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# Usefulness of flight simulator as a part of military pilots training – case study: Grob G 115E

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## Abstract

This article examines the use of the Grob G 115E simulator (GO simulator) in Air Force elementary flight training, its technical features, and their impact on various areas of training.

Questions about the use of the GO simulator will be answered through expert interviews and a user experience survey for flight instructors. In this way, the usefulness of the simulator was investigated.

According to the results obtained, the GO simulator and simulator training in general are an invaluable part of flight training. The realistic cockpit environment and avionics of the GO simulator, combined with precise terrain modeling and good maneuverability, create a high-performance entity capable of meeting the requirements of basic flight training. According to the user experience of flight instructors, the simulator is excellent in its function and, above all, easy to use and reliable.

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*Keywords:* simulators; training; usefulness

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## 1. Introduction

Flying is a good example of a situation where training in a real environment is too risky, especially at the beginning. As a result, simulator training has been an important part of flight training in both military and civilian organizations since the invention of aircraft. The first rudimentary flight simulators were developed as early as the

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1910s [1]. The main reasons for the popularity of flight simulators are the improvement of flight safety and cost-effectiveness. The flight simulator can also be used to train and practice things that would pose high risks when performed on a real airplane, such as emergency procedures and forced landings. The flight hour prices of flight simulators vary depending on the simulator, but without exception, the price per hour of the simulator is only a fraction of the price per hour of a real aircraft.

Simulator based studying is learning by doing. It is a bridge in between studying that happens in the classroom and the real world. Simulator-based learning takes away the problem of traditional learning that is based too much of remembering facts in order to reach knowledge-level needed. The term simulator training refers to a form of learning that utilizes a simulator. [2,3] It is not intended to eliminate the need to study skills using traditional methods, but to make learning to be meaningful and effective in education [4]. The simulator training provides better results in remembering the lessons learned than standard lecture-based teaching alone. [5]

In Finnish Air Force elementary flight training, the goal of simulator training is to give the student a feel for the airplane before the first flights, teach the basics of instrument flying, and create instinctive reactions for the student against emergencies. Simulator training is used, for example, to support type flights, instrument flights and emergency response training.

During 2020, the Finnish Air Force has replaced the previous Vinka school aircraft with the Grob G 115E school aircraft, which has changed the Air Force's basic flight training program. The Grob G 115E is more advanced in many areas compared to its predecessor, the Vinka, just as the GO simulator built on it is more advanced than the old Vinka simulator. This is a natural development, because as the Air Force's basic flight training equipment is updated, the simulator training will have to change to match the new aircraft, which will automatically set new requirements for the simulator as well.

The first chapter of the article gives motivation for the use of simulators in flight training. The second chapter describes the use of simulators in flight training and the general benefits use of simulators bring. The third chapter introduces the tested GO simulator and its use in basic flight training. The fourth chapter presents the main results of the expert interviews conducted and the user experience survey. The fifth chapter presents the conclusions and development prospects of GO simulator training.

## **2. Simulators in flight training**

While the safety of flight training is the main reason for using simulators, the second reason is to reduce costs and the third reason is to make training more efficient. When flying with a simulator, the trainer can, for example, stop the plane, give comments to the student and continue the simulation. Simulator training is an important part of flight training, but it is equally important to teach flying in practice. As an example of this, when the U.S. Air Force gradually reduced the flight hours of KC-135 pilots on the right aircraft and increased simulator flight hours in basic training, reduction saved costs, but as a result, pilots could not land properly on a real plane [6].

Simulator training involves the concept of the Transfer [7,8,9] that means how much the training with simulator influence to the performance in a real-world situation. [10] This also means that the success of Transfer can only be seen in a real-world performance. Transfer is positive when prior practicing with a simulator leads to the improved management in a real environment. If simulators used don't mimic correctly real environment conditions, or the simulator describes situations easier than they are in reality, the learned behavior will be wrong. [11] This will lead to a negative outcome in a real-world performance and Transfer is negative. It is challenging to change or re-learn, what has been learned wrongly. [12]

When looking at the accuracy and realism of a flight simulator, the term Fidelity is used. The simulator Fidelity is roughly divided into three parts: physical, cognitive and functional Fidelity. Flight simulators have several common weaknesses regardless of how high the simulator's Fidelity is. The most common problems are nausea in the

simulator, decreased user motivation, complex simulator architecture, and high cost. Students' lack of motivation arises from students realizing they are in a simulator, leading to a misconception of danger, resulting in students' stress levels lowering and they are taking risks they would never take with real airplane. A good example is the unstable instrument approach with airplane in bad weather. As the simulated flight approaches a decision height where a decision must be made as to whether to land or raise the airplane, students are more likely to bring the aircraft to land, even if it is dangerous to do so in a real situation. Of course, taking higher risks and analyzing them in the simulator also serves as a good learning experience for the student. Flight training places a lot of demands on simulators, as a result of which the technology of the simulators is very complex, especially if the Fidelity of the simulator is high. In flight training organizations, simulators must meet the requirements of the aeronautical authorities in order to obtain the necessary ratings for flight training. Meeting the requirements combined with complex technology is often a challenge. As a result of the complex technology, the operating costs and acquisition prices of the simulators can also be considerably high. The use of high precision simulators called High-Fidelity simulators improves the ability of users to perform tasks and increases the skill level of users. Simulators precision should always be at the maximum possible level in order to achieve the highest possible level of Transfer in training. [13]

Useful is a term used by Jacob Nielsen that combines the terms Usability and Utility. Usability is a qualitative measure that measures the ease of use of a software or device for its user. It answers the questions: Is the device easy to use and is it easy to learn how to use the device? Utility answers the questions: Does the device meet the requirements and does it fulfill its function? If the device or software has a good Usability and Utility, it can be said that the device is Useful. [14] The GO Simulator Usability and Utility were investigated through expert user survey and expert interviews.

### 3. GO simulator and its use in training

The cockpit environment of the simulator is almost identical to the cockpit of a real aircraft. The avionics panel of the simulator is according to the avionics panel of the real airplane panel. An identical simulator is not. However, it is not sensible or cost-effective to copy all the things from a real airplane to the simulator. One example is a teacher's seat that is out of the simulator cab because in the simulator, the teacher's workstation is behind a cab on a separate desk where teachers view and control is better see Fig.1.



Fig. 1. Illustration of the Go simulator cab, visual system and teacher workstation behind.

The simulator's visual system consists of a curved screen in front of the simulator's cab and three video projectors that create an image on the screen 180 degrees wide. The field of view (FOV) of the image is 120 degrees from the perspective of the student sitting in the cab of the simulator. The projectors are backed by IG (Image Generator) software, which creates an image for the video cannons and fits the image between the projectors so that a uniform and seamless image is created on a wide and curved screen. The software behind the visual system is the same as the Hawk and Hornet simulators used by the Finnish Air Force.

The simulator functions are based on commercial flight simulator software. Physics modeling based on data from test flights flown on a Grob school plane has been created in the software. The aircraft model has been created to be as realistic as possible compared to a real aircraft, so that the simulator has the highest possible Fidelity and the training it provides is of maximum benefit.

There are four GO simulators connected to the HLA (High Level Architecture) network. This means that the simulators also see each other on the visual display as well as in the MFD (Multi-Function Display), just like in a real situation. In addition, artificial Grob aircrafts can be created in the HLA network to fly direct horizontal flight in the same airspace, with which, among other things, department flight can be practiced. In the HLA network, simulators can also operate on the same radio frequencies in the simulator world, and one simulator teacher's workstation can participate in a radio conversation. This allows one teacher to act as an air traffic control and to lead all four aircraft from their workstations. Meanwhile other teachers can chat with their own student via Intercom.

Each GO simulator has its own teacher workstation see Fig. 1 with two monitors behind a cab, from which the simulation and simulator parameters are controlled. The left screen shows the parameter adjustment and the right screen shows the map view. The teacher can adjust the simulator time, season, brightness, weather conditions, location, airplane mass and fuels, airplane fault conditions, and numerous other parameters. Airplane fault conditions can be simulated so that a fault condition occurs immediately when the selection is made from the teacher's seat, or a threshold value can be set for the occurrence of a fault condition, such as flight altitude, time or airspeed. The simulator has the same flight task recording system as a real airplane. The recording system records flight and engine values, location information, and video generated by the camera. Flight mission recording begins when the avionics switch is turned on and ends when the power is turned off at the avionics switch. The recording is retrieved to a USB memory stick from the teacher's workstation.

### *3.1. Elementary flight training structure*

Air Force Basic Flight Training, the GO Flight Training Program, is a two-part process in which a flight student completes 139 individual flight tasks. The first phase of flight training, GO1, which is completed as a conscript during a flight reserve officer course, includes 59 flight missions, 21 of which are flown in a simulator. The second phase of the training, GO2, is completed in conjunction with the cadet school in the summer and partly in the fall of the second year. The second phase includes 80 flight missions, 20 of which will be flown with a simulator. In the GO training program, flight students are trained in type, navigation, instrument, skill and departmental flight.

The purpose of type GO1 flight training flights is to train the student to the level of mastery of the basic operation of the airplane, as a result of which he/she will be qualified to fly the airplane alone after the inspection flight. Type flights include ground operations, take-offs, landings in different situations and configurations, curves, forced landing drills, stallings, emergency drills, and downhill flight and rectification. About halfway through type flights, a student can begin orienteering training and instrument flight instruction. The GO2 flight training program emphasizes instrument and department flying.

The GO simulator can be used to train all flight tasks included in the GO flight training program, so the simulator does not impose any technical restrictions directly on the flight training program. Although the simulator does not impose significant limitations on the GO flight training program, it does have the inherent weaknesses of all flight simulators that occur in any training, both civil and military. Military pilot training includes skill flight with

movement and large G-forces. The flight simulator can be used to practice the correct execution of the flight paths of skill flight movements, but the simulator is not able to model G-forces.

#### 4. Results and discussion

The survey examined the perceptions of seven flight instructors about the use of a GO simulator in the basic flight training of the Finnish Defense Forces. This data is used to diagnose problem areas and measure Nielsen's five areas of usability. According to usability theory, a group of five users is enough to detect the biggest challenges in device usability. [14] The questionnaire contained 16 numerical questions as well as four oral questions. The questions measured usability according to the following areas: learnability, efficiency, memorability, error susceptibility, and user satisfaction. In addition, verbal questions map the strengths, weaknesses, and areas for improvement of the simulator through the experiences of flight instructors. Numerical questions were answered on a scale of 1-5, of which 1 = strongly disagree and 5 = strongly agree.

Based on feedback from GO simulator (Fig.2) Fidelity is high so we can conclude that Transfer level is also good. For questions "Is GO simulator easy to use?" and "Is it easy to learn how to use the device?", answer to these both questions seem to be yes, so we can conclude that simulator tested here also had a good Usability level.

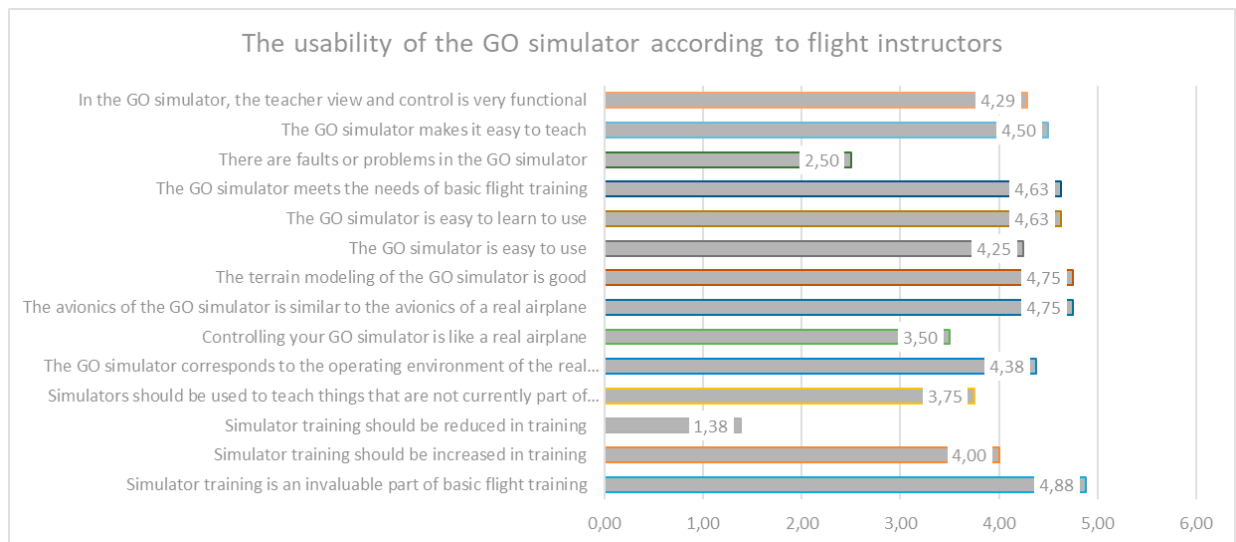


Fig. 2. The usability of the GO simulator according to flight instructors.

All respondents responded that simulator training is an indispensable part of basic flight training, with an average of 4.9. This is also supported by the interviews conducted. The statement "Simulator training should be increased in basic flight training" was answered with an average of 4.0, ie simulator training could be further increased from the current level. A large number of flight instructors were of the opinion that the simulator could also teach things that are not currently included in the flight training program, the average of the statement "Simulators should be used to teach things that are not currently part of the training program (eg skill flight)" is 3.75. Based on comments and interviews, for example, the teaching of orienteering training based on the use of MFD (Multi Function Display) could be increased and problem solving could be added to the emergency response training.

According to the experience of the target group, the Fidelity of the Grob simulator is so good that it can be considered as a high-precision simulator. The average for the statement "The operating environment of the Grob simulator corresponds to the operating environment of the real airplane" is 4.38, which is very good. Of the components of the simulator, the controllability of the simulator received the worst grade, 3.5. The highest scores were given to the sub-area simulator terrain modeling and simulator avionics, with averages of 4.75. Looking at the

results, it can be concluded that the simulator received excellent grades from the target group in terms of both the operating environment and the user experience. The statement “GO simulator is easy to use” received an average of 4.25 and the statement “GO simulator is easy to teach” received an average of 4.5, which suggests that the simulator is good for its purpose from the point of view of a flight instructor.

The target group's verbal comments on the strengths of the simulator tell well about the training opportunities with the simulator. Flight instructors and test pilots highlight the simulator visual, avionics, and cockpit environment in general. The avionics and cockpit are completely consistent and identical to the real airplane, making it easy transition from a simulator to flying a real airplane. In addition, the strengths of the simulator include the ability to network the simulators and the control feel, which is significantly better than in the previous Vinka simulator.

The target group also found shortcomings and weaknesses in the simulator that could affect the training. By far the biggest weakness is the behavior of the GO-simulator on the ground. According to the comments of the target group, the control feeling of the simulator on the ground is poor, because the friction modeling is poor, which makes it difficult to control the machine, especially in take-off. Due poor ground maneuverability, take-off is unrealistic. This is a challenge especially for inexperienced students who do not get a real picture of the take-off run in the simulator, but have to experience it for the first time on a real airplane.

## 5. Conclusions and future

Simulator training is integral part of the Finnish Air Force's flight training, and simulator flights are mandatory for passing flight-training programs. For simulator flights, precise objectives, tasks and flight times are defined and the results are evaluated according to the same criteria as for flights with real aircraft. In practice, this means that each simulated flight exercise has a number of areas to be assessed for which a standard level has been defined. If a student does not reach the standard level in more than two areas, the flight practice will be rejected. The student must complete the flight exercise successfully before he or she can proceed with his or her training. Thus, the use of a simulator is not only an additional training. Students can also practice with flight simulators on their own whenever the simulators are free from other use. Self-practice is desirable and encouraged with the GO simulator, as it will increase the student's own skill level in peace. The simulator provides a safe method to do exercises that are too dangerous or impossible on the right plane, such as forced landings outside the airport area.

Based on the survey and interviews GO simulator meets the requirements of basic flight training, and is suitable for this task. The simulator is sufficient in terms of usability and realism, and it can be used to train everything that is included in basic flight training programs. The target group of the study consisted of pilots with hundreds of hours of flight experience on different aircraft types from single-engine propeller aircraft to fighter jets. Pilots experience affects results by focusing verbal responses on details that students that are more inexperienced do not notice. This article looked at the usability of the GO simulator from a technical perspective. The experienced pilot highlighted the strengths and development points of the GO simulator. In the future, the pedagogical effects of the simulator could be exam by interviewing students.

The realism of the simulator is at such a good level that, according to the feedback from the flight instructors, the simulator could be used to maintain the flight instructors' flight ratings so that the inspection flights required for the ratings could be performed with a GO simulator. The same practice is already used with Hawk and Hornet simulators.

Experienced pilots found flaws in the simulator and made suggestions for improvement. The friction modeling of the GO simulator was the most criticized. However, the purpose of the simulator is mainly to train flying, so poor friction modeling is a problem only during the first simulator flights, when students do not yet have proper experience of real aircraft behavior. This could also be remedied, as these are not structural problems of the simulator.

The GO simulator is part of basic flight training, but its role in the training is relatively small at the start of the new flight-training program. In basic flight training, the number of simulator hours is well below half of the total flight hours. In the new degree program, the emphasis is on the student's ability to process new information, situational awareness, and decision-making skills, all of which can be practiced with the advanced avionics of the GO Simulator. Thus, the simulator's lack of FOV and controllability in ground contact remain insignificant. Training in a simulator is a good opportunity for the student to internalize the complex avionics of an aircraft before training in a real aircraft, which requires a focus on aircraft control and radiotelephony. The GO simulator, whose cockpit environment is almost identical to the cockpit environment of a real plane, is a good tool for getting the student used to the cockpit of an airplane. As the student develops as a pilot, the GO simulator works best in training tactical operations that play a key role in operating fighter equipment.

There are plans to develop the use of VR glasses in conjunction with the GO simulator. The combination of VR glasses with the simulator eliminates all field of view problems, giving the pilot a complete FOV in all directions. Thus, with this reform, the problems associated with FOV 120 degrees in skill and departmental flight training will be eliminated. After this, the only factor limiting the use of the GO simulator remains the controllability of the simulator in ground contact.

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