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AIR CREW TRAINING, HUMAN FACTORS AND REORGANIZING IN CASE OF IRREGULARITIES

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Abstract

Human resource is more and more important nowadays among the resources of a company, because output and level of services can be increased, specific cost can be reduced, and the efficiency can be better with a relative little investment in human resources. It is an important issue also according to air transport safety, since 60% of flight accidents are because of crew errors. Human resource management includes every exercise concerning the personnel; the most important issues are procurement of suitable staff, and optimal allocation among the works. Assignment of the crew must meet several requirements. The initial optimal allocation may change by carrying out the schedule, because flights are often not performed as planned. If this happens, crew must be also re-allocated, causing as little interruption as possible.

Keywords: air transport, crew management, crew training, re-planning, disturbances.

1. Safety Issues According to Cockpit Crew

Choosing and training the suitable person is very important for the safety of air transport. The big number of accidents what is a result of cockpit crew errors:

- not enough attention: 22 %
- too much self-confidence: 19 %
- bad flying technique: 18 %
- other: 41 %.

In another classification, and this is more serious, 50% of accidents because of pilot reasons is because of wrong decision!

1.1. Failure Possibilities of Cockpit Crew

People never operate perfectly, but reflex can become a routine by a suitable training. Extreme and special situations which cannot be trained enough require a complex behaviour and procedure, whose performance includes a high probability of failure.

Therefore the training must emphasize that crew must not hazard the safety of the transport, and they must always bring the right and safe decision.

A man carries always the possibility of several failures that can happen in different phases of the analysing process of information. Following sub-processes happen until the final decision is made (like in a decision process of a computer; each phase has its own failure probability):

- Perception of external signs (e.g. a command, noise, smoke). Failure possibility: no, or wrong perception. In case of periodic repeating effects or procedures the reason of the lack of perception can be the ignorance of changes, which the pilot does not notice. Reason of wrong perception can be the refraction because of fog.
- Analysing the sign, and transforming it into information. Failure possibility: wrong interpretation, which can happen because of the lack of concentration, but we can also speak about the psychical fact that a man is able to think to see something he wants to see, so he will get wrong information.
- Raising the attention; this is the most critical procedure, because people have only one level perception tunnel. Therefore, we are not able to process and analyse two signs that come at the same time, especially apperception is not possible. The failure here can be the lack of reaction to information because of another operation.
- Developing decision alternatives, where the possible outputs and the difficulties of performance are weighted. Failure can happen if the pilot chooses a wrong alternative. Training the suitable processes and sinking them into a rut is a very serious task in the education, because people's capability to bring a good solution decreases in case of emergency.
- Action. Here we can mention the miss of the chosen process. Reason can be less concentration, but also wrong ergonomic design.
- Feedback. Analysing the results of the intervention, and registering the modified outputs.

The most important emergency factor concerning the operation of an aircraft is the parallel operation of different types of aircrafts, because each of them has a different cockpit configuration, therefore the pilot can easy miss a process that should be automatic. Therefore, pilot licences are limited concerning the number of available aircraft types, but airlines often assign crew to different types also within a day because they want to use crew as much as possible and cost can be spared this way. A solution for this problem could be if cockpits were standardized in case of aircrafts that have similar flying parameters. Keeping the attention is only possible if automatic does not work alone, so pilot have to – at least– control it. About this idea there is no harmonization between the two big manufacturer companies: Airbus offers airplanes with high level of automatic, but Boeing prefers keeping the higher role of pilots.

In the following I show the failure possibilities of cockpit crew while flying, only choosing the most important and critical ones. These issues all hazard the safety of the flight, so emphasizing them in the training period should be important.

1.2. Wrong Reading of Instruments

While reading instruments having similar form and scale, the rate of wrong reading is about 30%! The probability of failure increases in case of instruments having more indicators, or in case of the combination of instruments with indicator and counter. In this case increases the time needed for reading, too. Therefore, digital display instruments have spread, where only the most important information can be seen, and secondary data are displayed on request.

Beyond construction, the level of lighting is also an important issue, at different weather conditions (darkness), different lighting level is needed. The probability of failure increases in critical situations (approach, landing), because of stress.

Units are important questions according to instruments and flying parameters. International standards in Europe require the use of metric units, but many airplane types show the data in anglo-saxon unit, which makes transformation difficult.

1.3. Explanation of Information

Analysing and explanation of information that come from many different sources (air traffic control, cockpit, displays, and documentations) are a difficult exercise, and it is easy to misunderstand a parameter.

The most serious source of misunderstanding is the radio communication, because crew has to talk with different English knowledge and accent, the connection is mainly bad (strays). There exist communication standards for special words and sentences; however, a free formulated sentence can cause misunderstanding (e.g. following air traffic control command means that the airplane has to descend to 2500 feet: ‘Two five zero zero’. If the pilot thinks to hear ‘To five zero zero’, flight level will be 500 feet).

The next failure in communication can be if two airplanes are compounded, and the command is performed by another flight.

Beyond the factors mentioned above, cockpit displays have another property that can cause failure in explanation, and this is the warning procedure. Several warning instruments (red lamp, horn etc.) operate not perfectly and not at the perfect time, so they behave like a disturbance factor. Therefore, pilots often deactivate these instruments in order to keep the flight undisturbed, but in this case warnings do not operate even if they would be needed.

1.4. Health of the Crew

The perfect state of health is the basic condition of good and responsible working. This includes both physical and psychical status. According to the physical issues, a survey has brought interesting results. It has stated that reasons for wrong decisions and operations are the following (ranking by importance): diarrhoea, retching, stomach ache, any initial ache, head- ear- teeth ache, weakness, nose blooding and cough. By the training it must be emphasized that even in case of above illnesses the pilot always must control the plane safe. Age also influences the performance, the elder we are, the less we are able to work and time for reaction will be longer, too.

Hazard of unavailability because of psychical reasons is low, because it is filtered at the recruiting phase, and pilots have to make psychical tests periodically. However, medicaments can influence the psychical state of people.

1.5. Board Automation

High-level automation can eliminate human errors, but the reduction of the role of pilots causes reduction of attention, too. So the suitable reaction in case of danger cannot be expected, and a survey has shown that skill and experience reduces, too. The level of automation should be chosen so that the system makes the procedures repeating periodically, and the pilot is given the possibility of intervention. It is continuously a topic in discussions, which role pilots should be given: only checking, controlling, or active operation.

Besides safety, automatics can increase the efficiency of flying too, because it is able to keep the airplane on the selected route with minimal performance, and –on yearly level– high cost can be spared especially because of the reduction in fuel consumption, and another issue is that shorter flying time does not generate delay costs. Crew have the second highest cost of an airline after fuel, therefore raises the question if higher level of automation can cause reduction of the number of crew, especially taking into account the cockpit crew.

Automatic operation generates several signs that pilots have to deal with in a suitable way. These signs are not always correct; there can be wrong warnings and signs that are difficult to handle. If pilots neglect a sign of the system, or eliminate an instrument because of continuous wrong operation, they have to be ready for the immediate intervention. Warnings are not harmonized, there are several audiovisual methods they use, and the attention of the crew is not always raised as requested. In practice, there exists no standardized solution, whether the system should do the intervention upon a warning, or should only show it to the pilot.

Taking into account every task mentioned above, trainings should contain both the use of automatics and manual flying, what includes simulator and real practice, too. It is clear that automation alone does not assure to bring the optimal decision. It requires higher knowledge of computers, different systems, and the

information must always be modified on the variable display according to the data the pilot requires. Finally, these newest systems are expensive, and are not always available for training objectives.

An optimal board system should satisfy following crew requests:

- reduce the probability of situations, which can go into an accident,
- ergonomic, healthy working conditions,
- economic operation, decreasing flying time.

2. Complexity of Decision Making

Since the correct decision of the pilot influences strong the safety of flying and the most important task during the training is the practice of the correct behaviour, I shortly show the psychology of the decision-making procedure of people. The importance of the correct decision-making grows by the competition of the airlines and the great number of low cost flights, and it is obligate not only because of safety, economic operation and comfortable travel, but influences the position on the market, too.

Several factors constrain the optimal decision. The most important is that the written and actual flying parameters are not the same. This means that the pilot does not see or hear what he should see based on the documents, board manual or theory. The next factor is the psychological pressure on the pilot what causes stress, and generates subjective behaviour and wrong discursive faculty. The higher the probability of damage or deficit, the higher the stress is. An example here is the choice of the route in bad weather conditions, where the pilot subjectively weights the following parameters:

- reliability of the forecasted weather parameters,
- flying behaviour and knowledge of the airplane and pilot,
- importance of the flight.

Depending on these factors, the pilot decides if an alternative route is necessary. Negative influencing factors are venture, hazardous activity and ability of demonstration of the pilot.

Decision procedures of pilots can be categorized as follows:

- Methods: performing routine procedures (navigation, fuel checking, communication etc.).
- Perception, controlling: exercises based on different information that are not routine procedures (guess distance, control the airplane based on geographical coordinates, choose the optimal speed etc.).
- Subjective decisions based on own experience and knowledge (e.g. guess the importance of warnings and failures).

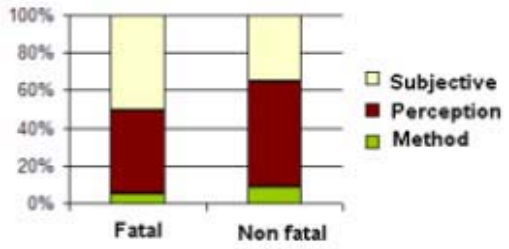

Fig. 1. Reasons for accidents because of wrong decisions (USA, 1980–1990).

Let us see the total number of accidents because of wrong decisions as 100%. Based on the categorization above, I show the rates in *Fig.1*.

Performing the routine procedures is a very important topic in the training process, but there exists no general system for teaching the subjective decisions.

I show the phases of the decision procedure in *Fig.2*. It is clear that decision is a very complex process, which is not easy to carry out, especially if people have to act under irregular circumstances.

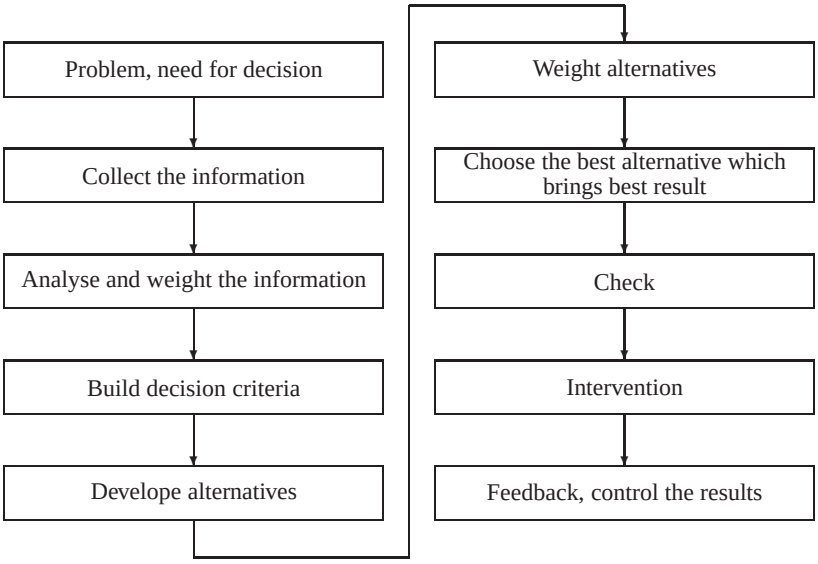

Fig. 2. Procedure of decision

Feedback is a very important element of the training, because a procedure, the behaviour will be automatic, it will be a routine, if it will have been practised several times and the effects are clear.

3. Training System of the Airlines

Keeping the quality requirements of flying – safety, efficiency and effects on passengers – makes necessary that crew members are objective and all-round controlled periodically.

By ensuring the requested number, the first step is the procurement of staff. This happens mostly by applications. After having checked that the person meets the base requirements, a course takes place organized by the airline. The objective of this course is to get the pilot licence. The general theoretic lessons are followed by an airplane type specified course, where the technical, operational and constructional data of the airplane must be learnt. Final course is the practice: flying on simulator, then in practice on selected routes. The final exam is organized by the airline, but controlled by the authority.

Pilot licences can be the following: licence for a type of airplane, co-pilot, captain, master pilot, test pilot, and licence for an airport or route. Licences must be extended yearly, what is done by the authority. These validation exams have three parts: theory, flying technique and health.

Procedure of re-training at Malév Hungarian Airlines is following. The first licence for an airplane type is always valid for the type that has the least requirements. The candidates are ranked according to the date of the first successful co-pilot exam, and then they can begin the re-training course for the captain licence. The Seniority Commission coordinates the procedure. The candidates can choose either they want to be a captain on a lower level airplane type, or co-pilot on a higher level type. This possibility is given only if it does not build a constraint for the performance of the schedule. Nomination happens if the frame of application *Fig. 3* contains the schedule of trainings. Every person has his own weather minimum (e.g. visibility), under which conditions he is able (allowed) to fly. Besides weather, pilots have an allowed airport category, where they are allowed to land at a given visibility condition.

Trainings should be harmonized and standardized on international level, because of the high safety requirements. It is a generally accepted idea that training should emphasize the following five areas:

- Communication: continuous transmission of information, use of suitable expressions, correct rank of the units which must be informed first etc.
- Harmonization of the crew: flying is teamwork; an individual must help to achieve the total success instead of his own success. Everybody must accept criticism, and must make clear the responsibilities.
- Planning: developing strategies for the flight and schedule. Everybody must plan in advance, and must modify these plans always, according to the actual situation.
- Managing the work performance: developing the measures to realize the strategy. Assignment of exercises among crewmembers, according also to the actual preferences.
- Stand-by: paying attention even if there is nothing to do.

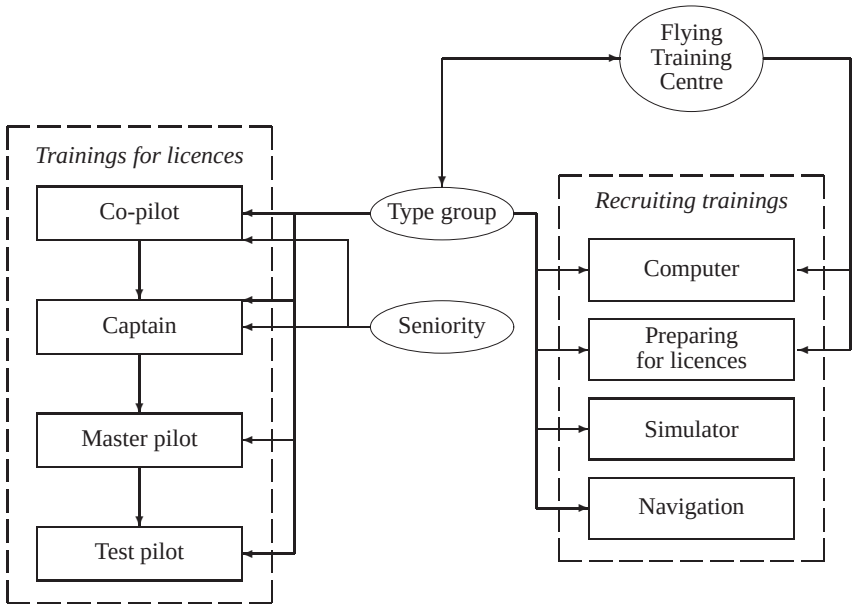

Fig. 3. Schedule of trainings

4. Re-planning of the Crew in Case of Disturbances

4.1. Sources of Disturbances, and the Need for Intervention

The schedule rarely is performed as planned. Changes in it – caused by weather, technical failures etc. – cause delays, cancellations. Changes can happen because of personnel problems (illness), too. Change in the type of aircraft influences also the management of the crew. One result is that the crew is not at the requested place to perform the flight, or is not suitable for the changed airplane type. Similar to the passengers, pilots can also miss the connecting flight, or in the case of cancellation, they cannot begin the flight starting from the destination airport of the previous flight. Delays cause high costs! Nearly every airline has daily the problem of reassigning crew for the changed flights.

Fast reassignment is needed in these cases in order to cover open flights, and to move crew to the required place. If original staff cannot be reassigned, we must involve the standby persons, but this is often limited.

Fundamentally, we have to find a solution, where the origin assignment is re-established as fast as possible, and standby crew is involved for the open flights.

If this process is made carefully and optimally, we can spare a lot of costs, what comes from the following:

- reduction of departure delays,
- less cancellation,
- reduction of the number of deadheading flights,
- less rerouting,
- spare of fuel,
- spare of hotel costs and daily salaries,
- spare of the need for passenger accommodation.

4.2. Process of Re-Planning, and Influencing Factors

The constraint of the process is to minimize costs and keep the safety requirements, reduce effects on passengers and disturbances in the operation of the company. Extra cost can be calculated as follows:

$$\Delta c_p = \max\{c_{p'} - c_{p0}; 0\}$$

where: Δc_p: extra cost of pair p,
$c_{p'}$: cost after re-planning,
c_{p0}: originally planned cost.

In order to motivate the original assignment, we can involve a weight factor marked 'ε', and its value depends on the subjective opinion of the decision maker. The above equation will be modified in the following way:

$$\Delta c_p = \max\{(1 + \varepsilon)c_{p'} - c_{p0}; 0\}$$

where let 'ε' be $0\% < \varepsilon < 1\%$.

By re-planning, we have to separate the two main constraints: minimal and maximal allowed flying time (daily and monthly, including the rest time), and the fact that crew must begin and end its duty at the crew base airport, considering the total period.

According to flying time, airlines often use the following method: they apply less duty and more rest time, so if delays occur, no standby crew is needed – the original crew has time to start the next flight. If a reorganizing is needed where more flights are affected, these reserves can be used.

Modifying the original determined assignment is not a good solution, because we assume that the crew not affected is assigned optimal. So our task is first of all to cover missed flights. We have to do the re-planning process real-time, based on the total schedule of the airline. Since the schedule is often complicated and contains many flights, and time available for the decision is limited, it can be useful to limit and simplify the problem.

Nowadays there are many hub & spoke airports, where several crew changes and generating of new pairs is possible. Depending on the re-planning algorithm, high cost and several delays can be spared. In some cases, the available crew are not able to perform every flight, because they do not have the needed information about the irregularities. In reality, we need to have the object to cover all flights! We have to create a strategy, where most important and immediate flights are covered, even if therefore less important flights are delayed or cancelled. This results time enough for coordination, for re-planning of the schedule. In most cases, these processes are done manually, without any decision supporting system; this makes the real-time optimal solution impossible.

The procedure of re-planning is similar to the initial assignment: first we have to generate all possible solutions, and then to choose the optimal one. If we have determined all constraints and chosen the feasible solutions, the number of all combinations is many thousands even in case of a smaller schedule. Sub-solutions are needed in order to ensure the continuum of the operation, and to use the limited resources optimally. Simplifying of the model is possible due to limitation of time available for optimization, and of pairing affected by the procedure. The fewer crewmembers are involved, the lower quality solution we will find. The optimal solution would be found if nearly every flight were influenced, but this is limited by the time and feasibility. Therefore, we have to find an intermediate solution. The number of influenced crewmembers can be increased depending on the time available.

In the solution process we have to analyse and weight several factors; the most important ones are the following:

- passenger accommodation,
- effects on crew,
- airplane maintenance,
- new slot time request.

All effects and parameters must be clear, and the actual situation decides whether cancellation or re-planning is the best solution.

Another important question concerning the re-planning is *deadheading*, when a crewmember flies on a plane as a passenger. They occupy high valued seats on the airplane, and get salary, too; so this is an expensive solution. It is unavoidable in some cases, because there is no other way to transfer crew between airports, e.g. in case of cancelled flights. There exist four types of deadheading:

- Multiple assignments: two or more pairs are assigned to a flight, and the crew operator decides who performances it.
- Flying outside the duty time: after duty time, crew has to be transferred to the base airport.
- Catching up the original assignment that has been modified. This is the shortest way to eliminate disturbances; usually cancellations are needed.

- Replacement to another airport to be able to begin the duty, which has been missed by the delayed crew. The originally assigned crew delays, and approach time cannot be foreseen. Here a crew, which should depart from another airport later, is transferred to the critical airport, and the other crew will be guided to the flights that became uncovered. In practice, this means the change of the two crews. Expenditure is here only that – if the flight is full occupied – some passengers must be taken down, and transferred by another flight.

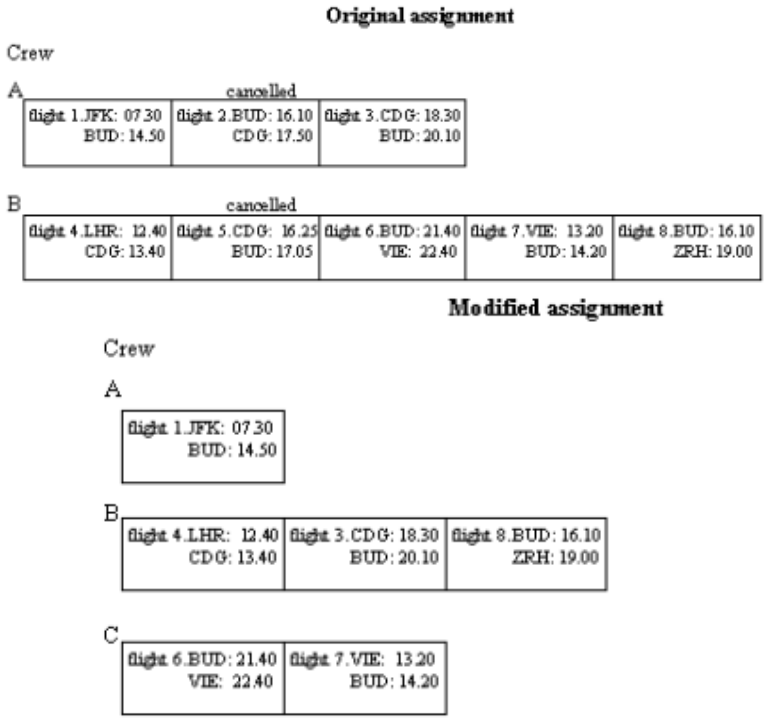

Fig. 4. Example for a re-scheduling

Transfer outside duty time is sometimes made on flights of other airlines because of the limited time available. The overall object is to minimize the cost and time (that can be expressed in money, too) generated by these activities. This extra cost includes the following:

- crew cost of performed flights,
- deficit because of cancellations,
- transfer cost of free crew to the base airport,
- deadheading cost of the crew needed for the modified flights.

4.3. Example for Modifying the Schedule

In *Fig. 4* a simple schedule with eight flights is shown, which are performed by the crews (A, B). Flight 2 and 5 are cancelled, so we need another solution, where I apply a third crew, marked 'C'.

I have assigned the crew 'C' for the flight between Vienna and Budapest. Crew 'A' is at Budapest, they could fly this flight too, but here we would be limited by duty time. Ground constraint for modification is the base of crew (they have to start from, where they have arrived) and the daily duty time limit. From the schedule it is clear that crew 'B' would have been accommodated in Vienna; it is placed here to Zurich; the night in Vienna gets the new crew 'C'. It can be seen that we tried to eliminate the disturbance as fast as possible, because the original crew 'B' performs flight 8.

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