Creation of an Anti G-LOC program at the FAB for the operation of the F-39 Gripen aircraft

Creación de un programa Anti G-LOC en la FAB para la operación de la aeronave F-39 Gripen

Criação de um programa Anti G-LOC na FAB para a operação da aeronave F-39 Gripen

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ABSTRACT

The F-39 aircraft is being incorporated into the Brazilian Air Force (FAB) and brings with it maneuvering capabilities of up to 9G (nine times the force of gravity). Thus, Brazilian pilots will be subject to the effect of G-LOC (G-induced loss of consciousness), which would be the loss of consciousness due to G-force, extremely dangerous and common in high-performance aircraft. This article argues that the creation of a structured program "Anti G-LOC" in the FAB, through classes, physical training, centrifuge training and performance monitoring, is necessary to guarantee the safe operation of the F-39 Gripen aircraft. First, it is argued that several air forces around the world have initiated programs to prevent G-LOC and achieved positive results in this regard. They used the centrifuge, in a controlled environment, to increase the pilot's tolerance to G, with training and execution of AGSM breathing maneuvers (Anti G Straining Maneuver), classes for crew awareness and anaerobic physical training. Secondly, the analysis of data collection, due to the large number of personal variables involved such as age, physical type, flight experience, etc., proved to be extremely important so that the knowledge produced could be reinvested in the programs themselves in order to improve them. them, considering that several studies lacked more data for their validation. Therefore, with the creation of an Anti G-LOC program, the FAB will invest in the Flight Safety of the F-39 Gripen, preventing accidents, saving material losses and safeguarding lives. Furthermore, the development and improvement of the program will serve as a reference for new studies to be initiated in the Armed Forces and in Brazil.

Keywords: *GRIPEN; G-LOC; Program; Training; Prevention.*

RESUMEN

El avión F-39 se está incorporando a la Fuerza Aérea Brasileña (FAB) y trae consigo capacidades de maniobra de hasta 9G (nueve veces la fuerza de la gravedad). Así, los pilotos brasileños estarán sujetos al efecto de G-LOC (pérdida de conciencia inducida por G), que sería la pérdida de conciencia debido a la fuerza G, extremadamente peligrosa y común en aeronaves de alto rendimiento. Este artículo argumenta que la creación de un programa estructurado "Anti G-LOC" en la FAB, a través de clases, entrenamiento físico, entrenamiento en centrífugas y monitoreo de desempeño, es necesaria para garantizar la operación segura de la aeronave F-39 Gripen. En primer lugar, se argumenta que varias fuerzas aéreas de todo el mundo han iniciado programas para prevenir G-LOC y han obtenido resultados positivos al respecto. Utilizaron la centrífuga, en un ambiente controlado, para aumentar la tolerancia del piloto a G, con entrenamiento y ejecución de maniobras de respiración AGSM (Anti G Straining Maneuver), clases de sensibilización de la tripulación y entrenamiento físico anaeróbico. En segundo lugar, el análisis de la recogida de datos, debido

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a la gran cantidad de variables personales involucradas como edad, tipo físico, experiencia de vuelo, etc., resultó de suma importancia para que el conocimiento producido pudiera reinvertirse en los propios programas con el fin de mejorarlos, considerando que varios estudios carecían de más datos para su validación. Por eso, con la creación de un programa Anti G-LOC, la FAB invertirá en la Seguridad de Vuelo del F-39 Gripen, previniendo accidentes, salvando pérdidas materiales y salvaguardando vidas. Además, el desarrollo y perfeccionamiento del programa servirá de referencia para nuevos estudios que se iniciarán en las Fuerzas Armadas y en Brasil.

Palabras clave: *GRIPEN; G-LOC; Programa; Capacitación; Prevención.*

RESUMO

A aeronave F-39 está sendo incorporada à Força Aérea Brasileira (FAB) e traz consigo capacidades de manobras de até 9G (nove vezes a força da gravidade). Assim, os pilotos brasileiros estarão sujeitos ao efeito de G-LOC (*G-induced loss of consciousness*), que seria a perda da consciência devido a força G, extremamente perigoso e comum em aeronaves de alta performance. O presente artigo defende que a criação de um programa estruturado "Anti G-LOC" na FAB, por meio de aulas, treinamento físico, treinamento em centrífuga e monitoramento de desempenho, é necessária para garantir a operação segura da aeronave F-39 Gripen. Primeiramente, argumenta-se que diversas forças aéreas ao redor do mundo iniciaram programas para prevenir o G-LOC e conseguiram resultados positivos neste sentido. Utilizaram a centrífuga, para, em um ambiente controlado, aumentar a tolerância do piloto ao G, com o treinamento e execução de manobras respiratórias AGSM (*Anti G Straining Maneuver*), aulas para conscientização dos tripulantes e treinamento físico anaeróbico. Em segundo lugar, a análise da coleta de dados, devido à grande quantidade de variáveis pessoais envolvidas como idade, tipo físico, experiência de voo, etc, se mostrou extremamente importante para que o conhecimento produzido fosse reinvestido nos próprios programas a fim de aprimorá-los, tendo em vista que diversos estudos careceram de mais dados para sua validação. Portanto, com a criação de um programa Anti G-LOC, a FAB investirá na Segurança de Voo do F-39 Gripen, prevenindo acidentes, poupando perdas materiais e resguardando vidas. Outrossim, o desenvolvimento e aprimoramento do programa servirá de referência para que novos estudos fossem iniciados nas Forças Armadas e no Brasil.

Palavras-chave: GRIPEN; G-LOC; programas; treinamento; prevenção.

1 INTRODUCTION

On October 23, 2020, the F-39 Gripen was presented in Brazil, after a long process that involved its selection, purchase and production. The aircraft has great technological and performance capabilities, such as sustaining maneuvers with loads of up to 9G (nine times the force of gravity). This maneuverability turns out to be a differential in flights, mainly aerial combat, in which the aircraft with better performance normally obtains an advantage for an armament launch over the other.

According to Pei L., Jenhung W. and Shih L. (2012), gravitational force is measurement of charge/weight acting on an object with proportional acceleration in multiples of "G" acting in the opposite direction from which the object receives the force. That is, if a pilot weighs 100 kg and executes a curve with 9 times the force of gravity, they will feel a load/weight on their body of 900 kg. This acceleration (G) is the greatest physical stress associated with combat flying.

High G loads always represent a great danger for fighter pilots, as they can result in "G-LOC", which would be the loss of consciousness induced by the G force (Pei L.; Jenhung W.; Shih L., 2012, our translation). Still according to Pei L., Jenhung W. and Shih L. (2012 apud Burton, 1988), G-LOC is defined as a state of altered perception where awareness of reality was absent due to the sudden and critical reduction of cerebral blood circulation caused by increased G-force. This decrease in blood circulation in the brain happens when pilots perform aerobatics involved in aerial combat maneuvers, through turns with small radius, vertical climbs and descents and rapid changes of direction.

Before the occurrence of G-LOC, it is common for pilots to experience changes in vision, presenting "tunnel vision", with the loss of peripheral vision (greyout), or the complete loss of vision (blackout). With the increased difficulty of cerebral perfusion due to +Gz and with the tendency for blood to go to the extremities of the body, such as the legs and feet, the pilot may completely or partially lose consciousness during the act of piloting. In high-performance aircraft, which can reach speeds one or two times faster than the speed of sound, this can, even if it occurs for a few seconds, be fatal for the crew.

A study carried out over 11 years with pilots in a human centrifuge demonstrated that crew members under high G load can spend 12 seconds under absolute

incapacity, due to G-LOC, and more than 16 seconds under relative incapacity (Xin-Sheng C. *et al.*, 2012). Taking into account that the current FAB fighter aircraft do not have the same maneuverability as the Gripen and their G load limits are lower, it becomes extremely important to focus on training our pilots so that the new fighter can be operated safely, avoiding occurrences of G-LOC.

2 DEVELOPMENT

2.1 Understanding G-LOC, Prior Training, and Proper Physical Conditioning

Although the first accidents due to G-LOC began to occur in World War I, regular reports of these events did not begin until the 1980s (Xin C. *et al.*, 2012). According to the United States Air Force (USAF) Security Center analysis, from 1982 to 2001 there were 559 G-LOC related events in the USAF. In this same period, in 18 incidents involving G-LOC, there were 14 fatalities (Terrence J. *et al.*, 1992). In 1987, the British Air Force conducted a study with 2,753 pilots and found that of this total, 19.3% had suffered some type of G-LOC symptom (Pei L.; Jenhung W.; Shih L., 2012).

The training and formation of a FAB combat pilot is a long and costly process, which can exceed 11 years of specialization and studies. According to Dolgin (1987), the average cost of training a fighter pilot exceeds US$800,000. In addition, fighter aircraft have advanced technology, weapons and cost millions of dollars. Based on costs alone, no country can afford losses on such investments due to accidents that could have been avoided.

In order to minimize losses and considering the costs mentioned above, Air Forces began to study and develop programs to prevent G-LOC, curbing, as in the United States of America (USA), the tendency for accidents to increase (Samuel M.; Thomas V.; Scott C., 2004).

According to Vashisth S. *et al.* (2017), mechanical, physiological, and educational measures are suggested to protect pilots of high-performance aircraft from extreme acceleration. Suits were developed so that, with the increase in the G load, they inflate and press the muscles of the abdomen and legs of the pilots, preventing the blood from flowing down. Still, according to Vashisth S. *et al.* (2017), while helping, the suits did not significantly increase G tolerance. Thus, G-LOC prevention programs have made extensive use of centrifuge training.

Gillingham and Fosdick (1988) mention that the centrifuge is an ideal simulator of flight conditions, where it allows the pilot to recognize, in a controlled and safe environment, the effects of G-LOC. The centrifuge consists of a large ground equipment, which simulates, through circular turns and the use of centrifugal force, the G force produced in flight. The pilot sits inside the equipment, as if they were inside an aircraft, and the training begins. According to Pei L., Jenhung W. and Shih L. (2012), benefits of centrifuge training are understanding the physical impact of G-force on crew members, the effects of high G-loads on the human body, training in breathing maneuvers to avoid G-LOC (*Anti G Straining Maneuver – AGSM*), reducing the cost of flight training and increasing adaptation or compensation of the cardiovascular system through repeated exposures to high G-load environments. In the US, data from 1982 to 2001 indicated a drop in the number of G-LOC accidents from 4.4 per million to 1.6 accidents per million takeoffs (Xin C. *et al.*, 2012) after training began in human centrifuge.

Unfortunately, Brazil does not have centrifugal equipment, either in the Armed Forces or in the civil initiative. With this, our pilots do not experience simulated flight conditions under 9G. Consequently, there is no training in the AGSM breathing maneuvers and other advantages already mentioned that training provides. A good alternative, if the equipment was not acquired in the future, would be to carry out centrifuge training in other countries. Even though it is expensive in the long run, such training would be justified by the significant increase in flight safety.

Furthermore, classes also played an important role in the training and awareness of pilots in order to avoid G-LOC. Through them, it becomes possible to teach the theory of maneuvers of AGSM, Aerospace Medicine, breathing ratio, G-LOC evidence, among others. According to Gillingham and Fosdick (1988), 80.3% of USAF pilots considered that classes on the G-LOC theme were important in their prevention and 55.6% felt benefited by centrifuge training. It is important to observe facts and results of the US Air Force, as it has been flying a large number of high-performance aircraft for many decades and has in its history several accidents related to G-LOC.

In addition to classes and centrifuge training, another important aspect in preparing fighter pilots to withstand high-G conditions is related to training and physical conditioning. Anaerobic training, such as weight training, has benefits in G tolerance. Generally,

this training can increase muscle mass, muscle endurance and strength, generating positive results during combat flight (Xin C. *et al.*, 2012).

In the FAB, in addition to the absence of a human centrifuge, the Squadron doctors teach classes on accelerations and their effects on organisms, but these are superficial and there is no type of physical training aimed at preparing our pilots for an extreme environment such as combat flight. Thus, observing the facts and statistical data above, we can verify the importance of creating a program involving all these factors so that the Gripen aircraft is operated safely.

2.2 The Survey of Statistical Data in the Improvement of an Anti G-LOC Program

Over the decades and even after several studies on the prevention of G-LOC, there is a great lack of statistical data in order to improve prevention programs for this event. By involving pilots with different ages, flight experience, weight, height and physical condition, for example, constant and extensive monitoring of such variables is necessary. This fact is mentioned by Samuel M., Thomas V. and Scott C. (2004) based on the analysis of the results of the *G-Risk Indicator Management* (GRIM), implanted at Luke Air Force Base to facilitate the early detection of problems related to G, which lacked valid data in its conclusion. The author suggested the need for further studies to improve and validate aspects of the program. William A. (2006) also comments that, even after carrying out his study on the relationship between aerobic physical conditioning and tolerance to G, more experiments and data need to be collected and analyzed to confirm such a benefit.

The F-39, as it is a new aircraft with great capabilities, will demand a lot from our pilots. What is the previous experience of hours of flight necessary for the safe operation of this fighter aircraft? Will new and inexperienced pilots be able to start flying without worrying about the effects of G-LOC? A good example of the importance of studies and statistical data collection was presented by Sevilla N., Gardner J. (2005). According to the authors, US Air Force F-16 pilots with less than 600 hours of experience are 3.5 times more likely to suffer G-LOC than more experienced pilots. Already F-15 pilots have 9.5 times greater chances. Regarding age, F-16 pilots under 30 years old are 4.5 times more likely to experience G-LOC than those over 30 years old. With information like this in hand, training profiles can be modified to increase the safety of operations. This occurred over several years with the US Air Force.

Although the FAB has already operated the French Mirage 2000 fighter, with maneuverability similar to the F-39 (capacity to sustain 9G), recent studies have not been carried out aimed at protecting G-LOC and collecting data on the occurrence blackout, greyout, etc., during the Mirage 2000 operating phase.

Therefore, with the creation of an "Anti G-LOC" program involving several instructions and training, it will be extremely important to monitor the individual and general performance of the pilots so that this new program evolves and increases safety in Gripen aircraft flights.

3 CONCLUSION

The F-39 Gripen aircraft is already a reality in the Brazilian Air Force. It has great maneuverability and sustains curves of up to 9G, making our pilots exposed to G-LOC.

It was observed that the G-LOC is extremely recurrent within fighter aviation. Due to the high cost of training a pilot and the equipment operated by them and due to the large amount of of accidents, several air forces have started programs to avoid accidents due to this problem. Such programs were effective and focused on the use of centrifuges, classes for pilots and physical training, such as bodybuilding.

It was also shown that the FAB does not have research and data on the occurrence of G-LOC. Such studies, even in other air forces, are of great importance and the knowledge generated can be used to create G-LOC prevention programs.

Thus, the creation of a structured program "Anti G-LOC" in the FAB, through classes, physical training, centrifuge training and performance monitoring, is necessary to guarantee the safe operation of the F-39 Gripen aircraft.

Finally, with the creation of such a program, the FAB will invest directly in the Flight Safety of the new F-39 GRIPEN vectors, preventing accidents or incidents related to the G-LOC, saving material losses and, mainly, human lives. Furthermore, the development and improvement of the Anti G-LOC program would serve as a reference for new studies to be initiated in the Armed Forces and in Brazil.

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