Produced: October 2015

ONE OR TWO SETS OF FLIGHT CONTROLS?

Research Request:

For operators who operate single pilot aircraft, they can choose to configure their aircraft with one or two sets of flight controls. Is there any benefit or risks associated with either configuration? Detail the risk and rewards associated with each. This topic can be viewed as filled with all kinds of opinion and personal thoughts paired with decades of "That's how we've always done it" arguments. PRISM will try to provide a clear picture for the operator to make a decision that fits their needs and risk tolerance.

Disclaimer:

This research brief should be used as informational purposes to help your organizations analyze and develop counter measures to prevent accidents. This report will provide suggestions and best practice techniques which should be properly evaluated by your management prior to use or implementation.

Background:

The leading arguments against dual controls are that mission equipment such as camera controllers and keyboards will interfere with the controls or the TFO will inadvertently interfere with them. On the flip side those who support TFO flight training and the second set of controls point to the needed system redundancies to maximize survivability in a slew of war gammed emergencies.

Initial thoughts and considerations behind each configuration can include:

One set of flight controls:

- More room for the TFO or Passenger.
- Less chance that binding of the cyclic or collective controls will occur.
- Less to maintain and no risk of second set of controls being damaged.
- Less risky when folks are getting in and out of the aircraft while its running.
- No added flight training program for the TFO.
- Easier for the TFO to maintain, focus and manage the added mission equipment.

Two sets of flight controls:

- Aircraft is always configured to be used for dual pilot operations or training.
- TFO or Passenger could potentially fly the aircraft if the pilot becomes incapacitated.
- No need to swap seats if two pilots were flying and logging time.
- TFO or Passenger could help during in-flight emergencies that relate to the use of flight controls.
- Two sets of controls provides system redundancies in the cockpit.

On the following pages you will find accident's involving pilots that become incapacitated, accidents involving passengers displacing the cyclic, reasons behind what can cause pilots to become incapacitated, TFO training program excerpts and a conclusion to this research brief.

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Examples of how Pilot's can become incapacitated

Incapacitations can be divided into two operational classifications: "obvious" and "subtle". Obvious incapacitations are those immediately apparent to the other crew members. The time course of onset can be "sudden" or "insidious" and complete loss of function can occur. Subtle incapacitations are frequently partial in nature and can be insidious because the affected pilot may look well and continue to operate but at a less than optimum level of performance. The pilot may not be aware of the problem or capable of rationally evaluating it. Subtle incapacitations can create significant operational problems. Further more they can be broken down into the below subcategories.

Medical:

The U.S. Federal Aviation Administration (FAA) Aeromedical Institute in Oklahoma City studied in-flight medical incapacitations and impairments in U.S. airline pilots from 1993 through 1998. It defined in-flight medical incapacitation as a condition in which a flight crewmember was unable to perform any flight duties and impairment as a condition in which a crewmember could perform limited flight duties such as reading checklists and making radio calls even though performance may have been degraded.

It found 39 incapacitations and 11 impairments aboard 47 aircraft over this six-year period with serious impacts on flight safety in seven flights, of which two resulted in non-fatal accidents The average age was 47 years for incapacitations and 43.3 for impairments with respective in-flight event rates of 0.045 per 100,000 flying hours and 0.013 per 100,000 flying hours. The probability that these events would end up in an accident was calculated at 0.04. Incapacitations significantly increased with age with more serious categories in the older age groups. In this study most frequent categories were loss of consciousness (9), gastrointestinal (6), neurological (6), cardiac (5) and urological (3).

In general, the various categories of incapacitation are loss of consciousness, cardiovascular, neurological, urological and gastrointestinal disorders. However, other less-frequent problems include respiratory, reaction to medications, diabetes, hemiparetic and epileptic seizures, earache due to blocked ears, traumatic or infected injury, faintness or general weakness and alcohol withdrawal syndromes.

Typical conditions for impairment pertain to food or carbon dioxide poisoning, nausea, baro sinusitis, vomiting and indigestion, viral gastroenteritis, vasovagal responses due to viral infection, the use of monovision contact lenses, fatigue and kidney stones.

Outside Factors:

An outside factor could include one of the following:

- Bird strike that penetrates the cockpit and incapacitates the pilot.
- A laser strike that blinds or damages the pilot's eye's.
- An impact with any object like a drone or UAS device that penetrates the cockpit and incapacitates the pilot.

LE Specific:

Due to the nature of LE being placed in harms way, small arms fire should be considered a possible reason or scenario for pilot incapacitation. Accidental discharge of a weapon during flight in which it impacts the pilot could also be a rare but possible scenario to lastly consider.

Risk of Pilot Incapacitation statistics & the 1% Rule

Pilot incapacitation has been of concern for as long as powered flight has existed. It represents an operational risk, and it can therefore be defined operationally as "any physiological or psychological state or situation that adversely affects performance."

A great deal about pilot incapacitation has been learned over the past decades. One of the most important things is that the risk to aviation safety in situations where a pilot is physically incapacitated can be virtually eliminated in air transport (multi-crew) operations by training the pilots to cope with such events. Below is a explanation of the ICAO Doc 8984 1% rule explanation.

- In a multi-pilot aircraft only 10 percent of flight time is critical (risk reduced by a factor of 10) as incapacitations are assumed to occur randomly. Therefore only one in ten in-flight incapacitations will occur during a critical stage of flight and thus pose a flight safety risk.
- Only one in 100 incapacitations occurring at a critical stage of flight is likely to result in a fatal accident (risk further reduced by a factor of 100).
- Therefore the total risk reduction with the addition of a second pilot is 1/10 × 1/100 = 1/1 000, i.e., the risk is one 1,000th of the risk of single pilot operations.
- For a pilot with an incapacitation risk of one in 10^6 hours, a second pilot therefore reduces the risk of a fatal accident from pilot incapacitation from one in 10^6 hours to one in 10^9 hours.

In other words, only one fatal accident in one thousand in-flight pilot incapacitations would be expected to result in a fatal accident, because the other pilot would take over safely in the other 999 times. For an individual pilot flying a multi-crew aircraft the acceptable risk of incapacitation may therefore be increased by a factor of 1,000.

The "1% rule" cannot apply to a solo pilot flying in public transport operations, because it is derived from two pilot operations and the availability of a second pilot to take over in the event of one pilot becoming incapacitated. However, the "1% rule" has also been applied to the private pilot population by some States, on a pragmatic basis, such that a private pilot who develops a medical problem may be permitted to continue to fly as a solo pilot if his risk of an incapacitation is 1 per cent per annum or less. This acceptance of an increased risk of incapacitation in a private pilot seems reasonable since the overall level of safety demanded of private operations is less than that of commercial operations, and it would therefore be out of place to demand a professional pilot medical standard for private pilot operations.

Resource: http://www.skybrary.aero/bookshelf/books/2242.pdf

Prevention Strategies and Lines of Defense for In-flight Incapacitation

The initial signs of crew incapacitation can be very subtle and may not be immediately obvious to other crewmembers during medical events. During events where A item were to strike the pilot, remaining crew members may have a very short period of time to react depending on altitude, speed and direction of flight.

Any crewmember feeling unwell prior to a flight or in flight should immediately report it so as not to compromise flight safety. It is clear that there are thresholds before a human being contemplates doing this. However, we should bear in mind that the safety of flight can be compromised if we don't speak up. Committing to a pre-cautionary landing to the nearest suitable landing area should be considered a priority during any serious onset of a possible incapacitation.

In the event of a crewmember illness in flight or incapacitation the organization should have published polices and procedures for each crewmembers actions. The Captain or to the most senior cockpit crewmember should take responsibility and decide if an immediate landing is to be made and follow all organization policies and procedures.

Examples of procedure action steps:

- The remaining crewmember must assume or maintain control of the aircraft assuming a set of controls are available
- Establish a safe flight profile and use all possible onboard automation for easy-of workload
- Obtain any additional cabin crew assistance
- Inform ATC / Operations
- Consider immediate landing locations such as hospitals or pre-arranged medical assistance sites
- Evaluate the condition of the incapacitated pilot and relay that information if able to first responders
- Provide medical assistance if able
- Always ensure overall safety of the flight
- Complete the approach and landing using the autopilot or automation if equipped
- A partially incapacitated pilot should strongly evaluate their effectiveness and may not be allowed to participate in the subsequent operation of the aircraft, as judgment may be impaired.

Pilot training in the early recognition of incapacitation and in safe handover of controls, pioneered in the United States, has been highly effective in preventing accidents from physical incapacitation. It seems less effective in the case of mental incapacitation. Because the majority of accidents result from human failure of some sort, degradation of performance from commonly occurring sub-clinical conditions such as mild anxiety and depression, sleep loss and circadian rhythm disturbance is an important factor in this area of relative incapacitation.

Although the practice is not commonly used outside the military rotary-wing community, the Pilot Not Flying or a crewmember with access to flight controls should guard the controls during situations in which the Pilot Flying could become incapacitated. This can include flying into a known area's of small arms fire, high density populations of birds or even areas known to have other flying objects like Drones. This technique allows for the other individual to rapidly respond and fly the aircraft.

Accident Example / Study (Pilot Incapacitation)

Pilot incapacitation, R-44 Tail # VH-HCA, Western Australia, 3 September 2011:

Summary: On 3 September 2011, the pilot and one crewman of a Robinson Helicopter Company R44 helicopter, registered VH-HCA (HCA), departed an airstrip located near Kumarina roadhouse, approximately 150 km south of Newman, Western Australia. The crew was conducting low-level geophysical survey operations when the pilot was observed to have slumped forward in the seat. The crewman, who was seated behind the pilot, made unsuccessful attempts to rouse the pilot. The helicopter subsequently impacted terrain causing significant injuries to the crewman and pilot. After the impact the pilot regained consciousness but later succumbed to his injuries prior to the arrival of medical assistance.

What the ATSB found: The investigation found that, following the pilot's probable incapacitation during flight, the helicopter's descent could not be arrested before impacting terrain. It was likely that the incapacitation was of a similar nature to other previous unconsciousness events reported experienced by the pilot while not flying.

The pilot held a Class 1 Aviation Medical Certificate with no restrictions, despite inconsistencies in recorded information in the pilot's aviation medical questionnaires, and one previous unconsciousness episode being recorded. If information about the pilot's medical history had been accurately documented and included on the medical questionnaires, further medical tests may have been required and the results used to better assess the pilot's current medical status.

Safety Message from ATSB: In addition to the regular aviation medical assessments, should a pilot become aware of any condition that may affect their ability to safely carry out the privileges of a licence, the advice of a Designated Aviation Medical Examiner (DAME) should be sought. Additionally, all information documented on the pilot's aviation medical assessment should be checked by the pilot for accuracy and completeness to allow for accurate assessment of medical status and potential risk to the safety of flight.

Human Factors: Since commencing the geophysical operations, the pilots and crewmen had utilised two central base locations near to the survey area. The accommodation used during the first 2 weeks of operations was reported to have been very basic, which meant there was limited access to good sleeping amenities and a good standard of food.

Conclusion: Given the reported similarities of the pilot's previous unconsciousness episodes, and that the examination of the wreckage did not identify any abnormality that would have precluded continued normal flight; it was probable that the pilot experienced a rapid onset of unconsciousness that prevented him from controlling and arresting the helicopter's descent before it impacted terrain. Despite the pilot initially regaining consciousness after the impact with terrain, the unavailability of ready medical support increased the risk that the pilot would succumb to his injuries.

Source: https://www.atsb.gov.au/media/4070241/ao-2011-109_final.pdf

Accident Example / Study (Pilot Incapacitation)

Pilot incapacitation, Turbo Commander Tail# N337DR, North Las Vegas, 5 May 2005:

Summary: The passengers stated they departed North Las Vegas Airport about 0830, en-route to San Diego. The airplane was level at 9,700 feet with one passenger in the copilot's seat (right seat) and one passenger seated behind the pilot. As they proceeded south of Boulder City, Nevada, the pilot started to cough repeatedly and donned the oxygen mask. He then contacted departure control and told the controller they were returning to North Las Vegas. Shortly after making the turn back to North Las Vegas the pilot collapsed against the control yoke. The passenger in the right seat took the controls and donned the radio headset. The passenger behind the pilot held the pilot back and away from the controls. It took both passengers a few minutes to locate and disconnect the autopilot, and then the passenger in the right seat started flying the airplane. He attempted to contact North Las Vegas tower on the radio with no success, but he had visually located the airport. The passenger behind the pilot's seat attended to the pilot but he was unresponsive. The passenger flying the airplane began to make a landing pass. The passenger behind the pilot was now kneeling between the pilot and copilot seats and had successfully established communications with the tower. Tower cleared them to land on any runway. They attempted three landing passes; each one was too high by their judgment. On the fourth pass they flew low over the nearby buildings, pitched the nose up, and landed the plane hard on its belly in a runway overrun area. Both passengers then egressed the airplane via the emergency exit. The pilot was transported to University Medical Center Trauma and did not recover from his medical condition.

What the NTSB found: The Clark County Coroner completed an autopsy and investigation. The coroner reported that the wife of the pilot said that the pilot had been battling what appeared to be a sinus infection for the past 2 weeks and that his physician had 'cleared' him for flight on May 2, 2005. The FAA Bioaeronautical Sciences Research Laboratory in Oklahoma City performed toxicological analysis from tissue samples obtained during the autopsy. The results of analysis were negative for carbon monoxide, cyanide, ethanol, and positive for atropine. The autopsy report states that the cause of death was arteriosclerotic cardiovascular disease

Source: http://www.ntsb.gov/_layouts/ntsb.aviation/brief2.aspx ev_id=20050510X00588&ntsbno=LAX05LA151&akey=1

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Dual Flight Controls installed at TFO / Passenger station

When it comes to the argument for dual sets of controls and TFO training, there are some good examples that support such a decision. Earlier this year a Dallas PD aircraft had a bird strike at night. The 'coot' entered the cockpit and hit the pilot in the face. He was not wearing a helmet or eye protection and the bird cut him above his eye, and cut his eye-ball. He was unable to see and had the TFO immediately take the controls. The TFO was a pilot and landed safely. They said that if the TFO couldn't fly, or did not have controls, that incident would have been a double fatality. Reference: http://www.wfaa.com/story/news/local/dallas-county/2015/03/24/dpd-helicopter-bird-strike-emergency-landing/70388496/

A few years ago a pilot and TFO were strapping into a MD500 at Columbus PD for a patrol flight. As they were going through the startup checklist, the pilot suffered a heart attack and died in the chair. Had that been five minutes later, the TFO would have been flying. Reference: http://alea.org/downloads/e-newsletters/2006/August_2006.pdf

Another indecent occurred in Southern California with Riverside PD. The aircraft was hit with gunfire. Shrapnel from the door entered the pilot's torso and he began to lose consciousness. The TFO got on the controls and helped the pilot land the aircraft. Reference: http://www.thefreelibrary.com/SHERIFF'S+COPTER+PILOT+SHOT+IN+WILD+MOUNTAIN+CHASE.-a083946313

Allowing outright strangers access to the flight controls, like when giving rides, is very risky. Even when a pilot knows the passenger, they need to be extremely cautious and give serious consideration as to whether someone should be provided access to the flight controls. If a passenger has access to a set of flight controls they should receive a proper passenger briefing on the ground prior to engine start. Entering or exiting the aircraft while its running could be considered one of the highest risk events, another would be accident input during flight. A passenger could kick, pull or snag their gear on the collective, cyclic or T/R pedals. This could lead to dynamic rollover, M/R blade angles decreasing and causing a blade strike to people or obstacles or the aircraft departing the ground. Environmental considerations like operating in the dark or limited visibility to snow or dust could be considered possible contributing risks and factors.

With the proper training, briefings and documented standards; the risk of an accident or incident would be far less. Increasing comfortability over survivability is a tough choice to make. In the following pages there are two accident reports that document how dual control aircraft ended up in a accident due to passenger control inputs. Comparing passengers to professionally trained TFO's is apple to oranges but in the event a non-TFO were to occupy the front seat, the pilot should be made aware of some of the possible hazards or accident scenarios.

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Accident Example / Study (Control input by passenger)

Passenger induced accident, EC-135 Tail# N127TS, Cave Creek Arizona, 14 Feb 2010:

Summary: a Eurocopter Deutschland GmbH EC135 T1 twinengine turbine-powered helicopter, N127TS, lost control and impacted terrain near Cave Creek, Arizona. The pilot and four passengers were fatally injured. The helicopter was substantially damaged. A ranch foreman reported he observed the helicopter owner and his 5-year-old, 42-pound daughter walk around in front of the helicopter and board the helicopter from the left forward cockpit door where they both occupied the left front cockpit seat, with the small girl positioned on her father's lap. When asked how frequently the child occupied the left front cockpit seat with her father, the ranch foreman replied "occasionally." The foreman stated that he could not tell if either the helicopter owner or the child were secured and restrained in the helicopter. The foreman revealed that on previous flights, the helicopter owner had strapped his daughter in on top of him. He said that after everyone was on board, he closed the right passenger door and ensured that it was locked and secured. He said he then went forward to the right front cockpit window area, looked at the pilot, who had his shoulder harness and seatbelt on, and motioned to him that the right passenger door was secured and the helicopter was ready for departure. The foreman indicated that he then proceeded away from the helicopter to his pickup truck, which was positioned about 90 degrees to the right (west) of the helicopter, which was oriented to the south. The foreman said that from his truck, he watched the helicopter lift off, ascend to about 100 to 150 feet, then make a 180 degree turn to the north and begin forward flight after which the helicopter departed to the northwest.

Witness #3, who was in line with the helicopter's flightpath and was about 2,350 feet due north of the accident site, stated that he initially saw the accident helicopter when it was about 1 mile north of his position and that it sounded perfect when he first sighted it. The witness reported that, about 10 seconds later, he heard what sounded like two small pops, followed by the helicopter making roaring noises. He said he then observed two flashes on the top of the main rotor. The witness stated that the helicopter started spinning and losing altitude and that it spun at least three times; he indicated that he then heard the engine cut out and make a big pop. The witness added that the tail of the helicopter went down, the nose went up, and then the aircraft fell tail first. In a follow-up interview, the witness reported seeing the helicopter spiral in a circular motion towards the ground and then rapidly gain altitude before it flipped upside down and spiraled nose first into the ground.

What the NTSB found: Considering that the child was sitting on the owner's lap in the left front cockpit seat, it is highly likely that the child inadvertently stepped on the collective with her left foot and displaced it to the full down position. This condition would have then resulted in either the pilot or the helicopter owner raising the collective, followed by a full-aft input pull of the cyclic control and the subsequent main rotor departing the normal plane of rotation and striking the left endplate and the aft end of the tail rotor drive shaft.

Source: http://www.ntsb.gov/_layouts/ntsb.aviation/Results.aspx?queryId=2d8167d5-90a2-4ab4-b750-c292a8bea9e2

Accident Example / Study (Control input by passenger)

Passenger bumps cyclic, R44 Tail# ZS-RSO, South Africa, 14 May 2005:

Summary: The pilot, accompanied by three passengers departed from the Base4 helipad at Cape Town International Aerodrome for a local pleasure flight of the Cape Peninsula. After being airborne for approximately 40 minutes they returned for a full stop landing. An aviation enthusiast that was standing nearby filmed the approach and intended landing. The video footage was made available to the investigating team and revealed that the aircraft was established in hover flight approximately 6 feet above the ground overhead the helipad. The pilot descended gradually with the right skid touching first. As the skid touched the aircraft was observed to pitch/tilt forward suddenly with the lower nose fuselage making contact with the ground. The pilot reacted almost immediately by applying backpressure on the cyclic stick, which caused the aircraft to fall back onto its skids, with the tail rotor guard nearly impacting the ground. It then pitched forward again with the pilot applying power, he took-off, flew a circuit and executed an uneventful landing. Nobody was injured in the incident. Following an interview with the passenger that was occupying the left front seat, he mentioned that he was readjusting his seatbelt shortly before touchdown and accidentally touched the cyclic control column that emerges from the floor center console with his right knee, which caused the pilot to take immediate corrective action.

What the CAA found: The passenger that was occupying the left front seat bumped his right knee into the cyclic control column on touch down, pushing it forward, which caused the aircraft to pitch/tilt forward violently. The pilot took immediate corrective action by pulling back on the cyclic control stick, which caused the aircraft to fall back onto its skids. The pilot applied power flew a circuit, followed by an uneventful landing.

Video: https://www.youtube.com/watch?v=qk03hk74QfE

Source: http://www.caa.co.za/Accidents%20and%20Incidents%20Reports/0404.pdf

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Conclusion

This research brief is not designed to be biased but based on all of the information derived from sources available to PRISM SMS, it can be concluded that there are more benefits of having two sets of controls along with a pilot incapacitation training program for all TFO's or crewmembers who would have access to a set of flight controls. This guidance is based on the fact that TFO's and other non-pilot crewmembers work in and around these aircraft on a frequent basis. If the scenario was based on tour operations or strictly passenger movement operations, the benefits may be vastly different.

In-flight pilot incapacitation is a safety hazard and is known to have caused accidents. Such incapacitation occurs more frequently than many other emergencies that are routinely trained for, such as sudden decompression. Incapacitation can occur in many forms, ranging from sudden death to a not easily detectable partial loss of function, and has occurred in all pilot age groups and during all phases of flight. It is important to recognize the operational ramifications of pilot incapacitation.

Instruction and training of flight crew concerning action in the event of in-flight pilot incapacitation should include early recognition of incapacitation as well as the appropriate actions to be taken by other flight crew members. TFO's should have regimented training on the ground and in the air. Focus should be given to how to locate suitable landing areas, communicating distress and requesting help from ATC and performing landings. Aircraft landing curriculum should focus on the easiest way to land the specified airframe and communicating the most risk adverse locations (level grass field Etc.). FAA Certified Flight Instructors should be used to complete this training and flight tasks and standards should be recorded in a TFO's training record.