills, verbal skills, short-term memory capacity, and visual sensitivity) of pilots, which could make them more sensitive to hangover effects.

One shortcoming of some existing studies (Morrow, et al., 1993; Taylor et al., 1994) on hangover effects is that the practice received by the subjects may have reduced the observed effects of alcohol. In fact, Morrow et al. (1993) demonstrated that when alcohol was manipulated within subjects, significant practice effects were only observed when alcohol was administered first, suggesting that practice effects may mask alcohol hangover effects. The present study manipulated dose of alcohol as a between subjects factor in order to reduce these problems. Using alcohol as a between-subjects factor allows different groups of subjects to perform the same tasks under alcohol conditions or placebo conditions. This permits the comparison of the groups without the possibility of confounding due to practice effects. In addition, this study exclusively tested subjects with a moderate degree of flying experience (200 hrs in aircraft, 50 hours in the simulator) to assure that the participants could sufficiently perform the flight tasks. Moreover, this screening for a

certain flight experience level in subjects provided that the subjects were more likely to have similar flight performance ability. The FAA rates pilot abilities according to number of flight hours. This presumes that pilots with similar amount of flight hours have similar piloting ability (Aviation Regulations & Airman Information Manual, 2001; Spence, 2001; Yesavage & Leirer, 1986).

In consideration of the cognitive and experiential differences found in a wide age range of aviators, the age of the subjects in the present study was also limited (ages 21 to 45). Reaction time on complex cognitive tasks has been shown to increase with age (DiGiovanna, 1994). However, older aviators may have more experience piloting and therefore may exhibit superior performance. The specifications in the present study were put in place to determine the characteristics of pilots that could make them more sensitive to hangover effects. Pilots with extensive aviation practice were not included in this study due to the fact that their superior skill might mask hangover effects (Morrow, et al., 1990; Yesavage et al., 1994).

The present study was intended to be a thorough, yet concise, investigation of hangover effects on complex cognitive performance. It was fashioned after the design that Yesavage and Leirer (1986) employed. Yesavage and Leirer (1986) found significant hangover effects in performance of the subjects in the alcohol condition. They concluded through their study that discretion should be exercised when piloting an

aircraft 14 hours or less after consuming enough alcohol to cause a 0.1% BAL. It was presumed that the reason other research studies did not find significant hangover effects is that these other studies did not include a complex enough performance task. They stated that the literature on hangover reviewed indicated that the more complex the task studied, the longer the hangover effects occurred. That is why these authors chose instrument aircraft piloting as the task to assess hangover effects on complex cognitive performance. The present study was designed to include these assumptions and to replicate the 1986 study with a few alterations.

The method employed by Yesavage and Leirer (1986) was applied to the present study. Subjects received alcohol or placebo the night before their flying session. However, different than the 1986 study, in the present study a moderate dose (0.05% BAL) alcohol group was added and more subjects were used per group. Subjects drank until they attained a BAL of 0.1% (high dose), a BAL of 0.05 (moderate dose), or ingested a placebo. The present study was completed in an attempt to observe in subjects any hangover effects occurring while employing complex cognition.

In the present study, decrements in performance were predicted to occur when comparing subjects' performance in the two treatment groups that received alcohol to subjects' performance in the placebo

group. Larger decrements in performance were predicted to occur with the high alcohol dose group.

CHAPTER II

METHOD

Subjects

The subjects in the present study were 36 instrument-rated male pilots who were 21 to 45 (mean age – 21.83) years of age. All subjects had a minimum of 200 hours of experience in the aircraft and 50 hours of experience in a simulator. A pool of potential subjects was identified through the John D. Odegard School of Aerospace Sciences at the University of North Dakota. All subjects were moderate social drinkers and were in good health. Moderate social drinkers average 2 to 21 drinks per week (Yeasavage & Leier, 1986)

Initially, 58 prospective subjects were given a short interview to assess their medical history in order to determine whether they could safely participate in the study (see appendix A and D). Those with a history of or current problems with high blood pressure, ulcers, heart disease, epilepsy, liver disease, kidney disease, or allergies to alcohol were excluded (.034% of subjects) from participation. Two prospective subjects were excluded because they had ulcers. Subjects who drank less than two drinks a week and those who had ever been treated for alcoholism were excluded (.155% of subjects). Nine prospective subjects were excluded because they did not drink at least two drinks a week.

Further, persons taking prescribed medication were excluded (.034% of all subjects) and persons were only allowed to participate if administration of an over-the-counter (OTC) drug had ceased at least seventy-two hours before the experiment. Two subjects were excluded because they were taking prescription medication. Subjects abstained from consuming any alcoholic beverages for at least 24 hours prior to their participation. Subjects were paid \$100 for their participation.

This experiment only utilized male subjects for a variety of reasons. First, the number of females in the population of aviators at the School of Aerospace Sciences and in the Grand Forks, ND community was less than 15% and thus would have provided insufficient numbers for a powerful enough statistical analysis that is needed to detect significant differences. Second, the examination of gender differences in the impact of intoxication with ethanol is complicated by the phase of the menstrual cycle and the use of oral contraceptives (Cole-Harding, & Wilson, 1987; Lammers, Mainzer, Breteler, 1995). The purpose of the research project was to explore individual difference variables that may modulate the degree of hangover effects observed, thus only males were used.

Procedure

Subjects were recruited through a newsletter of the Center for Aerospace Sciences, through advertisements on the University of North Dakota television Channel 3, and through announcements posted at various locations throughout the Center for Aerospace Sciences.

Subjects who responded to these advertisements were scheduled for a preliminary interview where they responded to questions about their health history and their drinking habits. Those subjects who were eligible to participate were contacted by telephone and invited to participate in the experiment. Those who agreed to participate first signed an informed consent form (see appendix C), and then were informed of their right to withdraw at any time for any reason without bias. All procedures and the consent form were reviewed and approved by the UND Institutional Review Board.

The risks for participation in this research were relatively minimal, given the extensive screening procedures that were employed, and the fact that subjects ate dinner at least one hour before consuming any alcohol. Furthermore, the range of doses of alcohol that were employed has been used previously in published research in this area without causing adverse effects (Morrow, et al., 1990; Yesavage & Leier, 1986).

Confidentiality was maintained by using only a subject number to code and identify data for analysis. The subject's name as associated with his subject number co-existed only on the consent form. These procedures have worked well in the past to protect the confidentiality of subjects (see appendix B).

Each intoxicated subject was constantly monitored (watched) by a research assistant being with him in the lab for two hours after he finished drinking to check for nausea or other possible adverse effects of

the intoxication. In addition, one of the experimenters was in close proximity (in an adjacent room) to the subject during the night. In the unlikely possibility that the subject required medical attention, the Altru Hospital of Grand Forks was only 1/2 a mile from the research lab.

The minimal risks to the subjects in the present project were reasonable relative to the benefits. Each individual subject received a considerable amount of financial compensation for his participation (\$100). In addition, subjects were exposed to an interesting educational experience as to what is involved in conducting research.

The proposed group size for this study was 15 (n=45). Regardless, utilizable data for 36 subjects was collected. During the experiment 45 subjects were tested. Unfortunately, there were inadvertent problems with the flight simulator malfunctioning during the flight performance testing and eight subjects were not able to finish the flight performance tests. One subject became ill during his flight simulator performance tests and was excused. As a result we did not get complete data sets from nine of the subjects.

Prior to the subjects being chosen to participate, they completed several screening questionnaires to assess their drinking patterns and their physical health (see appendix A). The actual experiment took place over a two-day period. Because of availability of only one flight simulator for use in our study, each subject was tested one at a time. On day 1, subjects reported to the lab at 6 PM. Subjects ate dinner before they

reported to the lab. Subjects abstained from drinking alcohol for 24 hours prior to their participation. The study was explained to the subjects and informed consent was obtained (see appendix C). Then subjects were given several cognitive and optometric tests related to flying ability (see appendix E).

Screening Questionnaires

1. Khavari Alcohol Test: This is a self-report assessment of the subjects' typical level of alcohol consumption. The Khavari Alcohol Test (KAT) has been shown to be valid in discriminating diagnosed alcoholics from non-alcoholics (Khavari & Farber, 1978) (see appendix D).

2. Michigan Alcohol Screening Test (MAST): This is a self-report diagnostic tool for detection of alcoholism. The MAST has high known-groups validity, being able to categorize most respondents as alcoholic or nonalcoholic. In fact, even when respondents were instructed in advance to lie about their drinking problems, the MAST correctly identified 92% of the 99 hospitalized alcoholics surveyed as having severe alcoholic problems (Selzer, 1971) (see appendix D). The MAST has been found to produce an internal consistency reliability coefficient of 0.88 (Zung, 1979). Recently the MAST's utility was assessed for use in clinical settings. Data disclosed that the MAST is significantly valid when used in psychiatric settings (Teitelbaum & Mullen, 2000).

Cognitive Tests

1. Mental Rotation: Subjects completed the Vandenberg Test of Mental Rotation (Vandenberg & Kuse, 1978) (see appendix E). This test presents subjects with a series of problems where they are given a geometric figure as a target item and a row of four geometric figures as distracter items. The task for the subject is to select two of the four-distracter items that are the same as the target items. The two-distracter items that are the same as the target items have been rotated along their axes. Subjects are given 6 minutes to complete 20 problems with a maximum score of 40 on the test. Gordon and Leighty (1988) found that scores on this test predicted successful completion of aviator training in Navy pilots.

2. Computerized Mental Rotation Task (Vandenberg & Kuse, 1988): This test is very similar in nature as the paper Mental Rotation Task (Vandenberg & Kuse, 1978). It was used in the present study to yield further results on another test of spatial ability. The items on this test are a second version (with alternate items) of the paper Mental Rotation Test. This test presents subjects with a series of problems where they are given three-dimensional geometric figures that they have to match with possible rotations of the figure. A computer program scores the test results for accuracy and speed.

3. The Digit Symbol, Digit Forward, Digit Backward, Block Design and

Vocabulary sub-tests from the Weschler (1981) Adult Intelligence Scale-Revised (WAIS-R) were included (see appendix E). In the Digit Symbol test subjects are presented with a nonverbal symbol paired with each of the numbers 1-9. Then subjects are presented with several rows of numbers with empty boxes below each number. The subject must fill in the box with the symbol associated with each number and complete as many as possible within 90 seconds. Gordon and Leighty (1988) reported that this task was marginally significant ($p < .1$) in its ability to predict successful completion of naval aviation training.

The WAIS-R Digit Forward and Digit Backward tests are tests of short-term memory in which the subject is read aloud a sequence of digits. The digit sequence gets longer as the tests progress. The subject is to immediately verbally recall the digit sequence either exactly as it was read (digit forward) or inverse the digits (digits backward).

The vocabulary WAIS-R sub-test is a list of terms read to the subject and the subject is asked to define them. The vocabulary sub-test consists of 35 words of increasing difficulty.

The Block Design sub-test is a task of pattern completion. The subject is given a picture of a pattern to complete with blocks. The subject's task completion speed is recorded.

4. The optometric measure used was the Contrast Sensitivity Test (CS) (see appendix E). Kohl, Coffey, Reichow, Thomson, and Willar (1991) have demonstrated that contrast sensitivity was significantly better in

pilots than matched controls. This test of contrast sensitivity was conducted at 10 feet from the CS chart. In this research study, far contrast sensitivity (10 feet away) was assessed and near contrast sensitivity (chart 6 inches from the eyes) was assessed. It can be argued that both measures of contrast sensitivity should predict performance as the pilot scans the visual field outside the aircraft and the visual field presented by the instruments. Dynamic visual acuity was assessed, as Kohl et al. (1991) also reported that pilots scored higher than controls on tests of dynamic visual acuity.

Subjects were randomly assigned to the dose to insure that the groups would not be significantly different on body weight, age, and pretest flying performance. After practice time (see appendix F) in the simulator was completed, the subjects began drinking. Subjects received 1.0 ml 100% ethyl alcohol/kg body weight, 0.5 ml 100% ethyl alcohol/kg body weight, or a placebo. This formula was tested prior to the present study on subjects to insure average BAL for the treatment groups. Three practice sessions were held with male volunteers to reach average BALs of 0.1% and 0.05%. The alcohol was mixed with a lemonade drink mix in a 1:5 alcohol:mixer ratio while the placebo beverage consisted of five parts lemonade, one part water, and two drops of ethyl alcohol floated on the surface. A beverage was divided into three equal parts and served at 20-minute intervals with 5 minutes permitted for the consumption of each drink. Subjects were told that they would be drinking lemonade

that may have a large (1.0 ml) or small (0.5 ml) dose of alcohol mixed with it (they were not informed of the exact amount). After finishing each drink, subjects were asked to rinse their mouths with water and a breath alcohol reading was obtained using the Intoxolizer IV breathalyzer (Intoxometers, St.Louis). After the one-hour drinking period subjects remained in the lab for an additional 2 hours and BAL readings were taken every 30 minutes.

When the drinking session was completed, subjects were escorted to a room to sleep in University housing. The subjects were given a double room and a research assistant stayed in the same room to insure the safety of the subject. All subjects were awakened at 7 AM the next morning. Shower facilities were available and subjects were served breakfast. After breakfast, subjects were taken to the lab and asked to fly in the simulator (see appendix F). The research assistants who scored the flight scenario performance were not aware of the group (amount of alcohol that each subject had received the night before) to which the subject was assigned. Therefore a double blind procedure was exercised throughout the experiment.

Equipment

The subjects piloted a Frasca 241 flight simulator with a visual representation of both Visual Meteorological Conditions (VMC) and Instrument Meteorological Conditions (IMC). The aircraft was set up as a complex aircraft with retractable gear, flaps, constant speed prop, dual

radios, DME, ADF, and a carburetor engine. Standardized power settings were used; full power on takeoff, 25" manifold pressure and 2500 RPM for climb, 22" manifold pressure and 2400 RPM for cruise. Other power settings were set by the pilot to achieve the climb or descent rate, or airspeed desired. Instrument approach speed was 120 knots with the power setting determined by the pilot. Final approach was made with the gear down and flaps at the first setting. The Frasca 241 is a digital machine as compared to its analog predecessor (Frasca 141) that has been used in most of the previous work in this area. The use of a digital machine was therefore more accurate.

Before completing the cognitive and optometric tests, subjects piloted the Frasca 241 simulator for approximately 30 minutes (see appendix F). The purpose of this session was to insure that the pilot is comfortable with the operational characteristics of this simulator. Also, pilots were asked to perform several maneuvers, which were evaluated to determine their proficiency. This pretest score allowed experimenters to assign subjects to three treatment groups to insure equivalent flying ability. The specific tasks that the subjects performed in the simulator was a takeoff in the visual mode and a series of maneuvers including straight and level flight, turns, climbs, and descents in the instrument mode at a variety of configurations and airspeeds. Performance in the practice session was evaluated utilizing: 1) a computer-scored pattern that observed deviations from optimal flight parameters, 2) ten decision

making scenarios that require interpretation of aircraft position and initial reaction to fly toward a designated course or navigational aid, and 3) an ILS approach from outside of a marker beacon with no wind and high visibility and ceiling minimums.

Flight Scenarios

The flight scenarios used in the present study were designed by John Bridewell, Associate Professor of Aviation at the University of North Dakota. Subjects were instructed to fly two different flight scenarios (see appendix F) that would take about 45 minutes each to fly. Each flight scenario required a pattern that involved all three skills necessary to fly under instruments. They were instructed to fly the aircraft at different altitudes, airspeeds, and headings. They were given VOR (Very High Frequency Omnidirectional Range Navigational Radio) radials and NDB (Non-Directional Beacon Navigational Radio) bearings to intercept and track. They were given, by ATC, a holding procedure, vectors to an instrument approach, followed by an instrument approach, which was not possible to complete, a missed approach, with a second instrument approach via the pilot's own navigational skills and abilities to a landing. To increase the difficulty, light turbulence was encountered upon execution of the missed approach, along with a reasonably acceptable crosswind component of 15 knots. The goal was not to push the pilot to task saturation, but to have sufficient difficulty as to require a high level of mental workload in all three skill areas during the procedure.

Scoring

Each flight scenario was scored for the number of procedural errors, the number of times the pilot asked the ATC to repeat a directive, the number of seconds the subjects exceeded the limits for altitude, heading, and airspeed. The limits were +/- 100 feet for altitude, +/- 10 knots for airspeed, and +/- 10 degrees for heading. Each flight scenario contained two computer-scored holding patterns (i.e., deviations from altitude, heading, and airspeed) and two computer-scored instrument approaches.

CHAPTER III

RESULTS

Demographics

The group sizes used in this study were: placebo, 11; moderate alcohol dose, 13; high alcohol dose, 12; for a total of 36. Moderate alcohol dose administered was 2mg/kg and the target BAL was 0.05%. High alcohol dose was 3mg/kg and the target BAL was 0.1%. Data was collected for mean age, flight experience and alcohol use (drinks per week) of subjects. Mean age for all subjects was 21.86; divided by group the mean ages were: placebo, 21.72; moderate dose, 22.15; high dose, 21.86. To assess flight experience, subjects chose a range in which reflected their hours of experience (see appendix A). All subjects had 201-300 hours of flight experience. Mean alcohol use was 5.69 drinks per week for all subjects; placebo, 5.8; moderate dose, 5.53; high dose, 5.75.

ANOVAs

Analyses of variance (ANOVAs) were conducted separately on all the flight performance measures generated in this study. In addition, analyses of variance were used to compare the three groups on their vocabulary scores, mental rotation, digit span, digit symbol, and contrast sensitivity scores. Also, multiple comparison analyses using Tukey HSD

(Honestly Significant Difference) and Dunnett's test were used to further clarify ANOVA data. Finally, a series of post-hoc analyses were conducted to examine whether these individual difference measures modulate the degree of hangover effect observed.

The analyses did not show significant differences across the three groups on their vocabulary scores, mental rotation, digit span, digit symbol, contrast sensitivity scores. The three groups were statistically similar in these aspects (see Tables 3, 7, and 8).

Five performance measures were assessed for each flight pattern for every subject. One measure assessed was flight deviations from optimal Altitude (1 error added per each foot off per second). Altitude is height, usually with respect to the terrain below (radar altitude is feet above closest dirt) or fixed earth reference (barometric altitude is feet above mean sea level). A second measure assessed was flight deviations from optimal Heading. Heading is the direction in which an aircraft's nose points in flight in the horizontal plane and is expressed in radial degrees (1 error added per each radial off per second). Radial error probability (REP) is used to measure errors in Heading. REP is the probability that a percentage of one-dimension measurements will lie on a radial (line) of given length, with the origin centered at truth or mean of the measurements; used to specify test cases for measurement errors of sensors of one dimension. A third measure assessed was deviations from optimal Airspeed (1 error added per each knot off per second). A fourth

measure assessed was Rate of Turn (ROT) (1 error added per degree off per second). And lastly, the measure Bank was assessed. Bank is the degree of angle in a flight turn (1 error added per radial degree off per second from optimal-15 degrees). Radial error probability (REP) is used to measure errors in Bank. The means and standard deviations for these measures are presented in Table 1 as a function of group and specific pattern.

Table 1.
Flight Performance Measures as a Function of Dose and Scenario Flown

Scenario	Placebo		Moderate		High	
	One	Two	One	Two	One	Two
Altitude (feet)	5436 (2732)	6501 (2764)	5487 (3713)	5676 (1928)	6043 (2944)	8737 (8355)
Bank (radial Degrees)	4771 (3615)	5189 (2717)	4212 (1183)	4285 (1780)	5889 (2610)	7443 (3550)
Heading (radial Degrees)	8609 (2851)	8858 (3762)	8619 (6025)	7918 (3885)	9560 (5111)	8786 (3714)
Airspeed (knots)	8589 (1780)	9423 (1832)	10140 (2735)	10153 (4008)	10589 (5936)	10464 (2860)
ROT (degrees)	446 (354)	551 (274)	397 (157)	372 (227)	548 (256)	732 (354)

A series of 3 (Group) x 2 (Pattern Flown First or Second) mixed analysis of variance was conducted on these five measures. No significant effects were observed in the analyses of deviations from altitude, heading, or airspeed (see Table 2). The analysis of the Rate of

Turn measure revealed a significant main effect of Group, $F(2, 33) = 4.53$, $p = .018$. A subsequent analysis of this main effect using Tukey HSD and Dunnet's test indicated that the moderate dose group (2 mg/kg) did not differ significantly from the placebo group ($p > .05$), but the high dose group (3 mg/kg) made significantly more errors than the placebo group.

The analysis of the deviation from optimal bank measure revealed a significant main effect of Group, $F(2,33)=4.65$, $p=.017$. A subsequent analysis of this main effect using Tukey HSD and Dunnet's test indicated that the moderate dose group (2 mg/kg) did not differ significantly ($p > .05$) from the placebo group, but the high dose group (3 mg/kg) made significantly more errors than the placebo group. The analyses did not show significant differences in the groups' flight performances overall.

Table 2. Comparison of group performance on flight tasks

	<u>Scenario One</u>	<u>Scenario Two</u>
Altitude	$F = .133, p = .876$.	$F = 1.144, p = .331$.
Bank	$F = 1.336, p = .277$.	$F = 4.65, p = .017$.
Heading	$F = .147, p = .864$.	$F = .236, p = .791$.
Airspeed	$F = .813, p = .452$.	$F = .339, p = .715$.
ROT	$F = 1.067, p = .356$.	$F = 4.53, p = .018$.

Note: All degrees of freedom are (2, 33).

Variability was assessed by using Levene's Test of Equality of Error Variances. Table 3 shows the results from Levene's Test on the groups flight performance. Significant variance was shown on the performance measures Altitude, $F = 4.891$, $p = .014$. and Airspeed, $F = 4.138$, $p = .025$.

Table 3. Levene's Test on group performance		
	<u>Scenario One</u>	<u>Scenario Two</u>
Altitude	$F = .053$, $p = .948$.	$F = 4.891$, $p = .014$.
Bank	$F = 1.361$, $p = .270$.	$F = 2.156$, $p = .132$.
Heading	$F = .764$, $p = .474$.	$F = .018$, $p = .982$.
Airspeed	$F = 4.138$, $p = .025$.	$F = 2.828$, $p = .074$.

Note: All degrees of freedom are (2, 33).

A one-way analysis of variance computed on mental rotation, WAIS vocabulary, WAIS Digits Forward, WAIS Digits Backward, WAIS Digit Symbol, and WAIS Block Design scores revealed no significant differences (Table 4).

Variability was assessed by using Levene's Test of Equality of Error Variances. The results from Levene's Test on the groups' cognitive tests performance variance was not significantly different.

Table 4. Means and Standard Deviations of Cognitive Tests

	Placebo	Moderate	High
N	11	13	12
Mental Rotation	20.82 (5.46)	25.46 (7.32)	22.17 (8.73)
Vocabulary	56.18 (5.69)	52.85 (5.85)	51.92 (6.39)
Digit Span Forward	10.36 (1.96)	10.38 (1.94)	9.33 (1.92)
Digit Span Backward	8.82 (2.63)	10.31 (5.02)	7.83 (2.25)
Digit Symbol	66.45 (6.02)	62.54 (4.09)	67.33 (10.60)
Block Design	43.18 (4.87)	41.69 (12.09)	43.75 (8.76)

Mental Rotation – $F = 1.29$, $p = .288$.

Vocabulary – $F = 1.59$, $p = .218$.

Digit Span Forward- $F = 1.15$, $p = .328$.

Digit Span Backward – $F = 1.50$, $p = .238$.

Digit Span Total – $F = 2.31$, $p = .114$.

Note: All degrees of freedom are (2, 33).

Table 5 displays the recall of flight clearances as a function of dose, scenario, and memory load.

Table 5.
Percent of Recall of Clearances as a Function of Dose, Scenario, and Memory Load

Scenario	One		Two	
	High	Low	High	Low
Placebo	86.18	90.27	84.27	94.54
F(2, 33) = 1.394, p = .228.				
Moderate	80.31	91.92	81.23	95.31
F(2, 33) = 2.54, p = .218.				
High	76.58	88.42	80.08	90.33
F(2, 33) = .312, p = .718.				

Table 6 shows the percentage of flight operations correctly executed as a function of dose and scenario.

Table 6: Percentage of Operations Correctly Executed as a Function of Dose and Scenario

Scenario	Procedures in Clearance		Procedures outside Clearance	
	One	Two	One	Two
Placebo	93.09	93.36	80.54	79.09
F(2, 33) = 1.52, p = .318.				
Moderate	95.08	94.46	83.15	86.23
F(2, 33) = .162, p = .826.				
High	91.25	89.41	83.58	82.92
F(2, 33) = 1.14, p = .358.				

A one-way analysis of variance on the Khavari scores and the MAST scores revealed no significant differences (Table 7).

Table 7. Means and Standard Deviations of KAT and MAST Scores

	Placebo	Moderate	High
Khavari Total	4247 (4026)	4377 (4441)	4845 (2810)
F(2, 33) = .079, p = .924.			
MAST	3.36 (3.78)	2.46 (1.98)	3.08 (1.38)
F(2, 33) = .407, p = .669.			

A series of one-way analyses of variance for the near and far contrast sensitivity vision tests data revealed no significant group differences (Table 8 and Table 9).

Table 8. Far Contrast Sensitivity

	Placebo	Moderate	High
Far A	83.63 (23.36)	66.00 (25.83)	75.42 (23.12)
F(2, 33) = 1.594, p = .218.			
Far B	139.09 (42.88)	118.00 (54.58)	109.92 (45.86)
F(2, 33) = 1.104, p = .343.			
Far C	145.09 (74.32)	141.54 (72.73)	141.25 (64.88)
F(2, 33) = .010, p = .990.			
Far D	95.36 (45.46)	79.31 (48.46)	94.00 (35.55)
F(2, 33) = .517, p = .601.			
Far E	21.36 (10.38)	33.00 (20.24)	29.17 (16.64)
F(2, 33) = 1.506, p = .237.			

Table 9. Near Contrast Sensitivity

	Placebo	Moderate	High
Near A F(2, 33) = 1.928, p = .162.	72.72 (27.14)	54.77 (20.91)	62.25 (18.75)
Near B F(2, 33) = 1.023, p = .371.	85.00 (00.00)	82.15 (35.78)	100.67 (46.36)
Near C F(2, 33) = 2.382, p = .108.	107.27 (48.96)	99.62 (48.71)	138.33 (41.19)
Near D F(2, 33) = .328, p = .722.	78.91 (39.96)	72.53 (34.71)	84.33 (34.88)
Near E F(2, 33) = .999, p = .379.	33.91 (18.83)	26.54 (11.69)	26.58 (12.15)

Table 10 displays the mean BALs that were taken after subjects were administered either the moderate or high dose of alcohol. Comparisons of the BAL readings show no significant differences within the moderate and high dose groups. The readings for the moderate alcohol dose group were a mean of .067% BAL. The readings for the high alcohol dose group were a mean of .107% BAL.

Table 10. Mean Breath Alcohol Level (BAL) Readings

	T1	T2	T3	T4	T5	T6
Moderate	.071	.069	.072	.069	.063	.062
High	.104	.109	.112	.108	.108	.104

Tests of power (1-beta) and effect size (eta squared) were performed for each AVOVA executed on the cognitive and flight measures. The average power was 0.259 which is categorized as low power. The average effect size was 0.01 and this falls in the small effect size category. Therefore, it can be assumed that the present experiment had low sensitivity.

Correlations

Pearson R correlations were performed on flight performance measures and cognitive tests (see table 11).

Table 11. Correlations

	ALT	ALT2	BANK	BANK2	BLOCK	DIGSPANB	DIGSPANF	DIGSPANT	DIGSYMB	HEAD	HEAD2	IAS	IAS2	MENROT	ROT	ROT2	
Altitude - Scenario 1 -	ALT	1.000	.365*	.452**	.340*	-.563**	.140	-.547**	-.131	-.420*	.227	.242	.362*	.646**	-.169	.416*	.283
Altitude - Scenario 2 -	ALT2	.365*	1.000	.050	.285	-.305	-.263	-.423*	-.420*	-.052	.189	.234	.391*	.315	-.422*	-.063	.309
Bank - Scenario 1 -	BANK	.452**	.050	1.000	.242	-.244	-.033	-.385*	-.205	-.189	.116	.168	.290	.276	-.213	.864**	.204
Bank - Scenario 2 -	BANK2	.340*	.285	.242	1.000	-.158	-.125	-.412**	-.297	-.129	.272	.078	.225	.324	-.236	.346*	.957**
Block Design -	BLOCK	-.563**	-.305	-.244	-.158	1.000	-.090	.495**	.150	.471**	-.234	-.053	-.341*	-.510**	.108	-.222	-.091
Digit Span Backward -	DIGSPANB	.140	-.263	-.033	-.125	-.090	1.000	.064	.889**	-.546**	-.219	.010	-.065	.263	.153	.020	-.224
Digit Span Forward -	DIGSPANF	-.547**	-.423*	-.385*	-.412**	.495**	.064	1.000	.514**	-.101	-.002	-.349*	-.456**	.327	-.362*	-.375*	
Digit Span Total -	DIGSPANT	-.131	-.420*	-.205	-.297	.150	.889**	.514**	1.000	-.309	-.235	.008	-.215	.017	.282	-.149	-.365*
Digit Symbol -	DIGSYMB	-.420*	-.052	-.189	-.129	.471**	-.546**	.350*	-.309	1.000	.089	-.019	-.291	-.513**	.023	-.104	-.096
Heading - Scenario 1 -	HEAD	.227	.189	.116	.272	-.234	-.219	-.101	-.235	.089	1.000	.274	.242	-.040	-.344*	.392*	.315
Heading - Scenario 2 -	HEAD2	.242	.234	.168	.078	-.053	.010	-.002	.008	-.019	.274	1.000	.245	.163	-.213	.062	.162
Airspeed - Scenario 1 -	IAS	.362*	.391*	.290	.225	-.341*	-.065	-.349*	-.215	-.291	.242	.245	1.000	.405*	-.295	.181	.266
Airspeed - Scenario 2 -	IAS2	.646**	.315	.276	.324	-.510**	.263	-.456**	.017	-.513**	-.040	.163	.405*	1.000	.034	.093	.323
Mental Rotation -	MENROT	-.169	-.422*	-.213	-.236	.108	.153	.327	.282	.023	-.344*	-.213	-.295	.034	1.000	-.212	-.289
Rate of Turn - Scenario	ROT	.416*	-.063	.864**	.346*	-.222	.020	-.362*	-.149	-.104	.392*	.062	.181	.093	-.212	1.000	.270
Rate of Turn - Scenario	ROT2	.283	.309	.204	.957**	-.091	-.224	-.375*	-.365*	-.096	.315	.162	.266	.323	-.289	.270	1.000

CHAPTER IV

DISCUSSION

Substantial research in both psychology and medicine has focused on the cognitive effects of alcohol ingestion (Easdon & Vogel-Sprott, 2000; Fillmore, Vogel-Sprott, Gavrilesco, 1999; Howland, Rohsenow, Cote, Siegel, & Mangione, 2000; Maylor & Rabbitt, 1993; Tzambazis & Stough, 2000; Usakov & Egorov, 1996). NTSB accident statistics suggest that the examining the risks of alcohol use and piloting aircraft is consequential (Yesavage & Leirer, 1986; National Transportation Safety Board, 2000). The topic of hangover effects on complex cognitive tasks, such as piloting an aircraft, has also been a noteworthy topic pertaining to alcohol and cognition research. The present study adds to the objective data that performance may be impaired in a hangover situation.

The outcome of the present study was anticipated to support the results from Yesavage and Leirer (1986) on hangover effects on aviation. Yesavage and Leirer (1986) found subjects' flight performances to be inferior in the hangover condition on one performance measure: landing heading. They also found significant variance on three flight measures: landing heading, takeoff heading, and glideslope. It was concluded from these results that caution should be taken when piloting 14 hours or less after drinking alcohol to raise BAL to 0.1%. The present study, as

predicted, corroborated the results from previous studies (i.e., Morrow et al., 1993; Yesavage & Leirer, 1986) on alcohol hangover and aviation performance. Significant impairment was shown on two performance measures: Bank and Rate of Turn.

The primary hypothesis of the present study was that alcohol hangover is related to performance decline on complex cognitive tasks. One predicted result from this study was that subjects in the higher BAL group would perform significantly worse than the lower BAL and placebo groups. Also predicted was that the groups which were administered the alcohol would perform significantly worse than the placebo group. Results did not support these hypotheses overall. However, there were significant differences on two performance measures: Bank and Rate of Turn. These differences were seen only between the placebo group and the high dose group (3mg/kg; 0.1% BAL). There were no significant differences in performance between the placebo group and the moderate alcohol dose (0.05% BAL) group. The results of the present study support the notion that alcohol impairs performance at least 10 hours after reaching 0.10% BAL. These results indicate that the current FAA regulated 8 hour waiting period after drinking is insufficient if a pilot consumed enough alcohol to have a 0.1% BAL.

The results of the present study may be understood in part by alcohol's result in curtailing the ability to process information. There is much evidence that alcohol impairs various aspects of memory (Easdon

& Vogel-Sprott, 2000; Fillmore, Vogel-Sprott, Gavrilesco, 1999; Howland, Rohsenow, Cote, Siegel, & Mangione, 2000; Maylor & Rabbitt, 1993; Milam & Ketcham, 1981; Tzambazis & Stough, 2000; Usakov & Egorov, 1996). Alcohol reduces working memory ability and divided attention ability (Birnbaum, Parker, & Hartley, 1978; Mitchell, 1985; Ryback, 1971). Pilot performance is related to these aspects of memory. Pilots have to keep information in working memory the majority of a flight. During takeoffs and landings, pilots must be aware of air speed, altitude, rate of descent or climb, heading, etc. Alcohol also lessens the ability to execute non-standard actions and has even greater effects when people are required to respond in an alternative way, such as in an emergency (Robinson & Peebles, 1974). Therefore, pilots may experience an overwork of information processing requirements when their processing capacity has been decreased by alcohol intake (Yesavage & Leirer, 1986).

It was presumed for the present study that the research design would be sensitive enough to detect performance impairments between groups. Yesavage and Leirer (1986) found significant indications of hangover effect with only 10 subjects. Conceivably, this study could be replicated with a larger sample size per group. Though Yesavage and Leirer (1986) found significant hangover effects with $n=10$, Lemon et al. (1993) did not find effects with $n=16$.

However, the subjects tested in the present study and the subjects examined in previous research may not be comparable. For instance,

Yesavage and Leirer (1986) tested Navy pilots as subjects, while the Lemon et al. (1993) did not investigate pilots and used other means to assess complex cognitive skills besides simulated flight scenarios. Hence, the present study's and the two aforementioned studies' varied subject sampling may have played a part in the different outcomes of these three experiments. In other words, the present study's results are valid and add to the findings of Yesavage and Leirer (1986) and Lemon et al. (1993).

Furthermore, the fact that the subjects in the present study slept 8 hours before their flight performance was tested may have contributed to the lack of hangover effects detected. Lack of nourishment or sleep deprivation could possibly add to cognitive impairment due to hangover effects because these conditions may also impair cognitive performance (Wiese et al., 2000). Frequently, when individuals drink the evening before they have to work early the next morning, they do not get 8 hours of sleep. Perhaps the way the present study allowed sufficient sleep for the subject may have covered up the hangover effects that could occur with drinking and sleep deprivation.

However, as stated previously there are various studies that have failed to find effects of alcohol hangover on cognitive performance (Bowden, et al., 1988; Finnigan, et al., 1998; Lemon et al., 1993; Streufert, et al., 1995).

The fact that the present study showed differences on only two performance measures on simulated flight tasks in no way excludes the actuality of an individual hangover effect frequently reported by drinkers. The results of the present study also do not exclude adverse effects on performance of other tasks. It is probable that higher doses of alcohol, more subjects, or more sensitive tests might have found significant hangover effects. Until this study can be replicated using larger group sizes, it cannot be known if the lack of statistical power in the study influenced the results.

The results of the present study in view of low experimental design sensitivity lends support to the objective that it is necessary to continue the research in alcohol hangover effects. It is imperative in regards to public safety and knowledge, as well as scientific clarity, to determine conclusive information about alcohol hangover effects.

Though, while waiting for more conclusive evidence to be found through research, it would be perceptive to heed the recommendation given by Yesavage and Leirer (1986) in context with their results. They imply that caution should be practiced when piloting an aircraft 14 hours or less after drinking enough alcohol to obtain a 0.01% BAL. With this in mind, research should continue in this area to verify the 8-hour "bottle to throttle" standard.

Taylor et al. (1994) state that over 6,000 pilots would have to be tested to have an 80% chance of detecting significant alcohol decrements

on routine tasks such as takeoff and visual landing. However, they state that fewer than 40 pilots would need to be tested to detect decrements in less routine tasks such as traffic avoidance or heavy workload situations. This suggests that routine aviation tasks are less likely to be influenced by hangover effects than less predictable or heavy workload situations.

Whether these detrimental effects of alcohol hangover are permissible is a question for the transportation regulatory agencies. However, it is likely that pilots look to flight regulations, and not alcohol research results, as to guide their behavior in regard to alcohol use and flying. Many pilots may not be aware of the possible hangover effects that can effect performance on certain aviation tasks.

The results of the present study support the 1989 Federal Aviation Authority's policy that states that pilots should have to be tested randomly for alcohol use. This is concluded because hangover effects are more likely to compromise aviation safety if pilots are unaware of the possible impairments due to hangover. Aviator subjects have been shown to be inappropriately confident in their ability to fly 8 hours after having a 0.10% BAL (Morrow et al., 1993). This indicates that pilots should not depend on their own judgement of hangover effects when determining whether they are qualified to fly.

Morrow et al. (1993) state that alcohol hangover effects are most likely to compromise aviation safety if pilots are unaware of the possible impairment and decide that they are able to fly safely. Pilot survey

results show that pilots are often inappropriately confident of their ability to fly 8 hours after reaching 0.10% BAL. Therefore, educating pilots of possible hangover effects is advisable.

Data from alcohol hangover studies provides important information as to critical parameters that may influence alcohol induced hangover effects. For that reason, the present study was a useful experiment in the area of alcohol hangover effects. The results of this study may be applicable not only to aviation concerns, but also to tasks involving operating any complicated machinery when similar doses of alcohol are consumed.

The results of the present study did not reveal hangover effects of in a moderate dose (0.05% BAL) of alcohol. This finding is important in understanding hangover effects because it adds to the extent of BALs that may lead to hangover effects. However, focusing on hangover effects of moderate doses of alcohol is not justified for future research. Testing complex cognition at the 0.08% BAL is warranted, especially now that it is a legal intoxication limit in 19 states.

Future research on hangover effects will be helpful to add to the findings of the present study. A follow-up study to the present study should use larger groups and focus on high doses (0.08% BAL and above). Further studies that assess hangover effects on different cognitive tasks are justified in light of the present study's results and results from previous research conducted.

The results of the present study affirm that alcohol hangover from a large dose of alcohol (0.01% BAL) does influence cognitive performance. The results also indicate that it is important to educate the public about possible hangover effects because drinking alcohol is a common human behavior. If people are not aware of hangover effects that may occur and influence their performance or behavior, they may embark on activities that could be dangerous to them or others (i.e., piloting, driving, operating machinery).

APPENDICES

Appendix A

Initial Screening Tool

Name:

Email address or Phone Number:

1. **Total Time** - Circle the appropriate answer.
0-100 101-200 201-300 301-400 401-500 501-1000 1001 or greater

2. **Certificates** - Circle all that apply.
Private Commercial Airline Transport Flight Instructor

3. **Ratings** - Circle all that apply.
Instrument Multi-engine Other

4. Are you instrument **current**? Yes No

5. How many hours have you flown in the past 6 months? Circle the appropriate answer.
0-25 26-50 51-100 101-150 151-200 201-250 251-300 301-350
Greater than 350

6. How many hours do you have in a simulator? Circle the appropriate answer.
0-50 51-100 101-150 151-200 201-250
251-300 301-350 Greater than 350

7. What is your total instrument time? (actual, simulated, ground trainer, or simulator) Circle the appropriate answer.
0-50 51-100 101-150 151-200 201-250
251-300 301-350 Greater than 350

8. **Age:**

9. Our research team is doing a study on the impact of alcohol hangover on aviation performance. The study would require you to drink at night, stay overnight in university accommodations, and then fly a simulator the next morning? Would you be willing to participate if paid \$100?
Yes No

Appendix B

Participant Information Form and Testing Record

Participant Number _____ Group A B C

Dates tested _____

Age _____ Birth date _____ Grade or Education background _____

Hangover Study Order of Events

1. Subject reports to ATRC building by 6 PM after they have eaten their dinner
2. Have them fill out the consent form
3. Administer a Breathalyzer Reading-if > 0 send home. Remember, prior to taking each breath reading have them rinse out their mouth thoroughly with water.
4. Have them study the flight profile stuff and when ready administer the quiz, score the quiz and go over the quiz with the subject.

Simulator Practice-Approximate time 1 Hour

5. Administer the MAST _____ and the Khavari _____
6. Administer the Vocabulary Test _____
7. Administer the Older Version of the Mental Rotation Test _____
8. Administer Dsymbol _____, then the D-Span _____, and BD _____ subtest
9. Administer the computer mental rotation

Rotation 1 Rotation 2 Rotation 3 Rotation 4
RT

Errors

A B C D E

10. Administer Near Contrast Sensitivity

Drink-Phase	Drink 1	Drink 2	Drink 3	Far Contrast Sensitivity Should last one hour Then give subjects 5 minutes to rinse their mouth with water. Then start BAL readings every 15 minutes.
_____	_____	_____	_____	
alcohol				

Mix				

Start Time _____

BAL 1 _____ BAL 2 _____ BAL 3 _____ BAL 4 _____

BAL 5 _____ BAL 6 _____ BAL 7 _____

Sleep Phase-Take BAL 7 when the subject gets to where they sleep-30 minutes after BAL 6

Next Day Phase

1. Subject wakes up at 7AM is allowed 1 hour to shower and get ready
2. Subject is given a breakfast at 8:00
3. Reports to ATRC by 8:45 and takes a BAL reading
4. Ask them to review flight profile stuff for 5 minutes. Subject takes quiz again from the previous night. Errors are corrected.
5. Begin flying by 9

Scen 1 Scen 2 Scen 2 Scen 1

Appendix C

Consent Form

You are invited to participate in a study about the effects of acute alcohol on pilot performance. You are being asked to participate in this study because you are an instrument rated pilot with at least 200 hours of experience in the aircraft and 50 hours of experience in a simulator. You are also being asked to participate in the study because your responses to our screening interview suggested that you would be able to safely consume a moderate dose of alcohol.

Your participation in this study will involve sleeping in university housing arranged for you. You will be asked to report to the lab by 6 PM after having eaten your typical dinner. When you report to the lab you will be familiarized with the simulator and asked to fly several procedures for about 30 minutes and your performance will be scored. Then you will be asked to take several tests of cognitive ability that will include a vocabulary test, a test of mental rotation, and two tests of short term memory. In addition, you will be asked to take a test of near contrast sensitivity and far contrast sensitivity, both measures of optometric functioning. The cognitive and optometric tests should take about 1 hour of time to finish. When your testing is finished the drinking procedure will begin.

You will be asked to consume a drink that will contain either alcohol mixed with lemonade or lemonade. The amount of alcohol you will receive will be 3.0 ml of 50% ethyl alcohol per kilogram of your body weight, or 2 ml/kg of 50% ethyl alcohol. The dose will be divided into three drinks, and you will have 60 minutes to drink them. After your drinking is complete you will stay in the lab for two more hours watching TV or reading, or whatever you choose. The research assistant will monitor your blood alcohol levels during that time period. Then you will be escorted to university housing where a double room will be reserved for you and the research assistant. At 7 AM the next morning you will be awoken and allowed to shower and offered breakfast. Then the research assistant will escort you to the simulator and you will be asked to fly 2 patterns in a Frasca 241 flight simulator. The computer will be monitoring your performance and will evaluate your flight performance.

We understand that you have consumed your typical dinner before you arrived at our lab and are not here with an empty stomach. We understand that you have not ingested any drugs, including alcohol, within the past 24 hours.

If you receive alcohol, there is a slight possibility that you may experience some nausea. However, several procedures we are following make this very unlikely. First, you were selected because your drinking history suggested that you should be able to tolerate the dose of alcohol used in this study. Second, the dose of alcohol that we are using has been used safely many times before. Finally, the fact that you have eaten dinner should help to minimize the possibility that you will experience nausea, so it is very important that you eat before you report to the lab. The individual scores in this study will remain totally confidential as data will only be presented in aggregate form.

The benefits from this study stem from improved understanding of how the effect of recent ingestion of alcohol may carry over and effect the flight performance many hours after finishing drinking. Immediate benefits to you are the opportunity to experience what research is about and a \$100.00 stipend. If you withdraw early from the study, you will be paid commensurate with the time you have already put into the study. If you withdraw early you will still be escorted home by one of the researchers. In order to insure unbiased results, you will be randomly assigned to receive either alcohol or the placebo.

In return for your participation, you will receive a \$100.00 stipend. Your decision whether or not to participate will not prejudice your relations with UND, the Aviation Department, or the Psychology Department. If you decide to participate, you are free to discontinue participation at any time without prejudice. In addition, the scores from your participation, including your responses to the alcohol consumption questionnaires will remain totally confidential.

The investigators involved in this study will make themselves available to answer any questions that you have regarding this study. In addition, you are encouraged to ask any questions that occur to you in the future. You are not required to enter into this research if you wish not to. Any questions you have will be answered by either John Bridewell from Aviation, 777-2791 or by Tom Petros or JoAnne Bates from Psychology, 777-3451. You will be given a copy of this form. Medical treatment will be as available as it is to any member of the general public in similar circumstances. Payment for any such treatment must be provided by you or your third party payor.

I have read all of the above and willingly agree to participate in this study as explained to me by

_____.

Signature

Date

Witness

Date

Appendix D
Khavari Alcohol Test (KAT)

Code: _____ Date: _____

This is a series of questions about the use of alcoholic beverages. What beverages people drink, how much, and how often. Please check the statement that best applies to you.

- | | | |
|---|-------------------------|--|
| 1. How often do you usually
drink beer? _____ | A. daily | K. I have tried, but
don't drink it now |
| How often do you usually
drink wine? _____ | B. 3 or 4 times a week | L. I have never tried |
| How often do you usually
drink whiskey or liquor?
_____ | C. twice a week | |
| | D. once a week | |
| | E. 3 or 4 times a month | |
| | F. twice a month | |
| | G. once a month | |
| | H. 3 or 4 times a year | |
| | I. twice a year | |
| | J. once a year | |
-

2. Think of all of the times you have had beer recently. When you drink beer, how much beer do YOU USUALLY DRINK each time in cans or glasses?

_____ cans or glasses _____ I don't drink beer

Think of all the times you have had wine recently. When you drink wine, how much wine do YOU USUALLY DRINK each time in glasses (4 oz)?

_____ glasses _____ I don't drink wine

Think of all the times you have had drinks containing whiskey or liquor recently. When you drink whiskey or liquor, how much do YOU USUALLY DRINK each time (in mixed drinks, approximately 1 oz shots)?

_____ drinks _____ I don't drink liquor

3. Each time you drink beer, what is the MOST YOU DRINK at one time?

_____ cans or glasses _____ I don't drink beer

Each time you drink wine, what is the MOST YOU DRINK at one time?

_____ glasses _____ I don't drink wine

Each time you drink liquor, what is the MOST YOU DRINK at one time?

_____ drinks _____ I don't drink liquor

4. [Use the response possibilities from question #1]

How often do you drink this MOST amount of beer? _____

How often do you drink this MOST amount of wine? _____

How often do you drink this MOST amount of liquor? _____

5. Have you ever had a close relative with a serious drinking problem?

mother _____ father _____ step mother _____ step father _____
sibling _____ grandparent _____ myself _____ other (specify) _____

Michigan Alcohol Screening Test (MAST)

Please circle either Yes or No for each item as it applies to you.

- Yes No (2) 1. Do you feel you are a normal drinker?
 Yes No (2) 2. Have you ever awakened the morning after some drinking the night before and found that you could not remember a part of the evening before?
 Yes No (1) 3. Does your wife (or do your parents) ever worry or complain about your drinking?
 Yes No (2) 4. Can you stop drinking without a struggle after one or two drinks?
 Yes No (1) 5. Do you ever feel bad about your drinking?
 Yes No (2) 6. Do friends or relatives think you are a normal drinker?
 Yes No (0) 7. Do you ever try to limit your drinking to certain times of the day or to certain places?
 Yes No (2) 8. Are you always able to stop drinking when you want to?
 Yes No (5) 9. Have you ever attended a meeting of Alcoholics Anonymous (AA)?
 Yes No (1) 10. Have you gotten into fights when drinking?
 Yes No (2) 11. Has drinking ever created problems with you and your wife?
 Yes No (2) 12. Has your wife (or other family member) ever gone to anyone for help about your drinking?
 Yes No (2) 13. Have you ever lost friends or girlfriends/boyfriends because of drinking?
 Yes No (2) 14. Have you ever gotten into trouble at work because of drinking?
 Yes No (2) 15. Have you ever lost a job because of drinking?
 Yes No (2) 16. Have you ever neglected your obligations, your family, or your work for two or more days in a row because you were drinking?
 Yes No (1) 17. Do you ever drink before noon?
 Yes No (2) 18. Have you ever been told you have liver trouble? Cirrhosis?
 Yes No (5) 19. Have you ever had delirium tremens (DTs), severe shaking, heard voices, or seen things that weren't there after heavy drinking?
 Yes No (5) 20. Have you ever gone to anyone for help about your drinking?
 Yes No (5) 21. Have you ever been in a hospital because of drinking?
 Yes No (2) 22. Have you ever been a patient in a psychiatric hospital or on a psychiatric ward of a general hospital where drinking was part of the problem?
 Yes No (2) 23. Have you ever been seen at a psychiatric or mental health clinic, or gone to a doctor, social worker, or clergyman for help with an emotional problem in which drinking had played a part?
 Yes No (2) 24. Have you ever been arrested, even for a few hours, because of drunk behavior?
 Yes No (2) 25. Have you ever been arrested for drunk driving after drinking?

WAIS – DIGIT SPAN SUB-TEST

Discontinue after failure on both trials of any item.

DIGITS FORWARD	Pass-Fail	Score 2, 1, or 0	DIGITS BACKWARD	Pass-Fail	Score 2, 1, or 0
1. 5-8-2 6-9-4			1. 2-4 5-8		
2. 6-4-3-9 7-2-8-6			2. 6-2-9 4-1-5		
3. 4-2-7-3-1 7-5-8-3-6			3. 3-2-7-9 4-9-6-8		
4. 6-1-9-4-7-3 3-9-2-4-8-7			4. 1-5-2-8-6 6-1-8-4-3		
5. 5-9-1-7-4-2-8 4-1-7-9-3-8-6			5. 5-3-9-4-1-8 7-2-4-8-5-6		
6. 5-8-1-9-2-6-4-7 3-8-2-9-5-1-7-4			6. 8-1-2-9-3-6-5 4-7-3-9-1-2-8		
7. 2-7-5-8-6-2-5-8-4 7-1-3-9-4-2-5-6-8			7. 9-4-3-7-6-2-5-8 7-2-8-1-9-6-5-3		
Total forward -			Total backward -		
Total of both -					

WAIS - BLOCK DESIGN Discontinue after 3 consecutive failures.

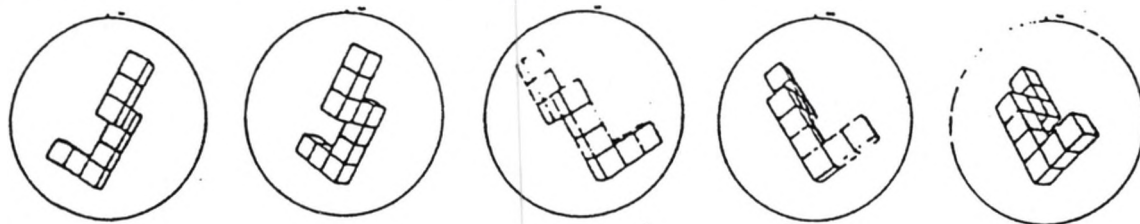
Design	Time	Pass-Fail	Score							
			(Circle the appropriate score for each design)							
1. 60"	1									
	2		0	1						2
2. 60"	1									2
	2		0	1						
3. 60"			0	16-60/4	11-15/5	1-10/6				
4. 60"			0	16-60/4	11-15/5	1-10/6				
5. 60"			0	21-60/4	16-20/5	11-15/6	1-10/7			
6. 120"			0	36-120/4	26-35/5	21-25/6	1-20/7			
7. 120"			0	61-120/4	46-50/5	31-45/6	1-30/7			
8. 120"			0	76-120/4	56-75/5	41-55/6	1-40/7			
9. 120"			0	76-120/4	56-75/5	41-55/6	1-40/7			

Max= 51

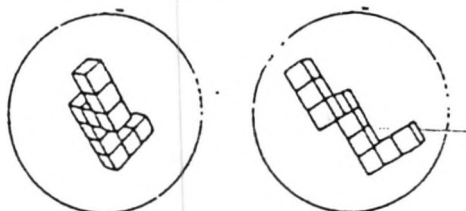
Total -

Mental Rotation Test

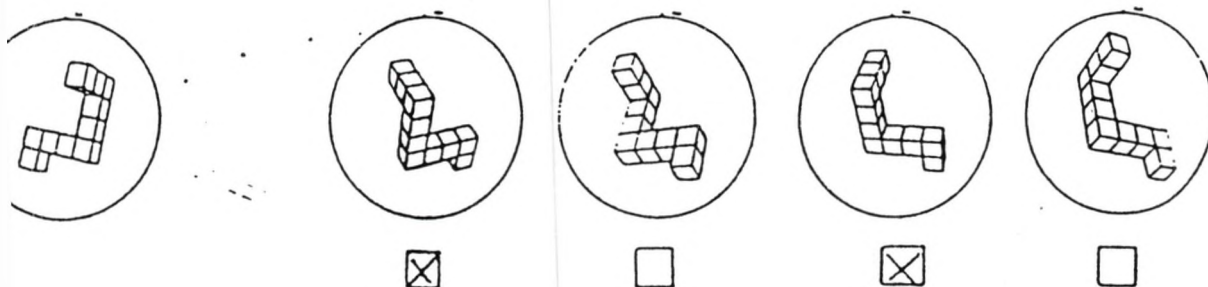
This is a test of your ability to look at a drawing of a given object and find the same object within a set of dissimilar objects. The only difference between the original object and the chosen object will be that they are presented at different angles. An illustration of this principle is given below, where the same single object is given in five different positions. Look at each of them to satisfy yourself that they are only presented at different angles from one another.



Below are two drawings of new objects. They cannot be made to match the above five drawings. Please note that you may not turn over the objects. Satisfy yourself that they are different from the above.



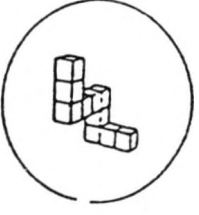
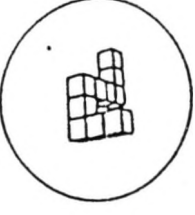
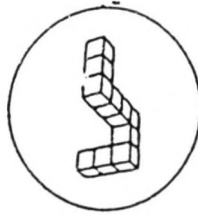
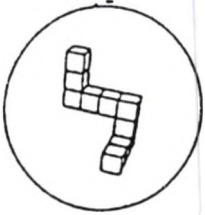
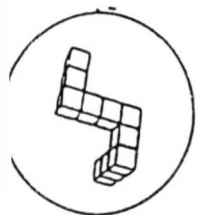
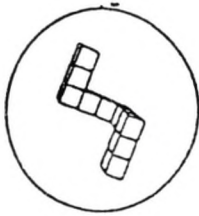
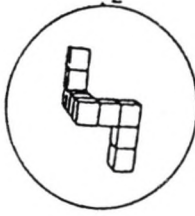
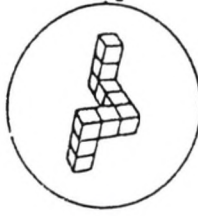
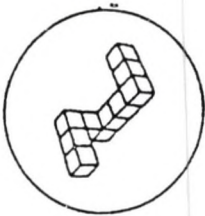
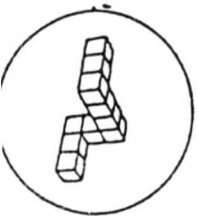
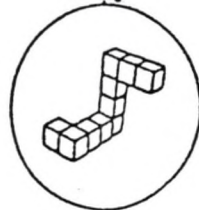
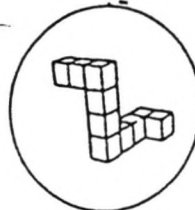
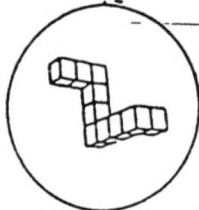
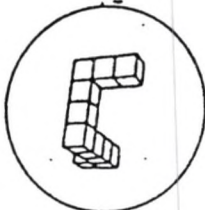
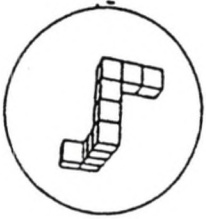
Now let's do some sample problems. For each problem there is a primary object on the far left. You are to determine which two of four objects to the right are the same object given on the far left. In each problem always two of the four drawings are the same object as the one on the left. You are to put Xs in the boxes below the correct ones, and leave the incorrect ones blank. The first sample problem is done for you.



Go to the next page

Mental Rotation Test

Do the rest of the sample problems yourself. Which two drawings of the four on the right show the same object as the one on the left? There are always two and only two correct answers for each problem. Put an X under the two correct drawings.

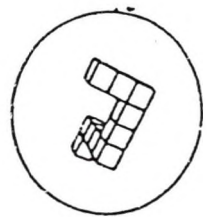
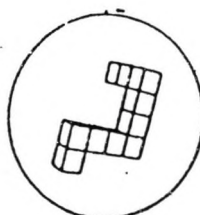
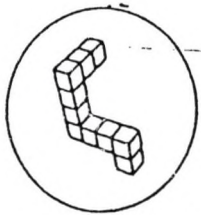
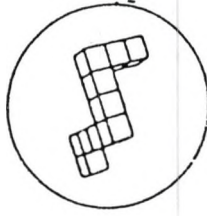
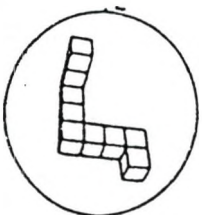
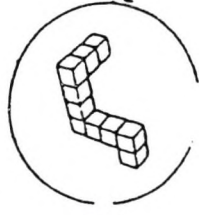
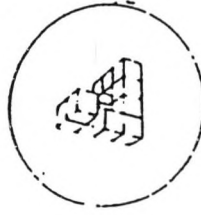
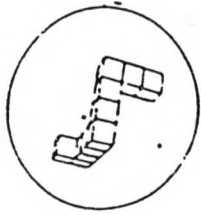
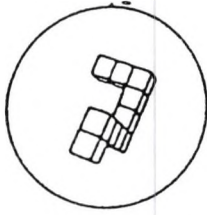
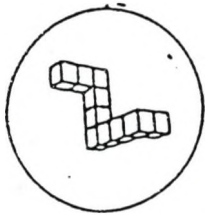
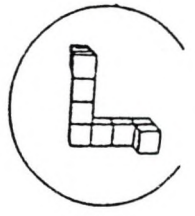
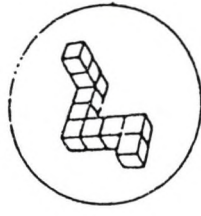
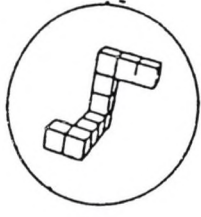
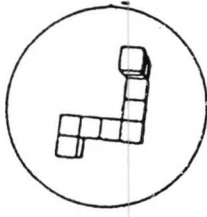
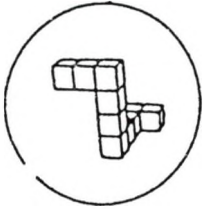
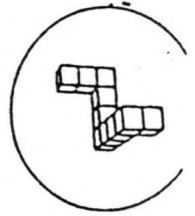
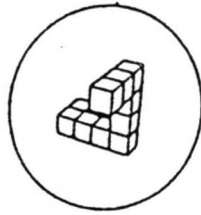
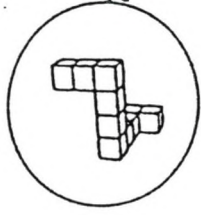
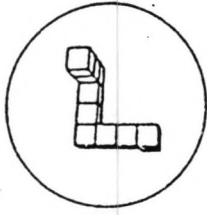
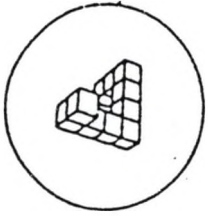
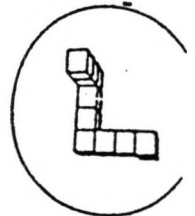
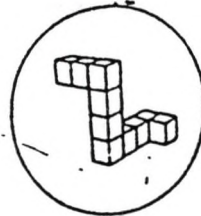
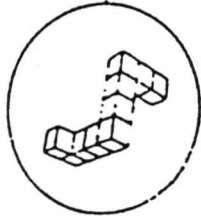
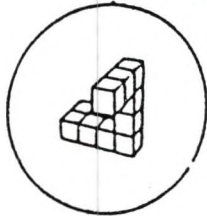
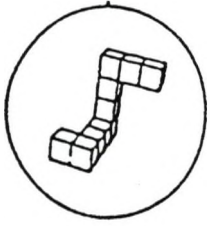


- Answers: (1) first and second drawings are correct
 (2) first and third drawings are correct
 (3) second and third drawings are correct

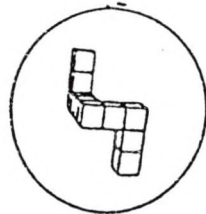
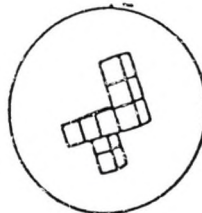
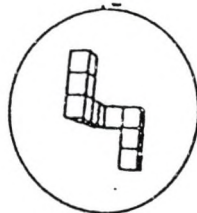
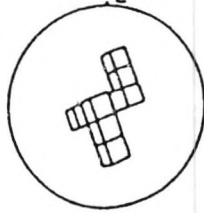
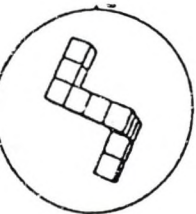
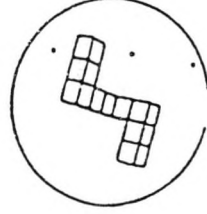
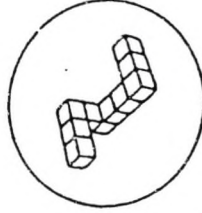
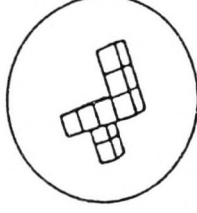
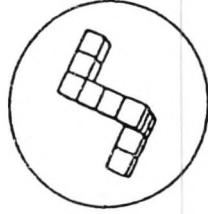
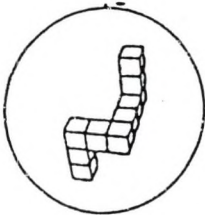
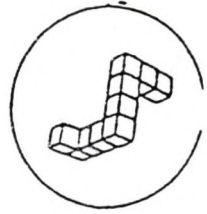
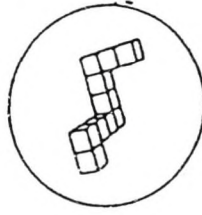
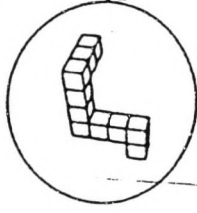
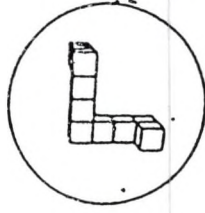
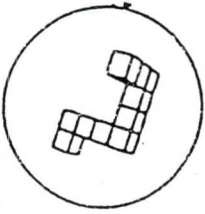
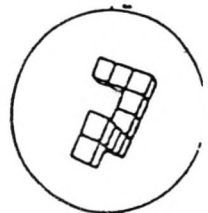
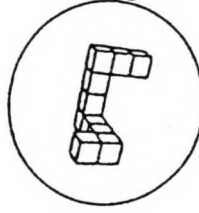
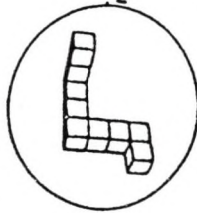
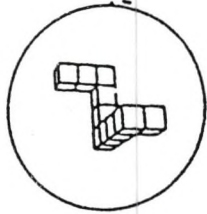
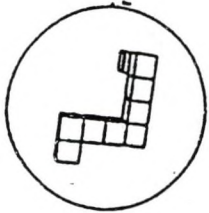
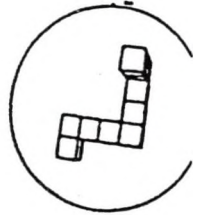
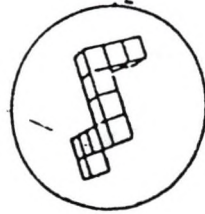
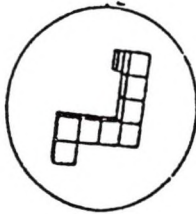
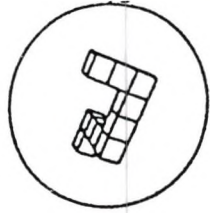
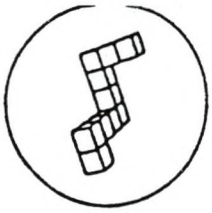
This test has two parts. You will have 3 minutes for each of the two parts. Each part has two pages. When you have finished Part I, STOP. Please do not go on to Part 2 until you are asked to do so. Remember: There are always two and only two correct answers for each item.

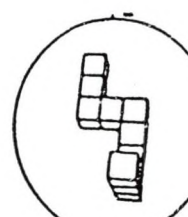
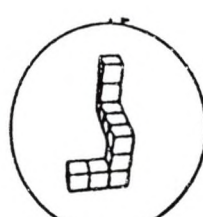
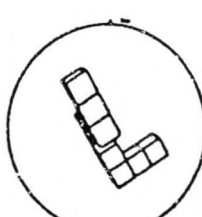
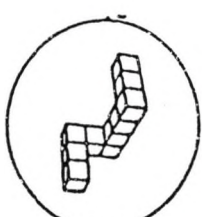
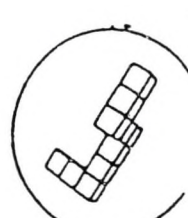
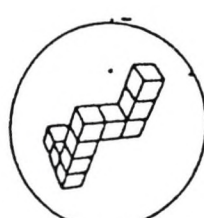
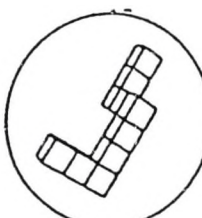
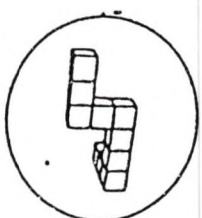
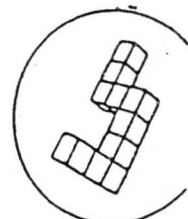
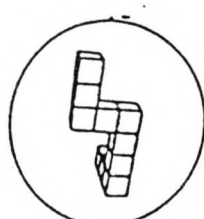
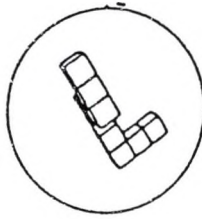
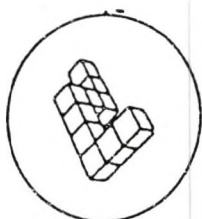
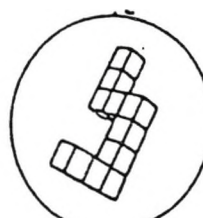
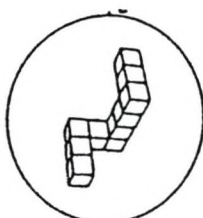
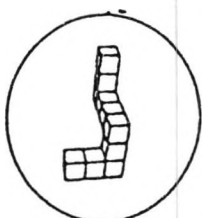
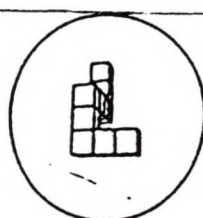
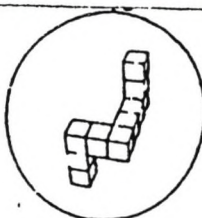
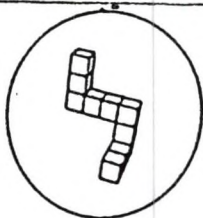
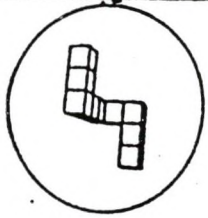
Work as quickly as you can without sacrificing accuracy. Your score on this test will reflect both the correct and incorrect responses. Therefore, it will not be to your advantage to guess unless you have some idea which choice is correct.

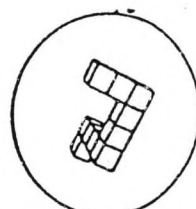
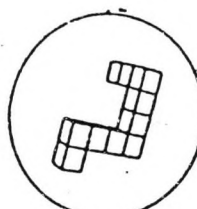
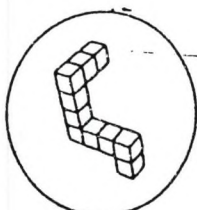
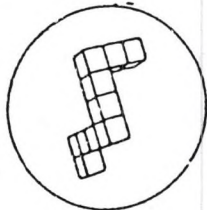
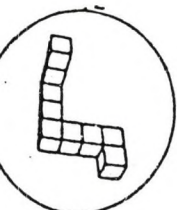
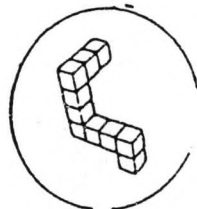
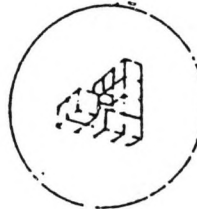
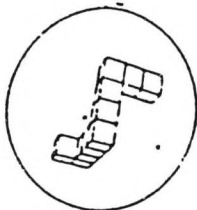
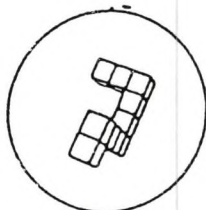
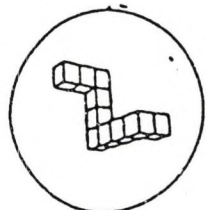
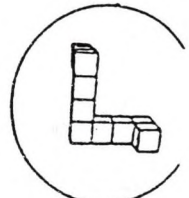
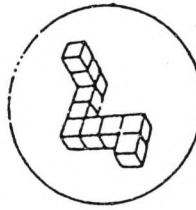
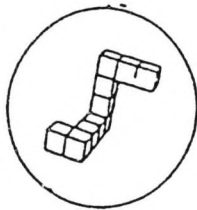
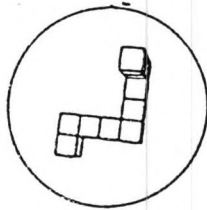
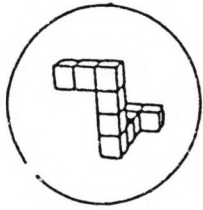
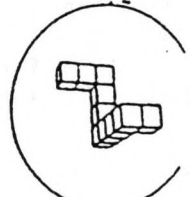
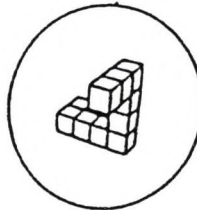
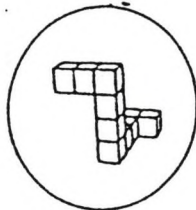
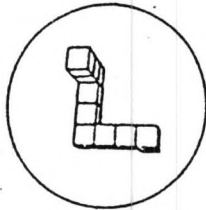
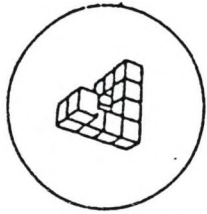
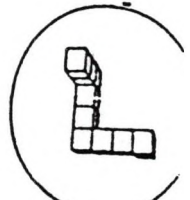
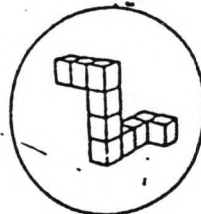
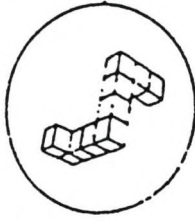
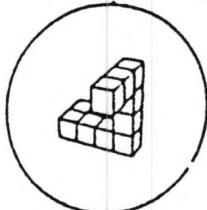
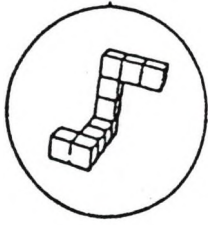
Mental Rotation Test



Mental Rotation Test



Mental Rotation Test

Mental Rotation Test

Appendix F
Flight Scenarios

Simulator Performance Data Quiz

Part One — Power Settings

Please fill in the following blanks.

1. Takeoff - _____ Power / Prop Setting
2. Climb - _____“Manifold Pressure / _____ RPM / Airspeed _____ / Rate of Climb _____
3. Cruise - _____“Manifold Pressure / _____ RPM
4. Holding — Power set as needed to obtain - _____ knots
5. Approach Maneuvering — Power as needed to obtain - _____ knots
6. ILS Approach — Power as needed to obtain - _____ knots
7. Missed Approach - _____“Manifold Pressure / _____ RPM / Airspeed _____ knots / Rate of Climb _____
8. Cruise — All climbs and descents must be performed at _____ rate of climb/descent.

Part Two — Important Points to Remember

Please give your best short answer.

9. What airspeed must you establish prior to entering holding?
10. What are the three types of entries into holding patterns?
11. If you are approaching your holding fix from the opposite heading of your inbound holding course, what type of entry should you execute into the holding pattern?
12. What should you do when given a clearance by ATC?
13. When encountering in-flight emergencies of abnormal conditions, what actions should you take?
14. When executing an instrument approach, upon reaching the Missed Approach Point, if you do not see the runway, what actions must you take?
15. What are two ways in which an intersection can be identified?

Practice Scenario

Researcher- Give Subject current ALTIMETER setting 29.95 and inform them that their callsign is N328ND. They are near WRN and will intercept the 038 radial from GFK. Contact GFK APROACH when established on the 038 radial.

APPROACH

November 328
Squawk 0327 and Identify

Subject- Dials in proper squawk code	YES	NO
Subject- Identifies	YES	NO

APPROACH

November 328
Prepare to copy
Holding instructions
Subject- advises when ready
NO

YES

APPROACH

November 328
Hold NE of the
EYWUS intersection
On the 038 Radial
Expect one turn in holding
Report established
Subject- reads back clearance

YES NO

Practice
Scenario**APPROACH**

November 328

Upon completion of this turn in holding Track inbound
to the GFK VOR on Vi 71

Subject- Reads back clearance

NO

YES

APPROACH

November 328

Do you have current ATIS?

Frequency change approved

Subject- dials in ATIS(119.4)

NO

YES

ATIS

Grand Forks international Airport

Information Echo

1 600 Zulu Observation

Indefinite Ceiling 200'

Sky Obscured

Visibility 1/2 mile

Snow

Temperature -7

Dewpoint -10

Altimeter 29.97

Wind Calm

Landing and Departing Runways 35 Left and Right

Contact Ground on 1 21.9

Advise on initial contact, you have information Echo

Subject- sets colesman window(29.97)

YES NO WRONG

Practice
Scenario

APPROACH

November 328
 Vectors to the ILS Approach RY 35L
 Turn left to 180
 Descend and maintain 2600'
 Subject- Reads back clearance
 NO

YES

APPROACH

November 328
 Turn right to 230
 Subject- Reads back clearance
 NO

YES

APPROACH

November 328
 Turn right to 320
 Intercept Localizer
 Report established on localizer

Subject- Reads back clearance

YES NO

Subject- reports established on localizer

YES NO

Researcher- scores approach

APPROACH

November 328
 Cleared for ILS approach RWY 35L
 Upon passing HISER contact Grand Forks tower 118.4
 Fly Missed Approach as published

Subject- Reads back clearance

YES NO

Subject- dials in proper frequency(118.4)

YES NO

Subject- puts gear down upon passing HISER(6.9 DME)

YES NO

Subject- contacts tower passing HISER(6.9 DME)

YES NO

Practice
Scenario**GFK TOWER**

Chatter

GFK TOWER

November 328

Cleared to land runway 35L

Subject- Reads back clearance	YES	NO
Subject- goes missed approach without busting DH(1044')	YES	NO
Subject- retracts gear	YES	NO
Subject- proper climb setting(25, 25)	YES	NO
Subject- calls missed approach to tower	YES	NO
Subject- executes published MAP	YES	NO

MISSED APPROACH

*Climb to 1700' then climbing right turn to
2600' direct GFK VOR/DME and hold.*

GFK TOWER

Chatter

GFK TOWER

November 328

Contact GFK Approach 11 8.1

Subject- Reads back clearance	YES	NO
Subject- dials in proper frequency(118.1)	YES	NO
Subject- calls approach	YES	NO

APPROACH

November 328

Radar contact

Continue missed approach as published

Expect two turns in holding

Report established in holding

Subject- Reads back clearance

YES NO

Researcher- scores holding pattern

Subject- reports established in holding

YES NO

MISSED APPROACH

*Climb to 1700' then climbing right turn to
2600' direct GFK VOR/DME and hold.*

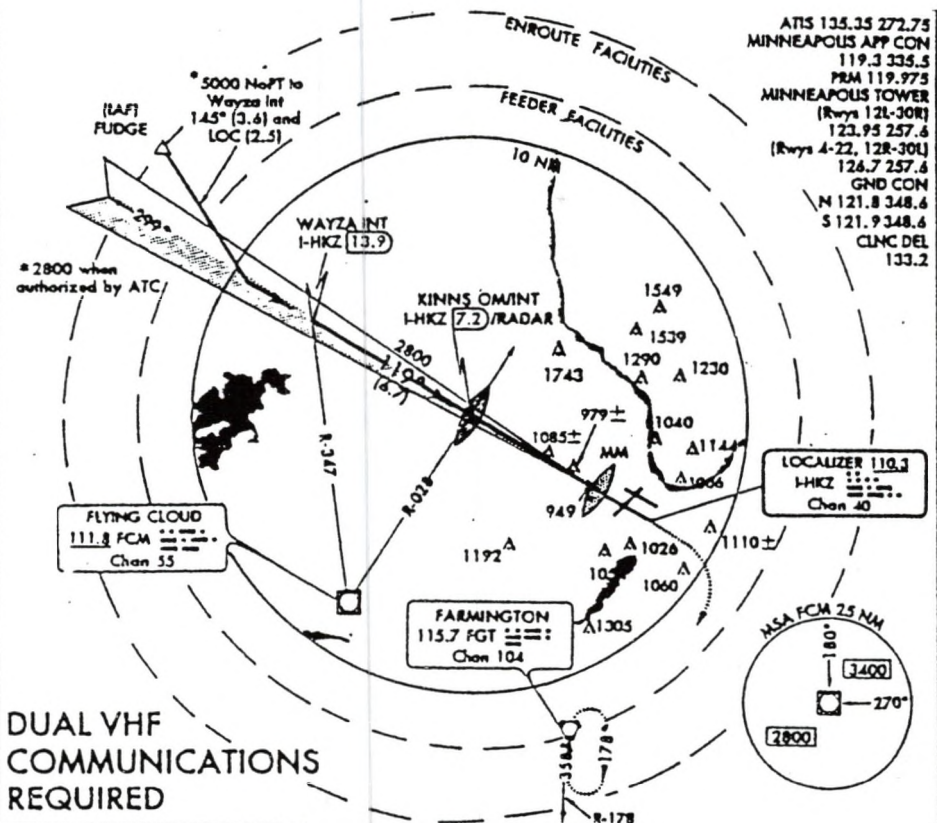
APPROACH

Chatter

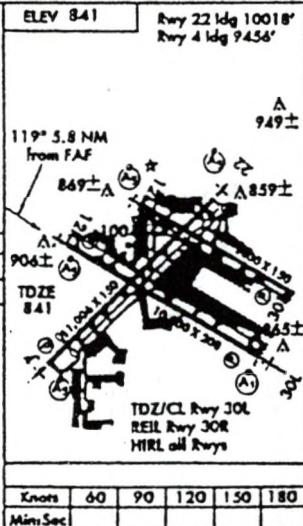
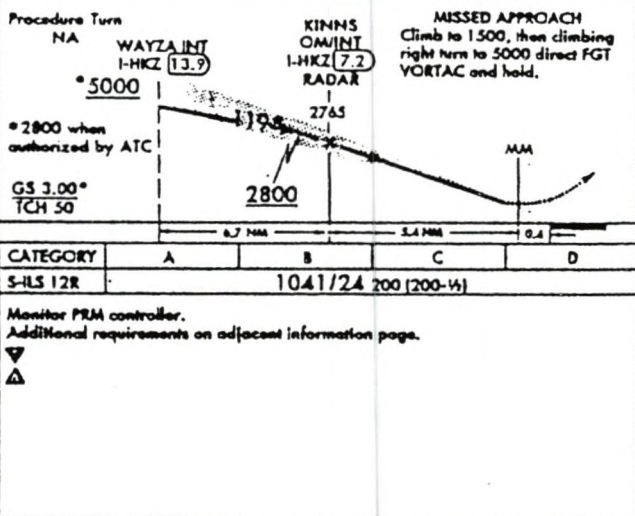
Researcher- configures simulator for test pattern

Upon completion of scored test pattern Researcher concludes scenario.

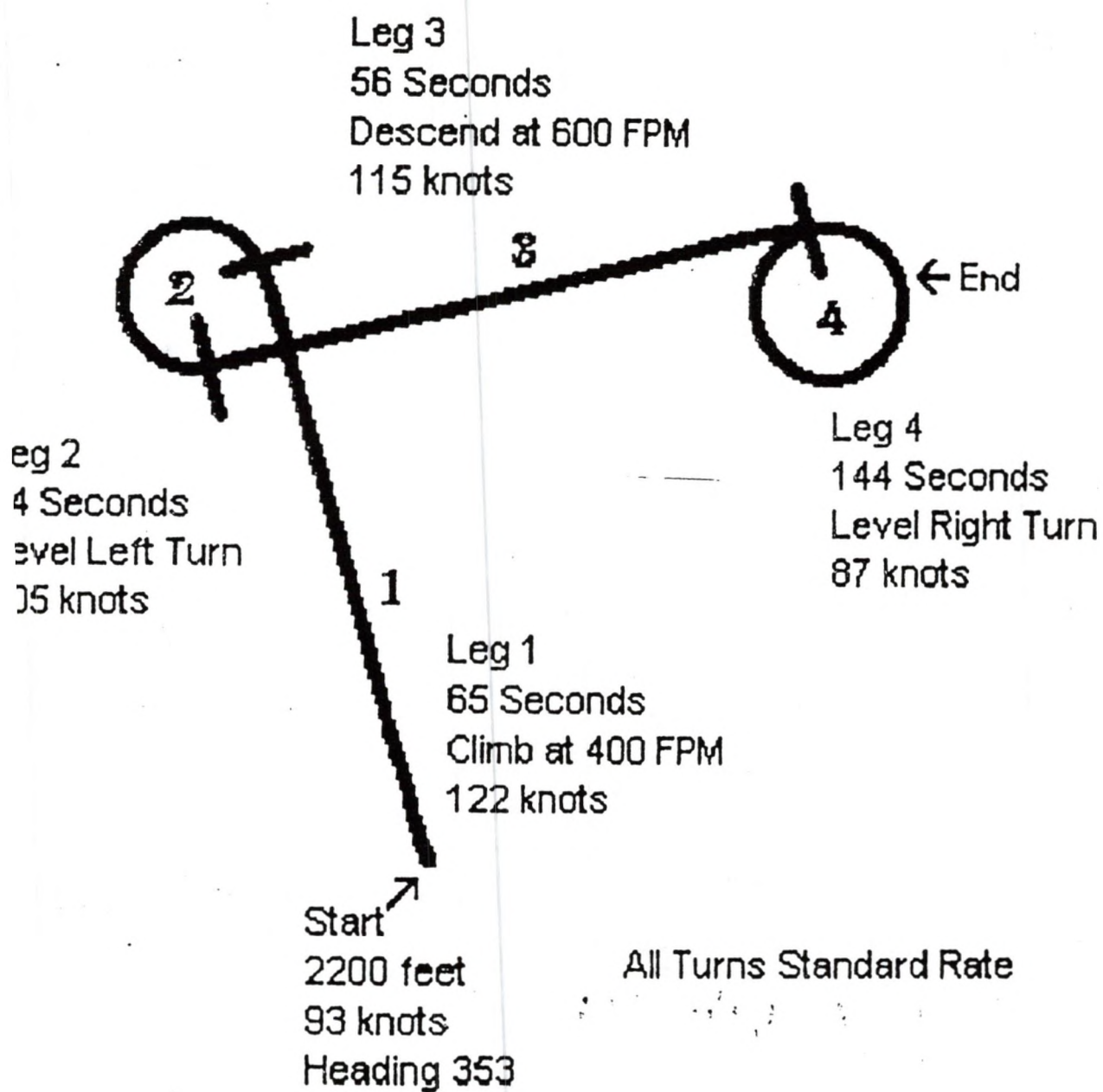
Flight Scenario Map



ATIS 135.35 272.75
 MINNEAPOLIS APP CON
 119.3 335.5
 PRM 119.975
 MINNEAPOLIS TOWER
 (Rwys 12L-30R)
 123.95 257.6
 (Rwys 4-22, 12R-30L)
 126.7 257.6
 GND CON
 M 121.8 348.6
 S 121.9 348.6
 CLNC DEL
 133.2



(SIMULTANEOUS CLOSE PARALLEL) 44°53'N-93°13'W MINNEAPOLIS, MINNESOTA
 ILS PRM RWY 12R MINNEAPOLIS-ST PAUL INTL (WOLD-CHAMBERLAIN) (MSP)
 Orig 97338 179 NC-1, 1 JAN 1998

Flight Scenario Chart

FLIGHT SCENARIO #1

SUBJECT _____

DATE _____

TIME OF SCENARIO _____

ORDER OF SCENARIO ON THIS DAY FIRST SECOND

RESEARCH ASSISTANTS CONDUCTING SCENARIO

TOTAL TIME TO RUN SCENARIO _____

Prior to Flight

Subject - dials in ATIS (135.35) for MSP

YES NO

ATIS

Minneapolis International Airport

Information Bravo

1400 Zulu Observation

Indefinite Ceiling 200

Sky Obscured

Visibility 1/2 mile

Snow

Temperature - 4

Dewpoint - 5

Altimeter 29.98

Wind Calm

Landing and Departing RYs 12 Left and Right and RY 4

Contact Clearance Delivery on 133.2 prior to taxi,

Advise on initial contact to Ground Control that you have information Bravo.

Subject - sets colesman window (29.98)

YES NO WRONG

Subject - dials in Clearance Delivery (133.2)

YES NO WRONG

Subject - Calls for clearance

YES NO

CLEARANCE

November 328

Minneapolis Clearance Delivery

You are cleared to the Flying Cloud Airport

Via the Farmington VORTAC 3600 radial

To the Farmington VORTAC,

Victor 171,

Radar Vectors,

Direct Flying Cloud

Climb and Maintain 3000'

Departure will be 124.7

Squawk 0427

Subject - reads back clearance (9) YES NO WRONG

 Cleared to the Flying Cloud Airport Via the Farmington VORTAC 360° radial To the Farmington VORTAC, Victor 171 Radar Vectors, Direct Flying Cloud Climb and Maintain 3000' 124.7 0427

Subject - sets in proper squawk code (0427) YES NO WRONG

Subject - dials in Ground Control Frequency (121.9) YES NO WRONG

Researcher - Empty right hand fuel tank(B,B,0)

Subject - calls for taxi instructions

Researcher -advises that the aircraft is already taxied into position, and that the subject may continue to do the run-up, and to contact the tower when ready for takeoff*Researcher* - Verify altimeter setting proper before takeoff

Subject - does run-up and sets up radios

Researcher -During run-up kill left magneto(F,A,A)

Subject - Reports right fuel tank empty YES NO

Subject - Reports loss of left magneto YES NO

LEG 1

Subject - dials in Tower Frequency (126.7) YES NO WRONG
Subject - calls ready for takeoff

TOWER
 November 328
 Minneapolis Tower
 After Takeoff,
 Fly RY Heading,
 Cleared for Takeoff

Subject - repeats revised clearance (2) YES NO WRONG

_____ Fly RY Heading,
 _____ Cleared for Takeoff

Subject - Takes Off

Subject - Retracts Gear YES NO

Subject - Proper Climb Setting (25, 25) YES NO WRONG

Subject - Flies RY Heading (120 degrees) YES NO

TOWER
 November 328
 Contact Departure 124.7

Subject - Subject repeats frequency YES NO WRONG

Subject - dials in Departure Frequency (124.7) YES NO WRONG

DEPARTURE
 November 328
 Minneapolis Departure
 Ident,
 Turn Right
 To intercept the Farmington VORTAC 3600 radial
 Report Established

Say altitude leaving
Report Reaching 3000'

Subject — Idents YES NO
Subject - repeats clearance YES NO WRONG
 ___ Turn Right
 ___ To intercept the Farmington VORTAC 360° radial
 ___ Report Established
 ___ Say altitude leaving
 ___ Report Reaching 3000'

Subject - turns right (initially) YES NO
Subject - NAY frequency correct (115.7) YES NO WRONG
Subject - OBS course correct (180° ± 3°) YES NO WRONG
Subject - reports established YES NO LATE (2500' or higher)
Researcher - scores climb (SC1 A--Li) Time _____

DEPARTURE
Chatter

DEPARTURE
November 328
Radar Contact

Subject - levels off at 3000' (± 300') YES NO
Subject - reports reaching 3000' YES NO

104

LEG2

DEPARTURE

November 328

I have a holding clearance for you.

Advise when ready to copy

Subject - advises ready to copy (1)

YES NO

DEPARTURE

November 328

Hold North

Of the 8 DME Fix

On the Farmington VORTAC 3600 Radial

Maintain 3000'

Expect one turn in holding

1 minute legs

Report established in holding

Subject - repeats holding clearance (5)

YES NO WRONG

Hold North

8DMEFix

1 minute legs

Farmington VORTAC 360° Radial

Report established

Researcher - scores holding pattern(SC1 A--L3-6)

Subject - Begins Turn at 8 DME

YES NO

Subject - Makes Right Turns

YES NO

DEPARTURE

Chatter

Subject - reports entering holding YES NO LATE (final turn inbound or after)

Researcher - Fails NAV1 during outbound leg of holding (E., A.)

Subject - Reports failure of NAV 1 YES NO

DEPARTURE

Chatter

DEPARTURE

November 328

Continue to track inbound to Farmington VORTAC on the 360°Radial

Subject — Responds YES NO

Subject — Departs Holding and begins tracking inbound

YES NO

LEG 3

DEPARTURE (Upon leaving holding)

November 328

Climb and Maintain 4000'

Subject - reports leaving 3000' for 4000' (1) YES NO

Researcher - scores cimb(SC1 A--L8) TIME _____

DEPARTURE

Chatter

Researcher — Fails DME (E,E)

LEG 4**DEPARTURE**

November 328

Minneapolis Departure

Upon reaching Farmington VORTAC

Hold Southeast

On the 1100 radial

Maintain 4000'

Expect 1 turn in holding,

Report established in holding

Subject — Repeats Holding clearance (4) YES NO WRONG Upon reaching Farmington VORTAC Hold Southeast On the 110° radial Report established in holding**Subject** — Reports loss of DME YES NO**Subject** — levels off at 4000' ($\pm 300'$) YES NO**Subject** — Executes proper holding entry (Parallel) YES NO WRONG**Subject** — Sets up inbound course on OBS ($290^\circ \pm 3^\circ$) YES NO WRONG**Researcher** - Sets oil pressure at 0% (F., F., 0%)**Subject** — Reports entering holding YES NO LATE**Subject** — Makes right turns YES NO**Subject** - Reports loss of oil pressure YES NO**Researcher**— Scores holding pattern(SC1 A--L10-13)DEPARTURE

Chatter

LEG 5

DEPARTURE

November 328

Upon completion of this turn in holding,
You are cleared to the JONNA intersection

Via V-171

Maintain 4000'

Report established outbound from FGT VORTAC on V- 171

Subject - Repeats clearance (2) YES NO
 _____ JONNA intersection
 _____ Report established

Subject - Gets established on V — 171 YES NO LATE/POOR TRACKING

Researcher - Fails Gyro Pump (C., F.)

Subject - Reports loss of vacuum pressure YES NO

Subject - Activates auxiliary vacuum YES NO

Subject — Reports established on V — 171 YES NO

Subject — Sets proper cruise power setting(23/24) YES NO

Researcher — Scores straight and level(SC1 A--L15)

DEPARTURE

Chatter

Researcher - Fails Artificial Horizon (D., A.)

Subject - Reports failure of Artificial Horizon YES NO

LEG 6**DEPARTURE**

November 328
For traffic,

Turn left 3600

And then continue tracking the 2910 radial from FGT VORTAC.

Subject — Repeats clearance (1)

YES NO WRONG

Researcher — Scores 360 degrees turn(SC1 B—L1)

DEPARTURE

Chatter

Researcher - Fails Directional Gyro (D.,E.)

YES NO

Subject - Reports loss of Directional Gyro

DEPARTURE

November 328
Contact Minneapolis Approach 125.0

Subject — Repeats frequency change (1)

YES NO

Subject — Dials in correct frequency(125.0)

YES NO

Subject — Calls Approach

YES NO

APPROACH

November 328
Radar contact
Continue tracking inbound to the JONNA intersection
Expect further clearance in 2 minutes

Subject — Responds

YES NO

Researcher - Reconfigure Visual

LEG 7

APPROACH

November 328

Descend and maintain 3000'.

Subject — Repeats clearance (1)

YES NO

Researcher — scores descent (SC1-B-L3)

Time _____

Subject — Levels off at 3000' (\pm 300').

YES NO

LEG 8

APPROACH

November 328
 Hold NW
 Of JONNA intersection

On V-171
 Left turns

Expect 1 turn in holding.
 Maintain 3000'

Report Established

Subject - Repeats Holding clearance (5) YES NO WRONG

Hold NW

JONNA intersection

On V-171

Left turns

Report Established

Subject — Dials in Gopher (117.3) YES NO WRONG

Subject — Sets up proper radial ($210^\circ \pm 3^\circ$) YES NO WRONG

Subject — Executes proper holding entry (Teardrop) YES NO WRONG

Subject — Makes left turns
 YES NO

Subject — Sets up inbound course on OBS ($111^\circ \pm 3^\circ$) YES
 NO WRONG

Subject — Reports entering holding YES NO LATE

Researcher — Scores holding pattern(SC1 B--L5-8)

Researcher - Fails NAV2 during outbound leg of holding (E., B.)

Subject - Reports loss of NAV2 YES NO

APPROACH

Chatter

LEG 9

APPROACH

November 328

Depart JONNA

Heading 030degrees

This is a vector to the Flying Cloud LOCALIZER Final Approach Course.

Upon intercepting the localizer, track inbound.

Descend and maintain 2600'

Report Established inbound on the localizer course

Subject — Repeats clearance (6)

YES NO WRONG

____ Depart JONNA Intersection

____ Heading 030°

____ Upon intercepting the localizer

____ Track inbound.

____ Descend and maintain 2600'

____ Report Established inbound

Researcher — Returns DME (E,E)

Subject — Dials in localizer frequency (109.7) YES NO WRONG

Subject — Sets up inbound course on OBS (098° ± 3°) YES NO WRONG

Subject — Reports intercepting course

YES NO LATE

(if ready to give approach clearance)

Researcher - Scores descent(SC1 B--L10)

Time _____

APPROACH

Chatter

ATIS

Flying Cloud Airport

Information Romeo

1400 Zulu Observation

Cieling Overcast 300

Visibility ½ mile

Light Snow

Temperature — 7

Dewpoint -9

Altimeter 29.98

Wind Light and Variable

Landing and Departing RYs 9 Left and Right

Advise on initial contact you have information Romeo.

LEG 10

APPROACH

November 328
 Cleared ILS RY 9R Approach
 Upon passing STUBR
 Contact Flying Cloud TOWER on 118.1.
 Say approach speed on final

Subject - Repeats approach clearance (4)

YES NO WRONG

_____ Cleared ILS RY 9R Approach

_____ Upon passing STUBR

_____ Contact Flying Cloud TOWER on 118.1.

_____ Approach Speed on final

Researcher — Scores ILS Approach(SC1 B—L12)

Time _____

Subject — Sets in correct tower frequency (118.1)

YES NO WRONG

Subject — Puts gear down upon passing STUBR (5.4 DME) YES NO

Subject — Calls TOWER upon passing STUBR (5.4 DME) YES NO

TOWER

November 328
 Flying Cloud TOWER
 Cleared to land

Subject — responds

YES NO

TOWER

November 328
 Be advised, a Cessna went missed approach, and then a King Air landed, but the Pilot indicated that the ceiling and visibility were at minimums.
 Advise when ready to copy Missed Approach Instructions.

Subject - Advises ready to copy

YES NO

TOWER

November 328
 If missed approach is necessary
 Report missed approach to me
 Turn right
 Heading 340degrees

Climb and maintain 3500'
 Squawk 2543
 Departure Control Frequency will be 125.0

Subject - Repeats missed approach clearance (6)

YES NO WRONG

___ Report missed approach to me

___ Turn right

___ Heading 340°

___ Climb and maintain 3500'

___ 2543

___ 125.0

Subject - Goes missed approach without busting decision height (1106')

YES NO

Subject - Retracts Gear

YES NO LATE

Subject - Proper Climb Setting (25,25)

YES NO

Subject - Makes right turn

YES NO

Subject — Calls missed approach to tower

YES NO

TOWER

November 328

Contact Minneapolis Approach 125.0

Subject — Responds

YES NO

Subject — Dials in approach frequency (125.0)

YES NO WRONG

LEG 11
YES NO

Subject - Calls approach

APPROACH

Aircraft calling Minneapolis Approach
Squawk 2543
And identify

Subject — Rolls out on heading 340degrees(\pm 3degrees) YES NO WRONG

Subject — Indicates that the aircraft calling is November 328 and may repeat code to approach

Subject — Dials in *code*(2543) YES NO WRONG

Subject — Identifies YES NO

Researcher — Scores Climb(SC1 B--L14) Time

LEG 12

November 328

Radar contact 12 miles Southwest of the Minneapolis Airport

Climb and maintain 3500'

Subject — Responds

YES NO

APPROACH

November 328

For spacing

Turn left

Heading 0300

Subject — Repeats clearance (2)

YES NO

___ Turn left

___ ___ Heading 030°

Subject - Turns left

YES NO WRONG

Researcher— Scores turn(SC1 B--L16)**Subject** — Rolls out heading 030° ($\pm 3^\circ$)

YES NO

Subject — Levels off at 3500' ($\pm 300'$)

YES NO

APPROACH

Chatter

APPROACH

November 328

I understand that you would like to proceed to your alternate — Minneapolis International

Subject — Responds in the Affirmative

YES NO

Researcher - Reconfigure Visual

LEG 13

November 328

Turn left

Heading 270degrees

Vectors to the ILS 12R final approach course.

Expect the ILS to RY 12 R,

Due to traffic, climb and maintain 4500'

I will get you lower as soon as I can.

YES NO WRONG

Subject — Repeats clearance (4)

YES NO WRONG

Turn left

____ Heading 2700

____ ILS toRY 12R,

____ Climb and maintain 4500'

Subject — Turns left

YES NO

Subject — Rolls out on 270° (±3°)

YES NO

Subject - Proper Climb Setting (25,25)

YES NO

Researcher — Scores climb(SC1 C—L1)

Time _____

APPROACH

Chatter

APPROACH

November 328

Say Altitude

Subject — Says Altitude (1)

YES NO

Subject — Levels out at 4500' (± 300')

YES NO

LEG 14**APPROACH**

November 328

Turn right

Heading 040degrees

Upon reaching 040degrees

Descend and maintain 4000'

Subject — Repeats clearance (4)

_____ Turn right

_____ Heading 040°

_____ Upon reaching 040°

_____ Descend and maintain 4000'

Researcher — Scores descent(SC1 C--L3)

Time _____

Subject - Rolls out on heading 040° ($\pm 3^\circ$)

YES NO

Subject - Begins descent AFTER reaching heading

YES NO

Subject - Levels off at 4000' ($\pm 300'$)

YES NO

LEG 15

Researcher — Must time the issuance of the next clearance to provide enough time for scoring next leg
APPROACH

November 328

Turn right

Heading 090°

Maintain at or above 2800' until established on a published portion of the approach

Cleared ILS RY 12R approach.

Report established inbound.

Subject — Repeats approach clearance (5) YES NO WRONG

___ Turn right

___ Heading 090 degrees

___ Maintain at or above 2800'

___ Cleared ILS RY 12R approach.

___ Report established inbound.

Subject — Dials in localizer frequency (110.3) YES NO

Subject — Reports established inbound YES NO

Researcher — Scores descent(SC1 C--L5)

ATIS

Minneapolis International Airport

Information Charlie

1500 Zulu Observation

Ceiling 200 Overcast

Visibility ^{3/4} miles

Snow

Temperature —4

Dewpoint -6

Altimeter 29.98

Wind calm

Landing and Departing RYs 12 Left and Right and RY 4

Advise on initial contact you have information Charlie.

LEG 16

APPROACH

November 328

Upon crossing the 7.2 DME fix

Contact Minneapolis TOWER on 126.7.

Subject — Repeats clearance (2)

YES NO WRONG

____ Upon crossing the 7.2 DME fix

____ TOWER on 126.7

Subject — Sets in correct tower frequency (126.7)

YES NO WRONG

Subject — Puts gear down upon passing 7.2 DME

YES NO

Subject — Calls TOWER upon passing 7.2 DME

YES NO

Researcher — Scores ILS approach(SC1 C--L7)

Time _____

TOWER

November 328

Minneapolis TOWER

Cleared to land

Caution wake turbulence departing Heavy DC-10.

Subject — Responds to clearance to land

YES NO

Subject—Lands

YES NO

**ALCOHOL / PILOT RESEARCH GRANT
SCENARIO #2**

SUBJECT _____

DATE _____

TIME OF SCENARIO _____

ORDER OF SCENARIO ON THIS DAY FIRST SECOND

RESEARCH ASSISTANTS CONDUCTING SCENARIO

TOTAL TIME TO RUN SCENARIO _____

PRIOR TO FLIGHT**Subject** - dials in ATIS (135.35) for MSP

YES NO

Minneapolis International Airport
 Information Hotel
 1400 Zulu Observation
 Indefinite Ceiling 200
 Sky Obscured
 Visibility 1/2 mile
 Snow

Temperature - 5

Dewpoint -7

Altimeter 29.98

Wind Calm

Landing and Departing RY 22

Contact Clearance Delivery on 133.2 prior to taxi,

Advise on initial contact to Ground Control that you have

information Hotel.

Subject - sets colesman window (29.98)

YES NO WRONG

Subject - dials in Clearance Delivery (133.2)

YES NO WRONG

Subject - calls for clearance

YES NO

CLEARANCE

November 328
 Minneapolis Clearance Delivery
 You are cleared to the Airlake Airport
 Via Victor 82-161
 To the Farmington VORTAC,
 Direct Airlake,
 Climb and Maintain 3000'
 Departure will be 124.7
 Squawk 5271

Subject - reads back clearance (7) YES NO WRONG ____
 ____ Airlake Airport
 ____ Victor 82-161
 ____ Farmington VORTAC,
 ____ Direct Airlake,
 ____ 3000'
 ____ 124.7
 ____ 5271

Subject - sets in proper squawk code (5271) YES NO WRONG

Researcher - During run-up - fail alternator (C,E)

Subject - reports alternator failure YES NO

Researcher - During run-up - oil pressure at 0% (F,F,0)

Subject - reports no oil pressure YES NO

Subject - dials in Ground Control Frequency (121.9) YES NO WRONG

Subject - calls for taxi instructions

Researcher - advises that the aircraft is already taxied into position, and that the subject may continue to do the run-up, and to contact the tower when ready for takeoff

Researcher - Verify altimeter setting proper before takeoff

Subject - does run-up and sets up radios

LEG 1

Subject - dials in Tower Frequency (126.7) YES NO WRONG

Subject - calls ready for takeoff

TO
WE
R

November 328
Minneapolis Tower
After Takeoff,
Fly RY Heading,
Cleared for Takeoff

Subject - repeats revised clearance (2) YES NO WRONG

____ Fly RY Heading,
____ Cleared for Takeoff

Subject - Takes Off

Subject - Retracts Gear YES NO (if not retracted prior to scoring)

Subject - Proper Climb Setting (25,25) YES NO

Subject - Flies RY Heading (220°) YES NO

Researcher - scores cirnb(SC2 A--Li) Time

November 328
Contact Departure 124.7

Subject — repeats frequency YES NO

Subject - dials in Departure Frequency (124.7) YES NO WRONG

DEPARTURE

November 328
 Minneapolis Departure
 Ident,
 Turn Left
 To intercept Victor 82-16 1 southbound
 Report Established on airway
 Report Passing 2300'

Subject - Idents

YES NO

Subject - repeats clearance (4)

YES NO WRONG

___ Turn Left
 ___ V 82-161
 ___ Report Established
 ___ Report Passing 2300'

Subject - turns left (initially)

YES NO

Subject - NAY frequency correct (115.7)

YES NO

Subject - OBS course correct ($159^\circ \pm 3^\circ$)

YES NO WRONG

Subject - reports established on airway

YES NO

LATE(within 8DME of

FGT)

Subject — report passing 2300'

YES NO

DEPARTURE

Chatter

DEPARTURE
 November 328
 Radar Contact

Subject - levels off at 3000' (within 300')

YES NO

LEG 2

DEPARTURE

November 328

Climb and maintain 3500'

Subject - reports leaving 3000' for 3500' (1)

YES NO

Researcher - scores climb(SC2 A--L3)

Time ____

DEPARTURE

Chatter

Subject - levels off at 3500' (+300')

YES NO

LEG 3**DEPARTURE**

November 328

I have a holding clearance for you.

Advise when ready to copy

Subject - Advises ready to copy

YES NO

DEPARTURE

November 328

Hold North

Of the 6 DME Fix

On the Farmington VORTAC 339° Radial

Maintain 3500'

Expect one turn in holding

Left hand turns

1 minute legs

Report established in holding

Subject - repeats holding clearance (7)

YES NO WRONG

_____ Hold North

_____ 6DME Fix

_____ Farmington **VORTAC 339° Radial**

_____ Left hand turns

_____ 1 minute legs

_____ Report established

Researcher - scores holding pattern(SC2 A-L5-8)**Subject** - begins turn at 6 DME

YES NO

Subject - makes Left Turns

YES NO

Chatter

DEPARTURE

Subject — reports entering holdingYES NO LATE (final turn
inbound or after)**Researcher** - fail artificial horizon (D, A)**Subject** - Reports artificial horizon failure

YES NO

Chatter

DEPARTURE

LEG4

DEPARTURE

November 328

Upon completion of holding

Continue to track inbound to the Farmington VORTAC on V82-161

Contact Minneapolis Approach on 125.0

Subject - repeats clearance (1)

YES NO

_____ 125.0

Subject - departs Holding and begins tracking inbound

YES NO

Researcher -scores Straight and Level(SC2 A--LIO)

Subject - contacts approach

YES NO

APPROACH

Chatter

Researcher - Reconfigure Visual

LEG 5

APPROACH

November 328
Descend and maintain 3000'
Expect the ILS RY 29 Approach to Airlake

YES NO WRONG

Subject - Repeats clearance (2)
____ Descend and maintain 3000'
____ Expect the ILS RY 29 Approach to Airlake

Time _____

Researcher - Scores descent(SC2 A--L12)

APPROACH

November 328
Airlake Weather
200 Overcast
Visibility 1/2 mile
Altimeter 29.98
Wind Calm

YES NO

Subject — Responds

YES NO

Subject - Levels off at 3000' (within 300')

APPROACH
Chatter

LEG 6

APPROACH
 November 328
 Upon reaching the Farmington VORTAC
 Cleared ILS RY 29 Approach
 Upon passing LAAKE
 Frequency change to CTAF approved
 If missed approach is necessary
 Report back to me on 125.0
 Upon going missed approach

- Subject** - Repeats approach clearance (5) YES NO WRONG
 _____ Upon reaching the Farmington **VORTAC**
 _____ Cleared ILS RY 29 Approach
 _____ Upon passing LAAKE
 _____ Frequency change to CTAF approved
 _____ If Missed Approach is necessary, Report back to me on 125.0
 Upon going missed approach
- Researcher** - Vacuum failure (C, F)
- Subject** - Reports vacuum failure YES NO
- Subject** - Hits auxillary vacuum pump YES NO
- Researcher** - fails nay 1 (E, A)
- Subject** - Reports nay failure YES NO
- Researcher** - Scores ILS outbound(SC2 A--L14)
- Researcher** - Scores ILS approach(SC2 A--L16)
- Subject** - Sets in correct CTAF frequency (123.0) YES NO WRONG
- Subject** - Checks AWOS (115.7) YES NO
- Subject** - Puts gear down upon passing LAAKE (5.1 DME)YES NO
- Subject** - Makes traffic advisory upon passing LAAKE (5.1 DME) YES NO
- Subject** - Goes missed approach without busting decision height (1208') YES NO

Subject	- Retracts Gear	YES NO
Subject	- Proper Climb Setting (25,25)	YES NO
Subject	- Makes Left turn	YES NO
Subject	- Calls missed approach over CTAF (123.0)	YES NO

APPROACH
Chatter

LEG 7

Subject - Contacts Minneapolis Approach (125.0)	YES NO WRONG
Researcher - Scores Climb(SC2 B—L1)	Time _____
APPROACH	
November 328	
Minneapolis Approach	
Squawk 7215	
Ident	
Fly Missed Approach Procedure as published	
Report entering holding	
Say Altitude	
Verify Squawking Mode C	
Subject - reads back clearance (5)	YES NO WRONG
_____ squawk 7215	
_____ missed approach as published	
_____ says altitude	
_____ verifies mode C	
_____ report entering holding	
Subject - Dials squawk code (7215)	YES NO WRONG
Subject — Idents	YES NO
Subject - Executes proper holding entry (Parallel)	YES NO
Researcher - Scores holding pattern(SC2 B--L3-6)	
Researcher - Fails DME (E,E)	
Subject — Reports loss of DME	YES NO
Subject - Sets up inbound course on OBS ($265^{\circ} \pm 3^{\circ}$)	YES NO WRONG
Subject - Reports entering holding	YES NO
Subject - Makes left turns	YES NO
APPROACH	
Chatter	

LEG 8

APPROACH

November 328
 Upon completion of this turn in holding,
 You are cleared to the LDASH intersection
 Via V-26
 Maintain 2700'
 Report established outbound from FGT VORTAC on V-26

- Subject** — Repeats Clearance (4) YES NO WRONG
 ___ Cleared to the LDASH intersection
 ___ Via Victor 26
 ___ Maintain 2700'
 ___ Report established outbound from FGT VORTAC
- Subject** - turns left, staying on holding side YES NO
- Subject** - Gets established on V-26 YES NO LATE/POOR
TRAC
KING
- Subject** - Reports established on V-26 YES NO
- Subject** - Sets proper cruise power setting(23/24) YES NO
- Researcher** - fail artificial horizon (D, A)
- Subject** - Reports artificial horizon failure YES NO
- Researcher** - Scores straight and level(SC2 B--L8)

APPROACH
 Chatter

LEG 9**APPROACH**

November 328

Contact Minneapolis Approach 121.2

Subject — Repeats clearance (1)

YES NO

Subject - Calls Minneapolis Approach (121.2)

YES NO WRONG

APPROACH

November 328

Radar Contact Climb and Maintain 3500'

Subject - Repeats clearance (1)

YES NO

WRONG

Subject - Sets climb power setting (25,25)

YES NO

WRONG

Subject - Levels off at 3500' (within 300')

YES NO

WRONG

Researcher - fails nay 2 (E, B)**Subject** - Reports nay failure

YES NO

Chatter

Researcher - Reconfigure Visual

LEG 10**APPROACH**

November 328

For traffic,

Turn left 360°

Continue tracking V-26 Eastbound to LDASH intersection.

Subject - Repeats clearance (1)

YES NO

WRONG

Subject - Initially turns left

YES NO

WRONG

Researcher - Scores 360° turn(SC2 B--L10)**APPROACH**

Chatter

LEG 11

November 328
 Hold East
 Of LDASH intersection
 On Victor 26
 Expect two turns in holding
 1 minute legs
 Report Established

Subject - Repeats Holding Clearance (5)

YES NO WRONG

_____ Hold East
 _____ LDASH intersection
 _____ Victor 26
 _____ 1 minute legs
 _____ Report Established

Subject - Dials in Gopher (117.3)

YES NO WRONG

Subject - Sets up proper radial ($138^\circ \pm 3^\circ$)

YES NO WRONG

Subject - Executes proper holding entry (Teardrop)

YES NO WRONG

Subject - Makes right turns

YES NO

Subject - Sets up inbound course on OBS ($251^\circ \pm 3^\circ$)

YES NO WRONG

Subject - Reports entering holding

YES NO

Researcher - fails heading indicator (D, E)

Subject - Reports heading indicator failure

YES NO

Researcher - Scores holding pattern(SC2 B--L12-15)

APPROACH
 Chatter

LEG 12**APPROACH**

November 328

Upon completion of turn in holding

Turn right heading 050°

Vectors to the ILS RY 32 final approach course to St. Paul Downtown

Expect the ILS to RY 32

Say airspeed you will be using on final approach

Advise when you have information JULIET

Subject - Repeats clearance (4)

YES NO WRONG

____ Turn right heading 050°

____ Vectors to the ILS RY 32 final approach course

____ Say airspeed

____ Advise when you have JULIET

Subject - Turns right passing LDASH

YES NO

Subject - Rolls out on a heading of 050° ($\pm 3^\circ$)

YES NO WRONG

Researcher - Scores turn(SC2 C--Li)**Researcher** - Returns DME (E,E)**APPROACH**

Chatter

St. Paul Downtown Airport

Information JULIET

1400 Zulu Observation

Indefinite Ceiling 200

Sky Obscured

Visibility ½ mile variable ¾ mile

Snow

Temperature —4

Dewpoint -7

Altimeter 29.98

Wind Calm

Landing and Departing RY 32

Advise on initial contact that you have Information JULIET

LEG 13

November 328
Fly 050°
Descend and maintain 2500'

Subject — Repeats clearance (1)

YES NO

Subject - sets proper frequency IBAO(111.5)

YES NO WRONG

Researcher - Scores Descent(SC2 C--L3)

Time _____

Chatter

LEG 14**APPROACH**

November 328

Turn right heading 300°

Intercept localizer for ILS RY 32

Report established on localizer

Subject - Repeats clearance (3)

YES NO WRONG

_____ Turn right heading 300°

_____ Intercept localizer for ILS RY 32

_____ Report established on localizer

Subject - Turns right

YES NO

Subject - Rolls out on heading 300°(± 3°)

YES NO WRONG

Researcher - Scores turn (SC2 C--L5)**APPROACH**

Chatter

LEG 15**APPROACH**

November 328

You are cleared for the ILS RY 32 Approach

Contact tower on 119.1

Upon crossing the BABCO intersection

Report Passing 3 DME

If Missed Approach is necessary

Turn Right

Heading 180°

Climb and Maintain 3000'

Contact Approach 126.7

Subject - Repeats approach clearance (8)

YES NO WRONG

___ cleared for the ILS RY 32 Approach

___ tower on 119.1

___ Upon crossing the BABCO intersection

___ Report Passing 3 DME

___ If Missed Approach is necessary, Turn Right

___ Heading 180°

___ Climb and Maintain 3000'

___ 126.7

Researcher - Scores ILS Approach(SC2 C--L7)**Subject - Sets in correct tower frequency (119.1)**

YES NO WRONG

Subject - Puts gear down upon passing BABCO (6.3 DME)

YES NO

Subject - Calls TOWER upon passing BABCO (6.3 DME)

YES NO

APPROACH

Chatter

LEG 16

TOWER

November 328
Cleared to land **RY 32**

Subject - Repeats clearance to land (1)

YES NO

Researcher - Scores final approach(SC2 C--L9)

Time _____

Subject - Lands

TOWER
Chatter

Appendix G

Aviation Glossary

A

a/c - aircraft.

ACARS - Aircraft Communication Addressing and Reporting System.

accelerate-stop distance - calculated distance required for an aircraft to accelerate to V₁, reject take-off and brake safely to a halt.

AD - Airworthiness Directive, issued by airworthiness authorities to correct a defect found in an aircraft type after certification. Compliance is mandatory and may be required immediately and before further flight, within a specified period of time or number of flying hours, or when next due for routine maintenance.

ADF - automatic direction finder/finding. Radio compass which gives a relative bearing to the non-directional radio beacon to which it is tuned.

ADI - attitude deviation indicator. An advanced type of artificial horizon, part of a flight director system providing pitch and roll information and commands.

ADR - Accident Data Recorder.

aerodrome/airport elevation - highest point of an aerodrome's usable runway(s) expressed in feet above mean sea level (amsl).

AFCS - automatic flight control system, an advanced autopilot. Also IFCS, integrated flight control system.

AFTN - Aeronautical Fixed Telecommunications Network. A ground-based teleprinter network transmitting flight plans, weather information etc.

A/G - air-to-ground.

agl - above ground level.

AHRS - attitude-heading reference system. A sensor deriving aircraft attitude and heading information from gyros and accelerometers.

AIAA - area of intense aerial activity, usually military.

AIS - Aeronautical Information Service.

altimeter setting - barometric pressure reading in millibars, hectopascals.

Altitude - height, usually with respect to the terrain below (radar altitude, feet above closest dirt) or fixed earth reference (barometric altitude, feet above mean sea level).

AoA - angle of attack. Also alpha, thus 'high alpha', high angle of attack.

AoE - airport of entry.

AOG - aircraft on ground, a term used to denote urgency when requesting spares or service from suppliers or manufacturers, meaning that the aircraft cannot fly again until the parts have been supplied.

A/P - airport or autopilot.

APP - Approach (control).

APU - auxiliary power unit. Large transport aircraft and some business jets have an APU, typically a small turbine, to provide power for engine-starting and for running systems when on the ground, obviating the need for external power or ground power unit, GPU.

ASDA - accelerate-stop distance available.

ASI - airspeed indicator, a flight instrument which measures the speed of an aircraft through the air.

ASL - above sea level.

ASR - altimeter setting region, a geographical area for which the lowest value of QNH is forecast hourly and relayed by air traffic control centers. Also airport surveillance radar and air-sea rescue.

ATA - actual time of arrival.

ATC - air traffic control.

ATIS - automatic terminal information service, a continuous recorded broadcast of routine non-control airport information, usually at large airports.

ATS - air traffic service. Also ATSU, ATS Unit.

ATSORA - air traffic services outside regulated airspace.

B

Bank angle – the angle between the horizontal planes and the right wing in the lateral plane, positive when the right wing is down (also called roll).

BCP - break cloud procedure.

beta mode - manually-controlled mode for CS propellers on turboprop aircraft enabling reverse pitch to be selected for braking or to aid ground maneuvering.

BRG - bearing, the horizontal direction to or from any point expressed in degrees of the compass.

C

C - Celsius (temperature) or compass.

CAD/CAM - computer-aided design/manufacture.

CAT - clear-air turbulence. Also CATegory when referring to certain instrument landing systems which require special aircraft instrumentation, certification and pilot qualification beyond those needed for standard instrument approaches (e.g. a CAT III C ILS permits operation down to the surface of the runway without external visual reference, true zero-zero operation).

CAVU - ceiling and visibility unlimited. Cloudless (or scattered cloud) conditions with visibility in excess of ten kilometers.

CDI - course deviation indicator. The vertical needle of a VOR indicator which shows the aircraft's position relative to the selected VOR radial.

ceiling - height above ground or water of the base of the lowest layer of cloud below 20,000 feet which covers more than half of the sky. An aircraft's service ceiling is the density altitude (which see) at which its maximum rate of climb is no greater than 100 feet per minute. Its absolute ceiling is the highest altitude at which it can maintain level flight.

CH - compass heading.

CHT - cylinder head temperature (gauge). A device which, by means of a probe(s) gives a cockpit readout of the temperature of one or more of an aircraft engine's cylinder heads.

circuit - pattern around which aircraft fly when arriving at an airfield. The circuit is aligned with the active runway and may be either left- or right-handed. Dead side is the opposite side of the circuit pattern in operation from which arriving aircraft join for landing. See also finals below.

C/L - center-line (of a runway, for example).

Clearance - authorization from air traffic control to proceed as requested or instructed. Used for ground and air maneuvering, thus "cleared for take-off", "cleared flight-planned route", "cleared to descend" etc.

Clouds - commonly-used abbreviations for cloud types :-

- AC = altocumulus
- AS = altostratus
- CB = cumulonimbus
- CC = cirrocumulus
- CI = cirrus
- CS = cirrostratus
- CU = cumulus
- NS = nimbo stratus
- SC = stratocumulus
- ST = stratus

c of g - center of gravity. The point on an aircraft through which the entire aircraft's weight may be assumed to act (i.e. around which the aircraft, if suspended, would balance). C of G limits are the most forward and rearward positions of the C of G permitted for safe operation. An aircraft loaded outside its C of G limits can be difficult or impossible to control.

com(m) - communication(s)

C of P - center of pressure, the point through which the total effect of lift may be said to act on an airplane.

CPL - Commercial Pilot's License

CR or C/R - counter-rotating. Usually in general aviation referring to twin-engined aircraft with 'handed' engines whose propellers turn in opposite directions to eliminate propeller torque effect.

CRP - compulsory reporting point.

CRT - cathode ray (television) tube. Used in flight deck displays of new-generation airliners, business aircraft and military jets instead of conventional instruments. See also EFIS, below.

critical altitude - the highest density altitude at which it is possible to maintain the maximum continuous rated power or manifold pressure of an aero engine.

critical engine - the engine on a multi-engined aircraft whose failure would most seriously effect performance or handling of the aircraft, through asymmetric effects or loss of power to systems such as hydraulics.

CRS course - the intended direction of flight in the horizontal plane expressed in degrees of the compass.
c/s - call sign.

CS - constant-speed (propeller). A variable-pitch propeller which maintains constant rpm by automatically changing blade angle. Also CSU, constant-speed unit.

CTA - Control Area. An area of controlled airspace extending upwards from specified limit agl.

CTR - Control Zone. An area of controlled airspace extending upwards from ground level to a specified upper limit.

CVR - cockpit voice recorder. A tape recorder installed on the flight decks of commercial transport aircraft and helicopters and some business airplanes to record crew conversation, RT transmissions and cockpit background noises (e.g. trim-wheel operation, flap motor running) in case required for incident or accident investigation.

CW - carrier wave or continuous wave.

CZ - Control Zone

D

DA - Danger Area. Also DACS, Danger Area Crossing Service, and DAAIS, Danger Area Activity Information Service.

D & D - Distress & Diversion Cells at Air Traffic Control Centers. RAF units which provide a 24-hour listening watch on VHF and UHF emergency frequencies and can locate and assist pilots who are lost or in emergency situations.

deadstick - descent and landing with engine(s) shut down and propeller(s) stopped.

DCT - direct

density altitude - pressure altitude corrected for air temperature.

DETRESFA - distress phase of search-and-rescue operation.

DF - direction-finding. A DF bearing can be provided by airfields or other facilities such as D & D cells (above) having suitable direction-finding equipment to locate an aircraft.

DH - decision height. The height on a precision approach at which a pilot must have the runway approach lights in sight to continue the descent, or if not, must initiate a go-around.

DI - direction indicator. A gyro instrument which indicates the magnetic heading of an aircraft. The DI, also known as the directional gyro (DG), is free of the turning errors associated with magnetic compasses but is prone to precession (wander) and must be reset against the magnetic compass at intervals. ALSO - **DI** - is also used to refer to the daily inspection -- a thorough pre-flight check of an aircraft prior to the first flight of the day.

DME - distance-measuring equipment. A combination of ground and airborne equipment which gives a continuous slant range distance-from-station readout by measuring time-lapse of a signal transmitted by the aircraft to the station and responded back. DMEs can also provide groundspeed and time-to-station readouts by differentiation.

Doppler - Doppler effect (or shift) is the change in frequency of light, radio or sound waves when source and receiver are in relative motion.

DoT - Department of Transport.

DP - dew point

DR - dead (deduced) reckoning. Plotting position by calculating the effect of speed, course, time and wind against last known position.

dry - when referring to aircraft hire charges means 'without fuel', as opposed to wet, with fuel.

DZ - dropping zone, for parachuting etc.

E

EADI - electronic attitude director indicator. An ADI with CRT cockpit display forming part of an EFIS, below.

EAT - estimated approach time.

ECU - environmental control unit.

EET - estimated elapsed time.

EFAS - electronic flash approach light system.

EFATO - engine failure at (or after) take-off.

EFIS - electronic flight instrument system, in which multi- function CRT displays replace traditional instruments for providing flight, navigation and aircraft systems information, forming a so-called 'glass cockpit'. Now common in commercial transports, corporate aircraft and helicopters, military fighters and some GA piston singles and twins.

EGT - exhaust gas temperature (gauge). A device which provides a cockpit readout of the exhaust gas temperature of an aircraft's (piston) engine(s), enabling the pilot to lean the mixture for maximum fuel efficiency.

EHSI - electronic horizontal situation indicator. CRT-based HSI forming part of an EFIS.

EICAS - engine indicating and crew alerting system. CRT display which monitors engine performance and alerts the crew to system or airframe failure. Found in new-generation transports and business jets.

ELT - emergency locator transmitter. A small radio transmitter fixed to an aircraft's structure which is automatically activated by impact or water immersion and transmits a code on emergency frequencies enabling SAR satellites or search units equipped with DF to locate the crash or ditching site. Sometimes styled ADELTA, automatically deployable ELT, or ELB, emergency locator beacon.

empty weight - weight of the basic airplane including all fixed equipment, plus unusable fuel, oil, hydraulic and other fluids.

encoding altimeter - an altimeter which gives a digital output to the transponder (which see) for automatic transmission of the aircraft's pressure altitude to ATC.

EOBT - estimated off-blocks time.

EPNdB - effective perceived noise decibel. Unit of measurement of aircraft noise levels.

ETA - estimated time of arrival. Also ETD, estimated time of departure; ETE, estimated time en route.

EROPS - extended range operations, usually long over-water flights by twin-jet airliners.

F

FAA - Federal Aviation Administration.

FADEC - full-authority digital engine control.

FAF - final approach fix, the point at which a published instrument approach begins.

FAR - Federal Aviation Regulations

FBO - fixed-base operator, an American term for commercial operators supplying fuel, maintenance, aircraft sales, rental, flight training, handling and other general aviation services at an airport. (So-called because the first FBOs were early barnstormers who chose to settle at one field.)

FBW - fly-by-wire. Also FBL, fly-by-light. Aircraft control systems in which pilots' control inputs are transmitted to control surfaces electronically or via fibre optics rather than by mechanical linkage.

fcst - forecast.

FDR - flight data recorder, popularly known as a 'black box' (actually painted bright orange), by which various parameters of an aircraft's flight performance are recorded for analysis in the event of an incident or accident.

feather (of a propeller) - to set the angle of CS or VP propeller edge-on to the airflow to minimize drag and rotation following engine failure on multi-engined aircraft. Also applies to motor gliders which have feathering propellers to enhance engine-off soaring performance.

final(s) - final approach. The part of a landing sequence or aerodrome circuit procedure in which the aircraft has made its final turn and is inbound to the active runway. Downwind is the segment of the circuit paralleling the runway and flown on a reciprocal heading. Base leg is the crosswind segment bringing the aircraft from the downwind leg to final approach. The leg before downwind is called the Crosswind leg.

FJ - fast jet.

FL - flight level, a level of constant atmospheric pressure shown by an altimeter set to a standard 1013.2 millibars, expressed in rounds hundreds of feet, thus FL330 is 33,000 feet.

flag - warning signal incorporated in certain navigation and flight instruments indicating that the instrument is not operating satisfactorily or that the strength of signals being received from ground stations is below acceptable limits.

flat rating - throttling or other restriction of engine power output (usually in turboprops and turboshafts) at sea level to enable it to give constant predictable power at higher operating altitudes.

flameout - combustion failure in a turbine engine resulting in power loss.

flicker effect - nausea, dizziness or vertigo which can be brought on by flickering at certain frequencies of a bright light source such as sunlight or strobe when viewed through a rotating propeller or rotor blades.

Flight plan - A predetermined route, possibly including guidance modes, communications, and mission objectives, used by guidance and mission management for moding and planning; Series of navigation reference points, waypoints, and mode commands for navigation, radio navigation, guidance, and flight director.

FMS - flight management system.

FOD - foreign object damage, usually to turbine engines through ingestion of runway debris etc.

fpm - feet per minute, a measure of an aircraft's rate of climb or descent. Similarly m/s or mps, meters per second.

FSS - Flight Service Station

FTO - flying training organization.

G

g - the acceleration force of gravity, normally 1g on earth. Zero g (0g) is weightlessness, as experienced by orbiting astronauts. g is expressed as positive (+) and negative (-) values, During a normal loop a pilot experiences positive g, tending to force him down in his seat. In an outside loop, with the pilot's head on the outside of the vertical circle, negative g forces him up against his straps. Aircraft structural load limits are expressed in positive and negative values, the positive limit usually greater than negative, except in specialist aerobatic types.

g-loc - g-induced loss of consciousness. Pilot blackouts caused by excessive g or by too-rapid onset of g-forces. Experienced mostly by pilots of high-performance military jets and competition aerobatic aircraft, has led to fatal crashes.

GCA - ground-controlled approach. A landing approach in which a ground controller gives verbal guidance in azimuth and elevation to a pilot using precision approach radar (PAR) to monitor the aircraft's approach path. Still used by the military, but defunct in civil aviation.

gnd - ground

GP - glidepath

gph - gallons per hour, an expression of fuel consumption or fuel flow (FF) in either imperial or U.S. gallons. Usually lb/hr for turbine-powered aircraft.

GPS - Global Positioning System (Navstar). A U.S. developed satellite-based high-precision navigation system, intended primarily for military use but now in widespread use by commercial and private operators, though with reduced accuracy compared with military versions.

GPWS - ground proximity warning system. A radar-based flight-deck system to give pilots audible warning by means of horns, hooters, taped or synthetic voices of terrain close beneath an aircraft's flight path.

GS - glideslope. The vertical guidance part of an instrument landing system which establishes a safe glidepath (usually three degrees) to a runway.

G/S - groundspeed. The speed an aircraft makes over the ground, a product of its airspeed and wind speed.

H

half-mill(ion) - 1:500,000 scale ICAO aeronautical chart.

Hdg - heading. The direction in which an aircraft's nose points in flight in the horizontal plane, expressed in compass degrees.

Heavy - suffix used in RT callsigns to indicate that the aircraft is a large transport, alerting controllers and following aircraft to the possibility of wake turbulence.

Hertz - standard radio equivalent of frequency in cycles per second. See also kHz and MHz.
HF - high-frequency band, used for long-range radio communications in the 3-30 MHz range.
Hg - inches of mercury, a unit of pressure measurement.
HIAL - high intensity approach lighting.
HIRF - high intensity radiated (electromagnetic) fields.
HIRL - high intensity runway lighting.
HISL - high intensity strobe light.
holding pattern - racetrack-shaped maneuver which keeps aircraft within a specified airspace while awaiting further clearance from air traffic control.
hot-and-high - airfield conditions of high altitude and high ambient temperatures that can severely limit aircraft performance. See also density altitude.
HOTAS - hands on throttle and stick. Ergonomic cockpit design technology, originally developed for military combat aircraft, enabling a pilot to fly the aircraft and manage all navigation, weapons and other systems from control column/throttle lever hand grips.
HSI - horizontal situation indicator. A cockpit navigation display, usually part of a flight-director system, which combines navigation and heading.
HUD - head-up display. A method of projecting instrument readouts or data which enables a pilot to see them while looking through the aircraft's windscreen. Mostly used on military aircraft, but now in service on some commercial airliners.

I

IAS - indicated airspeed. An aircraft's speed through the air as indicated by the ASI, without correction for position error, altitude or outside air temperature. (see also CAS, RAS and TAS).
i/c - intercom
IF - instrument flying.
IFF - identification friend or foe.
IFR - instrument flight rules prescribed for the operation of aircraft in instrument meteorological conditions (see below).
IGE - in ground effect. Helicopter performance with an earth surface immediately below. Also OGE, out of ground effect. Helicopters can hover at a greater maximum altitude IGE (above a mountain slope, for example) than they can in free air, OGE.
IGS - instrument guidance system.
ILS - instrument landing system. The approach aid employing two radio beams to provide pilots with vertical and horizontal guidance during the landing approach. The localizer provides azimuth guidance, while the glide-slope defines the correct vertical descent profile. Marker beacons and high intensity runways lights are also part of the ILS.
IMC - instrument meteorological conditions: weather below VMC minima, see below.
INCERFA - uncertainty phase of search-and-rescue procedure.
INS - inertial navigation system. A gyroscope-based system which senses acceleration and deceleration and computes an aircraft's position in latitude and longitude with great accuracy. Used mostly by long-haul airliners, military aircraft and sophisticated business jets. Also IRS, inertial reference system.
INTER - intermittent or fluctuating, term used in Met reports.
Instrumentation - Hardware to measure and to monitor a system.
IR - instrument rating.
ISA - International Standard Atmosphere -- a set of standard conditions of temperature and pressure which serve as a basis for comparison. ISA = pressure 1013.2 millibars, temperature 15°C. Aircraft performance figures quoted by manufacturers are often based on such a 'standard day'.
ITT - inter-turbine temperature. Also TGT, turbine gas temperature TIT, turbine inlet temperature.

J

Jeppesen - navigational/approach chart system with worldwide coverage.

K

kHz - kilohertz, the frequency of a radio carrier wave measured in thousands of cycles per second. 1 kHz = 1,000 Hertz.

knot (kt) - one nautical mile per hour (never one knot per hour), the standard unit of aviation speed measurement. One knot equals 1.1515 mph; one nautical mile equals 6,080 feet.

kW - kilowatt.

L

lat - latitude.

lczt - (ILS) localizer

LDA - landing distance available.

Leg - a segment of a flight plan; flight path between two waypoints.

LF - low-frequency radio waves with frequencies in the 30-300 kHz band.

Localizer - The azimuth guidance portion of an instrument landing system. Part of ILS that provides lateral deviations from a preset course.

locator - medium-frequency non-directional radio beacon used as an aid to establishing yourself on final approach during an instrument landing procedure. Also LOM, locator outer marker.

lon(g) - longitude

Loran - low-frequency hyperbolic radio long-range navigation system which measures time difference between reception of synchronized signals transmitted from ground transmitters. Loran-C, operates in the 100-110 kHz frequency band with an operating range of 600-1,500 nm independent of line-of-sight, and is becoming very popular among GA aircraft operators.

M

M or mag - magnetic

Mach number - ratio of true airspeed to the speed of sound. Mach 1 is the speed of sound at sea level, ISA, approximately 1,100 feet per second or 760 mph.

MAP - missed approach point. The point on a published ILS approach expressed in time or distance from the final approach fix, or as an altitude on the glideslope, at which the missed approach procedure must be initiated if the runway or approach lights are not clearly in sight.

marker beacons (mkrs) - part of an instrument landing system using 75 MHz transmitters emitting fan-shaped or elliptical signal patterns vertically upwards, defining specific points along the glideslope. The outer marker OM is situated at or near the glideslope intercept altitude of the ILS localizer, the middle marker (MM) defines a point on the glideslope at or near decision height (DH). Markers provide aural and visual indications on a cockpit marker beacon receiver.

Mayday - international radio distress call (from the French, m'aidez -- help me). It signifies imminent danger to life requiring immediate assistance.

mb - millibar.

MDA - minimum descent altitude. The lowest altitude, in feet amsl, to which descent is authorized on final approach during a non-precision instrument landing (i.e. where no glideslope guidance is given) without visual reference to the runway.

MDH - minimum descent height, agl.

MEDA - military emergency diversion airfield.

Met - meteorology, weather.

MF - medium frequency. Radio waves with frequencies in the 300- 3,000 kHz range.

MFA - military flying area

MFD - multi-function display. An EFIS CRT offering selectable displays of weather radar, navigation maps, checklists and data other than primary flight information.

MH - magnetic heading

MHz - Megahertz, the frequency of radio carrier waves measured in millions of cycles per second.

minimums - weather condition requirements for a particular mode of flight (e.g. for VFR operation, IFR take-offs and landings).

MSA - minimum sector altitude or minimum safe altitude.

msl - mean sea level

N

NDB - non-directional beacon. A medium-frequency navigational aid which transmits non-directional signals, superimposed with a Morse code identifier and received by an aircraft's ADF.

nm - nautical mile.

NOE - nap of earth. Low flying, usually by the military, using contour-flying techniques and terrain-masking to avoid being seen.

NORDO - no radio (used on flight plan form).

NOSIG - no significant change, term used on Met reports.

NTSB - National Transportation Safety Board.

O

OAT - outside air temperature. The temperature of the air outside an aircraft measured by a probe with a cockpit gauge readout. OAT affects the measurement of indicated airspeed and its value is needed to calculate true airspeed. At high speeds kinetic heating demands correction to the indicated OAT for true outside air temperature.

obst - obstruction.

OBS - omni-bearing selector, part of a VOR used to select the radial from a VOR.

OCH - obstacle clearance height. The lowest height above the elevation of the runway threshold or above aerodrome elevation used to establish compliance with obstacle clearance criteria in an instrument approach. Also OCA, obstacle clearance altitude, and OCL, obstacle clearance limit.

OEM - original equipment manufacturer.

okta - a measurement of cloud cover. One okta means one-eighth of the sky is covered.

Omega - high accuracy, very-low frequency (VLF) long-range navigation system of the hyperbolic type, covering the entire earth down to the surface from eight ground-based transmitters. Used principally by airliners, military aircraft and intercontinental business aircraft.

o/r - on request.

o/t - other times.

P

Pitch - The angle of a rotor measured in the plane of rotation.

PPO - prior permission only. Certain airfields or events require advance notification (by telephone, for example) of your intended arrival. Also PNR, prior notice required, and PPR, prior permission required.

PROB - probability percentage, term used in Met reports.

procedure turn - maneuver which reverses the direction of an aircraft's flight during an instrument approach procedure to enable it to intercept the final approach course.

psi - pounds per square inch, a measurement of pressure.

PTT - press-to-transmit (switch) on an aircraft's control wheel or stick enabling the pilot to make RT transmission 'hands on' via a headset microphone.

Q

Q-code - code system developed when air-to-ground communication was by wireless telegraphy, enabling many routine phrases and questions to be reduced to three letters. Now largely redundant, except these:

- **QDM** magnetic bearing to a direction-finding station.
- **QDR** magnetic bearing from the station.
- **QFE** atmospheric pressure at aerodrome elevation. With its sub-scale set to the aerodrome QFE an altimeter will indicate height above that airfield.
- **QFU** magnetic orientation of runway in use.

- **QNE** reading in feet on an altimeter set to 1013.2 millibars (standard pressure) when the aircraft is at aerodrome elevation.
- **QNH** altitude above mean sea level based on local station pressure.
- **QTE** true line of position from a direction-finding station.
- **QUJ** true bearing

R

rabbit lights - colloquialism for sequentially flashing lead-in runway approach lights.

ramp weight - maximum permissible weight of an aircraft, which exceeds maximum take-off weight by an allowance for fuel burned during engine-start and taxi.

RAPID - change expected to take place in thirty minutes or less, term used in mer reports.

RAS (1) - rectified airspeed. Indicated airspeed corrected for instrument position error.

RAS (2) - Radar Advisory Service. Provided outside regulated airspace to notify pilots of conflicting traffic and to advise suitable avoiding action. Also RASA Radar Advisory Service Area.

rating - add-on qualification to a pilot's license, e.g. Night Rating, Multi-engine Rating, Instrument Rating, Seaplane Rating etc. Individual Type Ratings are necessary to fly aircraft over 12,500 pounds MTWA.

RCL - runway center-line.

RBI - relative bearing indicator, displaying information from the ADF.

RDO - radio.

RIS - Radar Information Service. Provided to notify pilots of conflicting traffic outside regulated airspace, but offering no avoiding action.

RMI - radio magnetic indicator. A navigation aid which combines DI, VOR and/or ADF display and will indicate bearings to stations, together with aircraft heading.

RMK - remark(s).

RMU - radio management unit.

Rnav - area navigation. A system of radio navigation which permits direct point-to-point off-airways navigation by means of an on-board computer creating phantom VOR/DME transmitters termed waypoints.

Roll - Bank angle.

RON - remain over night (night-stop).

RT - radio telephony. Voice communications, as opposed to WT, wireless telegraphy. Also styled RTF.

RVR - runway visual range, a horizontal measurement of visibility along a runway.

rw - runway.

Rx - receiver.

S

SAR - search-and-rescue. Also Sarsat, SAR satellite.

SAS - stability augmentation system. An automatic flight control system employed in many helicopters and some fixed-wing aircraft to enhance their stability and handling qualities.

satcoms - satellite communications, now being introduced on intercontinental airliners and business jets for (non- operational) air-to-ground voice communications via ground relay stations.

SB - Service Bulletin. Advisory notices issued by aircraft, engine and equipment manufacturers alerting owners and engineers to faults or problems requiring preventative or remedial maintenance or modification. Often termed 'mandatory', but do not have the legal force of Airworthiness Directives (which see).

'second pilot' - unofficial term used to describe short (usually 8-10 hours) flying courses designed to enable non-pilot light aircraft passengers to take control and land in an emergency such as pilot incapacitation. Also standby or safety pilot and pinch-hitter.

Sectional - VFR navigation chart, equivalent to our 1:500,000 or 'half-million'.

Semi-circular - system of cruising altitudes.

SELCAL - selective calling. A high-frequency system enabling air traffic control to alert a particular aircraft, by means of flashing light or aural signal in the cockpit, for receipt of a message without the crew having to maintain a listening watch. Used on long-haul over-ocean airline routes and by intercontinental bizjets.

sfc - specific fuel consumption of an engine, expressed in pounds of fuel consumed for each unit of power (hp, shp, lb/st) produced. Also surface.

SID - standard instrument departure. A standard IFR departure route enabling air traffic controllers to issue abbreviated clearances and thus speed the flow of traffic.

SIGMET - warning of severe weather conditions (active thunderstorms, hail, severe turbulence, icing etc.) issued by Met offices.

sl - sea level.

SMOH - since major overhaul. Term used in aircraft for sale advertisements where engine hours are quoted (see TBO). Also STO, since top overhaul, TTSN, total time since new; TTA/E, total time airframe/engine,

SMR - surface movement radar.

SOB - souls on board, the number of persons on board an aircraft. Also POB.

socked-in - A colloquialism referring to an airport closed to air traffic by bad weather, similarly clamped.

SOP - standard operating procedure.

specific range - measure of an aircraft's fuel efficiency, expressed as nautical miles flown per pound of fuel burned (nm/lb)

squawk - to transmit an assigned code via a transponder.

SR - sunrise.

SRZ - Special Rules Zone. An area of protected airspace surrounding an airfield and extending from the surface upwards to a specific level which affords safety to air traffic movements in the vicinity of airfields whose traffic level does not warrant the establishment of a Control Zone. Also SRA, Special Rules Area. extending vertically and horizontally from a level above the surface, but not necessarily terminating at the same upper level as the SRZ.

SRA - Surveillance Radar Approach. Also Special Rules Area.

SRE - Surveillance Radar Element of a GCA.

SS - sunset.

SSB - single sideband. Reduction of bandwidth by transmitting only one sideband and suppressing the other, and usually also the carrier wave.

SSR - secondary surveillance radar. A radar system comprising a ground-based transmitter/receiver which interrogates a compatible unit in the aircraft (see transponder below), providing instant radar identification without having to maneuver. Assigned four-digit transponder codes are referred to as squawk codes.

STAR - Standard Terminal Arrival Route, for inbound IFR traffic.

STC - Supplemental Type Certificate. U.S. system for post-type certification approval of aircraft modifications such as re-engining, STOL kits, etc, where the full certification process is not deemed necessary. Also used by manufacturers to certify (often greatly changed) new models of old types under so-called 'grandfather rights'.

STOL - short take-off and landing. Also VTOL, vertical take-off and landing; V/STOL, vertical/short take-off and landing; STOVL, short take-off, vertical landing.

T

T - true. Also TH, true heading, and TT, true track.

TACAN - tactical air navigation system. An ultra-high frequency electronic navigation aid which provides suitably-equipped aircraft with a continuous indication of bearing and distance to the selected Tacan station. The distance element can be received by civilian DMF equipment, but otherwise Tacan is principally a military navaid.

TAF - Terminal Area Forecast.

TAS - true airspeed. Rectified airspeed corrected for altitude and outside air temperature.

TBO - time between overhauls, an engine manufacturer's recommended overhaul interval in hours, a rough and not guaranteed guide to life expectancy of an aero-engine before it will need overhaul.

TCA - Terminal Control Area

TCAS - traffic alert and collision avoidance system

TEMPO - temporarily, term used in Met reports.

THR or thld - threshold.

TMA - Terminal Control Area. An area of controlled airspace at the intersection of airways in the vicinity of control zones (CTRs) around major airports.

TO - take-off (sometimes TKOF).

TODA - take-off distance available. Also TODR, take-off distance required, and TORA, take-off run available.

track - actual flight path of an aircraft over the ground.

transponder - airborne receiver/transmitter portion of the SSR system which receives the interrogation signal from the ground and automatically replies according to mode and code selected. Modes A and B are used for identification, using a four-digit number allocated by air traffic control. Mode C gives automatic altitude readout from an encoding altimeter.

transition altitude (TA) - altitude in the vicinity of an aerodrome at or below which the vertical position of an aircraft is controlled by reference to altitude, i.e. with the aerodrome QNH set on its altimeter. Above transition altitude QNE is set and flight levels used. Also transition level (TL) at which a descending aircraft changes from FL to QNH.

trend - Met forecast for the next two hours, added to some METARs.

TSO - Technical Standard Order. A standard established by the U.S. FAA for quality control in avionics, instruments and other airborne equipment. If it complies, equipment is said to be 'TSO'd' and is more expensive than similar non-TSO's equipment.

TVOR - terminal VOR. A low-powered VOR located at or near an airport and used as an approach aid.

TWR - Tower (aerodrome control tower).

TWY - taxiway.

Tx - transmitter.

U

UDF - UHF direction finding.

UFN - until further notice.

UHF - ultra-high frequency. Radio frequencies in the 300-3,000 MHz band.

UIR - Upper Information Region, covering the same geographic areas as a FIR, but extending vertically upwards from 24,500 feet, within which certain additional operational rules apply. Also UIS, Upper Information Service.

Unicom - privately-operated advisory A/G radio service at uncontrolled airfields.

u/s - unserviceable (i.e. not working) when applied to an aircraft or its equipment.

UTC - Co-ordinated Universal Time, formerly Greenwich Mean Time

V

V-speeds - designations for certain velocities relating to aircraft operation, thus:

- **V1** decision speed, up to which it should be possible to abort a take-off and stop safely within the remaining runway length. After reaching V1 the take-off must be continued.
- **Va** design maneuvering speed. The speed below which abrupt and extreme control movements are possible (though not advised) without exceeding the airframe's limiting load factors.
- **Vfe** maximum flap extension speed (top of white arc on ASI).
- **Vmca** minimum control speed (air). The minimum speed at which control of a twin-engined aircraft can be maintained after failure of one engine.
- **Vne** never-exceed speed, 'redline speed' denoted by a red radial on an ASI.
- **Vmo** maximum operating speed. Also Mmo, Mach limit maximum operating speed.
- **Vno** normal operating speed. The maximum structural cruising speed allowable for normal operating conditions (top of green arc on ASI).
- **Vr** rotation speed, at which to raise the nose for take-off.
- **Vso** stalling speed at MTWA, in landing configuration with flaps and landing gear down, at sea level, ISA conditions (bottom of white arc on ASI).
- **Vx** best angle of climb speed on all engines.
- **Vxse** best engine-out angle of climb speed.
- **Vy** best rate of climb speed on all engines.
- **Vyse** best engine-out rate of climb speed, 'blue line speed' (blue radial on ASIs of light twins)

Vnav - vertical navigation.

VAL - visual approach and landing chart.

var - variation (magnetic)

VASIS - visual approach slope indicator system. A colored light system providing visual guidance to the glidepath of a runway.

VDF - very-high frequency direction-finding, whereby an aircraft's bearing from a ground receiving station may be determined from its RT transmissions.

VFR - Visual Flight Rules. Prescribed for the operation of aircraft in visual meteorological conditions (VMC). VMC is generally defined as five miles visibility or more and 1,000 feet vertical and one nautical mile horizontal clearance from cloud, but variations apply to aircraft operating below 3,000 feet amsl. Special VFR (SVFR) clearances are granted at the discretion of ATC for VFR flight through some controlled airspace where IFR usually apply. Also CVFR, Controlled VFR Flight.

VHF - very high frequency. Radio frequencies in the 30-300 MHz band, used for most civil air-to-ground communication.

vis - visibility.

VLF - very low frequency. Radio frequencies in the 3-30 kHz band.

VLF/Omega - worldwide system of long-range navigation using VLF radio transmission.

VMC - Visual Meteorological Conditions.

Volmet - continuous recorded broadcasts of weather conditions at selected airfields.

VOR - very high frequency omnidirectional range. A radio navigation aid operating in the 108-118 MHz band. A VOR ground station transmits a two-phase directional signal through 360°. the aircraft's VOR receiver enables a pilot to identify his radial or bearing from/to the ground station. VOR is the most commonly used radio navigation aid in private flying. Increased accuracy is available in Doppler VORs (DVOR). Also VORTAC, combined VOR and TACAN, and VOT, VOR test facility.

VP - variable-pitch (propeller), whose blade angle can be altered in flight either automatically or manually.

VRP - visual reporting point. Landmarks used for position reporting by aircraft operating VFR.

VSI - vertical speed indicator. One of the primary flight instruments showing rate of climb or descent. Also IVSI, instantaneous VSI.

W

wake turbulence - wingtip vortices generated behind a wing producing lift. Behind a large heavy aircraft they can be powerful enough to roll or even break up a smaller aircraft.

WAT - weight-and-temperature.

w.e.f. - with effect from. Also w.i.e., with immediate effect.

wind shear - localized change in wind speed and/or direction over a short distance, resulting in a tearing or shearing effect, usually at low altitude, that can cause a sudden loss of airspeed with occasionally disastrous results if encountered when taking-off or landing.

WP - waypoint.

wt - weight

Wx - weather.

WX NIL - no significant weather, term used in Met reports.

X

xmsn - transmission.

xpdr - transponder.

Z

zero-fuel weight - maximum permissible weight of an aircraft beyond which an additional load must be in the form of fuel (i.e. max take-off weight less total usable fuel in applicable aircraft, which are so limited because of the wing-bending moments associated with near-empty wing fuel tanks).

zero-timed - overhauling an aero-engine to 'service limits' (not the same 'good as new' or factory remanufactured).

Zulu or Z - used worldwide for times of flight operations, formerly Greenwich Mean Time, now Co-ordinated Universal Time (UTC).

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