

# Classification and Argumentation Maps as support tools for liability assessment in ATM

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**Abstract** — In this paper we present an application of argument maps for assessing the liability impact of ATM systems. Such application has been recently developed within the ALIAS Project (Addressing the Liability Impact of Automated Systems), co-financed by EUROCONTROL on behalf of the SESAR Joint Undertaking.

*Argumentation maps; legal risk; liability assessment; Air Traffic Management*

## INTRODUCTION

Communication of legal concepts is often a very difficult task, especially between lawyers and experts who have no legal background, yet whose professional activities frequently intersect with serious legal questions. The difficulties increase when legal norms must be applied to complex socio-technical systems (STSs): such systems, characterized by complex interactions among human and technological components, can be seen as norm-governed systems, whose structure and behaviour strongly depend on legal and social institutions. Moreover, STSs are exposed to serious legal risks in case of adverse event. A mutual understanding among technical experts and lawyers is therefore crucial in order to design STSs, understand their functioning, and increase their efficiency and safety. However, this is not an easy task. Air Traffic Management is an example of this: on the one side, technical expert and operators have difficulties in grasping the complex normative structure regulating the system, which include different layers of norms (international, supranational, national legislation, technical rules, certification procedures, contractual clauses, etc.); on the other side, lawyers do not have the background of expertise needed to understand the details of the technical infrastructure and of the processes carried out by automated systems and human operators.

The ALIAS Project has recently developed a methodology, called “The Legal Case” (LC), which will help an interdisciplinary team, made of legal experts, engineers, software developers and other technical personnel, to foresee and mitigate the legal problems that an automated technology under construction might cause. In particular, the LC intends to foster the integration of any technology in the ATM system by

addressing the associated liability risk in a just and transparent way. To achieve this, the LC makes a wide use of argumentation maps as modelling tools for the legal risk analysis. The use of the legal maps covers the following functions:

- Connecting tool: the maps represent an innovative way to structure and connect information about the system and its possible failures on the one side, and the applicable legal framework on the other side: failures are mapped according to consolidated approaches adopted by the human factors domain [1][2], and connected to a mapping of possible liabilities, according to an actor-based framework of liabilities in ATM developed within the project;
- Communication tool: the maps provide support not only for organizing the legal and technical information in a way as to foster the process by which the lawyers and other stakeholders build their knowledge, but they also work as a powerful communication tool between stakeholders having different backgrounds and expertise, and speaking different professional “languages”: the visual representation provided by the maps improves shared reasoning and analysis of complex issues;
- Assessment tool: the maps provide a support for the legal risk analysis carried out in the LC: they assist the user in identifying and evaluating the legal risks.

Two kinds of maps are used in the LC: classification maps and argumentation maps. They are described as follows:

- Classification maps are meant to provide taxonomies of the objects within a certain domain. They consist in boxes linked simply by lines in either the direction top-down or the direction left-right. The boxes can be expanded and collapsed at different levels, since the classification maps can be multi-level. The goal of the classification maps is to help the Legal Analyst to structure his thinking and to focus his attention on specific level of classification. The classification maps

proposed to be used in the LC process are two: the failures maps and the legal risks maps. The **failures-maps** (engaged in step 1.3 of the LC) intend to map and classify the possible failures and damages resulting from the deployment and use of an automated technology. The **legal risks maps** (engaged in step 2.1 of the LC) link each failure to hypotheses of liability and propose one or more hypotheses of liability for each of the involved actors;

- Argumentation maps, instead, are visual representations of the structure of arguments: they include the components of an argument such as a main contention, premises, co-premises, objections, rebuttals. Argumentation maps are represented as diagrams with boxes corresponding to propositions and arrows corresponding to relationships between them. The goal of the argumentation maps is to link the premises (reasons) to a conclusion, either by supporting the conclusion or by attacking the premises (reasons) or the inference which brings to the conclusion. The argumentation maps proposed to be used in the LC process are two: the legal analysis maps and the legal design maps. The **legal analysis maps** (engaged in step 2.2 of the LC) intend to help the Legal Expert analyzing the legal rules and arguments which could support the attribution of liability, for each of the hypotheses previously identified, taking into account the applicable legal framework, and the factual circumstances of the accident resulting from the failures. The **legal design maps** (engaged in step 3 of the LC) enable the users to validate the legal design measures addressed for mitigating the liability risk identified in the previous step.

The scope of the current paper is to provide detailed information on how the classification and argumentation maps are engaged in the LC methodology. In line with this, the paper is organized in four parts, as follows:

Section I provides an overview of the LC methodology, addressing the description of each step and highlighting where the maps are proposed to be used across the whole process.

Section II provides detailed information on how the maps are engaged in the concerned steps of the proactive application of the Legal Case methodology.

Section III provides information on how the maps can support the retroactive application of the Legal case methodology.

Section IV provides conclusive remarks about the innovative value of the classification and argumentation maps as a way to structure and connect information about system failures and legal discipline.

## I. THE LEGAL CASE: OVERVIEW OF THE METHODOLOGY

As anticipated, the Legal Case is the methodological tool recently developed by the ALIAS Project so as to facilitate and smoothen the integration of the highly automated technologies into complex socio-technical systems, which in

our case, deal with air traffic management (ATM). In particular, the overall goal of the LC is to address the liability issues resulting from the interaction between humans and automated technologies, in such a way that these liability issues would not hinder the design, development and deployment of these technologies.

The Legal Case methodology is basically a legal risk management process. The 'legal risk management' approach considers legal risk as one of the components of risk management [3]. It addresses legal risk as a distinct type of risk, which is an isolatable part of the overall risks faced by a stakeholder. By legal risk we mean the probability and the severity of an unwanted legal outcome, being triggered by uncertain factual circumstances and/or uncertain future legal decisions. The legal risk management approach provides a systematic structure to identify, describe, analyze, evaluate and provide feedback on legal risks. In particular, the Legal Case provides for a participatory and interactive model for legal risk management. This, on one hand, favours an interdisciplinary perspective; on the other hand, it facilitates communication and integration of the legal risk management into the overall risk management procedures.

The LC offers two ways in dealing with the legal risk associated to the ATM systems: proactive and retroactive. The proactive perspective addresses the legal risks during the design phase of the system's lifecycle and is meant to prevent or mitigate legal risk, that is, it is anticipatory. The retroactive perspective addresses the legal risks which arise at the deployment phase of already existing automated technologies and intends to offer a strategic response to legal risks that have already taken place (or may take place in the future) thus providing a structure for their containment..

In line with this, the Legal Case can ideally be applied to any automated system, both under development or in operation. We assume that both proactive and retroactive applications of the Legal Case will be performed under the guidance of a *Legal Analyst*, namely, a person having a legal background in aviation and liability law which enables him/her to understand the legal issues involved in a project or accident. Obviously, the Legal Analyst will need to call on other skills available within the project or outside of it, in case that further technical knowledge is required. In fact, legal knowledge is necessary to deal with the liability topics while engineering knowledge and human factors are essential for the understanding of the technical and operational features of the object of the analysis, i.e., the automated process under examination. Thus, the Legal Analyst is assumed to be a member of an interdisciplinary project team dealing with the design or deployment of automated technologies. In this respect, the Legal Case can be conceived not only as a legal risk management tool, but also as a communication channel between different expertise and domains of knowledge. We also assume that the end-users of the Legal Case results could be the decision-makers, who could profit by the results of the Legal Case to make decisions and plan investments. In this sense the Legal Case can be considered as a decision support and planning tool.

The generic process of the Legal Case consists of four steps (Figure 1):

1. Understand the context. This step requires the collection of a set of background information about the object of the study (which may be an operational concept, a system, a service, or an accident in which a piece of technology played a crucial role);
2. Identify liability issues. This step defines the legal implications of the object of the study on the basis of the understanding of its socio-technical aspects.
3. Perform the analysis. This step analyses the stakeholders' acceptability of the legal implications defined in previous step, proposes ways to deal with all involved legal risks, and proposes possible mitigations and recommendations for the design.
4. Provide results and recommendations. This step presents the results of the study, highlighting the liability issues associated with the object of the study, the ways to deal with legal risks and further recommendations.



Figure 1 - the generic LC process

Each of the 4 steps is centered around the use of sets of argument maps developed using Rationale by Austhink (<http://rationale.austhink.com/>): these maps play a crucial role in the construction of a legal case for a new technology, by enabling the Legal Analyst to capture the logic of the legal issues, to explain them to non-lawyers, and make possible solutions understandable and subject to deliberation. The UML activity diagram in Figure 2 shows the workflow of the Legal Case. Round-cornered rectangles represent actions, i.e., substeps within each step of the Legal Case. Square-cornered rectangles represent a flow of objects from one action to another – that is, the information produced in each sub-step of the legal case. Bold arrows represent the main workflow. Light arrows represent other connections between object and actions – that is, the information used as an input for each sub-step.

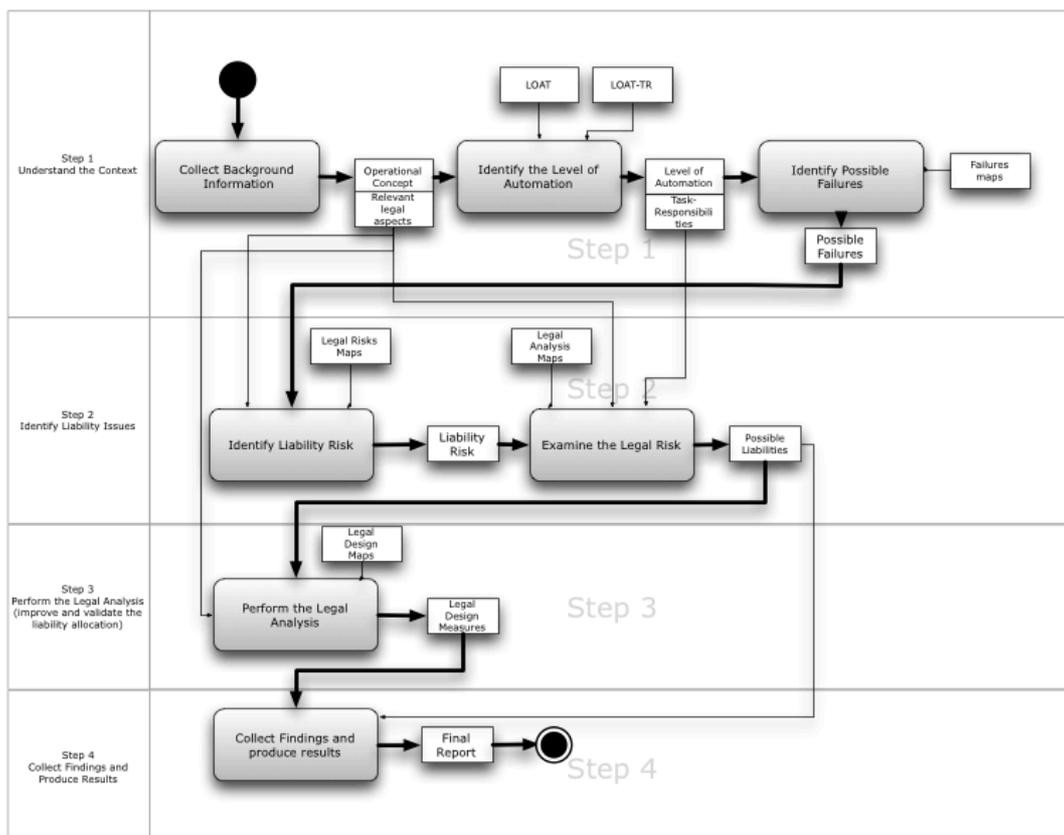


Figure 2 - UML activity diagram for the LC

As it is possible to see in the figure, the workflow shows the allocation of the complete set of maps (Failures maps, Legal Risks maps, Legal Analysis maps and Legal design maps) across the whole process, thus also highlighting how each of them serves as relevant input for the following actions.

In the following sections we provide a description of these maps and how they are engaged in the concerned step of, respectively, the proactive and retroactive applications of the Legal Case methodology.

## II. THE USE OF THE MAPS IN THE PROACTIVE APPLICATION OF THE LEGAL CASE

### A. The first step of the analysis: the failures-maps

Step 1 – Understand the Concept – has the threefold purpose to i) collect background information about the ATM concept being designed, ii) classify the level of automation of the associated system or technology, and iii) identify the possible failures of this new operational concept. We assess the level of automation of the system or technology (ii) with the help of the Level of Automation Taxonomy (LOAT) [5]. The LOAT is a tool helping to identify and assess the support that the automated system provides the human with: in particular, it divides the human-machine interaction into separate tasks (information acquisition, information analysis, decision and action selection, action implementation) showing in each of them how the tasks are divided between the human and the machine. In other words, the LOAT helps the Legal Analyst to see the significant changes in this allocation of tasks and alerts him to examine their legal significance.

A set of classification maps has been developed in order to identify risks of failures related to the development, training, use and maintenance of automated technologies, and different types of damages that may emerge whenever such failures result in accidents. The failures-maps have been developed on the basis of the socio-technical framework developed within ALIAS, according to which failures are divided into latent conditions and active errors: latent conditions may be either technical or organisational, while active errors may be either technical or human. Active errors are those acts or events that can be directly linked to the accident, such as the unsafe actions on the part of the operators that ultimately led to the accident, or the malfunctioning of one of the hardware components, etc. Latent conditions are those that may lie dormant or undetected for hours, days, weeks, or even longer, until one day they contribute to a sequence of events resulting in an accident. Examples of the latter are bad organisation of work processes, bad maintenance of hardware components, bad management of safety or training, etc.

The failures-maps present the list of failures through a tree-shaped structure. The failures-maps structure is a multi-level set of predefined types of failures that serve as a basis for identifying the potential failures of the project in question. The structure is multi-level, being composed of the four top-level failures. For each kind of failure, a different branch of the map shows a set of different sub-types of failures. For instance in Figure 3 below we show how the latent technical conditions can come in the form of, for instance, the absence or insufficiency of (or even defective) maintenance of essential safety tools, or the malfunctioning of safety devices.

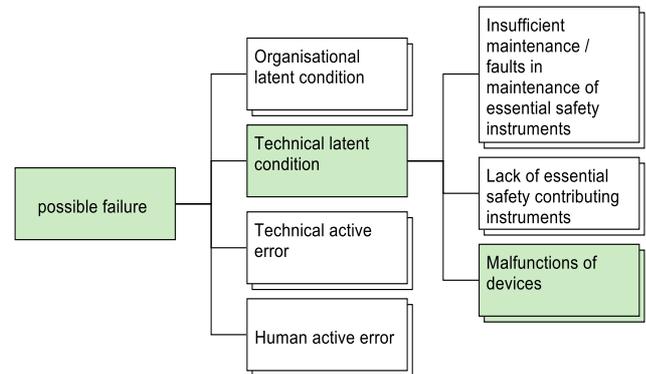


Figure 3 - the failures-maps

### B. Step 2: Legal Risk And Legal Analysis Maps

In the following step – Step 2: Identify the liability issues – we assess the risk of liability in the light of the existing legal framework. We perform this assessment with the help of two kinds of maps: legal risks maps and legal analysis maps.

A legal risk map is a support tool for highlighting the liability risks associated to the possible failures identified in the previous step. It links a particular factual constellation (in particular a kind of failure) to a possible legal liability. The purpose of legal risks maps is to suggest kinds of legal liabilities to be investigated for each possible failure identified in Step 1. The legal risks maps are classification maps: the main kinds of failures (first level of the mapping structure) are connected to the possible legal liabilities (second level of the mapping structure) resulting from them. In particular, each type of failure is linked to different hypotheses of attribution of liability to one or more of the subject involved (pilots, air traffic controllers, air carriers, air service providers, manufacturers, etc.).

The following map (Figure 4) shows a list of potential technical latent conditions, and related liabilities emerging from them.

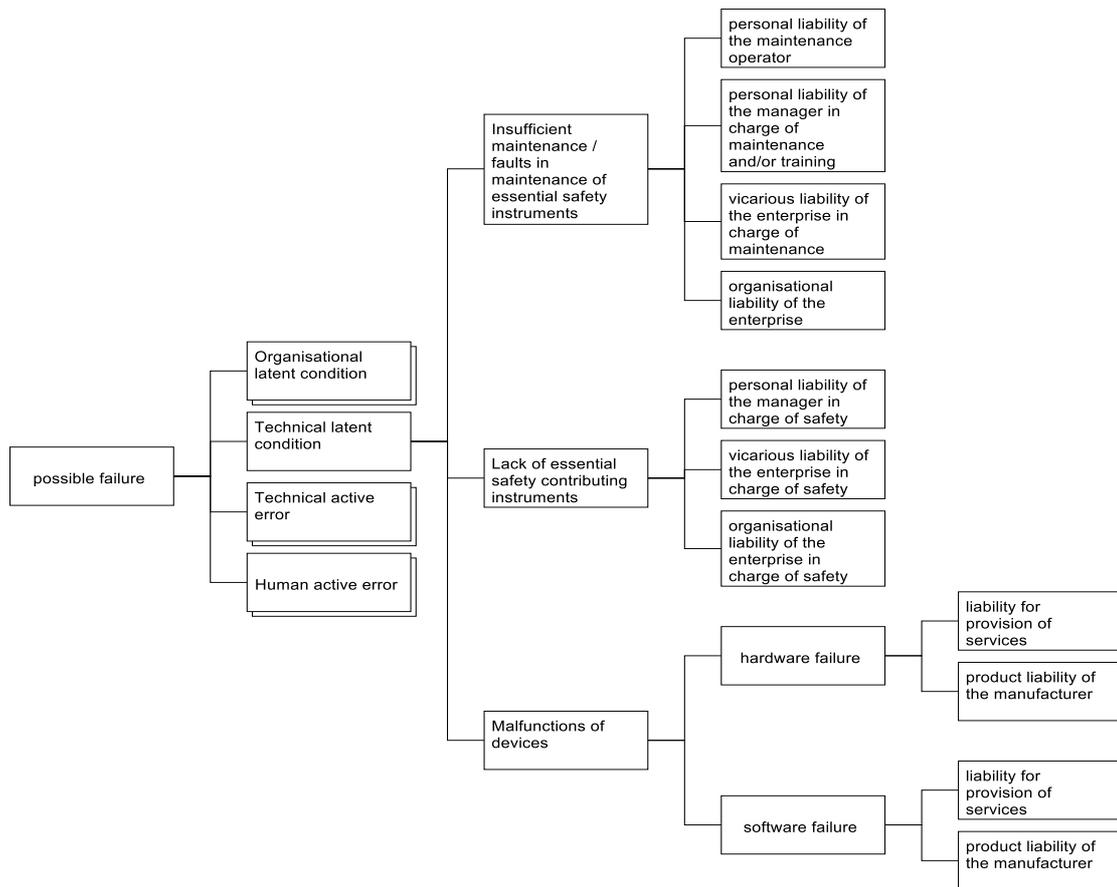


Figure 4 - risk liability map for technical latent condition

For instance, technical latent conditions, which could lead to an accident involving the Traffic Collision Avoidance System (TCAS), could be those regarding insufficient capacity of TCAS processors to compute advisories updates. This could engender product, organisational or managerial liabilities. Similarly, in the System Wide Information Management (SWIM) system, damage could result from prolonged technical shortcomings, deriving from the fact that the system had been upgraded with new functions without considering side effects and without ensuring compatibility with pre-existing functions. In this case organisational and managerial liability may be at issue, together with (software) product liability and with various contractual liabilities. Technical latent conditions could also threaten the functioning of Remotely Piloted Aircraft Systems (RPAS) in case in which

the software calculating avoidance maneuvers was malfunctioning, because it was not adequately tested. Here organization, managerial and product liability may be at issue, with regard to user, maintainer and the developer.

Another set of maps links damage to liability: usually liability is triggered by a damage (civil liability may be seen as the obligation to compensate for a damage). Moreover, according to the legal framework of ATM, different kinds of damages (onboard, on the ground, to passengers, to baggage, to third parties, above or below different values, etc.) may trigger different kinds of liability for the different actors involved in the event from which the damage arises.

For instance, the following map (Figure 5) shows the hypothesis of liability emerging from damages arising from accident taking place on board of the aircraft.

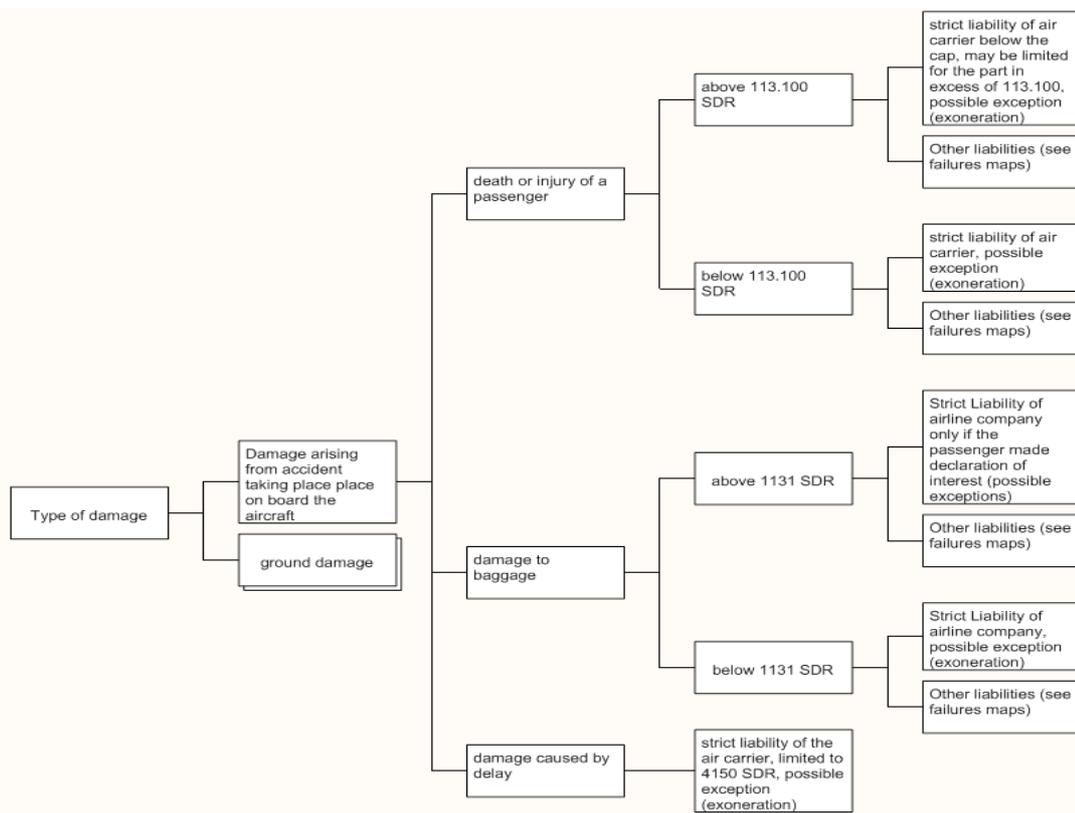


Figure 5 - damages map

After having built the legal risk map, the Legal Analyst needs to examine the possibility that a legal risk concerning a particular actor occurs in different contingencies. To do this, he can rely on the legal analysis maps (supported by the relevant legal and empirical knowledge).

Legal analysis maps reflect our understanding of the law on liability as it is represented in the current legal framework concerning air law, product liability, insurance and contract law. The answer which the Legal Analyst looks for through the map is whether there is the risk of a particular kind of liability, and this will be established by checking whether the conditions for that kind of liability may exist under some possible circumstances. Initial hypothesis of attribution are validated with the help of an extensive set of argument maps, which cover different types of liability (personal liability, enterprise liability, product liability, special cases of liability such as air carrier liability, etc.). In such maps arguments supporting the attribution of liability are combined which 1-level counterarguments attacking (by rebuttals and under cutters) the liability arguments, with further level counterarguments, providing attacks against 1-level

counterarguments, and so on. In this way a dialectical tree is built for each potential liability.

For example, the map shown below (Figure 6) explains the underlying legal logic of finding a product manufacturer liable in case of a defective product. The first thing to do is to check whether the technology is a product or a service from the legal point of view, and this map shows that we assumed that the technology in question is a product. The map shows that the defectiveness of a product might be related to the unreasonably dangerous design and, with the help of the Legal Analyst, the interdisciplinary team consults the jurisprudential texts on this matter to understand what the concept of unreasonably dangerous entails.

The legal analysis map also shows two possible defences against product liability, namely, that first of all the product was designed according to the current state-of-the-art in particular technological field, and, secondly, that the technology was built in compliance with the relevant technical standards and regulations. However, compliance with a standard is not enough to exonerate a producer from liability claims.

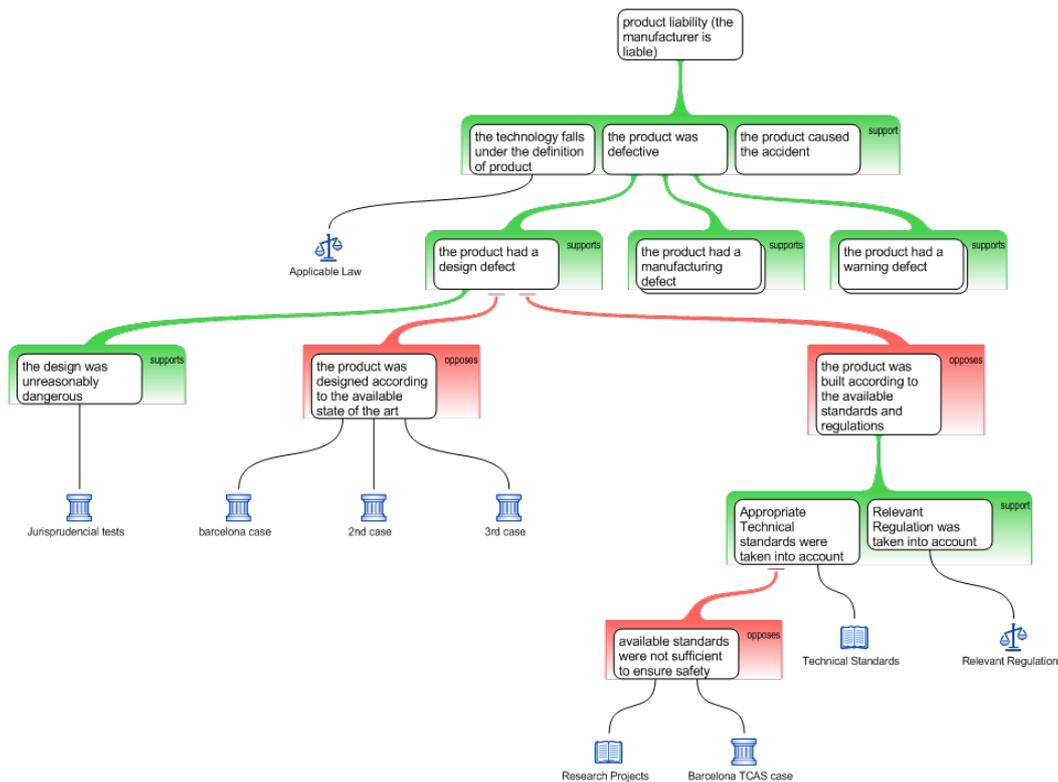


Figure 6 - legal analysis map for product liability

### C. The Third Step, Perform the Legal Analysis: Legal Design Maps

The third step – Perform the legal analysis – consists in engaging in legal design on the basis of the results of the legal analysis performed in the previous step. By legal design we mean proposing possible mitigations and recommendations for the systems design. Such mitigations and recommendations are targeted towards optimal acceptability of the liability risks for all stakeholders. This involves complementing the outcomes of the legal responsibilities analysis with private (contractual) legal regulations meant to ensure an allocation of liabilities which is acceptable to the parties. Three fundamental liability-design measures can be decided upon at this stage: Liability mitigating measures; Liability enhancing measures; Liability displacing measures.

In this step the argumentation maps allow the user to design and validate the legal design measures that may mitigate such risks. This concerns making changes in the

allocation of liabilities and considering what impact this has on the liability risks which are to be supported by each party.

In particular, we build Legal Design maps (Figure 7) which help to find suitable liability design measures, measures able to suggest different solutions to the problem of eventual liability for any failure that the technology in question could cause. For instance, the argumentation map represented in Figure 5 suggests that if a product has design defect, although it followed all the rules known to the state-of-the-art in that particular technological field, the air company is still liable because the rule of the state-of-the-art defense does not work in the aviation. This is why our map suggests to the stakeholders to place a stricter liability clause on technology (in our case, software) producer. This is however, just a suggestion and numerous other options are possible on how to re-balance the burden of liability among the stakeholders involved in design, development and deployment of highly automated technologies in the ATM.

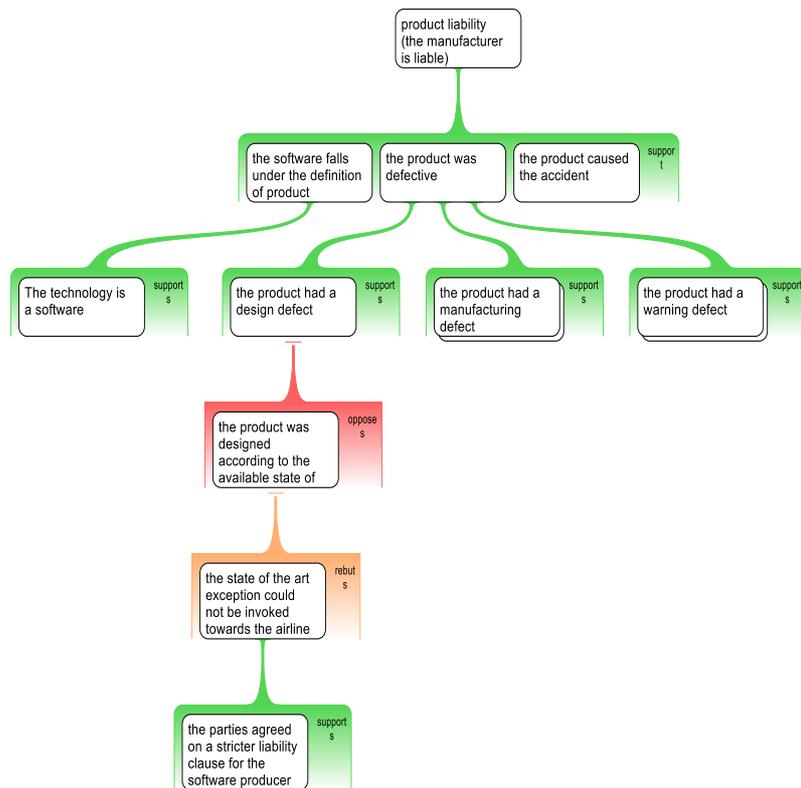


Figure 7 - legal design maps

In the last step – Step 4: Collect findings and produce results – the results of the analysis are presented to the stakeholders, highlighting the liability issues associated with the automated technology, the ways to deal with legal risks, and further recommendations. If all stakeholders agree with the results, the information regarding liability attribution and measures will be included in the concept documentation, so as to be implemented into contractual and other private agreements. We do not exclude that such agreements might not be achieved, and this is why we assume that if this is the case, the parties will reconsider the possibilities of a different legal design, but also the necessity to reconsider the allocation of tasks and the deployment of the technology – which will, in turn, also imply a need to re-examine the results of Safety and Human Performance Cases.

### III. THE USE OF THE MAPS IN THE RETROACTIVE APPLICATION OF THE LEGAL CASE

As already said, the Legal Case methodology supports also a *retroactive* application, which is intended to assess liability issues of already deployed technologies. The difference from the proactive application is that rather than being performed by an interdisciplinary design team, the retrospective application is carried out by an assessment team. Furthermore, differently from the proactive approach, the data on technology and its use can be obtained from the documentation (incident reports, handbooks, procedures, guidelines, past similar accidents, etc.), which is lacking in the proactive application. Finally, the results produced in

retroactive approach will focus on the current legal arrangements between the stakeholders (in particular contracts and insurance policies) and not on the suggestions on how the technology should be modified.

In the retroactive application, the second step (the analysis of the legal risk) concerns whether the accident being investigated can engender any particular liability and this will be established by checking whether the conditions for that liability exist in the given circumstances.

For this purpose, general legal analysis maps (which links a possible legal responsibility to the preconditions of its existence instantiated in the accident) can be supplemented and connected with more specific maps, which model the reasoning of the court which will deal, or has already dealt, with the accident in a particular legal system. For example, Figure 8 below shows a fragment of the complete set of arguments used by judges and parties in the Barcelona Appeal judgment of 2012, in assessing the product liability of the producers of the TCAS involved in the Uberlingen accident. The Barcelona Court considered TCAS II version 7 to have design defects, and hold the producers liable for product liability.

By connecting such specific maps to the general maps, the parties can predict or control the reasoning of the judges, and also avail of more specific indications concerning the open issues for the continuation of the case. For instance, the parties may consider whether to accept the outcome of the case, or to challenge it before a superior court.

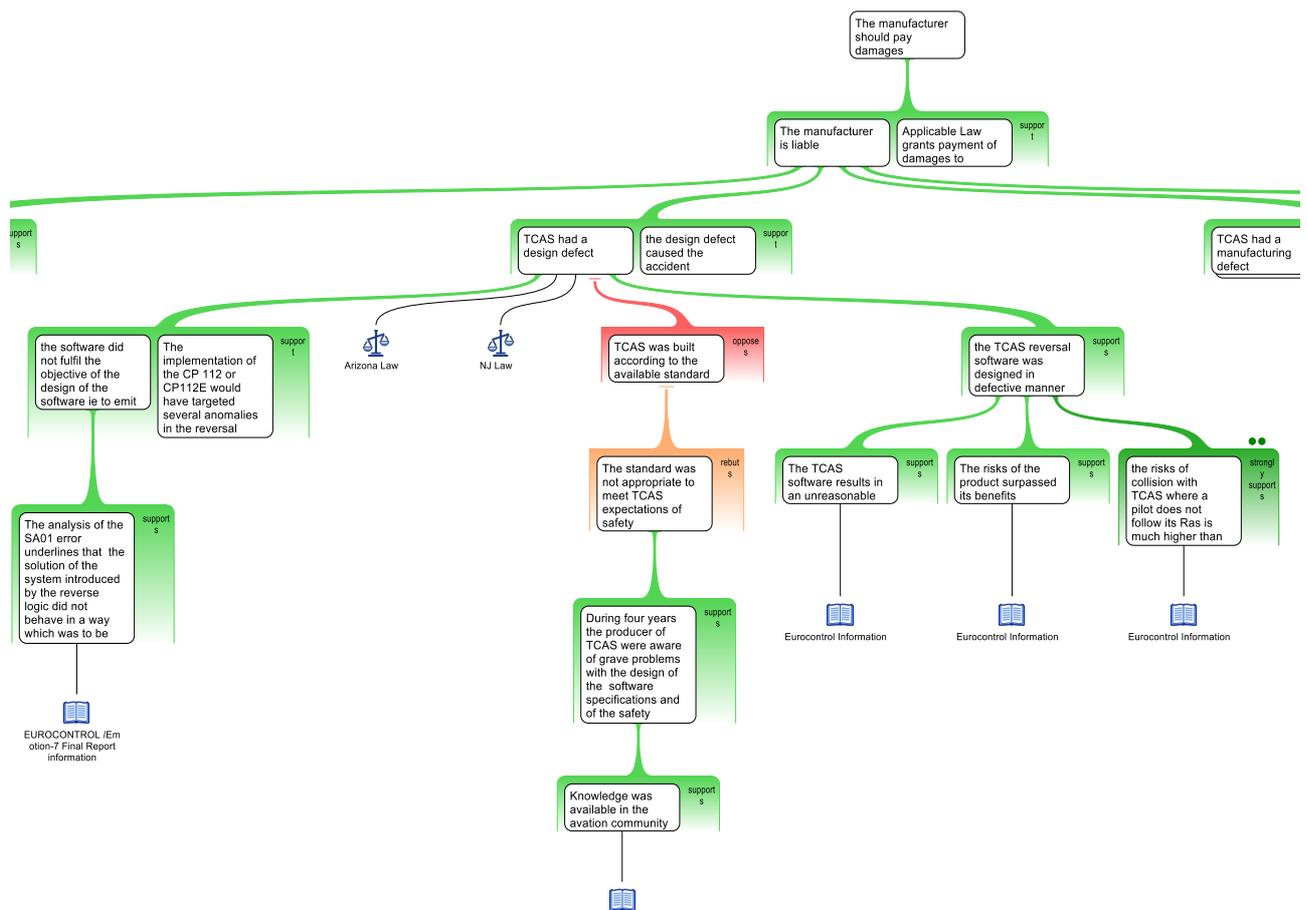


Figure 8 - argument maps for TCS judgement (section concerning the design defect)

#### IV. CONCLUSIONS

Although not yet finalised, the Legal Case methodology is gathering great interest from the ATM community. Industrial suppliers, ANSPs, research centres and authorities are unanimous in recognizing the need to address the liability impact of automated systems as early as possible during the project's lifecycle. Furthermore, the LC methodology represents a new approach in bridging the technological innovation and the legal perspective, and may be considered a novelty also for the legal domain, where very few legal scholars have endeavoured to design, develop or study legal risk management methods [4]. In addition, the maps have the capacity to present even very complex legal argumentation in a readily accessible and schematic manner, to an audience of non-legal experts. Besides linking the maps to source materials (case law, legislation, other documents regarding technologies, accidents, stakeholders, etc), and providing a more in-depth coverage of the most important and controversial subject matters (such as software liability), we intend to make the maps more interactive, enabling users to visualize and browse them on the web. The next release of the methodology will ought to enable the users of these argumentation maps to change old and add new arguments, personal notes and other information. The models provided in the Carneades [5] and OVA (Online Visualisation of Arguments) will be particularly

significant in this regard. The project will also consider providing automated assessment of the status of arguments, for instance according the semantics of Carneades [6] or of the ASPIC<sup>+</sup> system [7].

Furthermore, we want to investigate ways to quantify the legal risks emerging from the maps, which involves the combination of the quantification of possible losses resulting from litigation, and of the probability of such losses, for instance, developing some approaches combining studies in legal argumentation, probability and game theory [8].

Finally, the LC also represents the practical application of the legal argumentation maps, specifically developed to deal with the issues of liability: both in proactive and retroactive applications they contribute to build a common knowledge not only for the lawyers but also for non-lawyers involved in the technology's lifecycle. Needless to say that from this perspective, the legal argumentation maps used in LC are the key asset for dealing with communication breakdowns that so often arise in highly technologically developed contexts, which—although in need of legal involvement—are unable to dialogue with it.

Ultimately, the Legal Case will provide an important tool also for policy makers. Multiple parallel or joint applications provide much needed information about the allocation of liability from different perspectives that comprise all relevant stakeholders. Where several projects discover similar liability

misalignments these problems can be raised on a higher level. In the future, the potential of the Legal Case to address systemic issues will be strengthened, supporting policy makers to take action at systemic level.

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