



WHY-BECAUSE ANALYSIS

USING

SERAS[®] ANALYST

WHY-BECAUSE ANALYSIS

Why-Because Analysis (WBA) is a rigorous method for the analysis of undesired system behavior and failures (incidents and accidents). WBA determines the causal relations between the factors contributing to the incident and can be applied informally, semi-formally or as a formal method.



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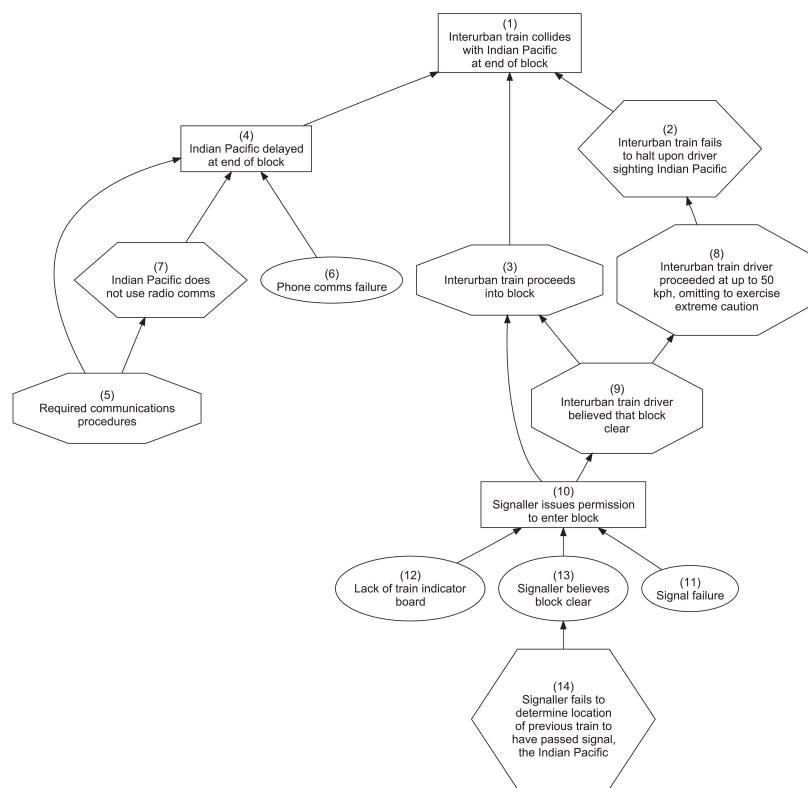
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WBA makes no assumptions either about the kind of technical or sociotechnical system whose behavior is to be investigated or about its structure. It is therefore not limited to any particular application domain, and has been successfully applied to incidents in aviation, rail, shipping, computer-security and electricity-blackouts. WBA is successfully used in industry and in court cases.

The formality of WBA allows the objectivity, reproducibility and relative completeness of a causal explanation to be assessed.

Why-Because Graph



The results of a WBA are presented primarily in a Why-Because-Graph (WBG), a graphical presentation of the causal relations between factors. A WBG can easily be interpreted by non-experts and is a simple representation of a sometimes complex set of causal relations. The WBG is accompanied by a Timeline, which lays out the times of occurrence of the factors and their participating entities ("actors").

Mathematically speaking, a WBG is a directed acyclic graph whose nodes represent the causal factors and whose edges show that one node is a necessary causal factor (NCF) of another. The Counterfactual Test (CT), formulated by David Lewis after David Hume, is used to determine whether one factor is an NCF of another: factor X is an NCF of factor Y if, when factor X had not been present, factor Y would not have been present either. With

practice, analysts often build a WBG using intuitive judgement, and then apply the Counterfactual Test to check carefully the correctness of the graph they have built.

The Causal Sufficiency Test (CST) is used to establish relative completeness of a WBG as an explanation of an incident: one asks whether, if all displayed factors (NCFs) of a node X are present, whether X must necessarily then be present. If the answer is yes, then the set of NCFs of X is deemed relatively complete. If no, then some factors of X are still missing and must be looked for. The explanation represented by the entire WBG is deemed relatively complete if each factor in WBG has a relatively-complete NCF set.

Both CT and CST are applied locally, to a factor and its immediate neighbors. If the tests are fulfilled by all small regions of the graph, then entire WBG is deemed both correct and relatively complete. This way of establishing a global property of the WBG through purely local judgements keeps even a complex analysis manageable.

SERAS[®] ANALYST PROGRAM SURVEY

MANAGEMENT OF WBA PROJECTS

Project Name	Last Opened	Filename	Created	File Found	Current Project
New Graph	11-Sep-2007	workspace_1188560280974...	31-Aug-2007	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Lathen 22.9.2006	11-Sep-2007	workspace_1189156403474...	07-Sep-2007	<input checked="" type="checkbox"/>	<input type="checkbox"/>
Longford Gas Plant Explosion	11-Sep-2007	Longford Gas Plant explosion.y...	11-Sep-2007	<input checked="" type="checkbox"/>	<input type="checkbox"/>
The Ueberlingen MidAir, Germ...	12-Sep-2007	ueberlingen.ybt2	12-Sep-2007	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>

Project location: /Users/drvolkerherrmann/YBT2Projects/ueberlingen.ybt2

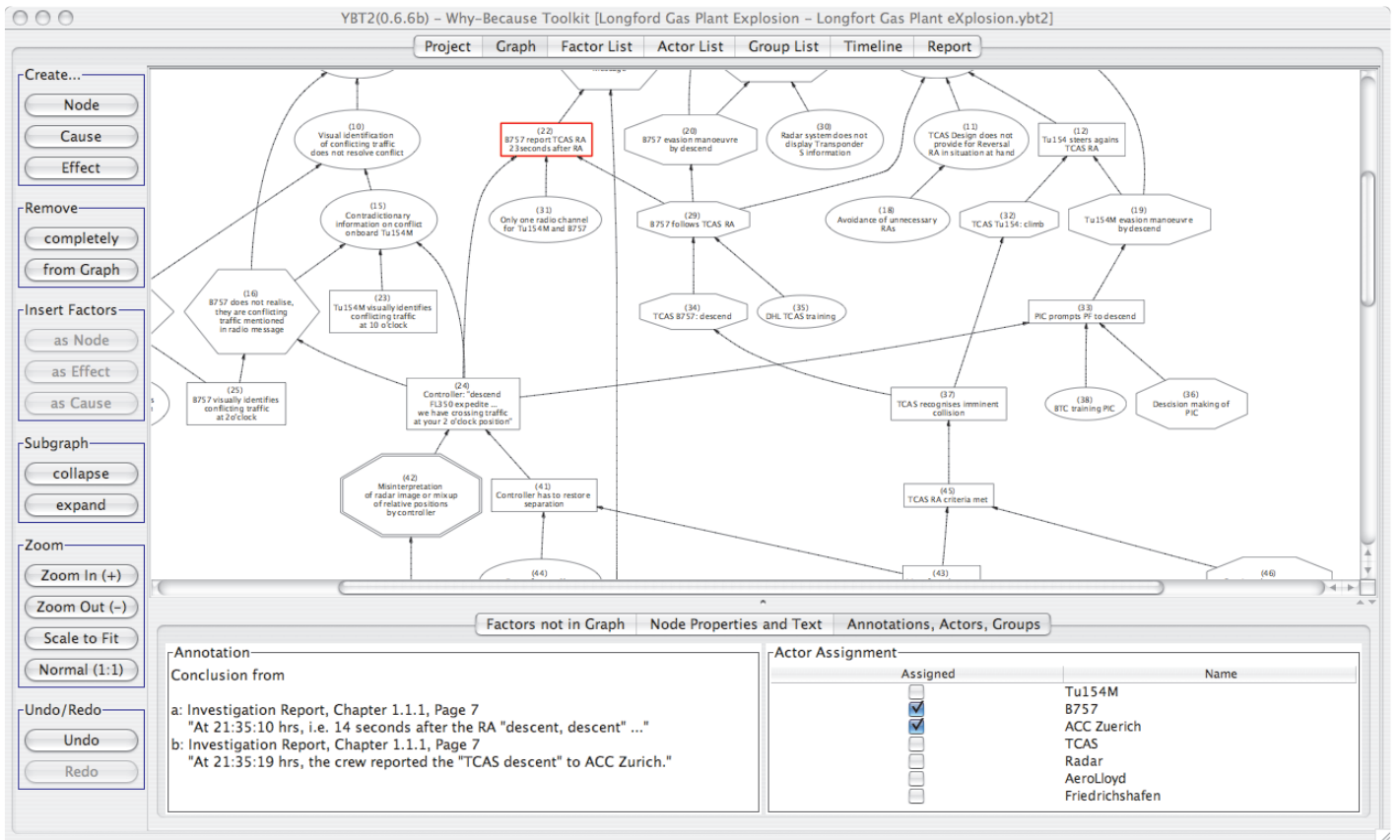
Author: Joern Stuphorn

Title: The Ueberlingen MidAir, Germany 01 Jul 2002

Description: In the night from 1 July 2002 to 2 July 2002, two aircraft collide over Lake Constance near the german town of Ueberlingen. Following the collision all 71 passengers on-board the Bashkirian Airlines Tupolev TU154M and the DHL B757-200 die.

A SERAS Analyst user manages active WBA projects with the Project view, which enables simple establishment of new projects as well as importing projects from other analysts and removing expired projects. When projects reside on network storage, the project-management screen enables collaborative work on projects by different analysts.

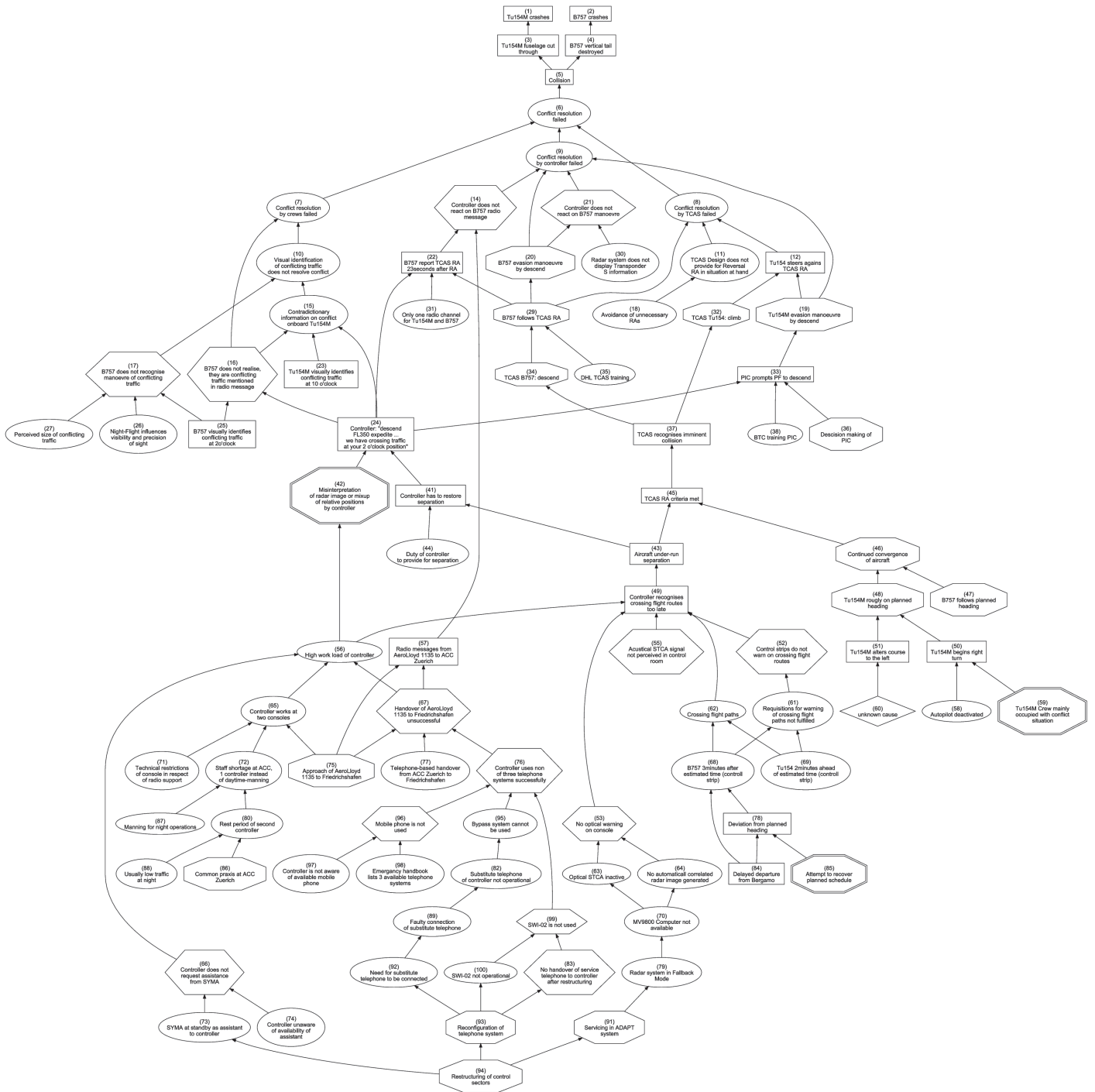
GRAPH VIEW



The Graph view displays dynamically the Why-Because Graph being constructed, or which has been constructed in a project, enabling the user to concentrate completely on the contents of the graph. SERAS Analyst data structuring ensures that the factors available in the graph-view screen are precisely those in the factor list, ensuring that changes are propagated throughout the different views of an analysis in progress.

OUTLINE OF A WHY-BECAUSE GRAPH AS EXPORTED IN THE REPORT

Why-Because Graph



TIMELINE VIEW

Factor	Date/Time	Duration	Government	Exxon	Personnell
(84) Delayed departure from B...	01.07.2002 21:06:00		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(51) Tu154M alters course to t...	01.07.2002 21:33:00		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(49) Controller recognises cros...	01.07.2002 21:34:49		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(19) Tu154M evasion manoeuv...	01.07.2002 21:34:56		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
(45) TCAS RA criteria met	01.07.2002 21:34:56		<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(34) TCAS B757: descend	01.07.2002 21:34:56		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(32) TCAS Tu154: climb	01.07.2002 21:34:56		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(43) Aircraft under-run separa...	01.07.2002 21:34:56		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
(29) B757 follows TCAS RA	01.07.2002 21:34:58		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(55) Acustical STCA signal not ...	01.07.2002 21:35:00		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
(50) Tu154M begins right turn	01.07.2002 21:35:00		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(24) Controller: "descend FL35...	01.07.2002 21:35:03		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
(58) Autopilot deactivated	01.07.2002 21:35:04		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(12) Tu154 steers agains TCA...	01.07.2002 21:35:05		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(25) B757 visually identifies co...	01.07.2002 21:35:05		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(14) Controller does not react ...	01.07.2002 21:35:22		<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(23) Tu154M visually identifies...	01.07.2002 21:35:23		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>
(5) Collision	01.07.2002 21:35:32		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(4) B757 vertical tail destroyed	01.07.2002 21:35:33		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(3) Tu154M fuselage cut through	01.07.2002 21:35:33		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(2) B757 crashes	01.07.2002 21:36:00		<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(1) Tu154M crashes	01.07.2002 21:36:00		<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(62) Crossing flight paths			<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(69) Tu154 2minutes ahead of...			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(68) B757 3minutes after esti...			<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
(33) PIC prompts PF to descend			<input checked="" type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(37) TCAS recognises imminent...			<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
(72) Staff shortage at ACC, 1 in...			<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
(94) Restructuring of control se...			<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>

The Timeline view brings the data in the factor list and in the actor list together, and arranges the factors according to date and time of occurrence, when this information is given in the factor data. The report renders the timeline in an easy-to-read format.

TIMELINE AS EXPORTED IN THE REPORT

Timeline of Events

		Tu154M	B757	ACC Zuerich	TCAS	Radar	Aerolloyd	Friedrichshafen
Delayed departure from Bergamo	01.07.2002 21:06:00		X					
Tu154M alters course to the left	21:33:00	X						
Controller recognises crossing flight routes too late	21:34:49	X	X	X				
Tu154M evasion manoeuvre by descend	21:34:56	X						
TCAS RA criteria met					X			
TCAS B757: descend			X	X				
TCAS Tu154: climb		X		X				
Aircraft under-run separation		X	X	X				
B757 follows TCAS RA	21:34:58		X	X	X			
Acustical STCA signal not perceived in control room	21:35:00			X		X		
Tu154M begins right turn		X						
Controller: "descend FL350 expedite ... we have crossing traffic at your 2 o'clock position"	21:35:03	X		X				
Autopilot deactivated	21:35:04	X						
Tu154 steers against TCAS RA	21:35:05	X		X				
B757 visually identifies conflicting traffic at 2 o'clock			X					
Controller does not react on B757 radio message	21:35:22		X	X				
Tu154M visually identifies conflicting traffic at 10 o'clock	21:35:23	X						
Collision	21:35:32	X	X					
B757 vertical tail destroyed	21:35:33		X					
Tu154M fuselage cut through		X						
B757 crashes	21:36:00		X					
Tu154M crashes		X						

FACTOR LIST VIEW

In Graph	ID	Name	Text	Annotation	Time	Duration
<input checked="" type="checkbox"/>	60		Rest period or second controller			
<input checked="" type="checkbox"/>	6		Conflict resolution failed	Systematical fragmentation T...		
<input checked="" type="checkbox"/>	9		Conflict resolution by controlle...	Summationary Factor Content...		
<input checked="" type="checkbox"/>	8		Conflict resolution by TCAS fai...	Summationary Factor Content...		
<input checked="" type="checkbox"/>	43		Aircraft under-run separation	Investigation Report, Chapter ...	01.07.2002 21:34:56	
<input checked="" type="checkbox"/>	49		Controller recognises crossing...	Investigation Report, Chapter ...	01.07.2002 21:34:49	
<input checked="" type="checkbox"/>	56		High work load of controller	Causal closure from: a: (65) ...		
<input checked="" type="checkbox"/>	53		No optical warning on console	Causal Closure from a: (63) ...		
<input checked="" type="checkbox"/>	63		Optical STCA inactive	Investigation Report, Chapter ...		
<input checked="" type="checkbox"/>	79		Radar system in Fallback Mode			
<input checked="" type="checkbox"/>	70		MV9800 Computer not availa...	Causal Closure from a: ACC ...		
<input checked="" type="checkbox"/>	66		Controller does not request a...	Investigation Report, Chapter ...		
<input checked="" type="checkbox"/>	86		Common praxis at ACC Zuerich			
<input checked="" type="checkbox"/>	93		Reconfiguration of telephone ...			
<input checked="" type="checkbox"/>	41		Controller has to restore sepa...	Conclusion from a: (43) Airc...		
<input checked="" type="checkbox"/>	20		B757 evasion manoeuvre by ...	a: Investigation Report, Chapt...		
<input checked="" type="checkbox"/>	7		Conflict resolution by crews fa...	Summationary Factor Content...		
<input checked="" type="checkbox"/>	29		B757 follows TCAS RA	Conclusion from a: (34) TCAS...	01.07.2002 21:34:58	
<input checked="" type="checkbox"/>	11		TCAS Design does not provid...	Investigation Report, Chapter ...		
<input checked="" type="checkbox"/>	35		DHL TCAS training	Investigation Report, Chapter ...		
<input checked="" type="checkbox"/>	38		BTC training PIC	Investigation Report, Chapter ...		
<input checked="" type="checkbox"/>	18		Avoidance of unnecessary RAS	Investigation Report, Chapter ...		
<input checked="" type="checkbox"/>	22		B757 report TCAS RA 23seco...	Conclusion from a: Investigati...		
<input checked="" type="checkbox"/>	31		Only one radio channel for Tu...	Conclusion from: a: Investigat...		
<input checked="" type="checkbox"/>	25		B757 visually identifies conflic...	Conclusion from a: Investigati...	01.07.2002 21:35:05	
<input checked="" type="checkbox"/>	23		Tu154M visually identifies co...	Conclusion from a: Investigati...	01.07.2002 21:35:23	
<input checked="" type="checkbox"/>	10		Visual identification of conflicti...	Causal Closure from a: (15) ...		
<input checked="" type="checkbox"/>	14		Controller does not react on B...	Rationale for the omission: a:...	01.07.2002 21:35:22	
<input checked="" type="checkbox"/>	57		Radio messages from AeroLo...	Investigation Report, Appendi...		
<input checked="" type="checkbox"/>	27		Perceived size of conflicting tr...	Investigation Report, Chapter ...		
<input checked="" type="checkbox"/>	15		Contradictory information ...	Causal Closure from: a: Inves...		

The Factor List view renders the data on the factors available for the analysis. Factors identified in the forensic phase of an analysis are entered, along with annotations (such as extended comments and references), along with date and time if pertinent. This data forms the data base from which the Why-Because Graph and the Timeline are built.

FACTOR LIST AS EXPORTED IN THE REPORT

Factor List - Details

1 Tu154M crashes

Type of Factor: Event
Date/Time: 01.07.2002 21:36:00
Actors involved: Tupolev Tu154M
Annotation: Investigation Report, Chapter 1.1, Page 7

2 B757 crashes

Type of Factor: Event
Date/Time: 01.07.2002 21:36:00
Actors involved: Boeing B757
Annotation: Investigation Report, Chapter 1.1, Page 7

3 Tu154M fuselage cut through

Type of Factor: Event
Date/Time: 01.07.2002 21:35:33
Actors involved: Tupolev Tu154M
Annotation: Investigation Report, Chapter 1.12.1, Page 25
(Wreckage and impacts information - Tupolev TU154M)

"The TU154 M suffered an in-flight break-up. At the four main crash sited the fuselage, the right and left wing includeing the central supporting structure and the tail unit, including the power plants were found."

4 B757 vertical tail destroyed

Type of Factor: Event
Date/Time: 01.07.2002 21:35:33
Actors involved: Boeing B757
Annotation: Investigation Report, Chapter 1.12.1, Page 24
(Wreckage and impacts information - Boeing B757-200)

"On collision, the airplane lost about 80% of the vertical tail. The manufacturer stated that the loss caused the airplane to become aerodynamically unstable in the yaw axis."

5 Collision

Type of Factor: Event
Date/Time: 01.07.2002 21:35:32
Actors involved: Tupolev Tu154M
Boeing B757
Annotation: Investigation Report, Chapter 1.1, Page 6
(History of the flights)

"On 1 July 2002 at 21:35:32 hrs a Tupolev TU154M on its flight from moscow-Domododovo/Russia to Barcelona/Spain and a Boeing B757-200, which was on a flight from Bergamo/Italy to Brussels/Belgium, collided near the town of Ueberlingen (Lake Constance) in a dark night; the in-flight visibility at the flight level concerned was 10 km and more.

6 Conflict resolution failed

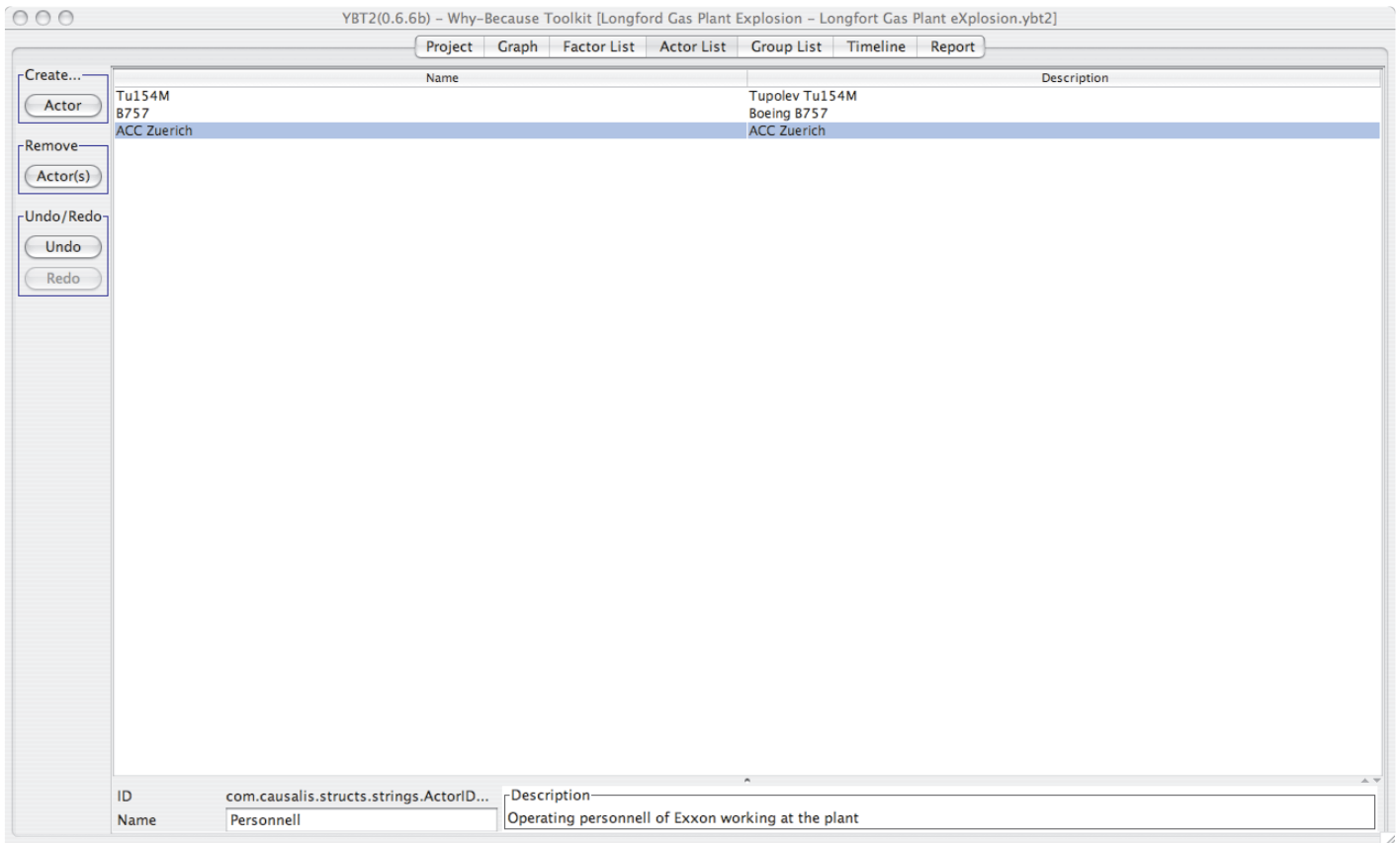
Type of Factor: State
Date/Time:
Actors involved:
Annotation: Systematical fragmentation

The Reason for the Failure to resolve the conflict situation can be explained by the concurrence of the following events:

- 1: Conflict resolution by crews failed
- 2: Conflict resolution by TCAS failed
- 3: Conflict resolution by controller failed

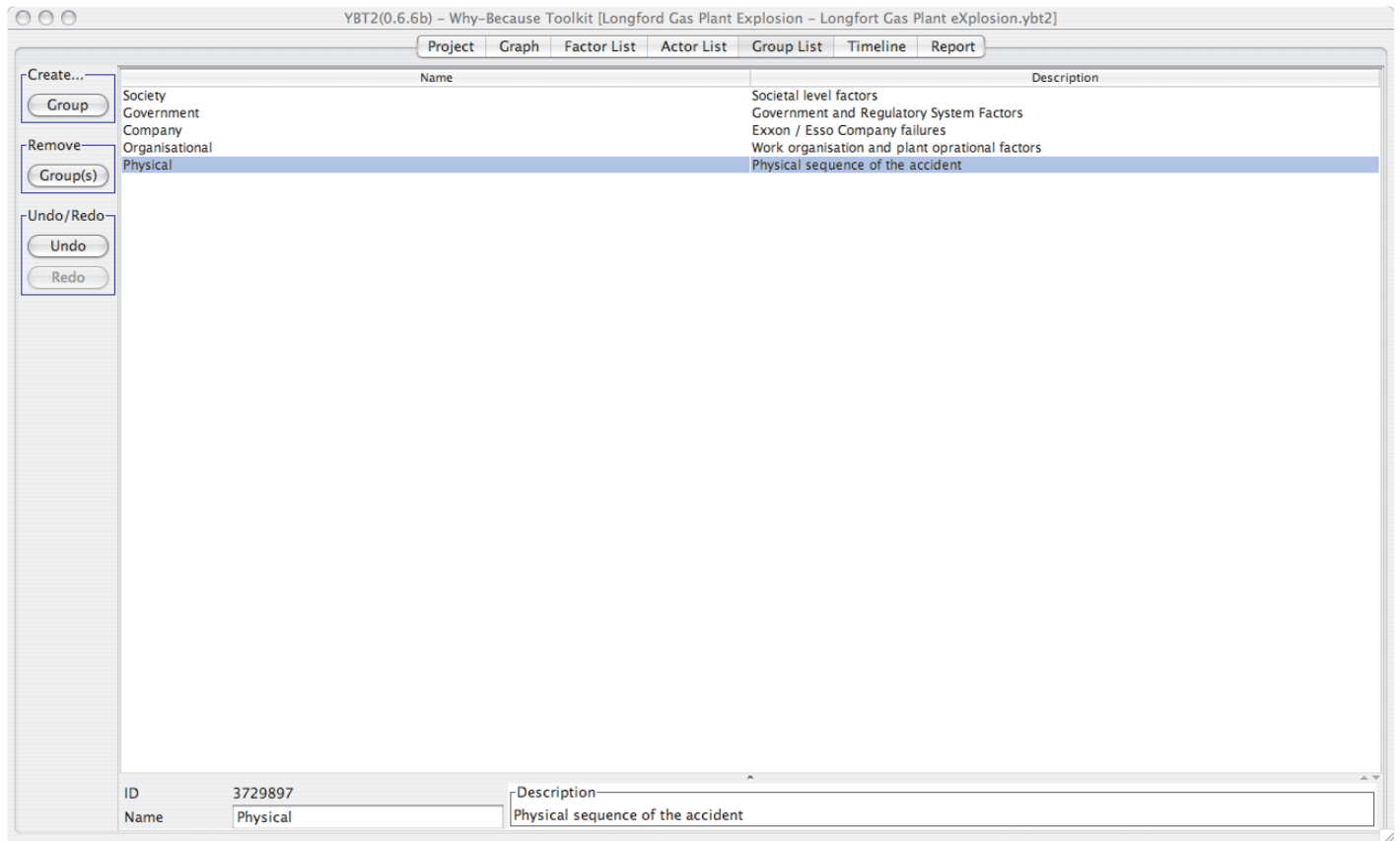
This fragementation suffices as only these 3 systems had controlling influence on the flight situation.

ACTOR LIST VIEW



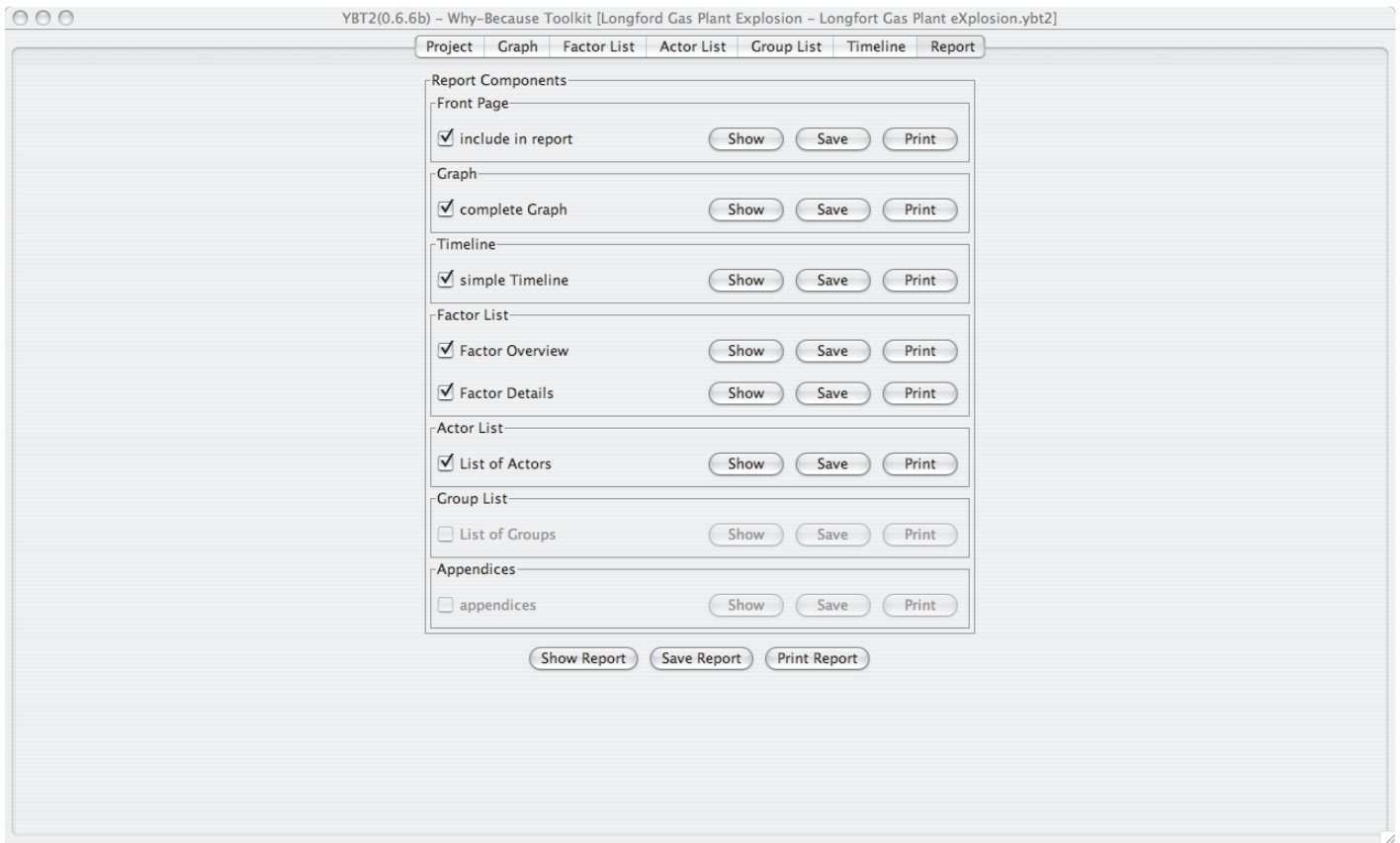
The Actor List view shows and describes all the participants (the objects involved, including both people and things) involved in an incident. The list shows acronyms used in the analysis, as well as the full name and description of an actor and any relevant further information.

GROUP LIST VIEW



The Group List view allows associated or related factors to be grouped as desired, for example according to system-subsystem divisions, or according to social-technical criteria such as organisational-regulatory-legal-governmental. The groupings are visible in the Factor List as well as in the WB-Graph.

REPORT VIEW



The Report view enables the full data set comprising an incident analysis to be formatted and output as a document, as well as selected parts such as the Timeline or the WB-Graph to be formatted individually as a document. The documents are currently rendered in PDF-format.