# Requirements engineering for sociotechnical systems: Case study of an Airline Operations Control Center

Nico Zimmer
*The Boeing Company Inc.*
Neu-Isenburg, Germany
nico.zimmer@boeing.com

Kuldar Taveter
*Institute of Computer Science*
*University of Tartu*
Tartu, Estonia
kuldar.taveter@ut.ee

***Abstract*—This paper is concerned with requirements engineering for sociotechnical systems. The paper describes and analyzes the requirements for the sociotechnical system of the Airline Operations Control Center (AOCC). This is done for studying the social part of the AOCC by means of agent-based simulation of AOCC employees with different personality profiles. The requirements are mapped to the viewpoint framework for holistic requirements elicitation and representation at different abstraction layers and from complementary perspectives. The design of an agent-based simulation system based on the requirements is briefly described. Finally, the benefits of this kind of requirements engineering approach are brought out and the directions for future work are set.**

***Keywords—sociotechnical system, requirements engineering, model, abstraction layer, perspective, viewpoint, agent-based simulation***

## I. Introduction

This paper is concerned with studying complex sociotechnical systems. A sociotechnical system consists of tasks, people, organization, and technology [1]. In other words, sociotechnical systems comprise humans, social, organizational, and technical factors [2]. Sociotechnical system (STS) is defined as a software intensive system that has defined operational processes followed by human operators and which operates within an organization and comprises both social and technical aspects [3]. STS consists of humans, software, and hardware [3].

The aviation domain contains many good examples of sociotechnical systems. First, modern aircraft should be viewed as STS [4]. In our previous work [5-6], we have studied airports as STS. This paper studies an Airline Operations Control Center (AOCC) as STS.

The research literature indicates that the agent-oriented paradigm is a natural metaphor for studying complex STS because it enables to elicit and represent requirements for both the social and technical aspects [6-9]. The purpose of this paper is to describe and analyze the requirements elicited for designing and implementing an agent-based simulation system [10] for the important social part of the AOCC STS – AOCC employees responsible for dispatching flights. As we have shown in [6], for successful agent-based simulation of some aspect of STS, the requirements for the greater STS should be elicited and modelled. Considering this, this paper describes the requirements elicited for the whole STS of AOCC. The requirements described in the paper were elicited from the AOCC stakeholders by following the elicitation approach described in [6] and [11].

The rest of this paper is structured as follows. In Section II, the holistic requirements engineering framework for STS used in the work is described. In Section III, the framework is applied to modelling the behavior, organization, and information perspectives of the AOCC. In Section IV, the design of the simulation system for the human subsystem of the AOCC is briefly described, based on the requirements. The conclusions are drawn and directions for future work are set in Section V.

## II. Requirements Engineering for STS

STS should be designed in a holistic fashion [11]. Holistic design means, among other things, that the software system to be designed should be viewed through complementary lenses of its social, informational, and behavioral context. For this purpose, we propose to apply a methodology that is centered on the *viewpoint framework* defined in [13]. The viewpoint framework consists of a matrix with three rows representing the abstraction layers of problem domain analysis, design, and implementation and three columns representing the perspectives of organization, information, and behavior. Each cell in this matrix represents a specific viewpoint, such as *organization analysis*, *information design* and *behavior implementation*. The perspectives of organization, information and behavior are respectively geared towards eliciting and representing social, informational, and behavioral contexts. In this paper, we address the viewpoint aspects of the system analysis layer because the focus of this paper is on requirements engineering for STS. Each of these perspectives – information, interaction, and behavior – can be represented by appropriate models. The models at the abstraction layer of system analysis represent the requirements elicited for the STS. Likewise, the models at the abstraction layers of design and implementation respectively represent the design and implementation of the STS. Since this paper is concerned with requirements engineering, we focus on the models required for capturing the highest abstraction layer of problem domain analysis and only marginally treat the models needed for addressing the abstraction layers of design and implementation.

The viewpoint framework has been previously applied for requirements engineering as described in, e.g., [6, 9, 14-17]. The methodology for filling in the viewpoint framework, including the order of filling, is described in [6]. The advantages of using the methodology based on the viewpoint framework are that it enables to model requirements for STS at three abstraction layers and from three complementary vertical perspectives. Another advantage is that the models included by the viewpoint framework are rooted in simple principles, which makes the models palatable for non-technical stakeholders. The viewpoint framework is represented in Table I. This paper is focused on the models of organization, information, and behavior analysis. Requirements models of AOCC of the mentioned viewpoint aspects are presented and explained in Section III. Design considerations of the agent-based simulation system at the system design layer are presented in Section IV. Finally, the simulation system is implemented at the layer of system implementation, which falls outside the scope of this paper.

Table I. The viewpoint framework

| | Viewpoint aspect | | |
|---|---|---|---|
| **Abstraction layer** | **Organization** | **Information** | **Behavior** |
| System analysis | Role models, organization model | Domain model | Goal model, Motivational scenario |
| System design | Models of platform-independent design | | |
| System implementation | Platform-specific implementation | | |

## III. Requirements for the AOCC

### A. Goal Models and Motivational Scenarios

Goal models are relevant for capturing the purpose and goals of the STS. Goal models belong to the viewpoint aspect of behavior analysis. According to Sterling and Taveter [12], goal models include functional goals denoted by rhomboids that represent functional requirements of the system, quality goals (clouds) that model non-functional requirements of the system, and roles (stick figures) that describe capacities or positions of the system required to achieve the goals. There can also be relationships between functional goals (solid lines), and between goals and quality goals (dashed lines). For easier reading, we indicate in this paper *goals* and *quality goals* as highlighted in the *italic font*, and **roles** in the **bold font**.

The overall goal or purpose of airline operations control is to *Maintain & control the day of operation network schedule* to provide an *Efficient, safe, quality & profitable network operation* to the airline's customers – mainly its passengers, but potentially also to its cargo customers. The goal model of airline operations control is shown in Figure 1.

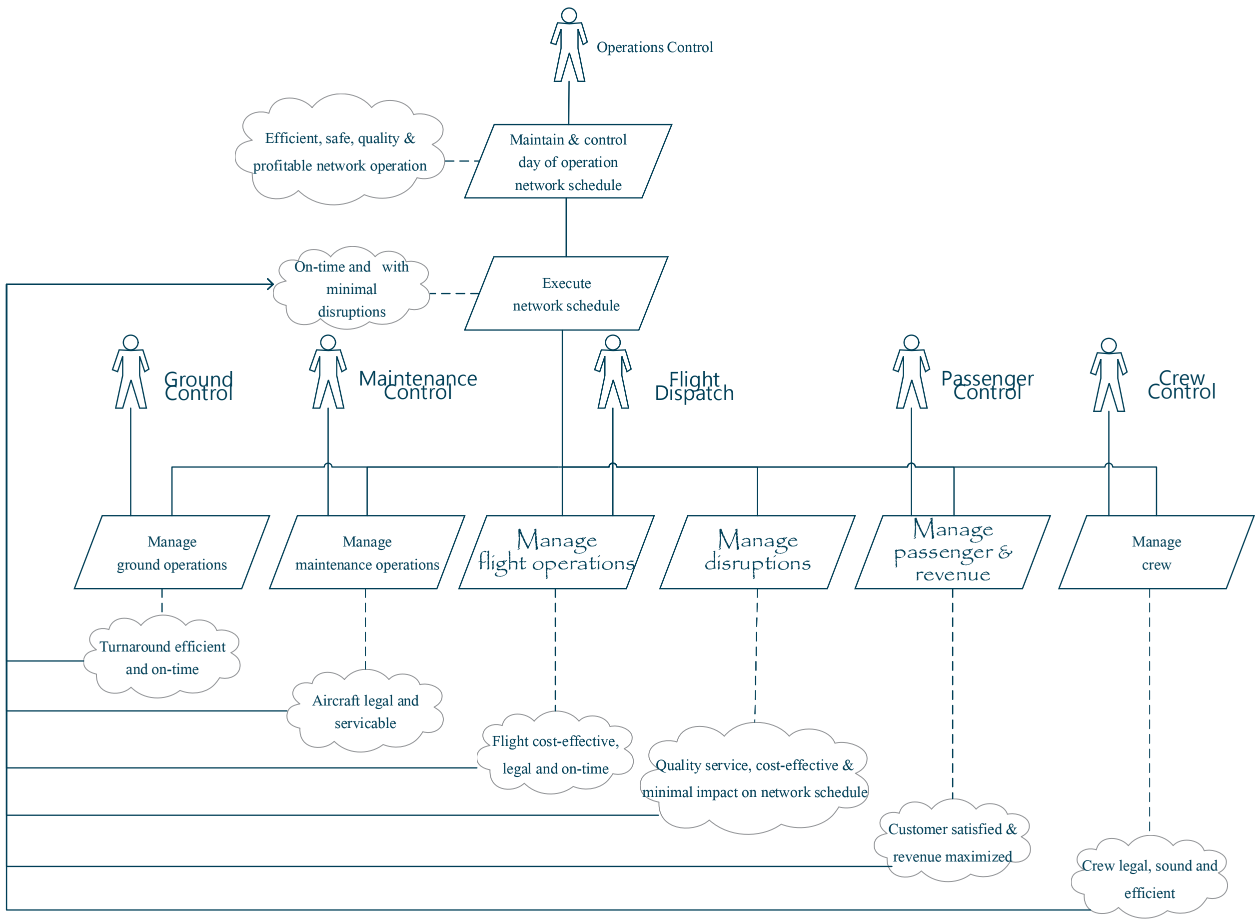


Figure 1. The goal model of airline operations control

Table II. The motivational scenario of airline operations control

| | |
|---|---|
| Scenario name | Airline Operations Control |
| Scenario description | The purpose of the airline operations control is to maintain and control the day of operation network schedule. This is done in through collaboration between the AOCC sub-roles. The following activities are included:<br>a) managing ground operations by preparing the aircraft on the ground and conducting weight and balance calculations |

| | |
|---|---|
| | b) managing maintenance operations by reviewing aircraft status, and tracking and solving maintenance issues<br>c) managing flight operation by preparing, dispatching, and following flights<br>d) managing passenger and revenue by tracking, re-booking, and accommodating passengers<br>e) managing crew by monitoring, tracking, and recovering crew members<br>f) managing disruptions by gaining situational awareness and optimizing and executing proper solutions |
| Quality description | Executing and controlling the day of operation network schedule should ensure an efficient, safe, and high-quality service to airline customers – the passengers. The airline's day of operation should be at the same time profitable, solvable, and punctual without large disruptions or delays to maintain the airline's reputation. |

Figure 1 reflects that achieving the overall goal of airline operations control is the responsibility of the duty manager performing the role **Operations Control**. To offer a service to airline customers, **Operations Control** is also responsible for achieving the goal *Execute network schedule* with the quality goal to deliver the service *On time and with minimal disruptions*. The responsibilities for achieving the sub-goals *Manage ground operations, Manage maintenance operations, Manage flight operations, Manage passenger & revenue, and Manage crew* are delegated to the respective roles **Ground Control**, **Maintenance Control**, **Flight Dispatch**, **Passenger Control** and **Crew Control**. Performers of these roles follow their own quality goals to ensure the entire network operation flow. All of these quality goals contribute to the achievement of the quality goal *On time and with minimal disruptions*. A more narrative-like way of representing the meaning of a goal model is motivational scenario [13]. Motivational scenarios belong to the viewpoint aspect of behavior analysis. Table II presents the motivational scenario of airline operations control and how agents fulfill their corresponding roles to achieve their goals. Additional goal models and motivational scenarios for a day of operation are available in [18].

Since the operational flow is regularly disturbed by disruptions which lead to irregular operation, a very important sub-goal shown in Figure 1 is *Manage disruptions*. Disruptions should be managed while they occur, but still ensuring a *Quality service, cost effective, and minimal impact on flight schedule*. The responsibility and final decisions of disruption management lie with the duty manager performing the role of **Operations Control**, but collaborative decision making is performed amongst all the sub-roles of the AOCC represented in Figure 2 to find an optimal solution. Figure 2 also shows the sub-goals of *Manage disruptions*. Different aspects of managing disruptions are represented by the sub-goals *Gain situational awareness*, *Optimize solution*, and *Execute solution* with their respective lower-level sub-goals. Table III shows the motivational scenario of disruption management.

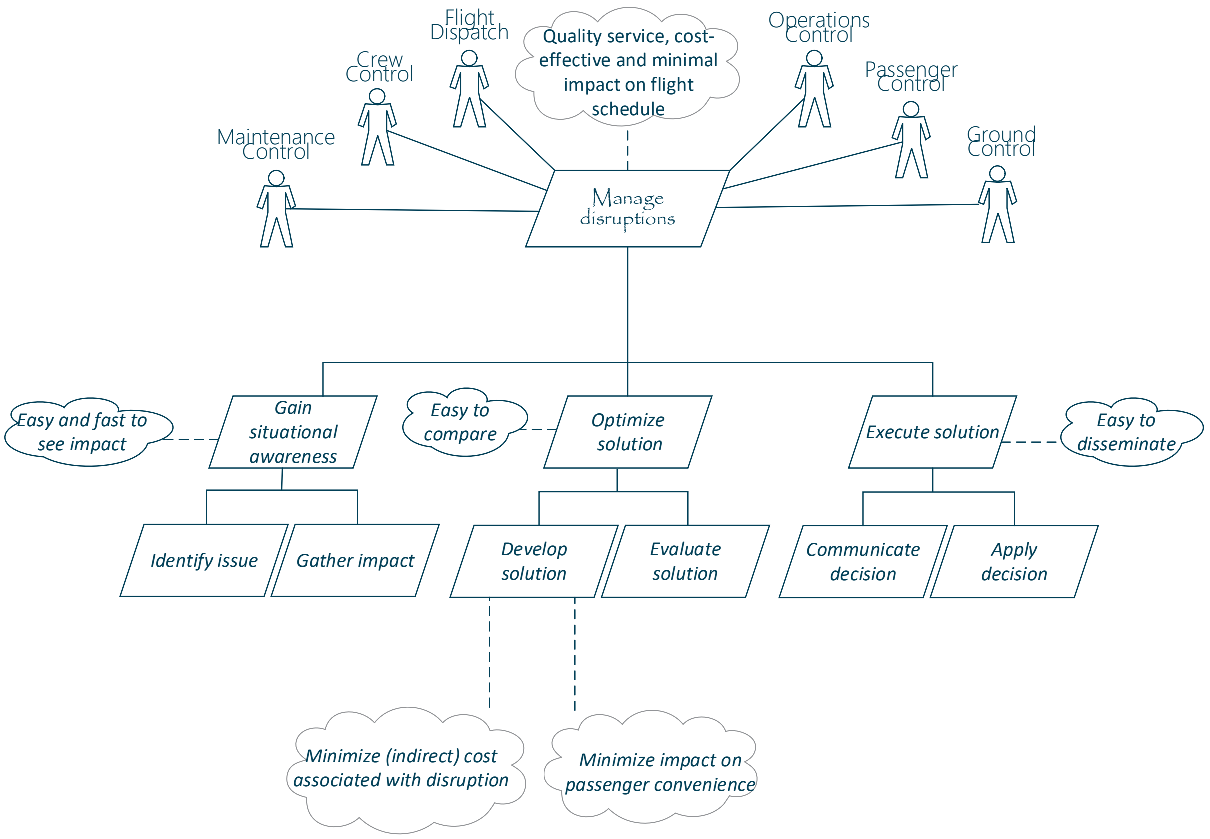


Figure 2. The goal model for managing disruptions

Table III. The motivational scenario of disruption management

| | |
|---|---|
| Scenario name | Disruption Management |
| Scenario description | Disruptions need to be handled proactively to avoid delays and additional costs. Managing disruptions potentially involves all sub-roles of the AOCC. The responsibility and final decisions lie with the duty manager performing the |

| | |
|---|---|
| | role of Operations Control. Disruption management includes the following activities:<br>a) gaining situation awareness by identifying and understanding the issue and its impact on the disruption, e.g., does it affect my fleet, crew, and/or passengers?<br>b) optimizing a solution by evaluating different solutions and developing one proper solution together with the involved AOCC roles<br>c) executing the solution by communicating a decision to relevant stakeholders and applying the decision |
| Quality description | Disruption management should allow to gain situation awareness, identify, and understand the impact, make fast decision by the controllers, but still ensure a quality service for passengers. The solution should be cost-effective and have a minimal impact on the overall network schedule, minimizing delays. |

### *B. Analyzing Quality Goals*

The analysis of quality goals constitutes an important tool for STS requirements analysis. According to Sterling and Taveter ([13], p. 140), quality goals can contribute positively or negatively to the achievement of a functional goal. In Figure 1, the quality goal *On-time and with minimal disruptions* is associated with the functional goal *Execute network schedule*, representing the positive plan at the beginning of a day of operation. Figure 1 reflects that in case of no disruption or minimal disruption, the following quality goals contribute positively to the quality goal *On-time and with minimal disruptions*: *Turnaround efficient and on-time*; *Aircraft legal and serviceable*; *Flight cost-effective, legal and on-time*; *Quality service, cost effective & minimal impact on network schedule*; *Customer satisfied & revenue maximized*; *Crew legal, sound and efficient*. However, the situation changes in case of a significant disruption. In such a case, each of these quality goals can also exert a negative influence on the achievement of the overall quality goal *On-time and with minimal disruption*. The reason is that cost, time, and resource availability continuously stand in conflict which each other during a day of operation and such conflicts become critical during disruption management. Handling conflicts in goal-oriented requirements is a separate issue that we have addressed more in detail in [19].

In the socio-technical context, it is interesting to further analyze how the technical and social dimensions may influence the achievement of the quality goals. Figure 3 elaborates the social and technical dimensions of the quality goal *Quality service, cost effective, and minimal impact on flight schedule* that is associated with the functional goal *Manage disruptions*. Each of the other quality goals could be elaborated the same way. The technical dimension is rather easy to grasp. If all technical systems deliver the information in a timely manner and without failure, the overall impact of the technical dimension would be positive. The social dimension is much more complex. This is because the team effectiveness framework, introduced in Section 2.3.1 of [18], includes three factors which may enable or impede the overall effectiveness: team member characteristics (personality), team-level factors (team taxonomy, e.g., cohesion), and organizational or contextual factors (organizational identity, e.g., organizational structure of an airline). All these factors influence collaborative team-based decision making. As has been concluded in Section 2.3.2 of [18], personality has a considerable impact on team effectiveness. The Five-Factor Model (FFM) of personality profiles and particularly the personality features Conscientiousness (C) and Agreeableness (A) have been identified as valid occupational performance predictors [18]. C and A may have positive or negative influence (indicated by the '+' or '-' sign) on the collaborative team-based decision making. At the same time, Openness, Extraversion and Neuroticism are expected to be neutral (indicated by the 'n' sign), based on Peters [20] who compared the personality profiles of an AOCC employee population with a norm population.

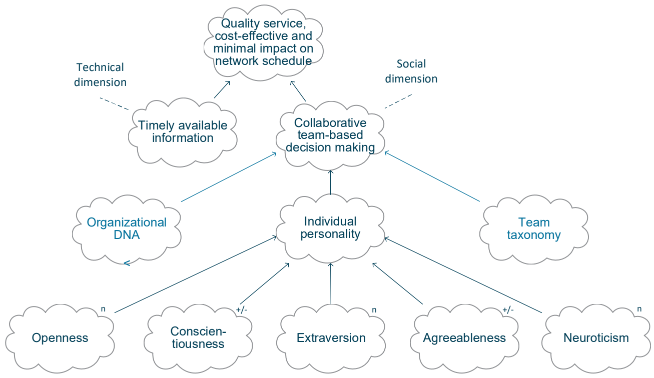


Figure 3. Social and technical dimensions of achieving the *Manage disruptions* functional goal

### *C. Role Models*

Role models describe each role of STS in terms of its responsibilities and constraints required to achieve the goals of the STS. Role models belong to the viewpoint aspect of organization analysis. Table IV contains the key responsibilities and constraints for the roles needed for achieving the goals of disruption management modelled in Figure 2.

Table IV. Role model for AOCC in case of disruption management

| Role name | Responsibilities | Constraints |
|---|---|---|
| Operations Control | Aircraft recovery: Find options for alternatives | Dependency on maintenance based on availability of a substitute aircraft or maintenance resources and complexity of the required maintenance |
| Crew Control | Crew recovery: Find alternative resources and keep crew duty times legal | Crew duty times, availability of stand-by resources, and dependencies on other flights |
| Maintenance Control | Aircraft: Ensure legality | Availability of maintenance resources |
| Ground Control | Turnaround process: Accelerate | Usually, the third party to which the turnaround procedure has been outsourced has no incentive to speed up turnaround |
| Passenger Control | Passenger recovery: Rebook and accommodate passengers | Availability of alternatives – flights or accommodation. Reputation is usually negatively influenced |
| Flight Dispatch | Flight plan: Speed up *en route* | A flight plan change should be approved by the Air Traffic Control |

### *D. Organization Model*

Organization model represents relationships between the roles. Organization models belong to the viewpoint aspect of organization analysis. A relationship can be defined as a control, benevolence, or peer relationship according to Sterling and Taveter (([13], p. 75). Figure 4 represents the organization model of the AOCC. The upper part of Figure 4 shows the relevant contextual organizational roles **Ground Operations**, **Crew Operations, Flight Operations**, **Maintenance & Engineering**, and **Revenue & Passenger Management**. These contextual roles represent organizational groups. They aggregate the key actors from the AOCC and outside actors related to the AOCC. The sub-roles of the AOCC denoted in Figure 4 by dark-filled roles include **Ground Control**, **Crew Control**, **Flight Dispatch**, **Maintenance Control**, and **Passenger Control**. All of them are peers to each other and are controlled by the **Operations Control** to maintain and control the day of operation. **Flight Dispatch** is a special role because it has the peer relationship with all the other organizational roles. Additional sub-roles denoted by white-filled figures in the lower part of Figure 4 are involved in a day of operation. They are essential for achieving the goals of the AOCC and disruption management modelled in Figures 2 and 3.

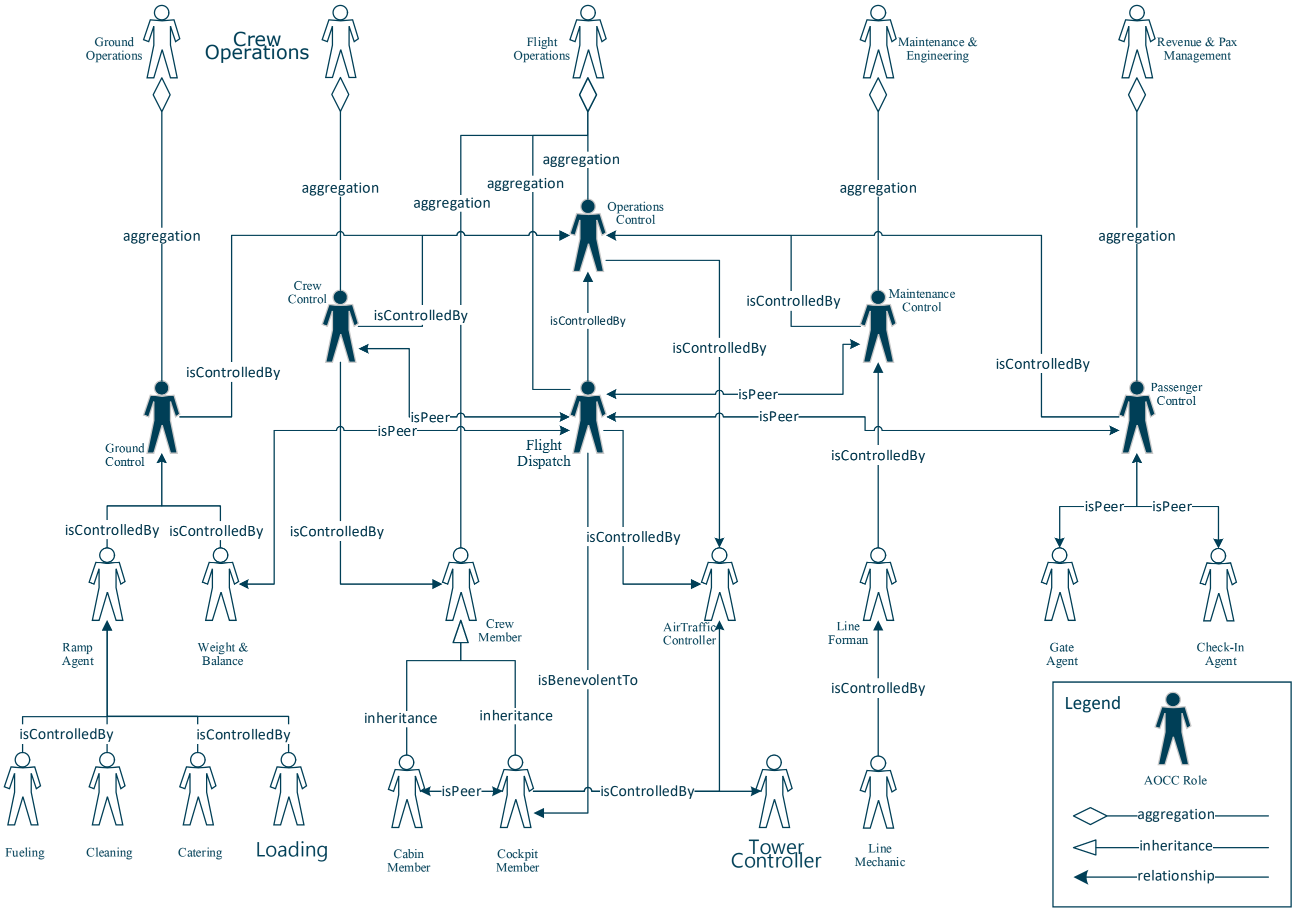


Figure 4. Organization model of AOCC

## *E. Domain Model*

Domain model represents the domain knowledge to be stored and handled within STS. Domain models belong to the viewpoint aspect of information analysis. Domain model consists of domain entities and relationships between them ([13], p. 76). The subject of the domain model represented in Figure 5 is the knowledge shared and handled within the AOCC. The AOCC domain model also includes the knowledge about disruptive events, their impact on cost and time, and the potential solution developed to mitigate the disruption. Additionally, the AOCC domain model represents technical systems – information systems – used by the AOCC as resources, which are denoted in the figure as AOCC environments by underlying their names. Resources are controlled by the performers of different roles. For example, the Maintenance Control System (MCS) is an information system overseen by **Maintenance Control** to track aircraft health status and provide **Operations Control** with the information about the aircraft airworthiness and legality. The MCS also stores aircraft maintenance data, such as Minimum Equipment List (MEL) and Configuration Deviation List (CDL), which are provided by a **Crew Member** before or after the flight, or through a **Line Mechanic** during the line maintenance checks. Finally, the MCS stores and provides information about the overall aircraft performance which is being utilized by the **Flight Dispatch** during the flight planning process and is forwarded to another information system – the Flight Planning System.

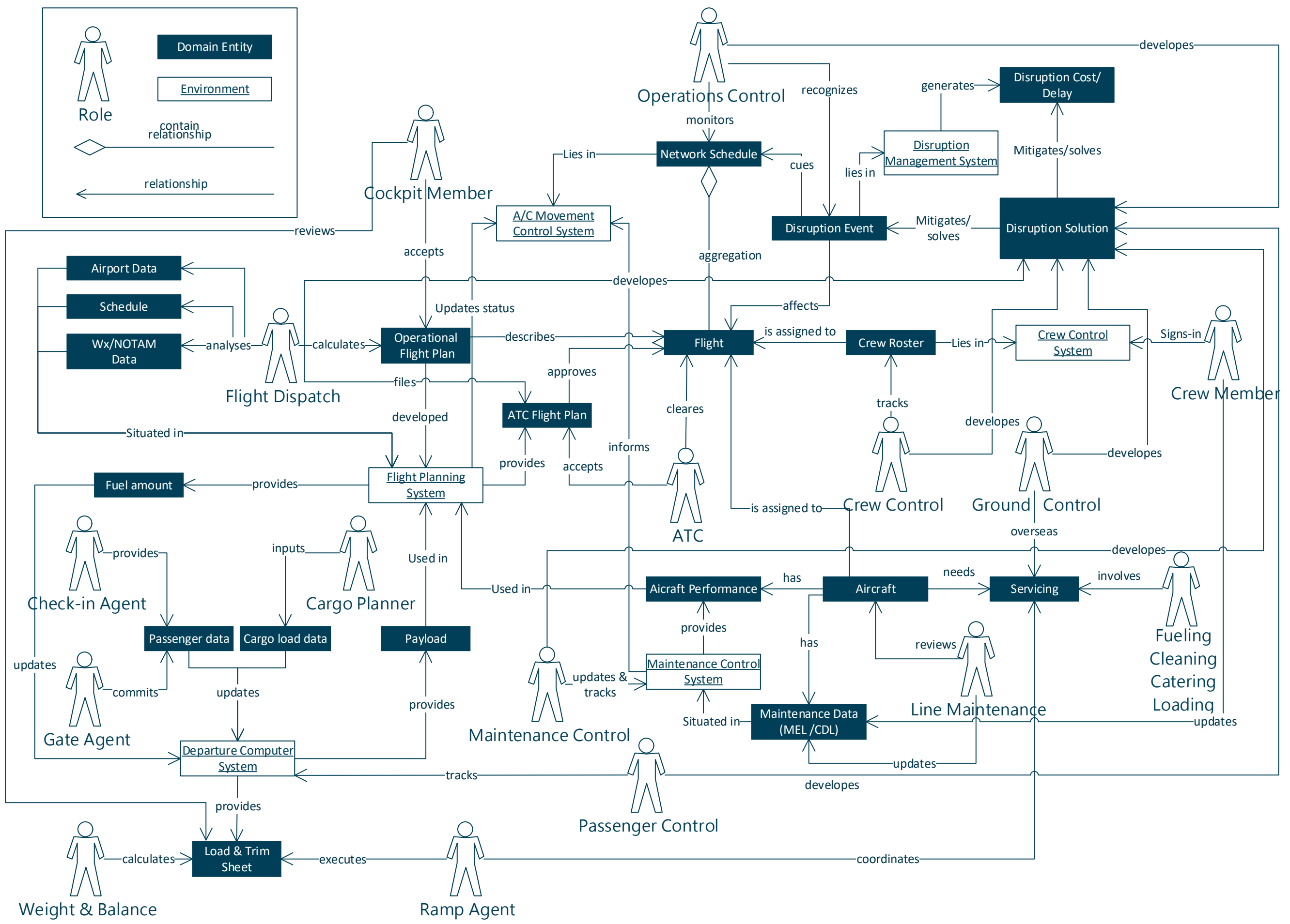


Figure 5. Domain model of AOCC

## IV. From Requirements to Design

As was stated in Section I, the requirements described in this paper serve the purpose of designing and implementing an agent-based simulation system [10] for the important social part of the AOCC STS – AOCC employees responsible for dispatching flights. As we pointed out in Section III.B, the technical dimension of STS is rather straightforward, as it is embodied in the corresponding information systems, such as various systems represented in Figure 5. Those systems make recommendations for solving disruptions in one way or another, effectively acting as decision-support systems. The social dimension is much more complex because of the inherent complexity of human decision-making processes. Considering this, the design stage of our work is concerned with designing simulation experiments to be performed with the social part of the AOCC STS. For this purpose, requirements for the greater STS described in Section III had to be represented and analyzed. Simulation experiments were designed as agent-based simulations of the human subsystem of the AOCC, where software agents performed the AOCC roles that are usually performed by humans [18]. Since this paper is concerned with requirements engineering for STS, we next just briefly outline the steps of the simulation system design, leaving treating the simulations for a different paper.

To manage a disruption, there are three basic kinds of solutions: passenger option, crew option and aircraft option. Those options are captured by the goal model shown in Figure 6, which elaborates the *Develop solution* functional goal represented in Figure 2. In Figure 6, the three solutions are modelled by the corresponding subgoals *Choose passenger option*, *Choose crew option*, and *Choose aircraft option*. The roles responsible for achieving these goals are respectively **Passenger Control**, **Crew Control**, and **Operations Control**. Each of the subgoals is characterized by the corresponding quality goals that are modelled from the perspectives of the relevant roles. For example, the quality goals *Minimal passenger compensation*, *Protected passenger* and *Minimal passenger delay* capture the decision-making criteria for choosing the passenger option from the perspective of **Passenger Control**. Figure 6 represents more elaborate options for each of the main solution types as lower-level sub-goals under the second-level goals *Choose passenger option*, *Choose aircraft option*, and *Choose crew option*.

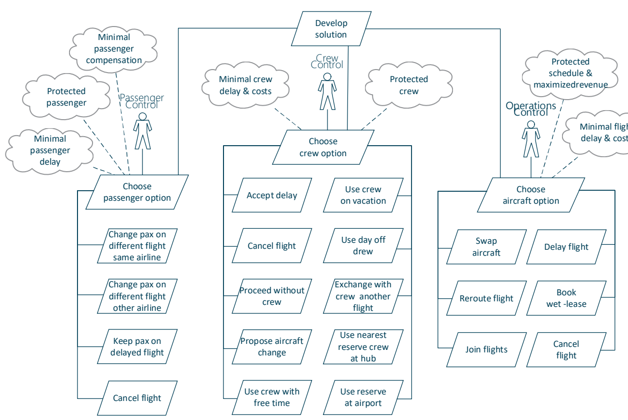


Figure 6. Goal model for developing a disruption solving solution

The goal model shown in Figure 6 is crucial as the foundation to develop the goal-driven behavior models of humans – the AOCC personnel – for simulating the decision-making process of disruption management. In Figure 6, some functional goals, such as *Cancel flight*, appear under several second-level functional goals. Since a given functional goal has the same meaning, no matter where it is in a goal tree, the decision to pursue one or another lower-level goal denoting a particular disruption solution is made based on evaluating how well the associated quality goals are met. By combining functional goals and quality goals pertaining to some role, such as **Passenger Control**, behavior models for agents playing the corresponding roles were developed which address the behavior perspective of the system design layer of the viewpoint framework shown as Table I. For executing the behavior model, a scenario of disruption management was defined that offered three different simplified solutions – cancel, reroute, and delay – to be chosen through collaboration between the roles **Passenger Control**, **Crew Control**, and **Operations Control**.

For evaluating the achievement of the quality goals defined for the corresponding roles, the *agent cost function* was derived based on [21]. The function evaluates each disruption management solution based on its cost and probability of success. For choosing one or another solution based on the return value of the agent cost function, the agent-based simulation also considers the simulated FFM personality profile of the AOCC decision-maker simulated by the agent. For example, whether the simulated decision-maker accepts the solution such as the passenger solution described in Table V, also depends on the FFM personality profile of the decision-maker, considering the goal-oriented planning process of a human [22-24].

Table V. Interpretation of goals for the **Passenger Control** role

| Role | Functional goal | Quality goals | Plan assessment | Solution | | |
|---|---|---|---|---|---|---|
| | | | | Cancel | Delay | Reroute |
| Passenger Control | Choose passenger option | Minimal passenger compensation, Protected passenger, Minimal passenger delay | Probability | Low | High | High |
| | | | Effort | Low | High | Med |

In the simulations, qualitative values 'low', 'high' and 'med' that were used in choosing a disruption solution, such as the passenger solution described by Table V, were interpreted as quantitative values [18].

Like the agent cost function for a human decision-maker, the *system cost function* represents the disruption solution offered by the information systems of the AOCC. This way, we put equal weights on the disruption solutions of the STS generated by (simulated) humans on one hand and (simulated) information systems on the other. The overall decision-making process is a collaborative majority-based decision-making process by the involved agents. The majority-based decision is made by applying the *agent selection function*. Figure 7 illustrates the decision-making process with the simplified cancel, delay and reroute options to be chosen between that are offered by simulated humans and simulated information systems.

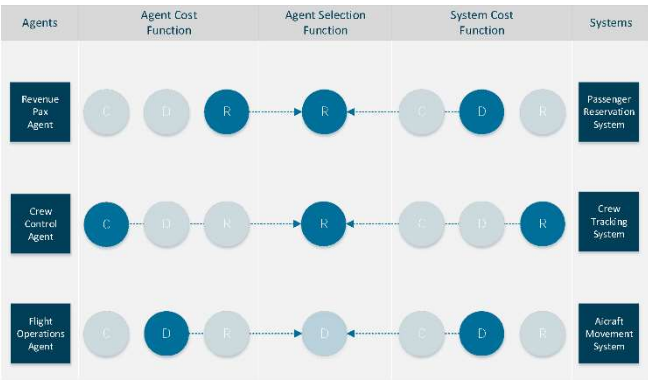


Figure 7. Disruption solution matrix with the *Cancel* (C), *Reroute* (R), and *Delay* (D) options

## CONCLUSIONS

This work discussed requirements engineering for sociotechnical systems, using the example of the AOCC. We specifically applied the viewpoint framework for ensuring holistic requirements representation from complementary perspectives and represented the requirements by the models included by the system analysis layer of the viewpoint framework. The requirements analysis addressed the organization, information, and behavior analysis viewpoint aspects of the AOCC. The application of the goal-oriented modeling approach allowed to differentiate between functional goals and quality goals. This is beneficial as qualitative concerns could be matched to personality-driven behavioral patterns, which, in turn, could be mimicked by agent-based simulations. This is the main novelty of our approach, as this kind of agent-based simulation of a social part of STS has been done for the first time according to the best of our knowledge. Importantly, a prerequisite for adequate simulations of a social part is eliciting and representing the requirements for the greater STS surrounding the social part to be simulated. Engineering requirements for the greater STS is the main topic of this paper. Moreover, our approach allows to represent technical dimension of STS equally well. For that matter, in the future work we plan to model the technical part of the AOCC STS in more detail and integrate into holistic modelling and simulation of decision-making processes within the AOCC. The result would be a simulation of the AOCC as a whole which can be used for exploring and optimizing the existing airline operations control solutions by means of agent-based and other types of computer-based simulations.

## ACKNOWLEDGMENT

The contribution by the second author to this publication has been funded by the IT Academy program of the European Social Fund.

## REFERENCES

[1] M. T. O'Hara, R. T. Watson, C. B. Kavan, „Managing the three levels of change," *Information Systems Management*, vol. 16, pp. 63-70, 1999.

[2] G. Baxter, and I. Sommerville, „Socio-technical systems: From design methods to systems engineering," *Interacting with Computers*, vol. 23, no. 1, 2011 pp. 4-17, 2011.

[3] I. Sommerville, *Software Engineering* (Ninth Edition), London, England: Pearson, 2009.

[4] P. M. Salmon, G. H. Walker, and N. A. Stanton, „Pilot error versus sociotechnical systems failure: a distributed situation awareness analysis of Air France 447," *Theoretical Issues in Ergonomics Science*, vol. 17, no. 1, pp 64-79, 2016.

[5] L. Sterling, and K. Taveter, „Event-based Optimization of Air-to-Air Business Processes," in N. Stojanovic, A. Abecker, O. Etzion, and A. Paschke, Eds., *2009 AAAI Spring Symposium: Intelligent Event Processing*, The AAAI Press, pp. 80-85, 2009.

[6] T. Miller, B. Lu, L. Sterling, G. Beydoun, and K. Taveter, "Requirements elicitation and specification using the agent paradigm: the case study of an aircraft turnaround simulator," *IEEE Transactions on Software Engineering*, vol. 40, no. 10, pp. 1007-1024, 2014.

[7] P. Bresciani, A. Perini, P. Giorgini, F. Giunchiglia, and J. Mylopoulos, "Tropos: An agent-oriented software development methodology," *Auton. Agents Multi-Agent Syst*., vol. 8, no. 3, pp. 203–236, 2004.

[8] E. Yu, P. Giorgini, N. Maiden, and J. Mylopoulos, *Social Modelling for Requirements Engineering*. Cambridge, MA: MIT Press, 2011.

[9] K. Taveter, and M. Meriste, "How can agents help in designing complex systems?", *Journal of Telecommunication, Electronic and Computer Engineering*, vol. 9, no. 2-9, pp. 1-8, 2017.

[10] C. M. Macal, "Everything you need to know about agent-based modelling and simulation," *Journal of Simulation*, vol. 10, no. 2, 144–156, 2016.

[11] K. Mooses, and K. Taveter, "Agent-Oriented Goal Models in Developing Information Systems Supporting Physical Activity Among Adolescents: Literature Review and Expert Interviews," *Journal of Medical Internet Research*, vol. 23, no. 5, 2021.

[12] G. J. Read, P. M. Salmon, N. Goode, and M. G. Lenné, „A sociotechnical design toolkit for bridging the gap between systems-based analyses and system design," *Human Factors and Ergonomics in Manufacturing & Service Industries*, vol. 28, No. 6, pp. 327-341, 2018.

[13] L. S. Sterling and K. Taveter, *The Art of Agent-Oriented Modeling.* Cambridge, MA: MIT Press, 2009.

[14] K. Taveter, H. Du, and M. N. Huhns, "Engineering societal information systems by agent-oriented modeling," *Journal of Ambient Intelligence and Smart Environments*, vol. 4, no. 3, pp. 227-252, 2014.

[15] I. Shvartsman, K. Taveter, M. Parmak, and M. Meriste, "Agent-oriented modelling for simulation of complex environments," in *Proceedings of the International Multiconference on Computer Science and Information Technology* (IMCSIT 2010), pp. 209-216, IEEE, 2010.

[16] I. Shvartsman, and K. Taveter, "Agent-oriented knowledge elicitation for modeling the winning of "hearts and minds"," in *2011 Federated Conference on Computer Science and Information Systems* (FedCSIS), pp. 605-608. IEEE, 2011.

[17] K. Taveter, and A. Norta, "Agile software engineering methodology for information systems' integration projects," in *Future Data and Security Engineering* (FDSE 2017), pp. 215-230. Springer, Cham, 2017.

[18] N. Zimmer, "*Socio-technical modeling and simulation of airline operations control*," Doctoral thesis, Technische Universität Braunschweig, Germany, 2020.

[19] I. Gambo, and K. Taveter, "A Pragmatic View on Resolving Conflicts in Goal-oriented Requirements Engineering for Socio-technical Systems," in *Proceedings of the 16th International Conference on Software Technologies* (ICSOFT 2021), SCITEPRESS, pp 333-341, 2021.

[20] T. Peters, "*Personality Traits Modeling of Operations Control Center (OCC) Personnel and Vocational Implications*," Master's Thesis. Technical University of Berlin, 2015.

[21] T. Doce, J. Dias, R. Prada, and A. Paiva, "Creating individual agents through personality traits," in *International Conference on Intelligent Virtual Agents*, pp. 257-264, Springer, 2010.

[22] S. Ahrndt, J. Fähndrich, and S. Albayrak, "Modelling of personality in agents: From psychology to implementation," in *Proceedings of the 4th International Workshop on Human-Agent Interaction Design and Models* (HAIDM 2015), pp. 1-16, Smart Society Project, 2015.

[23] J. K. Connor-Smith, and C. Flachsbart, "Relations between personality and coping: A meta-analysis," *Journal of Personality and Social Psychology*, vol. 93, no. 6, pp. 1080-1107, 2007.

[24] I. Robertson, D. Bartram, and M. Callinan, "Personnel selection and assessment," in P. Warr, Ed., *Psychology at Work*, pp. 100–152, Penguin Press, 2002.