Decision-Making Tools for Aeronautical Teams: FOR-DEC and Beyond

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Abstract: Many case studies show that unstructured decision-making processes in teams are contributing factors to accidents. In situations without any preconfigured solutions, airlines have developed decision models. In our article, we give an overview and comparative analysis of different models. We discuss FOR-DEC, developed by Lufthansa and the German Aerospace Center. Findings from an explorative study on pilots' experiences with FOR-DEC and from a workshop with pilots and experts from non-aviation high-risk domains are reported. The model is useful for structured decision-making in complex situations when there is enough time. Moreover, some extensions to FOR-DEC could be beneficial, for example, the integration of expert knowledge into the decision process and the explicit integration of the team in the decision-making process. Results give advice for the useful implementation, application, and training of decision-making tools using the example of FOR-DEC.

Keywords: decision-making, problem-solving, FOR-DEC, team, emergency, comparison of tools

Flight Hapag Lloyd 3378 from Crete to Hannover on July 12, 2000: After take-off the landing gear was impossible to retract. The pilots continued the flight with extended landing gear. Turning back to Crete was not addressed. The fuel consumption rate was drastically raised; therefore, Vienna was planned as an alternate. The copilot's calculations showed less fuel than originally reckoned. Nevertheless, the crew stuck to Vienna as alternate instead of landing at one of the enroute airports. Only as the engines stopped because of the lack of fuel did the crew declare an emergency. The highly experienced captain landed the gliding aircraft 600 m before the runway. Although the aircraft was severely damaged, only a few people suffered minor injuries. The accident report of the Austrian ministry of traffic mentions "a lack of developing alternative strategies to overcome the fuel problem" (Österr. Bundesanstalt f. Verkehr, 2006) as one of the reasons for the accident.

This case study and the psychological research about decision-making processes show that humans tend to decide on an ad hoc basis; they are led by their preassumptions and preferences. Moreover, they cling to their aims for too long and follow heuristics rather than starting to analyze the situation (Dörner, 1996; Jungermann, Pfister, & Fischer, 2005; Kahneman, 2012; Kahneman, Slovic, & Tversky, 1982; Klein, 1989; Reason, 1990; Tversky & Kahneman, 1974). These findings have been shown in many laboratory studies. A fortiori this applies in situations where perceived stress is increased. Stress leads to additional mistakes and worse decisions (overview in O'Hare, 2003). Whenever decision-making processes go badly, they are mostly unstructured, not thoroughly adjusted in the team. They simply "happen" rather than being conscientiously developed.

Hence, there is a need for a "manual for good decisions". Such a manual was formalized first in aviation because pilots are frequently bound to act under time pressure and in hazardous situations.

Basically there are two ways to minimize wrong decisions in the cockpit: Most of the possible inflight situations can be predicted and the appropriate response can be written down as procedures in manuals. Knowledge about these procedures is trained and checked. Thus, the likelihood of wrong decisions is reduced and the headline is: "Follow the rules!"

On the other hand, there are situations where no procedures are available. This is where problem-solving and decision-making step in (e.g., Dörner, 1976; Klein, Orasanu, Calderwood, & Zsambok, 1993). Thus, pilots frequently

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have to make decisions. Orasanu (1993) defines three elements that are inherent in decisions in the cockpit:

- Choice among options;
- Situation assessment; and
- Risk assessment.

These three elements are consistently included in all procedure models that support pilots in their decision-making. The available time seems to play an important role in situational judgment when pilots experience an unexpected situation (e.g., O'Hare, 1992, 2003). In time-critical situations the decision process has to be compact and efficient. Hence, in these situations few or no thinking processes can be carried out.

How can pilots' decision-making be improved? The literature on aeronautical decision-making was normative until the 1970s. It was all about the key question: "How should a good pilot behave?" Later, the perspective became more descriptive. The question then changed to: "What do pilots really do?" (e.g., Wickens & Flach, 1988). For the pilots themselves, the academic literature is not useful in aeronautical daily routine. There is a gap between decision-making theory and pilots' experience. Because of this, the development of procedure models began in the 1970s. These models should support pilots in decision-making using the knowledge of human decision-making and requests. Some of these models are presented here. Yet, none of the models has been evaluated considering their usefulness in real-world aeronautical decision-making.

In the following sections we provide a brief outline of decision-making procedures in aviation. Subsequently, FOR-DEC, the best-known model in Germany, is discussed. FOR-DEC was chosen because in Germany and several other European countries it is widely used in aviation and is also being transferred to other high-risk domains (see next section). Its development and current applications are presented here. An explorative study about pilots' experience with FOR-DEC is reported: When do pilots use FOR-DEC? For what is it useful? For what is it not useful? What kind of criticism has been leveled? These results will be compared with results of a workshop composed of experts held in 2011. In concluding, suggestions are made for the further development of the FOR-DEC model to enhance the decision-making process in teams.

Decision-Making Models in Aviation

Here we describe decision-making processes in aviation that are available in the literature and in some unpublished models we found. O'Hare (2003) has summarized the published decision-making models with their acronyms and their stages (see Table 1).

Except for FOR-DEC, these models have had limited application, as shown in the literature and by requests in airlines. FOR-DEC is the only one that became widely accepted, at least in Europe.

In addition to the models O'Hare presented, the authors identified several decision-making tools (see Table 2) by asking colleagues, pilots, and airline representatives about models they use.

Comparison of the Tools

Despite their heterogeneity, the presented models all include some key steps that are further classified according to the phases of problem solving (overview in Betsch, Funke, & Plessner, 2011; Dörner, 1996). Table 3 shows which steps are used in the different models.

The structure using problem-solving phases depicts our considerations. Unfortunately, not only do the authors of the models usually describe their models very tersely but also they do not compare them with other models.

Every model includes an analysis of the situation. Most of the models contain a decision-making process with options to act and/or make an evaluation of risk. This finding corresponds to the parts of the decision-making process described by Orasanu (1993). Interestingly, most of the models do not contain the real decision-making step nor the action afterward, but most of them include a control step.

Nevertheless, despite the similarities and differences in the models, no one has ever evaluated which model is the best. Li and Harris (2005) asked 60 Chinese military instructor pilots to evaluate five decision models in terms of suitability for situation assessment, risk management, response time, and applicability using paper-based scenario descriptions. Results varied among different conditions. The pilots preferred SHOR for time-pressure situations; DESIDE and FOR-DEC were regarded to be best for knowledge-based decision-making for well-defined problems.

FOR-DEC

Development of FOR-DEC

In autumn 1992 Lufthansa established a Crew Resource Management (CRM) workgroup. The goal of this workgroup was to make CRM knowledge visible and teachable. To reach this aim the workgroup was set up with experts both from Lufthansa (department of flight and simulator training in Frankfurt) and from the German Aerospace

Table 1. Published decision-making tools (O'Hare, 2003)

Acronym	Steps	Author(s)
DECIDE	Detect, Estimate, Choose, Identify, Do, Evaluate	Benner, 1975
DESIDE	Detect, Estimate, Set safety objectives, Identify, Do, Evaluate	Murray, 1997
FOR-DEC	Facts, Options, Risks & Benefits, Decision, Execution, Check	Hörmann, 1995
PASS	Problem identification, Acquire information, Survey strategy, Select strategy	Maher, 1989
SOAR	Situation, Options, Act, Repeat	Oldaker, 1995
SHOR	Stimuli, Hypotheses, Options, Response	Wohl, 1981
QPIDR	Questioning, Promoting, Ideas, Decide, Review	Prince & Salas, 1993

Table 2. Other aeronautical decision-making tools

Acronym	Steps	Airline
DODAR	Diagnosis, Options, Decision, Assign Tasks, Review and risk assessment	British Airways, CityJet
SPORDEC	Situation Catch, Preliminary Action, Options, Rating, Decision, Execution, Controlling	Swiss
SOCS	Situation, Options, Consequences, Select	

Center (Department of Aviation and Space Psychology, Hamburg; DLR). The topic of "judgment behavior and decision-making" was handled by Hans-Jürgen Hörmann from DLR. He presented the following flow model representing a basis for most of the decision-making models (Hörmann, 1994, p. 80):

1. Situation analysis;
2. Generating optional responses;
3. Assessing risks and benefits – comparing options;
4. Selecting the most appropriate option (and also a back-up option);
5. Planning and execution of the selected option; and
6. Monitoring actions and outcome – review of the procedure.

Having these steps in mind, a mnemonic aid displaying plausibly the judgment and decision-making processes in the cockpit had to be found. The workgroup eventually agreed on the easy-to-remember "FOR-DEC": Facts, Options, Risks and Benefits, Decision, Execution, Check. An essential part of this invented word is represented by the hyphen between the *R* and the *D*. It was inserted to make the pilot stop and reflect on whether anything essential was missing and whether all available information had been taken into consideration. In order to focus the crew's concentration on these six phases of the decision-making process, every phase of the FOR-DEC model was linked to a question:

- Facts: "What's the matter?"
- Options: "What kind of possibilities do we have?"
- Risks and Benefits: "What pleads for what?"
- Decision: "What are we going to do?"
- Execution: "Who does what, when, and how?"
- Check: "Is everything still ok?" (Hörmann, 1994).

Distribution of FOR-DEC

Since its introduction, the FOR-DEC model has become not only established as an important decision-making tool in the cockpit, but also a synonym for effective cooperation in teams in many other domains. Although scientific publications are scarce (e.g., Hörmann, 1994), the use of FOR-DEC has spread quickly.

To our knowledge, FOR-DEC is used by numerous airlines, for example, Air Nostrum, Austrian Airlines, Air Europa, Lufthansa, Germanwings, and Finncomm (now Flybe Nordic). Air France, Iberia, and Finnair are about to introduce it.

The FOR-DEC model has gained currency in aviation as well as in organizations and institutions that try to learn about safety by inviting pilots to lectures and seminars. It is increasingly being taught and published in the medical context via CRM courses (St. Pierre, Hofinger, Buerschaper, & Simon, 2011).

Moreover, it has been applied and trained by military staff and crisis teams. In German nuclear power plants, FOR-DEC is mandatory in exceptional occurrences.

Explorative Study 1: Experience with FOR-DEC and Suggestions for Improvement

The starting point of this study was provided by statements from experienced pilots during simulator sessions that FOR-DEC had not been applied as planned. For example, sometimes FOR-DEC is used only because it is compulsory ("You ask for the weather between Lisbon and Riga when

Table 3. Comparison of decision-making tools

Phase	Model									
	DECIDE	DESIDE	FOR-DEC	PASS	SOAR	SHOR	QPIDR	DODAR	SPORDEC	SOCS
Problem/Change	Detect	Detect		Problem identifi-cation		Stimuli				
						Hypotheses				
Problem analysis	Estimate	Estimate	Facts	Acquire information			Questioning	Diagnose		
		Set safety objectives								
Situation analysis	Choose	Identify		Survey strategy	Situation		Promoting		Situation catch	Situation
Immediate measures									Preliminary Action	
Options	Identify		Options		Options	Options	Ideas	Options	Options	Options
Risk assessment			Risks and benefits					Rating	Rating	Consequences
Decision			Decision	Select strategy			Decide	Decision Assign tasks	Decision	Select by deciding
Execution	Do	Do	Execution		Act	Response			Execution	
Control	Evaluate	Evaluate	Check					Review	Controlling	
Re-evaluation					Repeat		Review			

landing in Cologne"). They stated that, "pilots use this tool rather as a justification of a decision," and that "the *C* (check) is often omitted due to an urge of immediate action" [captain, instructor A320]. On the other hand FOR-DEC is seen as positive, because it forces the crew to name the facts ("Without FOR-DEC we'd be stuck"). It also gives copilots the option to make their voices heard ("Let's do FOR-DEC!").

These and other statements led to the idea of asking pilots about their experiences with FOR-DEC more systematically. We especially wanted to know in which situations FOR-DEC is applied and what pilots like and dislike about it.

Method

An explorative, qualitative study using a simple questionnaire was conducted. Because we wanted pilots to answer the questionnaire in their free time, the questionnaire had to be short. As it was to be distributed by e-mail, it had to be simple and self-explanatory. On the other hand, we wanted to know as much as possible about pilots' experience, so we chose open questions. A German and an English version were developed.

In the questionnaire, the following four questions were posed:

1. Did you experience situations in which you used FOR-DEC for an appropriate and successful decision-making process? If yes: please describe one or more situations.
2. Did you ever experience situations in which FOR-DEC was applied *although* you thought that it wouldn't make sense? If yes: please describe one or more situations.
3. (a) What do you like about FOR-DEC, (b) what do you miss?
4. Which other decision-making models do you know? How do you evaluate these?

The questionnaire was sent via e-mail to approximately 20 experienced pilots the authors knew, asking for further distribution among German-speaking pilots. The total number of recipients (and, consequently, the answer rate) is therefore unknown. Recipients were given the authors' e-mail address. Some answers came back anonymously (using nicknames). General anonymization was achieved by separating answers from e-mail headers.

The questionnaire was broadly distributed in order to reach pilots with a wide range of experience.

Sample

In all, 14 German-speaking male pilots, 12 from a German airline and two from a Swiss airline, answered the four questions in written form (two of them gave opinions of several colleagues). Of them, 12 were captains, one senior first officer, and one first officer. Their experience ranged from 6,000 to over 20,000 flight hours. Before answering the questions, all of them stated that they knew FOR-DEC as a decision-making tool. The sample is described in Table 4.

Data Analysis

Answers to the four questions were gathered from all participants. Owing to the small sample and missing information about most participants, no formal system of categories was built. Data analysis followed a qualitative approach (e.g., Dey 1993; Flick, 2014): Content categories were built in inductively from the material. Where appropriate, a simple *yes/no* categorization was used (Question 1). Answers were then grouped to these categories by two of the authors separately. Differences were discussed until consensus was reached (Steinke, 2000). As it was of interest to describe the range of experience found in the sample, it was decided to present all answers to the four questions in the sample without statistics, only grouped into the content categories. All statements are the opinions of the pilots based on their personal experience. In the following section, the qualitative results of the survey are described.

Results

Results of Question 1 (Appropriate and Successful Use of FOR-DEC)

All participants stated that they had used FOR-DEC for an appropriate and successful decision-making process. To provide insight into the answers of the second part of the questions, here are some typical examples:

> "On a German domestic flight the (landing) gear couldn't be retracted. As there was no time pressure some options were created via FOR-DEC. The first thought, flying back to the departure airport, was rejected. Instead we continued the flight safely to the destination with enough fuel reserve."

The positive results of this decision were that all passengers could be transported to their destination and that no further time delays resulted.

Another pilot's example shows the precarious situation of a medical emergency after take-off. Again, different options were possible and FOR-DEC could help to find them and to sort out an informed decision.

Altogether FOR-DEC is described as a useful tool, if:

- There is enough time (eight mentions), and
- The situation is complex and/or there is a need for structure (11 mentions).

Results of Question 2 (Use of FOR-DEC Although It Did Not Make Sense to the Pilot)

The results of Question 1 showed that eight participants saw FOR-DEC as rather counterproductive when little time is available and/or the (only) solution is clearly evident. One pilot gave the example of a fire on board that led to an immediate landing at the nearest possible airport. In this case, mindlessly using the FOR-DEC model would only result in an aggravation of the actual situation, according to the pilot. Another pilot describes the following comprehensible example:

> "Due to a severe technical problem the destination will not be reached. Even a continuation of the flight is risky. An alternate is in close proximity, suitable for a safe landing. Using the FOR-DEC model would only be an obstacle to quick and safe action."

Despite such experience, one participant added to this question: "I have experienced more situations in which I should have used FOR-DEC than vice versa."

During simulator checks (regular review of the pilots in the flight simulator) FOR-DEC is sometimes reported to be used inappropriately. Pilots obviously assume that the application of FOR-DEC should be presented in an exam situation. This leads to an artificial atmosphere and possibly to a FOR-DEC sullenness resulting in ignoring FOR-DEC in critical situations in real flight operations.

Results of Question 3a (What Do You Like About FOR-DEC?)

Participants referred to the clear structure of the model (N = 11), its reputation as an established instrument, and its high popularity (N = 3), for example: "Everybody in the company knows FOR-DEC, so that all can use the same language." The clear structure prevents jumping to conclusions and helps especially in complex situations, where different options with pros and cons must be weighed against each other.

Some participants reported that working with FOR-DEC means establishing a critical distance to oneself (which is needed for reflection). Also, it can eventually lead to withdrawing a decision without losing the leadership authority. Thus, FOR-DEC can be understood as a "protection" and functions with a small authority gradient, but still requires leadership.

Two benefits were also mentioned: Solutions are jointly developed and all important issues are present in the

Table 4. Description of the sample (Study 1)

Subject ID	Gu1	Gu2	He1	He2	He3	So1	So2	So3	So4	So5	So6	So7	So8	So9
Age	42		54	45	56									
Sex	m	m	m	m	m	m	m	m	m	m	m	m	m	m
Status	SF/O	FO	Cpt	Cpt	Cpt	Cpt	Cpt	Cpt	Cpt	Cpt	Cpt	Cpt	Cpt	Cpt
Flight experience (hrs)	10,000	6,000	14,000	14,000	16,000	13,000	10,000			18,000		20,000		
Airline (country)	CH	CH	GER	GER	GER	GER	GER	GER	GER	GER	GER	GER	GER	GER

Note. SF/O = senior first officer; FO = first officer; Cpt = Captain; CH = Switzerland; GER = Germany; m = male.

model. Furthermore, FOR-DEC forces you to revise decisions that have been made at the outset.

Results of Question 3b (What do you miss in FOR-DEC?)

As mentioned, the main criticism is that FOR-DEC is time consuming. Almost all (N = 10) participants missed having a shorter FOR-DEC when facing time-critical situations. It was repeatedly mentioned that sticking too strictly to the model (when the solution is clearly visible; see also Question 2) can result in an adverse effect. According to the authors, this issue seems to be more of a training problem rather than primarily a FOR-DEC problem.

One participant suggested a decision loop where the *C* (Check) is not a unique event but, at best, an iterative decision-making process to consider changes in the situation. As this is part of the FOR-DEC instruction, this again does not seem to be a FOR-DEC problem but more likely a training issue.

Some suggestions were focused on the acronyms of the model. One pilot recommended enhancing the balance of the *O* (Option). Another said that the *R* (Risks/Benefits) should include economic efficiency.

Results of Question 4 (Knowledge and Evaluation of Other Decision-Making Models)

Except for the two tools PPAA (Power, Performance, Analysis, Action) and NITS (Nature of Problem, Intention, Time, Specials), which were both mentioned once, no other model was mentioned. As PPAA has a technical focus and NITS is rather an aid for communication, we have not included them in Table 3.

Summary of Results

The results of the survey with experienced pilots show not only the advantages and the familiarity of the FOR-DEC model but also potential for improvement and problems in training. According to this, FOR-DEC can be used calmly and meaningfully whenever there is enough time in complex decision-making situations. In this case, it can help to detect nonobvious options and risks. Thus, it is used when enough time is on hand. But whenever the solution of a problem is obvious, action is prescribed by procedures, or the decision has already been made without using a formal process, using FOR-DEC might be a waste of time. Moreover, being forced to use the FOR-DEC model can lead to reluctance and the model probably being disregarded in critical situations. Therefore the circumstances in which pilots should use FOR-DEC have to be further discussed. Moreover, appropriate training methods should be reflected accordingly.

Explorative Study 2: Expert Workshop

The topics of Study 1 were presented to an interdisciplinary group at a conference workshop on decision-making in Berlin in June 2011. The aim was to see whether and how experts from other domains make use of decision-making models.

Method

First, without presentation of any model or literature, small groups had to work on a non-aeronautical decision-making task. The authors observed the participants' discussions and strategies. After this scenario, FOR-DEC was presented and discussed. The following questions were debated in small groups of four to six participants, each with participants from aviation and other domains:

- What do you like about FOR-DEC?
- what do you miss?
- New ideas "beyond FOR-DEC?"

Questions 1 and 2 were taken from the questionnaire reported in Study 1. Question 3 aimed at general requirements for decision-making tools.

Sample

The workshop had 20 participants, all of whom participated actively in discussions. For discussions of Questions 1–3, they were grouped into four small groups of four to six participants.

Participants came from aviation (N = 4), medicine, engineering, psychology, and other domains. All of them work in safety-related fields. All of them either teach decision-making or are themselves in the role of making critical decisions under time pressure, for example, as surgeons. Owing to the workshop setting, no additional data on subjects' background or experience could be gathered.

Data Analysis

The authors observed the participants' discussions and strategies during the scenario task and small group discussions. The results of the discussions in small groups were visualized in the form of statements on flip charts. There was consensus about these statements in the respective groups. The results of all groups were then discussed with all participants. As Study 2 was meant to give additional insight into the strengths and weaknesses of the results from Study 1, we report all statements given by the small groups, noting if a statement was made by several groups. No further analysis of these data was undertaken.

Results

In the decision-making task, participants from military, police, or fire brigades tended to use FOR-DEC or other models that they are used to. When asked by the observers, they reported that formalized decision-making was familiar to them and they judged it as helpful.

Results of Question 1 (What Do You Like About FOR-DEC?)

All four groups highlighted the "structured," "guided," and "standardized" course of action made possible by FOR-DEC. The structure of the model was seen as "simple" and "catchy." The process was perceived as a "logical cycle" or "closing the loop." In addition, the assessment of alternatives and the "break," symbolized by the hyphen, were mentioned. Finally the role of the team was highlighted: The model "integrates the team." Also, one group stated that FOR-DEC clarifies (using the hyphen) when the team works together and when the captain (or the team leader) decides.

Results of Question 2 (What Do You Miss in FOR-DEC?)

Regarding negative aspects, two critical points were prioritized: "the time taken" or "time factor" (two of four groups) and the lack of integration of experience, emotion, and intuition (three of four groups). The first part of the model was criticized in two groups: "a lack of a goal definition" and "lack of an instruction to generate 'facts'".

Results of Question 3 (New Ideas Beyond FOR-DEC?)

A variety of issues were proposed. New ideas concerning the framework conditions and the *implementation* and *application* of the model were discussed, for example, "define usage conditions" and "what comes 'before' FOR-DEC?" and evaluation of the model. Suggestions concerning *content* and *process* were made: "Don't ignore the expert's 'gut feeling'", "consider the team process," "use mental simulation (in the 'break')," "visualize the model."

Although the participants came from various professional fields, agreement was strong in terms of application, framework conditions, and prerequisites of FOR-DEC. Also, the results are comparable to those of the questionnaire survey.

New Developments: PRO FOR!DEC and FOR*e*DEC

The results of the explorative questionnaire study, the workshop with experts, and various comments and suggestions from pilots and aviation specialists showed that FOR-DEC is a very useful tool for structured decision-making – as long as it is used correctly. *Correct* means: in situations where no clear procedures exist, when time pressure is not critical, and when wrong decisions have severe or even fatal consequences.

FOR-DEC is sometimes used in situations where a decision is predetermined by procedures, or the team already knows exactly what they want to do. Thus, not surprisingly, teams consider it as senseless and skip the model in their professional routine. Considering this, clarifying the decision criteria and priorities beforehand seems to be most important. Moreover, the conditions of application should be defined more thoroughly: critical situations, where there are no clear procedures, but enough time to reflect.

Structuring the decision-making process in critical situations when there is no procedure available is the essential benefit of *all* decision-making aids. Working through the phases of the models can prevent ad hoc decisions. Thereby, aspects that have been unnoticed before can flow into the process.

Both models presented – PRO FOR!DEC and FOR*e*DEC – follow the principles of easy memorable and expressible acronyms like FOR-DEC among others.

First, PRO FOR!DEC emphasizes the importance of clarifying the situation before starting the decision-making process itself.

The *P* in PRO stands for *Problem and Procedures*:

- Problem verbalization/problem sharing.
- Evaluation of the situation: urgency?
- Procedures available?

When the initial situation is verbalized and a common understanding of the problem is achieved in the team, possible applicable procedures to successfully solve the problem can be applied immediately. Therefore, the crew avoids applying a FOR-DEC process that would not be necessary in this case. However, even if there is a procedure being applied, FOR-DEC can still be integrated during the process at a later stage.

The *R* stands for *Roles*:

- Who does what?
- Distribution of workload.

In order to ensure effective crew coordination, task distribution roles in the team must be clearly defined.

The *O* stands for *Operations*:

- First fly the aircraft.
- "Aviate, Navigate, Communicate."

The well-known and accepted maxim "Aviate, Navigate, Communicate" is an essential prerequisite before starting any decision-making process. The main purpose here is to ensure the safety of the flight. Once the situation is under control and when there are no procedures available (not time-critical, complex situation), then a decision-making process can be initialized.

Current FOR-DEC practice shows that the hyphen has disappeared. To reinvent the FOR-DEC as it was meant originally, the authors replaced the hyphen in the middle of the acronym by an exclamation mark. To distinguish the cognitive process *FOR* from the application process *DEC* is of utmost importance. The significance of the hyphen in the decision-making process has already been described in detail by Hörmann (1994, 1995).

Once the preliminary phase *PRO* has been successfully executed, the common FOR!DEC tool may be applied.

Whereas the PRO FOR!DEC tool aims not only at being used in aviation environments but also at being applicable in other high-risk domains, the second method presented – FOR*e*DEC – was created in the context of flight operations at Luxair Luxembourg Airlines. With the support of experts at Luxair, the goal was to design a tool that would fit into the current procedural framework of the company. The prefix *PRO* was not considered by Luxair since in the section "abnormal and emergency procedures" the crew coordination and task distribution provides clear guidance on how to start a process and how to proceed in the case of unforeseen circumstances.

In general, the FOR*e*DEC tool follows the same principles as the original FOR-DEC method.

What has to be noted is the linking and embedding of the tool into the flight operational context in the company. The aforementioned procedural framework describes two parallel processes that are displayed next to each other: a procedural process and an adaptive process. When facing a situation for which procedures exist, these procedures must be applied. Thereafter FOR*e*DEC can help to decide on further proceedings. In this way FOR*e*DEC will supplement procedures. Should there be no procedures available from the beginning, the FOR*e*DEC process can be initiated right from the start. Furthermore, it is vital to recognize whether a given situation is suddenly changing. Taking into account the natural dynamic environment, the crew should always reflect on the possibility to move from a procedural process to FOR*e*DEC and vice versa.

Figure 1 presents an outline of the processes.

To illustrate the aforementioned processes, an example from the introductory classroom training for pilots is given:

> "You are cruising at your cruising altitude when suddenly the cabin altitude starts fluctuating.
>
> Procedures do exist for this situation. Therefore we will enter the decision-making process in the procedural process, i.e., the captain will assign tasks. In our case, let's imagine the captain is PF and maintains this configuration. He will say "My controls, my radios. Your checklist." The first officer will apply the corresponding QRH [quick reference handbook] procedure. Let's imagine the procedure is accomplished; the system is now operating in manual mode.
>
> Shortly after, the cabin pressurization is lost and the cabin is slowly depressurizing.
>
> There are procedures for this situation. They can be found in the QRH and in our OPS Manuals A and B. In this case, apply these procedures.
>
> Finally the airplane will descend to, let's say, 10,000 ft. Now the situation changes. The technical aspect is covered but navigation becomes an issue. In this case the crew can use FOR*e*DEC to decide on further proceedings, continue to destination, or divert to a suitable airport."

Besides the linking and embedding of the FOR*e*DEC into the company's framework, additional adaptations were suggested. First, the removal of the hyphen from the original FOR-DEC tool and second introducing the letter *e* into the tool. The letter *e* represents *experience*.

As discussed before, there are two different processes represented in the acronym; the first part describes the cognitive process, where mental work is done, and the second part emphasizes the application process, where the solution is developed. Originally, the hyphen was supposed to clearly separate these two processes.

During the explorative study some pilots stated that the application of the FOR-DEC tool seems rather counterproductive when a solution is clearly evident. In these situations FOR-DEC is judged as an *obstacle* rather than helpful guidance for solving a problem. Furthermore, in these cases a forced completion of the FOR*e*DEC could

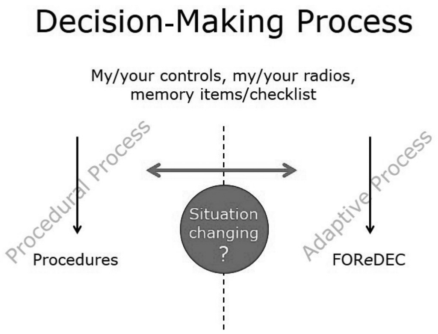

Figure 1. Decision-making process at Luxair.

result in ignoring the tool during critical situations in future. In order to overcome this limitation, the letter *e* (*experience*) was introduced to allow crews to exchange and share their experiences and solution approaches gained in the past concerning a particular situation. The aim here is not to simply follow an undefined gut feeling but first to enable crews to question a situation based on their intuition and second to make best use of experience and workable solutions that had been successfully applied in the past. The guiding question to read out is: "Have we seen this before?". The letter *e* is placed between the first and second part of the tool so as not to influence the preliminary phase of data collection and its analysis and to provide the possibility to speed up the process should there be a reasonable solution at hand. The character *e* is presented as a small letter to emphasize the importance of taking time for reflection during the current decision-making process. This step follows the same principles as discussed in the original model FOR-DEC by the hyphen and in the PRO FOR!DEC by the exclamation mark.

The inclusion of the term *experience* reflects the work of Gary Klein (2003) on recognition-primed decision-making and the work of Evans and colleagues (Evans, 2008; Evans & Stanovich, 2013) on intuition.

To allow an easy way to apply the FOR*e*DEC tool, the following leading questions were created, based on the former phrases developed by Hörmann (1994, 1995). The FOR*e*DEC tool is available on a small card that fits easily into a crew badge to facilitate crews reading out the model step by step to keep track of the application process (see Figure 2).

The FOR*e*DEC model was introduced to the Luxair pilot community during classroom trainings in 2014 and is currently evaluated in simulator sessions during line-oriented flight trainings (LOFT) on three different fleets. The results of the evaluation study are currently being analyzed.

Both decision-making tools PRO FOR!DEC and FOR*e*DEC require an in-depth introduction to their users during classroom courses and thereafter practical exercises to train the application process. To ensure an effective and successful application of both models in real-life situations, an adequate training phase must be implemented.

Discussion

The results of our explorative study and the workshop give advice for the useful implementation, application, and training of decision-making tools using the example of FOR-DEC. The limitations of the two studies lie in the small, nonrepresentative samples with only German-speaking participants. Both studies are explorative; the focus was on describing possible experiences and opinions. Thus, no statement can be made about the distribution of the results in the general population.

Our results show that FOR-DEC is a very useful tool for structured decision-making – as long as it is used "correctly". *Correct* means: in situations where no clear procedures exist, when time pressure is not critical, and when wrong decisions would have severe or even fatal consequences.

On the other hand, FOR-DEC is sometimes used in situations where a decision is predetermined by procedures or the team already knows exactly what they have to do. Thus, not surprisingly, in these situations teams consider FOR-DEC as pointless and skip the model in their professional routine. There is even the danger of not using the decision-making tools because of being "tired" of them. We suggest a stronger focus on instructing FOR-DEC as it was meant originally. This comprises, for example, clarifying the decision criteria and priorities beforehand. Moreover, the conditions of the application should be defined more thoroughly: critical situations, where there are no clear procedures, but enough time to reflect. It should also be stated clearly in which situations the tool is not needed. Structuring the decision-making process in critical situations when there is no procedure available is the essential benefit of *all* decision-making aids. Working through the phases of the models can prevent ad hoc decisions. Consequently, aspects that have been unnoticed before can flow into the process.

The critical points stated here are valid not only for FOR-DEC but also for the other models that have been mentioned. Herein lies the applicability of the present results for other airlines and decision-making tools. Hence, the following requests were derived for further development of aeronautical decision-making models:

(1) The decision-making aid should refer to already existing procedures. For example, to the quick reference handbook (QRH) in the cockpit ("do not dwell on something if not necessary"). Besides we

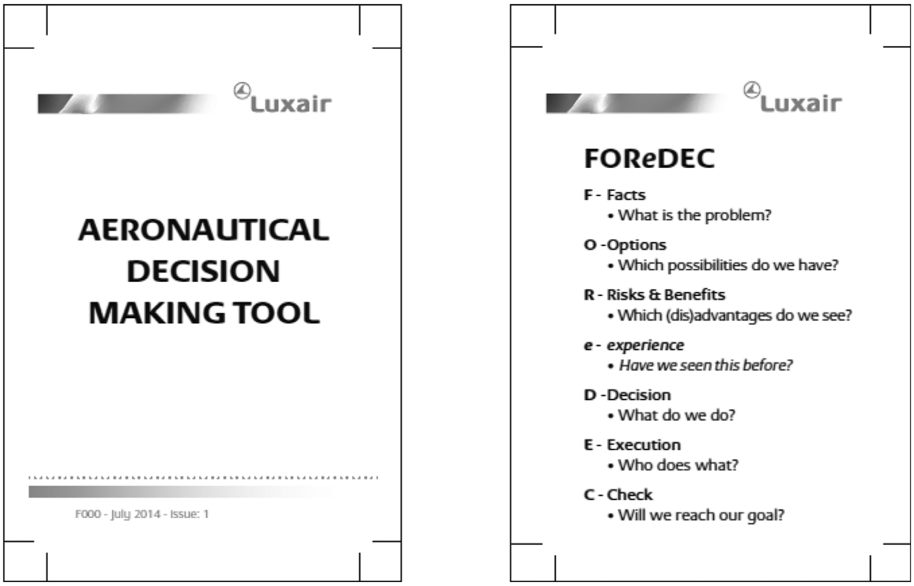

Figure 2. Aeronautical decision-making tool (Luxair).

should not forget that even during a decision-making process the aircraft must be flown ("aviate, navigate, communicate – think").

(2) Decision-making aids have been developed through the knowledge that spontaneous intuitive decisions often lead to errors. They force the user to analyze the situation. In order to achieve that, emotion and intuition have been left outside completely. Further developments should reconsider the roles of intuition and emotion for good decision-making: Gut feelings can be noncommunicable knowledge!
(3) In this context we should ask whether one size fits all. If the scientific results in the field of decision-making (e.g., Klein, 2003; Maarten, Militello, Orerod, & Lipshitz, 2008) were taken seriously, it could make sense to create different decision-making models for experts and for beginners.
(4) Finally, in most of the models the role of the team is not defined. In the FOR-DEC model the team is integrated explicitly in the first part (FOR). Nevertheless, without training it is difficult to know this. In no model do the keywords of the acronym include the team explicitly. Thus, the integration of the team should be clearly visible.

In light of our explorative results, it would make sense to evaluate the benefit of decision-making aids during aeronautical daily routine. To our knowledge, no study of this topic has been conducted to date. We hope to stimulate future scientific research by our ideas and findings.

We invite readers to comment on our results and ideas – which (if any) decision-making aid do you use? What are your experiences? Can you give us examples? And what do you think of our variations of FOR-DEC, PRO FOR! DEC and FOR*e*DEC?

References

Benner, L. (1975). DECIDE in hazardous materials emergencies. *Fire Journal, 69*, 13–18.

Betsch, T., Funke, J., & Plessner, H. (2011). *Denken – Urteilen, Entscheiden, Problemlösen. Allgemeine Psychologie für Bachelor* [Thinking – judgement, decision making, problem solving. General Psychology for bachelor students]. Heidelberg, Germany: Springer.

Dey, I. (1993). *Qualitative data analysis: A user friendly guide for social scientists*. Abingdon, UK: Routledge.

Dörner, D. (1976). *Problemlösen als Informationsverarbeitung* [Problem solving as information processing]. Stuttgart, Germany: Kohlhammer.

Dörner, D. (1996). *The logic of failure. Recognizing and avoiding error in complex situations*. New York, NY: Metropolitan Books.

Evans, J. S. (2008). Dual-processing accounts of reasoning, judgment and social cognition. *Annual Review of Psychology, 59*, 255–278.

Evans, J. S., & Stanovich, K. E. (2013). Dual-process theories of higher cognition: Advancing the debate. *Perspectives on Psychological Science, 8*, 223–241.

Flick, U. (2014). *An introduction to qualitative research* (5th ed.). London, UK: Sage.

Hörmann, H.-J. (1994). Urteilsverhalten und Entscheidungsfindung [Judgement and decision-making]. In H. Eißfeldt, K.-M. Goeters, H.-J. Hörmann, P. Maschke, & A. Schiewe (Eds.), *Effektives Arbeiten im Team: Crew Resource-Management-Training für Piloten und Fluglotsen* [Effectice team work: Crew resource management training for pilots and air traffic control] (pp. 73–96). Hamburg, Germany: Deutsches Zentrum für Luft- und Raumfahrt.

Hörmann, H. J. (1995). FOR-DEC. A prescriptive model for aeronautical decision-making. In R. Fuller, N. Johnston, & N. McDonald (Eds.), *Human factors in aviation operations. Proceedings of the 21st Conference of the European Association for Aviation Psychology (EAAP)* (Vol. 3, pp. 17–23). Aldershot, UK: Avebury Aviation.

Jungermann, H., Pfister, H.-P., & Fischer, K. (2005). *Die Psychologie der Entscheidung* [Psychology of decision making]. Heidelberg, Germany: Spektrum Akademischer Verlag.

Kahneman, D., Slovic, P., & Tversky, A. (1981). *Judgment under uncertainty: Heuristics and biases*. Cambridge, UK: Cambridge University Press.

Kahneman, D. (2012). *Thinking, fast and slow*. New York, NY: Penguin Books.

Klein, G. A. (1989). Recognition-primed decisions. In W. B. Rouse (Ed.), *Advances in man-machine system research* (Vol. 5). Greenwich, CT: JAI Press.

Klein, G. A. (2003). *The Power of intuition. How to use your gut feelings to make better decisions at work*. New York, NY: Random House.

Klein, G. A., Orasanu, J., Calderwood, R., & Zsambok, C. E. (1993). *Decision-making in action: Models and methods*. Westport, CT: Ablex Publishing.

Li, W. C., & Harris, D. (2005). Aeronautical decision-making: Instructor-pilot evaluation of five mnemonic methods. *Aviation, Space and Environmental Medicine, 76*, 1156–1161.

Maarten, J., Militello, L. G., Orerod, T., & Lipshitz, R. (2008). *Naturalistic decision-making and macrocognition*. Aldershot, UK: Ashgate.

Maher, J. (1989). Beyond CRM to decisional heuristics: An airline generated model to examine accidents and incidents caused by crew errors in deciding. In R. S. Jensen (Ed.), *Proceedings of the fifth international symposium on aviation psychology* (pp. 439–444). Columbus, OH: The Ohio State University.

Murray, S. R. (1997). Deliberate decision-making by aircraft pilots: A simple reminder to avoid decision-making under panic. *The International Journal of Aviation Psychology, 7*, 83–100.

Österreichische Bundesanstalt für Verkehr, Unfalluntersuchungsstelle. (2006). *Untersuchungsbericht Flugunfall mit dem Motorflugzeug Type Airbus A310 am 12. Juli 2000 am Flughafen Wien-Schwechat, Niederösterreich* [Reports on the accident with the aircraft type Airbus A310 on July 12, 2000 near airport Vienna-Schwechat]. GZ.85.007/0001-FUS/2006. Retrieved from http://versa.bmvit.gv.at/Uploads/media/A310_GZ._85007_vom_12._Juli_2000_2_03.pdf [01.10.2012]

O'Hare, D. (1992). The "artful" decision maker: A framework model for aeronautical decision-making. *The International Journal of Aviation Psychology, 2*, 175–191.

O'Hare, D. (2003). Aeronautical decision-making: Metaphors, models, and methods. In P. Tsang & M. Vidulich (Eds.), *Principles and practice of aviation psychology* (pp. 201–238). Mahwah, NJ: Lawrence Erlbaum.

Oldaker, L. (1995). *Pilot decision-making – an alternative to judgment training*. XXIV Organisation Scientific et Technique International du Vol a Voile (OSTIV) Congress, Omanara, New Zealand.

Orasanu, J. (1993). Decision-making in the cockpit. In E. L. Wiener, B. Kanki, & R. Helmreich (Eds.), *Cockpit resource management* (pp. 137–172). New York, NY: Academic Press.

Prince, C., & Salas, E. (1993). Training and research for teamwork in the military aircrew. In E. L. Wiener, B. G. Kanki, & R. L. Helmreich (Eds.), *Cockpit resource management* (pp. 337–366). San Diego, CA: Academic.

Reason, J. (1990). *Human error*. Cambridge, UK: Cambridge University Press.

St. Pierre, M., Hofinger, G., Buerschaper, C., & Simon, R. (2011). *Crisis management in acute care settings: human factors and team psychology in a high stakes environment* (2nd updated and enlarged edition). New York, NY: Springer.

Steinke, I. (2000). Gütekriterien qualitativer Forschung [Criteria for qualitative research]. In U. Flick, E. von Kardoff, & I. Steinke (Eds.), *Qualitative Forschung. Ein Handbuch* [Handbook of qualitative research] (pp. 319–331). Reinbek, Germany: Rowohlt.

Tversky, A., & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science, 185*, 1124–1131.

Wohl, J. G. (1981). Force management decision requirements for air force tactical command and control. *IEEE Transactions on Systems, Man and Cybernetics, 11*, 618–639.

Wickens, C. D., & Flach, J. M. (1988). Information processing. In E. L. Wiener & D. C. Nagel (Eds.), *Human factors in aviation* (pp. 111–156). San Diego, CA: Academic Press.

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