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STUDY OF THE PILOT'S ATTENTION IN THE CABIN DURING THE FLIGHT

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Abstract

The pilot, while performing certain tasks or being in the battlefield environment works in a time lag. He is forced to properly interpret the information and quickly and correctly take action. Therefore, the instruments in the cabin should be arranged in such a way that they are legible and the operator have always-easy access to them. Due to the dynamics of the aircraft and the time needed to process the information by the pilot, a reaction delay occurs, resulting in the plane flying in an uncontrolled manner even up to several hundred meters. This article discusses the VFR and IFR flight characteristics, the pilot's attention during flight, cabin ergonomics, and the placement of on-board instruments having a significant impact on the safety of the task performed in the air. In addition, tests have been carried out to determine exactly what the pilot's eye is aimed at while completing the aerial task. Six basic devices were identified: altimeter, artificial horizon, speedometer, turn indicator with transverse gauge, variometer and heading indicator. They also started to think about how to position them in relation to each other in order to achieve the best results in terms of ergonomics, which include, minimizing time of reading individual parameters, grouping devices with parameters closely related to each other, reducing to a minimum the value of errors during reading and the smallest possible pilot's effort.

Keywords*: transport, battlefield environment, pilot reaction delay, device parameters, parameters reading time*

1. Introduction

In order for the pilot's work in the cabin to give the greatest effects, give him the best conditions. Before designing cabins, it is worth considering what will ensure the comfort of a man sitting at the helm of the aircraft during the mission to make the best use of the airplane's capabilities [2]. In the process of creating the instrument booth one should consider the distribution of the pilot's attention in its particular regions. It was also found that the sight does not stop uniformly in all areas of the instrument panel. The frequency of stopping the eye as a percentage of the time of the observed surface is shown in Fig. 1.

From the drawing, it should be concluded that the most commonly used instruments should be placed in the upper left corner.

In order to correctly and as effectively as possible control the spatial position of the aircraft, ergonomics scientists have considered the need to find and locate basic devices closely related to manoeuvres and pilotage [1, 3]. For this purpose, six basic devices were identified, which are altimeter, artificial horizon, speedometer, turn indicator with transverse gauge, variometer and heading indicator. They also started to think about how to position them in relation to each other in

order to achieve the best results in terms of ergonomics, which include, among others, minimizing the time of reading individual parameters, grouping devices with parameters closely related to each other, reducing to a minimum the value of errors during reading and the smallest possible pilot's effort. The basic ways of grouping individual instruments with each other, shown in the figures below, are the so-called "basic six" and "basic T".

Fig. 1. Frequency of stopping the eyesight on individual instrument panel quadrants

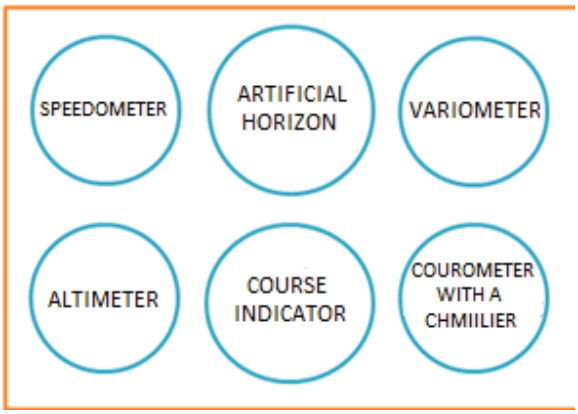

Fig. 2. „Basic Six" [own study]

Fig. 3. „Basic T" [own study]

The main and most important device located in the central part of the board is the artificial horizon. It allows you to control the position of the aircraft in the airspace. On the sides, there are instruments for speed and height control. Speedometer and altimeter located on the left, while variometer on the right.

With the development of aviation, along with the emergence of integrated and disposable indicators, a new way of positioning the instruments was created, the so-called "basic T". In the above arrangement, the vertical part of the letter "T" consists of the spatial position indicator ADI (Attitude Indicator) and HSI (Horizontal Situation Indicator), while the horizontal part "T" consists of speedometer, ADI and altimeter. Devices included in the "T" system are surrounded by

auxiliary devices such as variometer, turn indicator with crosswise or other. Instead of a turn indicator with a crossbow gauge, for example, an RMI radio magnetic indicator can be used. When using electronic indicators, the "T" system is also used. In the case of electronic indicators, the vertical part of the letter "T" consists of the electronic spatial position indicator EADI and EHSI (Electronic Horizontal Situation Indicator). On the EADI indicator, the basic indicators are also depicted based on the "basic T".

2. Rules for performing VFR and IFR flights

2.1. VFR Flights

Visible flight rules (VFR) require the pilot to be able to control altitude, navigate, avoid terrain obstacles and other aircraft based on observation of external reference points. The flight between two airports is therefore based on comparing the information from the map on the SP with what the pilot sees outside the cabin. It is important that the pilot makes sure of his position by observing appropriate on-board instruments. The performance of any aircraft evolution in VFR conditions is based on observation of the natural horizon and based on some navigational and pilot instruments. In VFR flights, the pilot is responsible for separating his own aircraft from others [4].

2.2. IFR Flights

Flights in difficult weather conditions, especially those according to the instructions of the instruments are quite a challenge for the pilot - they constitute the highest degree of flight skills. Before the flights of this type begin, one must master the pilotage almost perfectly, not only with visibility, but also in the clouds. In the course of flights with limited or no visibility of the ground and lack of visibility of the natural horizon, the pilot's visual impression of the aircraft's location is very limited or not at all [5, 6]. It is difficult not only to orientate in the field, but also spatial orientation. For this reason, the pilot is tasked with constantly knowing his location on the basis of specialized on-board instruments. In order to control their own position in space, to maintain the prescribed flight parameters, the pilot is obliged to constantly read the indications of the instruments analyse them and compare them. Based on the information provided by the on-board instruments, the pilot maintains the prescribed flight conditions by means of the joystick and throttle.

3. Tests of the pilot's attention in the cabin of the aircraft during IFR and VFR flights

The tests were carried out in the Microsoft Flight Simulator X computer program in the Lockhed Martin *Prepar3d* extension. It is a flight simulator for the Windows operating system that allows simulation piloting multiple aircrafts.

With the help of the "basic six", the pilot maintains the set speed, altitude, and course, while controlling that there will be no tilts, inclinations, yaws, or slides. The next action that the pilot in the cabin performs during a VFR flight is the observation of external references to determine its own geographical location. After determining the current position, the pilot again focuses his attention on the "basic six", thus controlling that all basic horizontal flight parameters have been retained. If they have been changed, they are immediately corrected, and if they have not been changed, they start observing the surroundings, thus checking whether there is no obstacle on the route or other SP that may pose a threat. After making sure that the flight can be safely performed, the pilot proceeds to observation of additional navigational and pilot devices such as GPS, VOR receiver, radio altimeter, and automatic radio compass. Another element of attention in the cabin is the analysis of indicators presenting the parameters of working engines and other important SP systems. The last elements that should be observed by the pilot in the cabin during the VFR flight are all kinds of levers, fuses, switches or potentiometers.

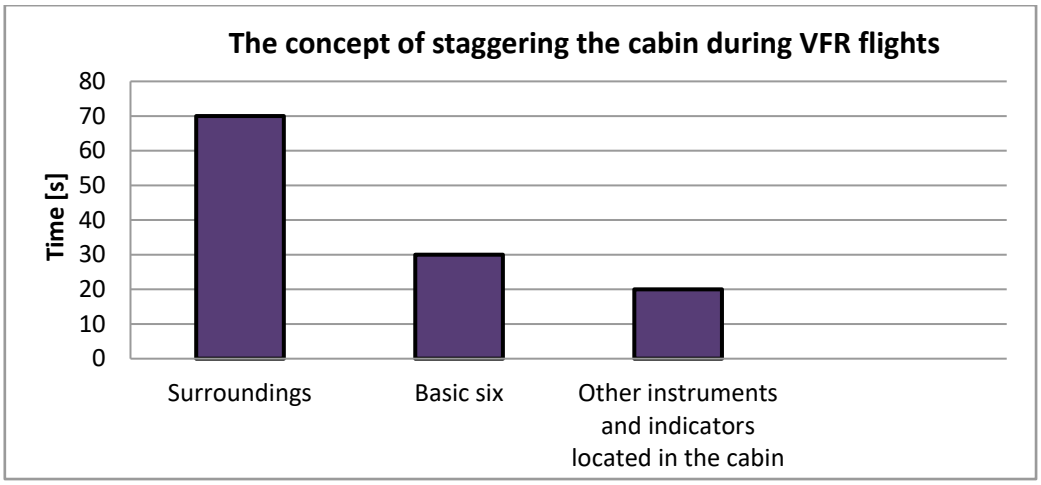

Fig. 4. The concept of staggering in the cabin during VFR flights [own study]

In order to start the flight according to the IFR, the pilot should determine the appropriate angle of the aircraft's position and the power of the engine, checking with the help of an altimeter if the aircraft is located at the intended altitude. The first and most important thing that pilot should focus his attention in the cabin is the "basic six". On its attitude, it is able to determine its own spatial position and required control actions to maintain or change this position. After several such cycles, the pilot proceeds to the observation of additional navigational and pilot instruments such as GPS, VOR receiver, radio altimeter and automatic radio composite (ADF). These devices have been added to the basic on-board equipment to provide additional information on the current location of the aircraft and to facilitate navigation, thereby increasing flight safety. After analysing the above the pilot returns to the "basic six" observation in order to detect possible deviations from the set flight parameters. If the pilot is sure that the flight he is flying is a horizontal flight, and the set parameters are properly maintained, he can observe any kind of levers, fuses, switches or potentiometers in the aircraft cab. Magnetic compass indications should be compared with the gyroscopic course indicator at least every 4-5 minutes of flight.

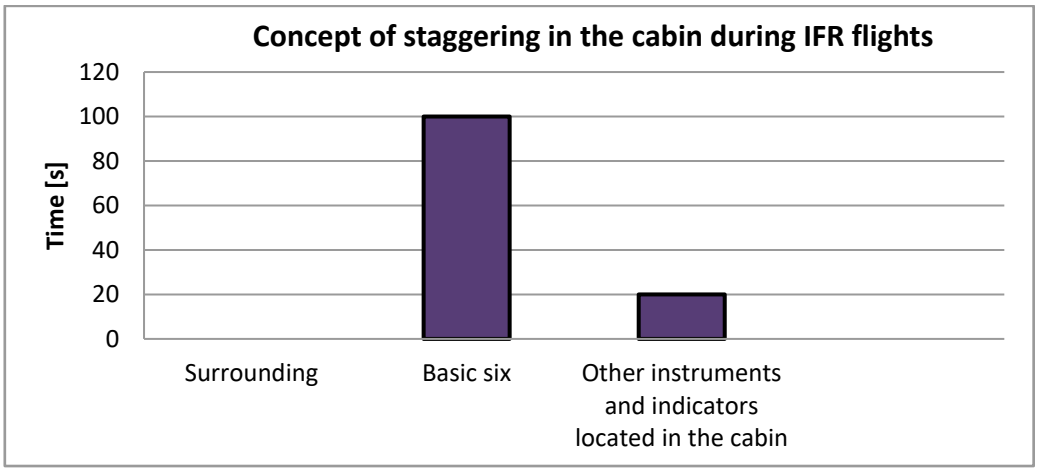

Fig. 5. The concept of staggering the cabin during IFR flights [own study]

4. Spreading the attention of IFR during individual flight stages

4.1. An ascending flight

When making a climb, the pilot should primarily focus on maintaining the silhouette of the artificial horizon of the plane, without any tilts in relation to the horizon line inside the instrument,

and on the climb speed, which will be indicated by the variometer. This has a significant impact on the correct implementation of this stage of the flight, other instruments at this moment are slightly less important. To accurately determine the flight range during the climb, the pilot of both the aircraft and the helicopter should monitor the instruments by moving the eyes from the artificial horizon to other pilot-navigational instruments such as: variometer, speedometer, course indicator, or turn indicator with a clinometer. Observation of devices controlling the operation of the drive unit should be carried out at intervals of 30-40 seconds. Any deviation from prescribed flight conditions, which the pilot observes using on-board instruments, should correct by means of smooth and coordinated movements the control stick and the power control lever. The recommended way of distributing the pilot's attention during the climb is as follows:

– horizon – variometer,
– artificial horizon – gyroscopic indicator of the course,
– artificial horizon – altimeter,
– artificial horizon – speedometer.

The frequency of the altimeter observation should increase as we approach the required flight altitude.

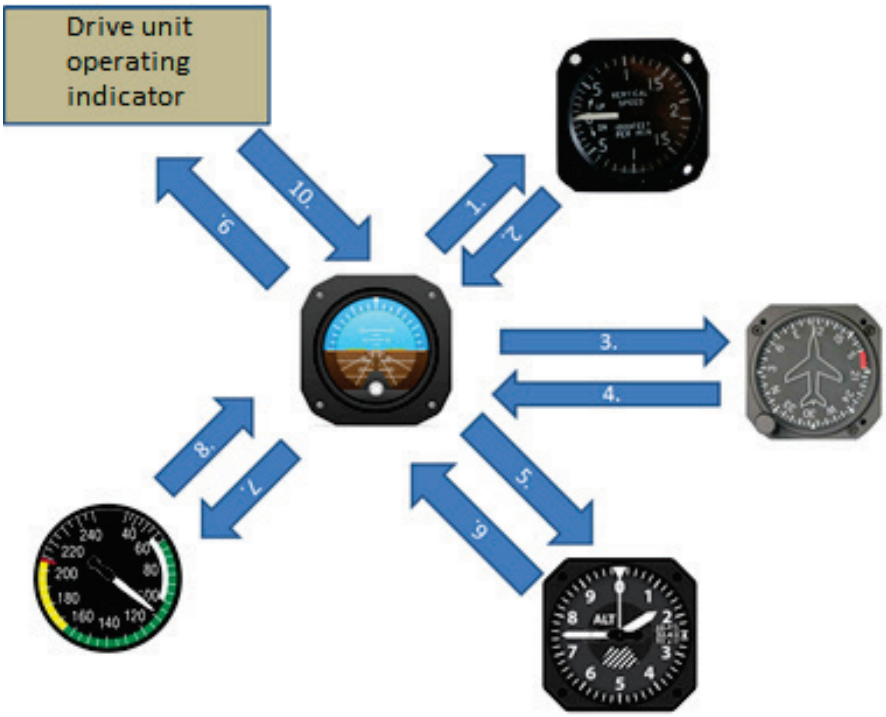

Fig. 6. Distribution of the pilot's attention during the climb [own study]

4.2. Horizontal flight

After reaching the prescribed altitude, the transition from a flight to a horizontal flight should be carried out in a strict order. The pilot does not change the range of the engine's operation in a smooth and coordinated way, "gives away" the stick from each other until the artificial horizon of the plane overlaps the horizon of the device. Keeps the position of the controls until SP does not reach the required speed. Then, using the engine control lever, it determines the required power range, while controlling the variometer and speedometer. If the variometer is in the zero position and the speedometer pointer indicates the appropriate speed for this type of flight, this means that the horizontal flight conditions are retained. If the variometer is in the zero position and the speedometer indicates the speed too high or too low in relation to the one prescribed for horizontal flight, it is necessary to reduce or increase the power with the help of the engine control lever.

After reaching the correct indications of the artificial horizon, variometer and speedometer, the pilot proceeds to observation of all on-board instruments. As in the case of an ascending flight, the pilot should observe the controls controlling the operation of the propulsion unit at intervals of 30-40 seconds. The recommended method of spreading the pilot's attention during a horizontal flight is as follows:

– artificial horizon – variometer,
– artificial horizon – gurgling – altimeter,
– artificial horizon – speedometer.

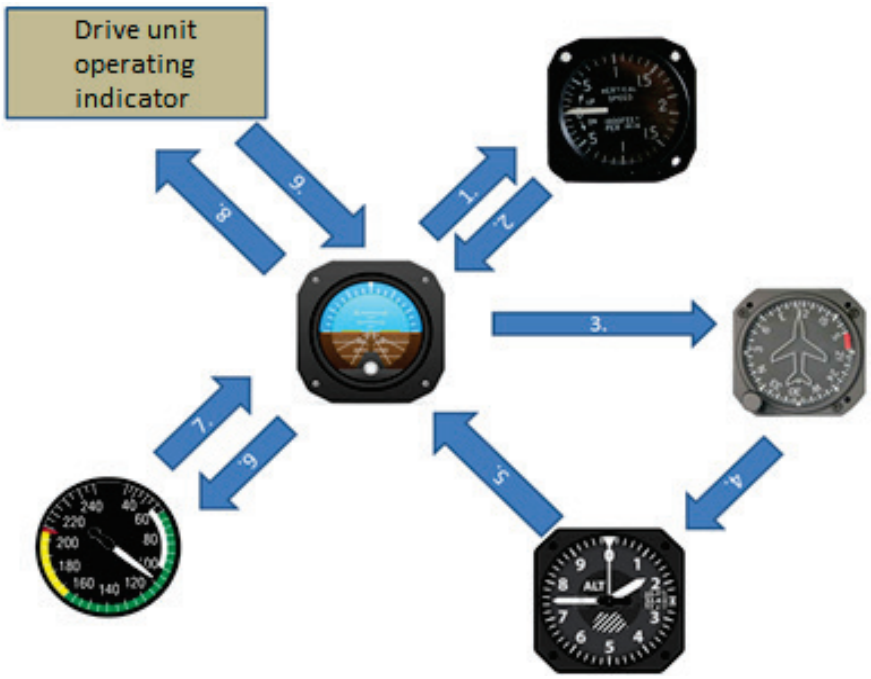

Fig. 7. Distribution of the pilot's attention during horizontal flight [own study]

4.3. Turns

In order to put the aircraft into a bend, one should keep the aircraft in the artificial horizon in a fixed position relative to the horizon line, smooth and coordinated movement of the joystick and rudder to tilt the airplane towards the bend, controlling whether there is no slide or slippage. Information about the slip or slippage is provided by the ball inside the clinometer or its more developed version – the turn coordinator (turn indicator and clinometer in one device). As in the case of ascending and horizontal flights, the pilot should observe the controls controlling the operation of the propulsion unit at intervals of 30-40 seconds. The recommended way of distributing the pilot's attention while making a steady turn is as follows:

– artificial horizon – turn coordinator – variometer,
– artificial horizon – speedometer,
– artificial horizon – gourmand – altimeter.

After getting out of the bend, make sure that the compass indicates the required course, and if not, make the appropriate corrections.

4.4. Descending

Pilot during descent should focus primarily on maintaining the silhouette of the "planes" of the artificial horizon, without any tilts in relation to the horizon line located inside the instrument and the speed of descent, which will be indicated by the variometer. This has a significant impact on the

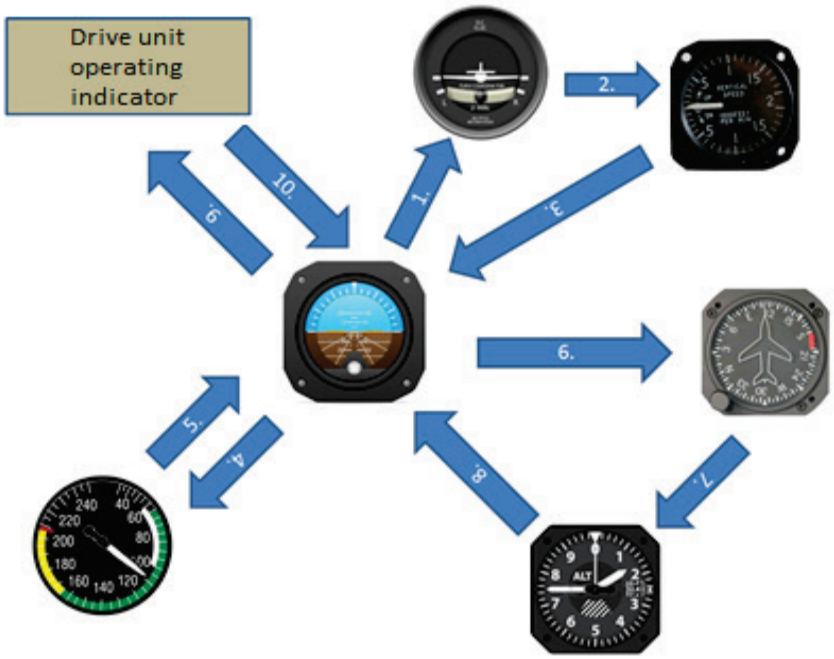

Fig. 8. Distribution of the pilot's attention during the turn [own study]

correct implementation of this stage of the flight, other instruments at this moment are slightly less important. The recommended way of spreading the pilot's attention during descent is as follows:

– horizon – variometer – altimeter,
– artificial horizon – variometer – speedometer – compass.

The frequency of the altimeter observation should increase as pilot approach the required flight altitude. During descent, take into account the inertia of aircraft. For this purpose, during the transition to horizontal flight, the value of the falling speed and the progressive aircraft speed must be taken into account. Both of these factors are important to calculate the altitude correction at which the aircraft should be initiated.

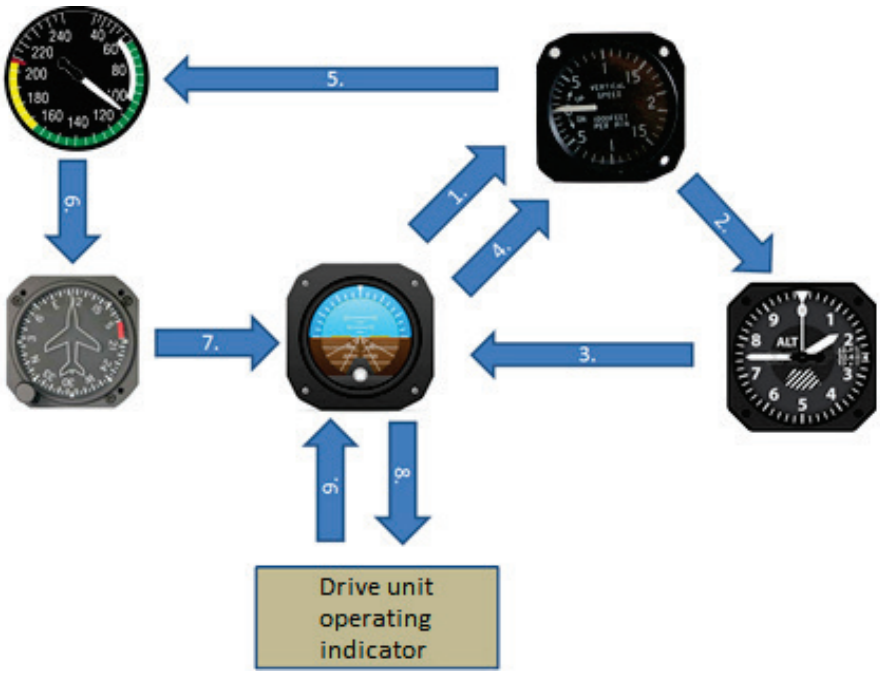

Fig. 9. Distribution of the pilot's attention during descent [own study]

5. Summary

The methods of spreading pilot's attention in the aircraft cabin have been developed by specialists and experienced pilots for decades. All of them were to increase the safety of the flight. This was done with the help of numerous tests and simulations, which along with the development of technology provided more and more new data. Now, there are several proven methods that are successfully used all over the world by both instructor pilots and students. Two of them deserve distinction:

– the method of transferring sight from each device to another always by observing the artificial horizon - the most precise method,
– circular method of transferring attention from one instrument to another – it is not as precise as the first method, but it is less tiring when performing long flights.

After the analysis, as well as referring to the whole of the research, the following conclusions are drawn:

– an important element that increases flight safety is the appropriate location of the pilot in the aircraft cab,
– proper placement of on-board instruments to allow for smoother movement of sight between individual indicators,
– cabin automation reduces the number of tasks that the pilot must perform in the cabin, thereby increasing flight safety,
– pilots participating in the research admitted that the simulator in approximately 80% reflected the real flight. This means that the test results are reliable.

Analysing the state of flight safety, the conclusion is that in the human-aircraft system, a more unreliable element is a human being. The most difficult part of flight training is the performance of IFR flights, because they require a constant focus from the pilot. The most important element during this type of flight is the correct distribution of the pilot's attention in the cabin. From the conducted research, it is clear that every pilot in his own way keeps track of deck instruments. This is due to various predispositions and other psychomotor options of the subjects. Hence the conclusion that from the moment of commencement of flight training instructors should develop appropriate habits in students. This will speed up and facilitate training of the aviation adept, and thus improve cooperation in the "human-SP" system.

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