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EUROCONTROL CARE Innovative Research III

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Summary

Safety culture is broadly recognized as important for ATM and various studies have addressed its characterization and assessment. However, relations between safety culture and formal and informal organizational structures and processes are yet not well understood. This impedes structured improvement of safety culture. In this Eurocontrol CARE Innovative III project we aim to improve the understanding of these relations by agent-based organizational modelling. Previously we developed an agent-based organizational model for safety occurrence reporting at an ANSP in relation to the ANSP's safety culture. This report presents a validation plan for this model, which uses results of the Eurocontrol Safety Culture Measurement Tool.

Contents

1 Introduction

The importance of proper organizational processes to maintain the safety of complex operations is currently well realized. It is generally recognized that the level of safety achieved in an organization depends on the constraints and resources set by people working at the blunt end (e.g. managers, regulators), which determine the working conditions of practitioners who are directly controlling hazardous processes at the sharp end (e.g. pilots, controllers, maintenance operators). The recognition of the importance of organizational aspects for operational safety is reflected in the considerable number of publications on organizational and safety culture (e.g., Gordon et al., 2006; Mearns et al., 2008; Choudhry et al., 2007; Hopkins, 2006; Ek et al., 2007), and in plans of Eurocontrol, FAA and CANSO to see more and more ANSP's go through safety culture processes as a prelude to SESAR and NextGen.

The main aspects of organizational culture are clearly reflected in a definition by Uttal (1983): 'Shared values (what is important) and beliefs (how things work) that interact with a company's people, organizational structures and control systems to produce behavioral norms (the way we do things around here).' There exists a large variety of definitions of safety culture (Choudhry et al., 2007), we use the term safety culture as those aspects of organizational culture that may have an effect on safety. As such, the understanding of what is safety culture stems from understanding of the organizational culture and its effect on safety, in line with reasoning of Hopkins (2006).

Various studies have focussed on characterization of safety culture and on assessment of safety culture of various organizations, including Air Navigation Service Providers (ANSP's). However, the links of safety culture with organizational structures and processes are yet not well understood and this affects the determination of ways to improve safety culture. As a way forward, the current research project aims to enhance safety analysis of organizational processes in air traffic by development of formal approaches for modelling, simulation and analysis of organizational relationships and processes. These models may provide a proper basis for understanding the causal relations between organizational processes that influence safety culture, such that robust and flexible policies may be identified to improve and maintain a sufficient level of safety culture in an organization.

In (Stroeve et al., 2007a,b,c) we reported about a suitable multi-agent organizational modelling method that was identified by a literature survey and applied in an air traffic case. In the continuation of the research, the development of the model has been focused on safety occurrence reporting and its relation with safety culture at ANSP's. The agent-based organizational model is aimed to describe the emergence of safety culture vulnerabilities in relation to safety occurrence reporting in ANSPs' organizational contexts.

As a basis for development and validation we coordinated our research efforts with safety culture research pursued at Eurocontrol Experimental Centre. In an effort to measure and understand safety culture at European ANSP's, Eurocontrol has been developing a Safety Culture Measurement Tool (SCMT) (Gordon et al., 2006; Mearns et al., 2008). The SCMT uses safety culture questionnaires with statements about potential enablers and disablers of safety culture in an ANSP, and employees are asked anonymously to indicate the applicability of these statements to their organization. Based on the aggregated results of the questionnaires, the SCMT uses workshops to analyse the key safety culture issues and to provide solutions for them. The tool has now been applied at several ANSP's.

The development of an agent-based organizational model in the current study is focused on the reporting of safety occurrences and its role within the Safety Management System as a facilitator for optimization of organizational processes (i.e. organizational learning). Occurrence reporting is an important aspect of safety management in an ANSP and it has a range of connections with safety culture. As a basis for the development of an agent-based model for safety occurrence reporting, methods and requirements have been identified in (Sharpanskykh and Stroeve, 2008). The development of the agent-based model itself is described in (Sharpanskykh et al., 2008). The current report presents a validation plan for the developed model. Section 2 presents the validation approach and Section 3 provides concluding remarks.

2 Validation approach

2.1 Introduction

The validation approach is planned according to the following steps:

1. Identification of safety culture indicators in the agent-based organizational model.
2. Sensitivity analysis to identify major factors that influence the safety culture indicators and obtaining additional information for these factors, which may be used to adjust the model.
3. Relating the identified safety culture indicators to specific questions in the SCMT questionnaire that has been used for ANSP-3.
4. Prediction of the results of the SCMT questionnaire of ANSP-3 and determination of the level of validity of the organizational model.
5. Prediction of organizational factors contributing to safety culture vulnerabilities and comparison with the results of ANSP-3 SCMT workshop.
6. Sensitivity analysis based inventory of safety culture improvement strategies and discussion of these with the SCMT team.

Next, the details of these steps are presented in Sections 2.2 to 2.7. The success criteria of the validation are shown in Section 2.8. A planning of the work in 2009 is presented in Section 2.9.

2.2 Identification of safety culture indicators

To enable evaluation of the occurrence reporting in the modelled organization and comparison with the real observed organizational behaviour, a set of safety culture indicators has been identified as listed in Table 1. These safety culture indicators are model variables in the agent-based organizational model described in (Sharpanskykh et al., 2008).

Table 1: Safety culture indicators monitored in simulations.

Index	Safety Culture Indicator
I1.1/ I1.2/ I1.3	Reporting quality (ratio reported/observed) for the whole organization (I1.1) / team (I1.2) / controller (I1.3).
I2.1/ I2.2/ I2.3	Average quality of the processed notification reports produced by the whole organization (I2.1) / team of controllers (I2.2) / a controller (I2.3). By quality the correctness and completeness of information about the reported occurrence is understood.
I3.1/ I3.2/ I3.3	Average quality of the received final safety occurrence assessment reports for the whole organization (I3.1) / team (I3.2) / controller (I3.3). By quality of a received final safety occurrence assessment report the completeness of the occurrence report with respect to the identification of actual causes of the occurrence is understood. If no final safety occurrence assessment report for a reported occurrence has been received by a controller, then the quality of the received report is equal to 0.
I4.1 / I4.2/ I4.3	Average quality of the monthly safety overview reports received by the whole organization (I4.1) / team of controllers (I4.2) / a controller (I4.3). By quality of a monthly safety overview report the completeness of the report with respect to the identification of actual safety trends in the organization is understood. If some

Index	Safety Culture Indicator
	monthly safety overview report has been received by a controller, then the quality of the received monthly safety overview report for that month equals to 0.
I5.1 / I5.2	Commitment to safety of a controller (I5.1) / perceived commitment to safety of a team of controllers (I5.2).
I6	Perceived commitment to safety of supervisor.
I7	Perceived commitment to safety of management.
I8.1/ I8.2/ I8.3	Average value of the reprimand constituent in the force to report for the whole organization (I8.1) / team of controllers (I8.2) / a controller (I8.3). The reprimand constituent forms a part of the formula for the force to report an occurrence. It determines the degree by which the reporting force of a controller is reduced due to the disciplinary measures expected as a result of reporting.

The safety culture indicators of Table 1 can be linked to safety culture issues presented in the D3 report (Sharpanskykh and Stroeve, 2008), which were identified using SCMT results of two ANSP's (ANSP-1, ANSP-2), safety culture data from the literature, and interviews with experts at Eurocontrol Headquarters and at ANSP-3. Table 2 shows the relation between the safety culture indicators and safety culture issues. Here, safety culture issues have been aggregated in safety culture vulnerabilities in relation to quality of reporting and commitment to safety. Those safety culture issues from the report D3, for which no link to the considered safety culture indicators was identified, are not shown in Table 2.

Table 2: Relations between safety culture indicators and safety culture vulnerabilities.

Safety Culture Indicators	Safety culture vulnerability	Safety culture issues from the report D3
I3.1, I3.2, I3.3	Lack of feedback on reported occurrences decreases the controller's motivation for further reporting	S1.2 Actors are not motivated to report their safety concerns because of the lack of feedback and interest experienced in the organisation. S1.6 The influence of occurrence reporting on the improvement of safety is not clear to individual human operators. S3.16 No feedback on reporting is received
I4.1, I4.2, I4.3, I3.1, I3.2, I3.3	Controllers lack knowledge about safety-related issues in the ANSP	S3.17 Feedback / lessons learned from incidents comes too late or not at all
I8.1, I8.2, I8.3	Disciplinary measures influence negatively occurrence reporting	S1.3 During analysis of more severe occurrences, the license of involved controller(s) may be temporarily retracted. S1.4 Fear of prosecution may lead to some reservation to formal (written) occurrence reporting and a preference for informal (oral) reporting. S2.4 Actors avoid informal discussion of problems with their peers, since it may lead to (unfavourable) consequences. S3.19 Lack of consistency about disciplinary measures for incidents. S3.20 In some countries controllers may get a financial penalty if they are involved in a safety

Safety Culture Indicators	Safety culture vulnerability	Safety culture issues from the report D3
		occurrence. S3.21 Controllers do not receive acknowledgement for reporting. S4.11 The Ministry of Justice may decide to investigate (severe) occurrences and decide to prosecute involved organisations or human operators. In investigation and prosecution, occurrence reports may be used.
I5.1	Mediocre commitment to safety of a controller	S1.14 Not all organisational actors recognize their responsibility for safety.
I5.2	A group has a negative influence on reporting of a controller	S1.5 In some exceptional cases, it may be that shame and peer pressure is a reason for not reporting. S2.2 Fixed teams may have a negative effect on reporting (peer loyalty).
I5.2	A group has a negative influence on attitude to safety of a controller	S2.8 Safe behaviour is not encouraged (e.g., neutral attitude) by a team.
I7	Commitment to safety of management is not trusted by a controller	S1.8 Actors do not report some minor occurrences because they consider that there is no enough staff to process these reports. S1.15 Organisational actors may question the safety commitment or safety improvement strategy of managers (not known, outward appearance of the commitment).
I1.1, I1.2, I1.3 (for insignificant occurrences)	Low motivation to report insignificant occurrences	S1.10 Actors do not recognize minor occurrences as important to report. S1.11 Actors consider that they are not supposed to report minor occurrences.
I1.1, I1.2, I1.3 (for significant occurrences)	Low motivation to report significant occurrences	S1.13 Older controllers are less disposed towards safety occurrence reporting than younger ones.
I1.1, I1.2, I1.3, I2.1, I2.1, I2.1	The organizational learning is impaired due to mediocre occurrence reporting	S4.13 Union has information about incidents, but does not want to share.
I6	Controllers supervisor does not reinforce safety culture	S2.9 Supervisors may not effectively reinforce safety culture

2.3 Sensitivity analysis

The major determinants in the organizational model that impact the values of the safety culture indicators are identified by sensitivity analysis using a Monte Carlo sampling approach. The identification of the identified major factors forms the basis for gathering of prime information about these organizational aspects (e.g. by interviews or organizational routines documentation). The sensitivity analysis is performed along the following steps.

a. A large number of (stochastic) simulations of the model is performed with diverse settings in the context of the Western European culture of ANSP-3. For model parameter x_i two sets of values are determined: $x_i|B$ contains all values of x_i from the simulations resulting in

satisfactory values of the safety culture indicators, and $x_i|\underline{B}$ contains all x_i values not leading to satisfactory values of the safety culture indicators. The range of satisfactory values is provided in Table 3.

b. The Smirnov two sample test is performed for each factor independently. The test statistics is defined by

$$d(x_i) = \sup_Y \| F_B(x_i|B) - F_{\underline{B}}(x_i|\underline{B}) \|,$$

here F_B and $F_{\underline{B}}$ are marginal cumulative probability functions calculated on the sets $x_i|B$ and $x_i|\underline{B}$ respectively; Y is the output. A low level of $d(x_i)$ supports null-hypothesis H_0: $f_B(x_i|B) = f_{\underline{B}}(x_i|\underline{B})$, i.e., the input factor x_i is not important, whereas a high level of $d(x_i)$ implies the rejection of H_0, i.e., x_i is a key factor.

c. Factors that gained significance due to interaction (correlation) with other input factors are determined by calculating total effect terms for each factor x_i identified as insignificant at step b, using the formula:

$$tet(X_i) = \frac{E(V(Y|X_{-i}))}{V(Y)}$$

Here $E(V(Y|X_{-i}))$ is the expected variance of the output Y obtained when all factors (set X) but x_i are fixed; $V(Y)$ is the variance of the output Y.

The statistical analysis is supported by the software package SIMLAB.

The satisfactory values for a safety culture indicator are determined based on the level of importance of the indicator for the evaluation of the safety occurrence reporting process, semantics of the indicator, and simulation results described in the report D4.

Table 3: Definition of satisfactory values for the safety culture indicators (see Table 1).

Safety Culture Indicator	Satisfactory values	Explanation
I1.1/ I1.2/ I1.3	(0.8,1]	To be satisfactory, at least 80% of the observed occurrences should be reported.
I2.1/ I2.2/ I2.3	(0.7, 1]	The range has been identified based on simulation results for organizations with mature safety culture.
I3.1/ I3.2/ I3.3	(0.5, 1]	It is considered that no feedback may be provided to notification reports about insignificant occurrences. This is not considered as major problem in the modelling context, leading to a reasonably extended range of satisfactory values.
I4.1 / I4.2/ I4.3	(0.8, 1]	The range has been identified based on simulation results for organizations with mature safety culture.
I5.1 / I5.2	(0.6, 1]	The range has been identified based on simulation results for organizations with mature safety culture.

Safety Culture Indicator	Satisfactory values	Explanation
I6	(0.7, 1]	The range has been identified based on simulation results for organizations with mature safety culture.
I7	(0.7, 1]	The range has been identified based on simulation results for organizations with mature safety culture.
I8.1/ I8.2/ I8.3	(0, 0.1]	According to the model the maximum value of this indicator is 0.3; a value 0.1 corresponds to the situation, when reprimands are provided for severe occurrences only (type A); a value 0 corresponds to the situation that no reprimands are provided.

As an example, Table 4 shows the results of a preliminary sensitivity analysis for the agent-based organizational model in the context of the Western European culture.

Table 4: Major factors of the model in the context of the Western European culture.

Variable	Description
e1	Priority of safety-related goals in the role description
e7	Sufficiency of the amount of safety investigators
e8	Sufficiency of the amount of controllers
e9	Availability of up-to-date technical systems for controllers
e10	Sufficiency and timeliness of training for changes
e12	Developed and implemented SMS
e26	Quality of formal procedures for system checks and repairs
e36	Quality of the formal safety occurrence assessment procedure
e40	Quality of the communication channel between controllers and safety investigators
e44	Average commitment of the agents involved in the safety analysis
e71	Formal support for confidentiality of reporting
e35	Intensity of informal interactions in the team of controllers
e4	Influence of a controller on safety activities
e14	Level of development of managerial skills
Personal consequences of occurrences	

2.4 Relating safety culture indicators to SCMT questions

As basis for evaluation of the validity level of the organizational model for ANSP-3, the identified safety culture indicators are related to particular questions in the SCMT questionnaire of ANSP-3. The safety culture indicators used for evaluation of the occurrence reporting in

ANSP-3, are related to particular questions of the survey as shown in Table 5. For the cases when an indicator is related to multiple questions, a weight is assigned to each question indicating the degree of importance of the question for the safety culture indicator.

Table 5: Safety culture indicators related to specific questions from the SCMT Questionnaire for ANSP-3.

Index	Safety Culture Indicator	Questions used for estimation	Weight
I1.1	Reporting quality (ratio reported/observed) in the whole organization.	A.24 People understand the need to report incidents in order to identify trends and make changes to the system if required	0.5
		A.31. If I see an unsafe practice by a colleague I am able to report it in a way that we all learn lessons from it.	0.3
		A.32. If I do something unsafe I am aware that I may be asked to explain myself	0.2
I2.1	Average quality of the processed notification reports produced by a controller in the whole organization.	No related question identified.	-
I3.1	Average quality of the received final safety occurrence assessment reports by controllers in the whole organization.	A.22 Appropriate responses are made after an incident to address why the incident occurred.	1
I4.1	Average quality of the monthly safety overview reports received by controllers in the whole organization.	A.24 People understand the need to report incidents in order to identify trends and make changes to the system if required	0.4
		A.29 Lessons learned from incidents are published in a de-identified manner in a newsletter or similar document	0.6
I5.1	Commitment to safety of a controller	B.10 Controllers would never compromise their responsibility to safety.	1
I5.2	Perceived commitment to safety of a team of controllers	A.4 My colleagues are committed to safety.	0.7
		A.11 Everyone at my Unit/Team feels that safety is their personal responsibility.	0.3
I6	Perceived commitment to safety of supervisor.	B.16 My concern about safety would be acted on if I expressed them to my supervisor	1
I7	Perceived commitment to safety of management.	A.7 My management is committed to safety	1
I8.1	Average value of the reprimand constituent in the force to report for controllers in the whole organization.	A.18 People are willing to report incidents because they know they will be treated in a just and fair manner.	1

2.5 Determination of the level of validity

To enable comparison of the values of the safety culture indicators with the SCMT survey results of ANSP-3, a three-valued qualitative scale (high / medium / low) is defined for the safety culture indicators in Table 6.

For the answers to the SCMT questionnaire the following related scales are defined:

- High = (4,5];
- Medium = (2,4];
- Low = [0,2].

If multiple questions are related to a safety culture indicator, then a qualified label is determined for the weighted average over the answers to the questions, using the weights defined in Table 5. The high values of the indicators I1-I7 and low values of I8 correspond to the satisfactory values of the indicators considered in Table 3. The medium and low values of the safety culture indicators were determined based on the level of importance of the indicator for the evaluation of the safety occurrence reporting process, semantics of the indicator, and simulation results described in the report D4.

Table 6: Definition of qualitative scales for the safety culture indicators.

Safety Culture Indicator	High	Medium	Low	Explanation
I1.1/ I1.2/ I1.3	(0.8, 1]	(0.4, 0.8]	[0, 0.4]	Organizations in which 40% or less of the observed occurrences are reported have a low value of these indicators.
I2.1/ I2.2/ I2.3	(0.7, 1]	(0.4, 0.7]	[0, 0.4]	The ranges have been identified based on simulation results for organizations with mature safety culture.
I3.1/ I3.2/ I3.3	(0.5, 1]	(0.2, 0.5]	[0, 0.2]	The value 0.2 corresponds to the situation, when feedback is provided for approximately 18% of the provided notification reports. The quality of feedback equal to and less than 18% is considered to be low.
I4.1 / I4.2/ I4.3	(0.8, 1]	(0.4, 0.8]	[0, 0.4]	The ranges have been identified based on simulation results for organizations with mature safety culture.
I5.1 / I5.2	(0.6, 1]	(0.3, 0.6]	[0, 0.3]	The ranges have been identified based on simulation results for organizations with mature safety culture.
I6	(0.7, 1]	(0.4, 0.7]	[0, 0.4]	The ranges have been identified based on simulation results for organizations with mature safety culture.

Safety Culture Indicator	High	Medium	Low	Explanation
I7	(0.7, 1]	(0.5, 0.7]	[0, 0.5]	The ranges have been identified based on simulation results for organizations with mature safety culture.
I8.1/ I8.2/ I8.3	(0.15, 0.3]	(0.1, 0.15]	[0, 0.1]	The value 0.15 corresponds to the situation, when reprimands are also provided for less serious occurrences (types B and C). In the case of the maximum value (0.3), significant reprimands are provided for all types of occurrences.

The validity level of the model is determined by comparing a qualified label for the points for the questions/statements from the survey related to each safety culture indicator, and the value of this indicator obtained by simulation. For example, the validity with respect to the indicator I5.2 'perceived commitment to safety of a team of controllers' is evaluated by the questions A.4 'my colleagues are committed to safety' and A.11 'everyone at my Unit/Team feels that safety in their personal responsibility'. If the value for I5.2 would be 0.8 (High), and the average answers for A.4 would be 4.2 (High) and for A.11 would be 3.8 (Medium), then the weighted average answer would be 4.1 (High), such that I5.2 would be considered valid. In this example, if the average answer for A.4 would reduce to 4.0 (Medium), then the weighted average would reduce to 3.9 (Medium), such that I5.2 would be considered invalid.

If a rating for a statement/question from the survey has a high variance, then less strong requirements for validity with respect to this statement/question can be applied.

Validation of model update

As a second validation step, the identified major determinants of the model are related to specific questions from the ANSP-3 SCMT survey, which are not used for the validity estimation. For example, the survey results of question A.25 'I trust the confidentiality of the reporting and investigation process' can be input of the organizational model. The answers to these questions will be used to update the parameter values of the major determinants. Next, the validity of the model will be evaluated using the outlined procedure. The hypothesis will be tested that the validity of the model increases due to parameter re-evaluation. If this is true it shows that the organizational model is internally consistent.

Based on the preliminary results of the sensitivity analysis shown in Table 4, the identified major factors of the model are related to specific questions from the ANSP-3 Safety Culture Survey as shown in Table 7.

Table 7: Major factors of the model related to specific questions from the ANSP-3 Safety Culture Survey.

Variable	Description	Questions used for estimation
e1	Priority of safety-related goals in the role description	A.1. Balancing safety against the other requirements of my job is a challenge A.5. Safety is a responsibility shared throughout the organization A.12. The other people in the organization do not understand the safety roles we fulfil
e7	Sufficiency of the amount of safety investigators	Evaluated based on the actual number of safety investigators at the ANSP-3
e8	Sufficiency of the amount of controllers	Evaluated based on the actual number of safety investigators at the ANSP-3
e9	Availability of up-to-date technical systems for controllers	B.8 I trust the ATC equipment that I use in my job.
e10	Sufficiency and timeliness of training for changes	A.28. Information about changes to procedures or the system is easily accessible A.30. I am kept informed of changes that have been made to procedures or systems B.12 We are consulted about changes to the technical/engineering system that impact on the way we do our work. D.21 Changes to the organization and ATC are well communicated to staff.
e12	Developed and implemented SMS	A.6. Management takes action on safety issues that we raise A.12. The other people in the organization do not understand the safety roles we fulfil A.21. Voicing concerns about safety is actively encouraged. D.18. Safety is well-integrated into our business management approach.
e26	Quality of formal procedures for system checks and repairs	B.6 Maintenance staff perform sufficient system checks
e36	Quality of the formal safety occurrence assessment procedure	Evaluated based on the ANSP-3's Safety Occurrence Assessment Procedure
e40	Quality of the communication channel between controllers and safety investigators	-
e44	Average commitment of the agents involved in the safety analysis	A.6. Management takes action on safety issues that we raise A.9. Management is interested in the safety issues that we raise A.10. My manager would always support me if I had a safety concern. A.23. People do not get involved in safety because their opinions are not listened to. D.12 I take a personal involvement in major safety initiatives. D.19 I clearly show that safety is one of my core personal values.
e71	Formal support for confidentiality of reporting	A.25. I trust the confidentiality of the reporting and investigation process.

Variable	Description	Questions used for estimation
e35	Intensity of informal interactions in the team of controllers	A.3. I have confidence in the people that I interact with in my normal working situation A.19. People in this organization share information in order to keep the organization working properly. A.15 People who raise problems are seen as trouble-makers.
e4	Influence of a controller on safety activities	B.2 Our opinion and input into safety assessments are actively sought after. B.15 I have the opportunity to provide input in the ATC systems development or acquisition process.
e14	Level of development of managerial skills	D.14 I have attended at least one safety related training course within the last year.
Personal consequences of occurrences		D.8 I would take disciplinary action against a controller who regularly took unacceptable risks.

2.6 Prediction of organizational factors

A sensitivity analysis will be performed for the updated model. This sensitivity analysis is used to identify the organizational aspects that largely determine the safety culture indicators. The validity of these predicted safety culture vulnerabilities will be determined by comparison with the results of the SCMT workshop of ANSP-3. During this workshop safety culture vulnerabilities of ANSP-3 will be determined by focused discussions based on the safety culture survey results.

2.7 Inventory of safety culture improvement strategies

The sensitivity analysis of Section 2.6 for the safety culture indicator values for organizational changes will be systematically evaluated to arrive at a set of promising safety culture improvement strategies. These results are discussed in a workshop with the SCMT team to consider their utility and the gained insights in addition to the prior ANPS-3 SCMT workshop. Furthermore, potential ways of interaction between SCMT and organizational agent-based modelling will be discussed, which may support understanding and improvement of safety culture.

2.8 Success criteria

The level of success in the above described validation will be evaluated by the following criteria:

Cr1 The number of safety culture indicators for which the qualitative scales defined in Table 6 are equal for the results of the organizational model and the SCMT questionnaire results weighted according to Table 5.

Cr2 The number of safety culture indicators for which the qualitative scales defined in Table 6 are equal for the results of the *updated* organizational model and the SCMT questionnaire results weighted according to Table 5.

Cr3 The increase in the number of valid safety culture indicators from *Cr1* to *Cr2*. This is a measure of the internal consistency of the model.

Cr4 The number of similar safety culture organizational vulnerabilities as identified in the SCMT Workshop at ANSP-3 and by the organizational model.

Cr5 The number of safety culture improvement strategies identified by the organizational model in comparison with those identified by the SCMT Workshop at ANSP-3.

Cr6 The number and quality of ways of interaction between SCMT and organizational agent-based modelling that may support understanding and improvement of safety culture.

2.9 Work planning

The work described above will be performed during 2009 in three work packages:

- WP6 : Evaluation and improvement of the organizational model;
- WP7: Validation of the organizational model;
- WP8: Final report & scientific publications.

The detailed planning of these work packages and their required input are presented in Table 8.

Table 8: Planning of 2009 work.

ID	Task	Due date	Required input	Input date
6.1	Sensitivity analysis to identify major determinants in organizational model	31 Jan 09	Organizational model	1 Jan 09
6.2	Obtain additional information for major factors	6 Mar 09	Major factors	1 Feb 09
6.3	Update model and predict safety culture indicators	31 Mar 09	Information for major factors	7 Mar 08
7.1	Evaluate validity via comparison with ANSP-3 SCMT questionnaire results	20 Apr 09	Model predictions	1 Apr 09
			ANSP-3 SCMT questionnaire results	1 Apr 09
7.2	Update major determinants of model by unused ANSP-3 SCMT questionnaire results and evaluate the model validity	10 May 09	Major factors	1 Feb 09
			ANSP-3 SCMT questionnaire results	1 Apr 09
7.3	Identify major organizational factors via sensitivity analysis of the updated model	31 May 09	Updated model	11 May 09
7.4	Compare identified major organizational factors with results of ANSP-3 SCMT Workshop and identify safety culture improvement strategies	15 Jun 09	ANSP-3 SCMT workshop results	31 May 09

ID	Task	Due date	Required input	Input date
7.5	Evaluate contributions of organizational modelling for safety culture evaluation and improvement	30 Sep 09	Workshop with SCMT team	15 Jun 09
8.1	Write paper(s)	15 Nov 09	Preliminary results	1 Aug 09
8.2	Write final report	15 Dec 09	All project results	1 Oct 09

The associated deliverables are:

- D6: Evaluation report, due 31 March 2009;
- D7: Validation report, due 30 September 2009;
- D8: Final report, due 15 December 2009.

Furthermore, one or more scientific papers will be produced.

3 Concluding remarks

Although currently a considerable amount of work has been done to characterize safety culture via survey studies (e.g. Gordon et al., 2006; Mearns et al., 2008; Choudhry et al., 2007; Ek et al, 2008), the causal relations of safety culture with organizational structures and processes, and ways of structured safety culture improvement are still not well known. We have shown in (Sharpanskykh et al., 2008) that it is possible to systematically develop models that account for a large variety of organizational aspects, thus providing a different and structured view on safety culture from the perspective of the formal organization in relation with the variable behaviour of agents in it. Such modelling provides the opportunity of new understandings of organizational effects on operational safety and the structured development of policies for improvement of safety culture. Preliminary model results provide remarkable insights in potential relations between the quality of occurrence reporting and organizational factors at an ANSP.

Grounding of such model results requires a proper validation process. In this report we presented a validation plan that is based on prediction of and comparison with independent results of the Eurocontrol Safety Culture Measurement Tool for ANSP-3. In follow-up research we will perform the planned validation study.

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