A SD-Demonstration Program for German Navy Tornado Aircrew, First Results

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Summary: Based on a class 1 aircraft accident of the German Navy in 1997 and a class 1 mishap of the German Air Force in 1998 with the loss of all 4 crewmembers, Division III of the GAF Institute of Aviation Medicine installed a program for Tornado aircrew to demonstrate various SD situations in the Flight Orientation Trainer. Although during these accidents every possible flight information was available to the aircrew, the situation was not perceived as disorienting and dangerous but the focus stayed on the primary task intended or wrong priority chosen.

Spatial disorientation, namely the loss of situation awareness, is one of the main factors and by far too often a contributing factor responsible for a/c accidents. But spatial disorientation is one of the main causes of accidents not only in modern, super-agile fighter aircraft; this is also true for older designs of jets and all other types of aircraft.
The last 15 to 20 years have seen dramatic developments in technology with an enormous impact on aircraft design and performance. Air Forces of many nations are introducing fighter aircraft of the fourth generation; the design of fifth generation fighter aircraft is already on the drawing boards.
Compared to today's fascinating technological possibilities of modern aircraft design, the evolution of the human being with its old-fashioned sensory apparatus is not really up to date.
The gap between the sensoric, motoric and general physiological capacities of man and modern technical capabilities is increasing in such a way as to make it impossible for the human body to keep up with or even master them.
Spatial disorientation is a killer. Almost all aircrews experience spatial disorientation during their career one time/way or another. All aircrews accept the potential dangers of SD but few of them perceive this danger as immanent and potentially dangerous in every flight. During flight briefings this fact is mentioned but all to often neglected or not given enough attention.
With the introduction of the Flight Orientation Trainer, FOT, the German Air Force acquired a tool to demonstrate and teach aircrews about the treacherous dangers of spatial disorientation in the flight environment. The Flight Orientation Trainer (Gyrolab 2000, ETC) was installed in Div. III, German Air Force Institute of Aviation Medicine in 1994. Over the years various scientific studies and research programs have been carried through with the FOT. In 1999 a test trial with German Naval Aviators took place and led to the SD Demonstration Program performed on a regular basis in 2000. More than 50 Navy pilots took part in the program.

The concept of use for the FOT had been decreed by the Surgeon General, GAF, in February 2000. It focusses on six major issues:

1. Demonstration of spatial disorientation for aircrew
2. Research
3. Development of demonstration profiles
4. Anti Airsickness Trainings Program (AATP)
5. Flight surgeon related problems
6. Aircraft mishap investigation – if requested

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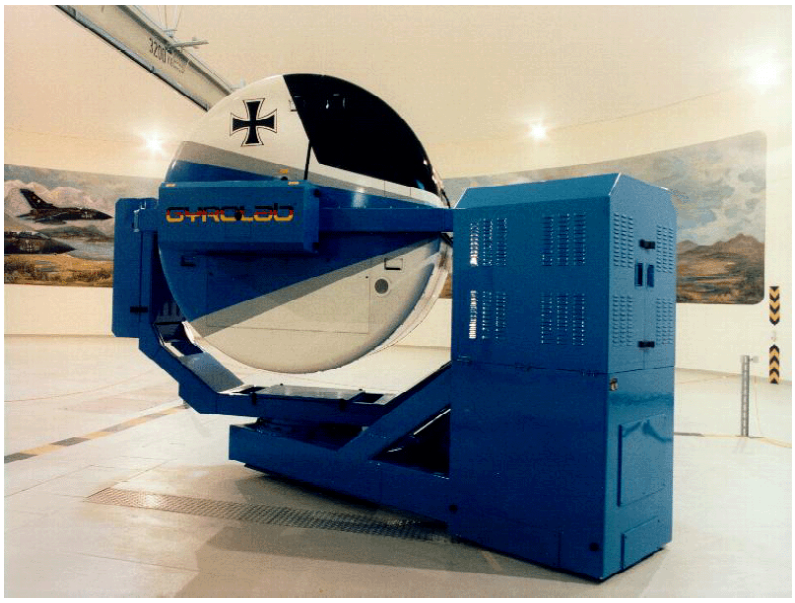

Figure 1: Flight Orientation Trainer (FOT)

The FOT generates vestibular and visual illusions.
The system can rotate 360° around all three spatial axes without any stop. In addition, a load factor of 2.2 G can be achieved using the planetary arm, similar to a centrifuge.
Planetary arm movements combined with simultaneous rotation around the vertical axis is used to simulate linear accelerations. Control authority can be transferred from the master console to the gondola and back. The device itself consists of two main components - the master control console (MCC) and the gondola assembly. The master control console is the heart and soul of the Flight Orientation Trainer. Here FOT rides are controlled, and profiles, movements and display modes are designed and generated. The cockpit of the FOT gondola resembles a virtual twin-jet aircraft.
Light cannons project the display of the virtual flight environment onto a concave mirror with the dimensions of 120 x 40°.

The system provides for two different databases concerning the virtual environment.
The pilot sitting in the gondola is continuously monitored by two cameras, one of them active in the infrared spectrum to guarantee that the pilot can be monitored even in a completely dark cockpit. Furthermore, the pilot’s actions and maneuvers can be taped on video.

Continuous communication with the personnel at the master control console is maintained via headset.
In 1998, initiated by the Senior German Naval Flight Surgeon in cooperation with the office of the General of Flight Safety and the German Air Force Institute of Aviation Medicine, we established a program for jet aircrews to again emphazise the dangers of spatial disorientation. Unfortunately, a tragic accident in the North Sea led to the starting point of the program. A German Tornado of a Naval Air Wing crashed into the sea, most probably because of technical problems. The time between when the problem occurred and the actual impact was approximately 30 seconds. The crew responded immediately to save the aircraft and continued their efforts right until the time of impact. There was no apparent attempt of the crew to eject.

The FOT program is designed to refresh the crews' memory of what they learned during the initial training to demonstrate that even extensive experience does not prevent a crew from becoming disoriented and that in hazardous situations the obvious and rational is often pushed aside by habit patterns that have become ingrained in the subconscious over the years.

The program's main objectives are to make the pilot recognize his/her own deficiencies like
- Spatial Disorientation
- Capacity to perform properly
- Situational Awareness
- Perceptual conflicts
- False assumption of safety

It consists of a variety of profiles, both passive and active, to put the pilot in the loop. Standard profiles designed to refresh the crew's awareness of basic problems are combined with situations from real aircraft accidents to demonstrate that time is precious, task prioritization essential and decision-making absolutely critical.

The program is designed to:

- Improve the aircrew’s judgment on situations which are likely to cause SD
- Determine priorities as to the flight attitude
- Recognize discrepancies between sensory perception and instrument readout
- Perform compensatory actions in the FOT during the SD profiles

Before entering the SD program the pilots received an in-briefing about the FOT, the different profiles and emergency procedures. After the program everybody had to fill in a questionnaire about the training. They were asked to rate the profiles as to quality and potential benefit as well as to give their opinion about the time frame for a refresher course.

In the table below the different profiles used in the program are listed.

Jet:	Heli:	Transp.:
- GYSPIN	- GYSPIN	- GYSPIN
- GYSPIN1	- GYSPIN1	- GYSPIN1
- EF15	- LEANS	- LEANS
- TOMSPIN	- DRKTKOFF	- DRKTKOFF
- DRKTKOFF	- FSUBYAW	- FSUBYAW

Table 1: Standard profiles for SD-training

The profiles represent the typical illusions and sensations experienced in flight by almost everybody.

The graveyard spin is being demonstrated passively (GYSPIN). During the second run (GYSPIN 1) the pilot in the FOT has the authority over the controls to compensate for the perceived motion. By showing the pilot his "overcompensation" it is possible to make him recover just by relying on the instruments, if the situation permits him to do so. The magnitude of the mismatch between perceived motion and real motion is generally very surprising. The "EF15" profile combines a counterclockwise angular acceleration on the FOT‘s planetary arm and simultanously a rolling motion to the left followed by an abrupt rolling to the left. That simulates the Weapon System Officer in the rear cockpit working his radar while the pilot starts maneuvering without informing his crewmember. After the right-rolling motion the authority is transferred to the pilot in the gondola, and he/she is to recover to straight and level flight. The majority of test persons has problems recovering the FOT. Pilots seem to perform better than the WSOs.

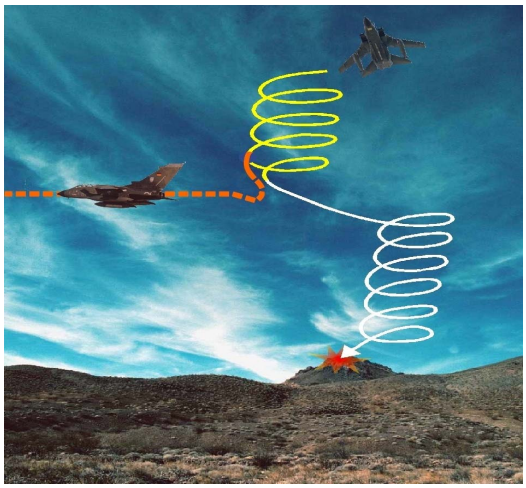

Figure 2: TOMSPIN flight accident profile

The "TOMSPIN" profile is a profile that was designed after a mishap in which an aircraft departed from controlled flight and was lost in a spin. In this scenario the pilot in the gondola is flown into that situation and asked to recover the aircraft using the appropriate **Boldface** procedure. This profile generated a wide variety of reactions from the pilots and WSOs. The range of reactions spanned from the immediate and correct response with the timely decision to eject from the aircraft to a total failure to perform the necessary Boldface procedures until impacting the ground. One pilot mixed up the recovery procedures of three different aircraft he had flown during his career.

The dark takeoff profile (DRKTKOFF) is well known as to its basics. During takeoff acceleration and level-off the pilot perceives a strong climbing attitude and pushes the stick forward to compensate, initiating an involuntary descent. In the FOT all pilots pushed on the stick after authority transfer, initiating a descent with a nose-low attitude ranging from 5 to 30 degrees.

Time permitting, the classic profiles "LEANS" and "FSUBYAW" (simulating a subthreshold yawing motion) were also used.

Table 2 combines the results of 'profile rating' and 'most beneficial profile', as indicated by the participants.

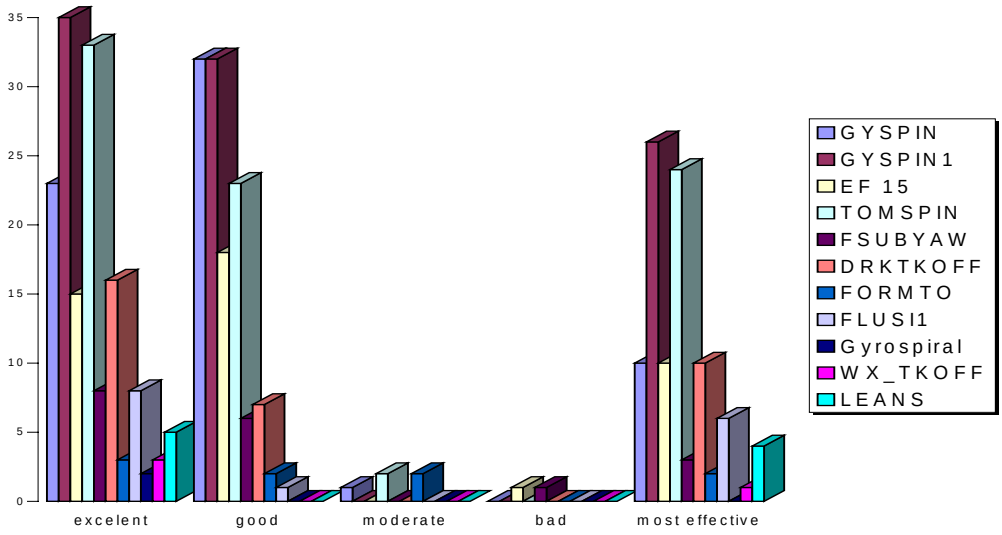

Table 2: profile rating by participating aircrew

The results of the survey clearly indicates that SD training is considered beneficial by the aircrews.
We were able to demonstrate to most of the participating aircrews that even long experience is no protection against spatial disorientation. Astonishment about their own reactions caused most participating pilots to reconsider their approach to SD. This was their clear message from the debriefing after the program to us. An additional indication is the statement of the participants that the training should be repeated every 3 to 4 years.

The objectives of the program have been achieved. The participating aircrews left the program with a heightened awareness of the SD problem, recognizing it both as an important factor affecting their performance and as a big safety hazard. Especially the flight accident profiles which related to their daily work had the biggest impact on the aircrews.
By implementing a well-accepted SD training program consisting of academic and practical instruction – in a demonstrator/ simulator or even better in the air – we have a good chance of reducing SD as a major lethal factor in aviation. We need to find a way to make every aircrew consider SD always and everywhere. Otherwise SD will continue to be a killer in the first degree.

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