The 2002 Ueberlingen Mid-Air

Bieleschweig VI

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Accident History (1)

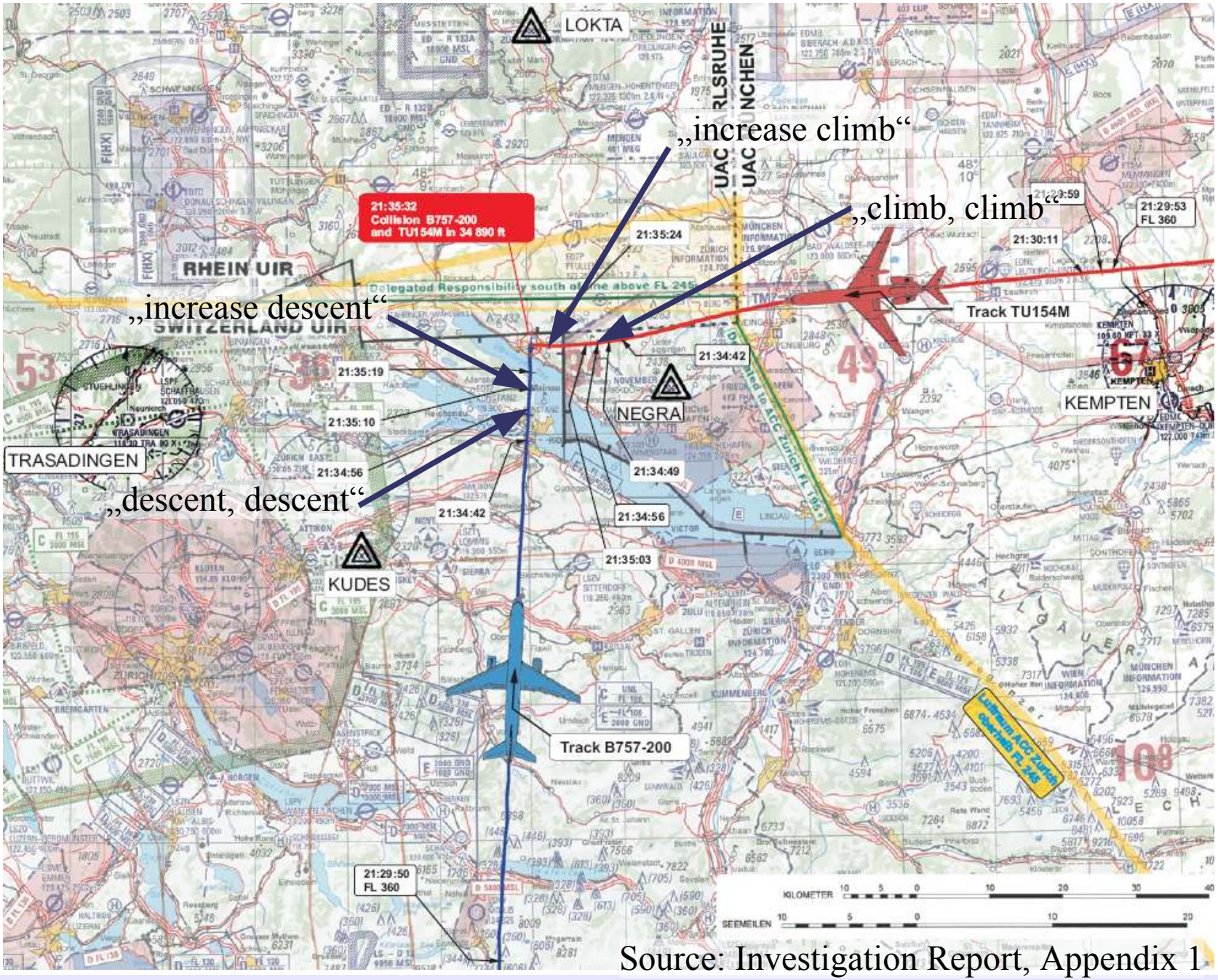
- Tupolev Tu154M
  - Departure: Moscow-Domodedowo, 18:48 hrs
  - Destination: Barcelona
- Boeing B757-200
  - Departure: Bergamo, 21:06 hrs
  - Destination: Brussels
- 21:21:50 hrs: B757 enters Controlarea Zurich
  - Flight Level 260 (26.000 ft)
  - Clearance to climb to FL320
  - 21:26:36 hrs: Request to climb to FL360 granted
  - 21:29:50 hrs: FL 360 reached
- 21:30:11 hrs: Tu154 enters Controlarea Zurich
  - Flight Level 360

Accident History (2)

- 21:34:42 hrs: TCAS TA generated
- 21:34:49 hrs: ACC Zurich to Tu154:
  - “descend flight level 350, expedite, I have crossing traffic”
- 21:34:56 hrs: Tu154 descends
- 21:34:56 hrs: TCAS RA generated
  - B757: “descend, descend”
  - Tu154: “climb, climb”
- 21:34:58 hrs: B757 descends
- 21:34:59 hrs: Discussion with Tu154 crew
- 21:35:10 hrs: B757 TCAS RA: “increase descend”
- 21:35:24 hrs: Tu154 TCAS RA: “increase climb”

- 21:35:32 hrs: Collision near Überlingen

Reconstructed Flight Paths



Source: Investigation Report, Appendix 1

WBA Analysis

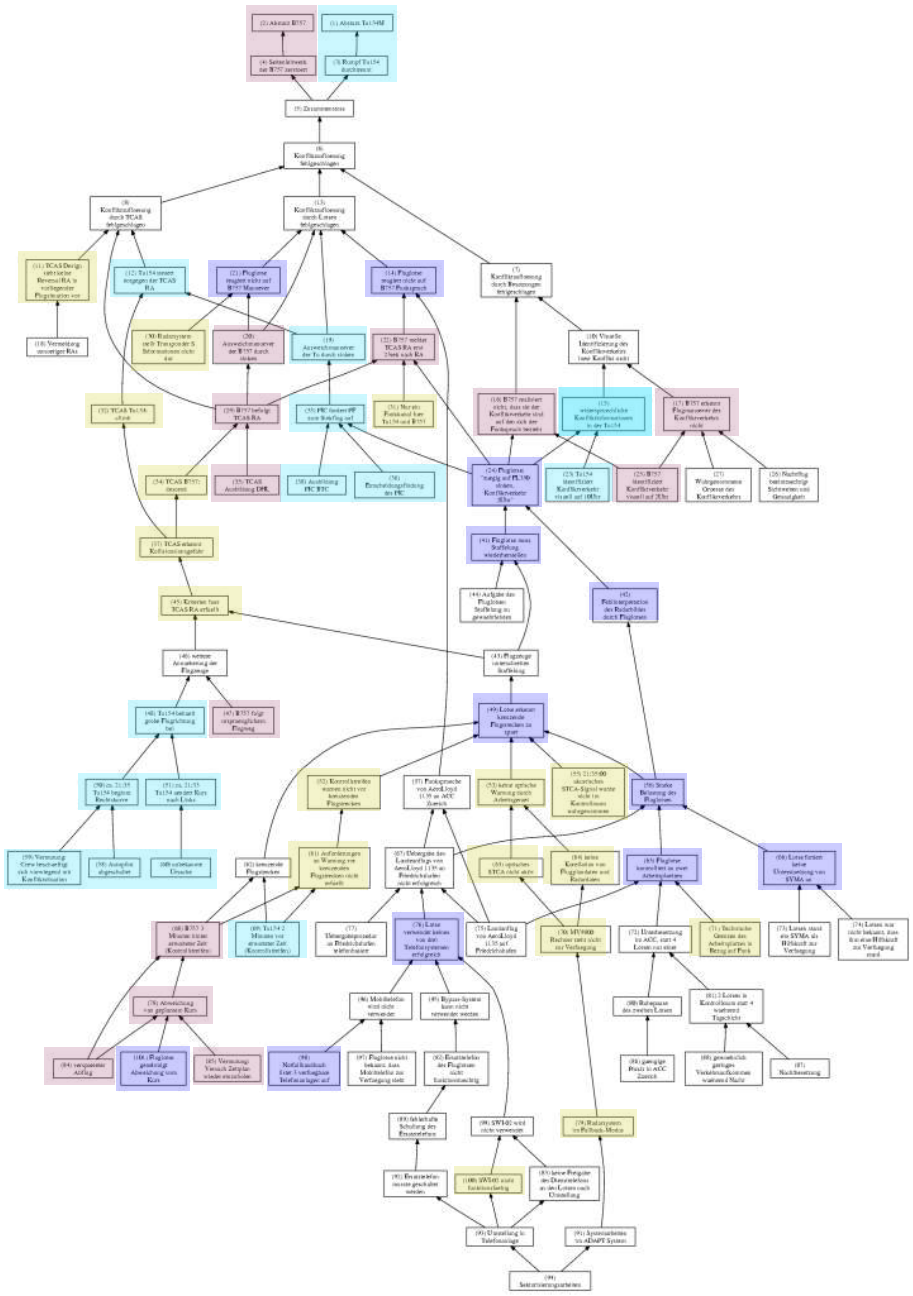
- Winter Term 2004/2005
- Analysis done by group of 8,
  - 7 beginners in regard of WBA
- Time needed for analysis:
  - 15 sessions, each 1.5 hrs (180 hrs)
  - Additional work during course (about 25 hrs)
  - Substantiation of List-of-Facts (about 35 hrs)
  - Total: about 240 hrs

Analysis Proceeding

- Study of investigation report
- Beginning to compose List-of-Facts
  - Questions on sequence of events arrise
    - Some events given with absolute time
    - Some events given with relative time
    - Sequence of events not always chronological
- Composition of the timetable
- Extension of List-of-Facts
- Identification of causal relationships (WB-Graph)
- Error detection
  - Application of
    - counterfactual test
    - completeness test
  - Formulation of substantiated List-of-Facts

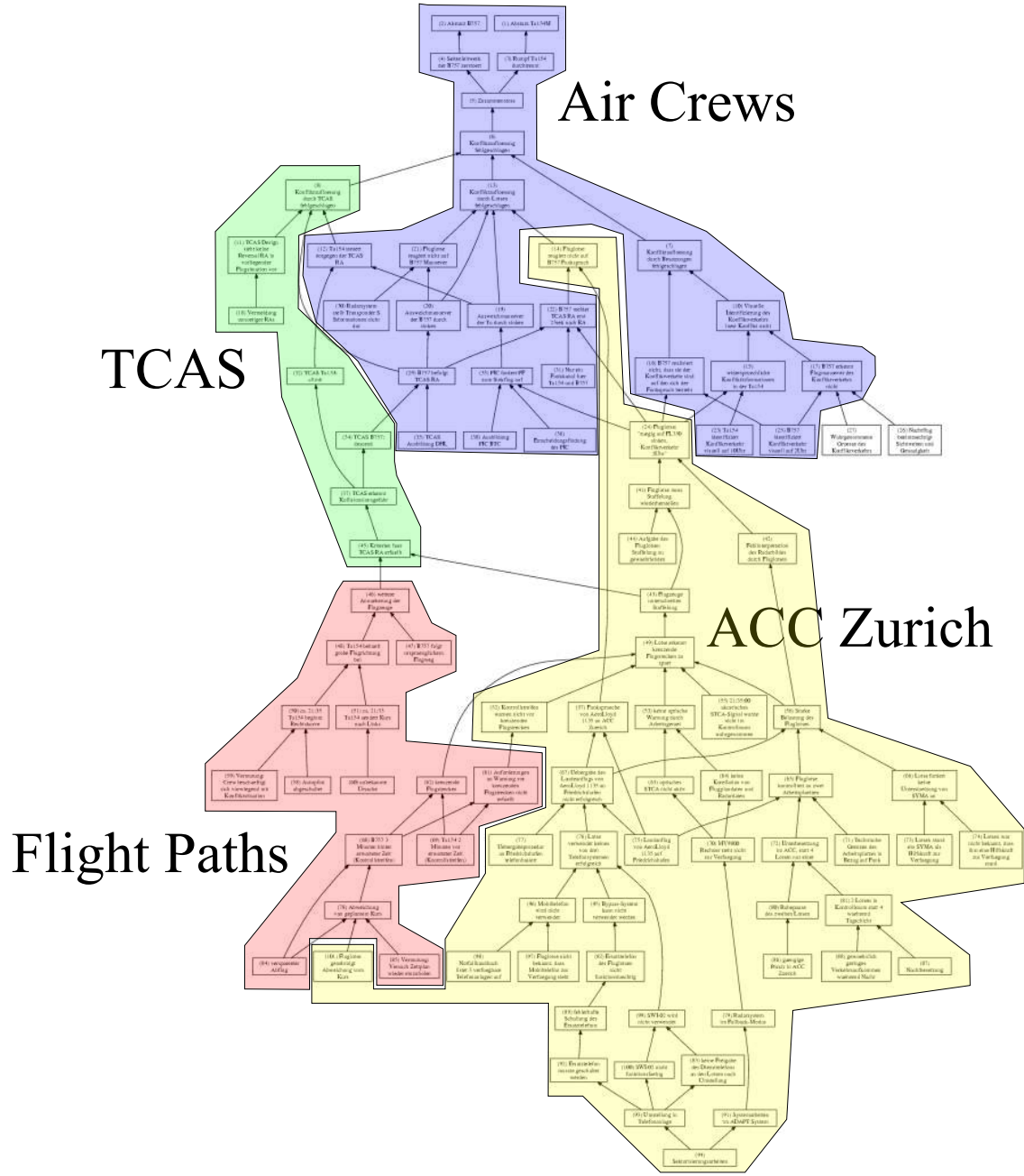
Why-Because Graph

- Statistic:
  - total of 94 knots
  - 28 source factors
  - 66 internal factors
- Main actors:
  - Tu154M (ca. 16 factors)
  - B757 (ca. 14 factors)
  - Controller (ca. 11 factors)
  - Technical (ca. 17 factors)

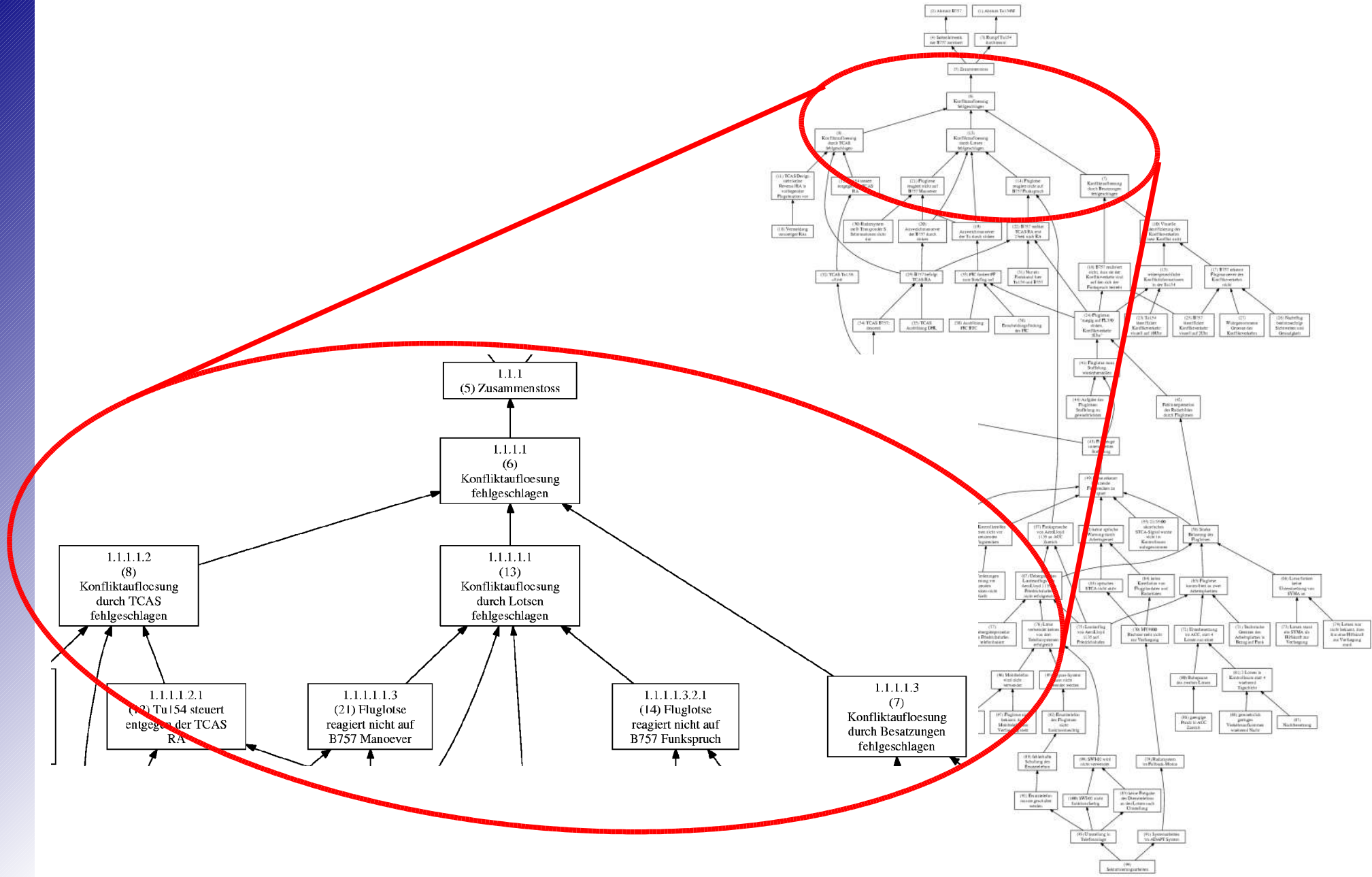


Why-Because Graph

- Areas of Responsibility:
  - TCAS
    - Devices
    - Design
  - ACC Zurich
    - Controller
    - Organisation
    - Devices
  - Air Crews
    - B757
    - Tu154M
  - Flight Paths
    - B757
    - Tu154M

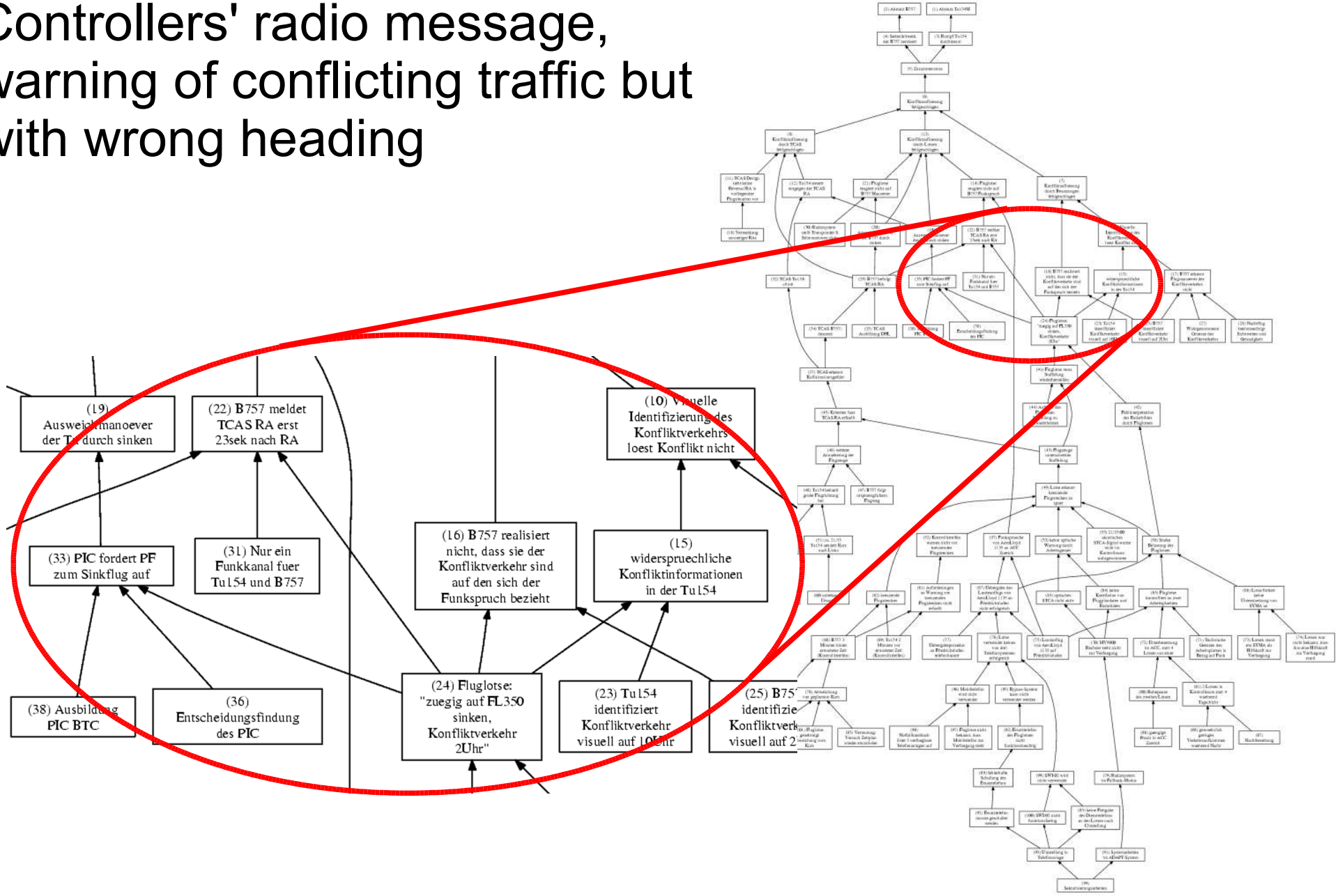


The Collision



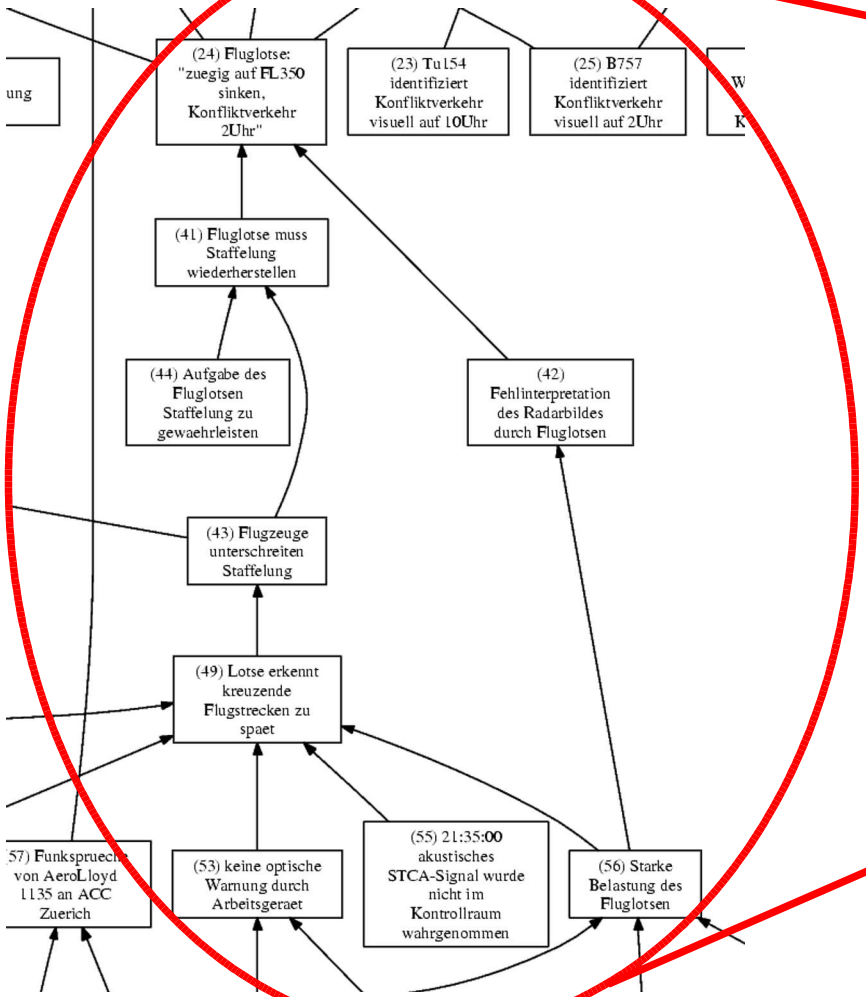
Interesting Points (1)

- Controllers' radio message, warning of conflicting traffic but with wrong heading



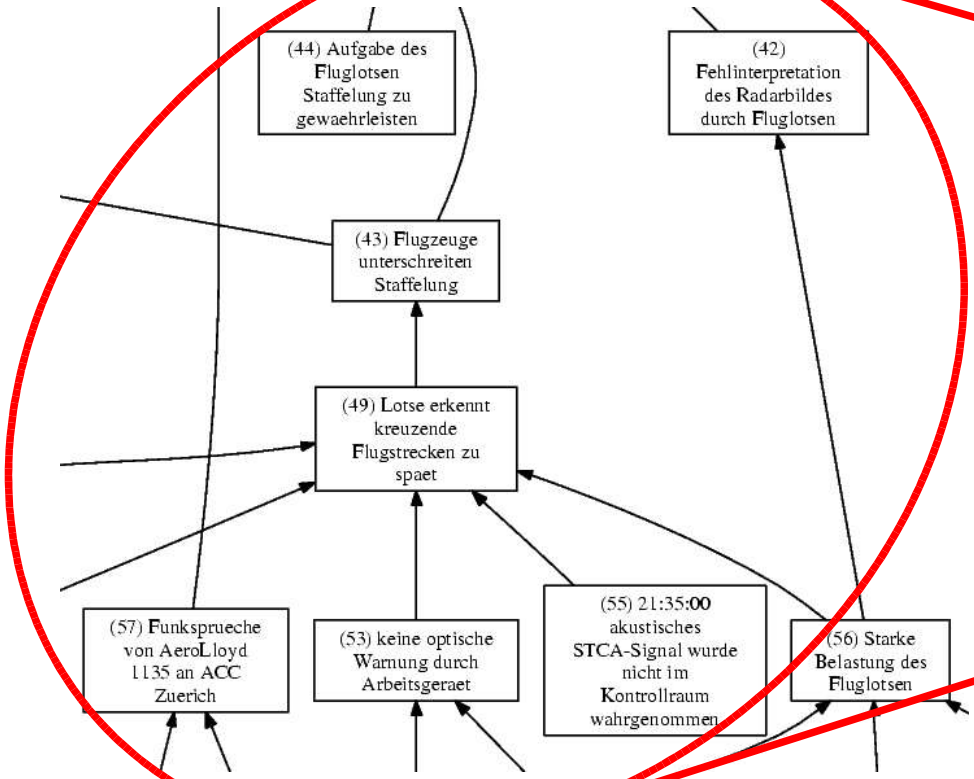
Interesting Points (2)

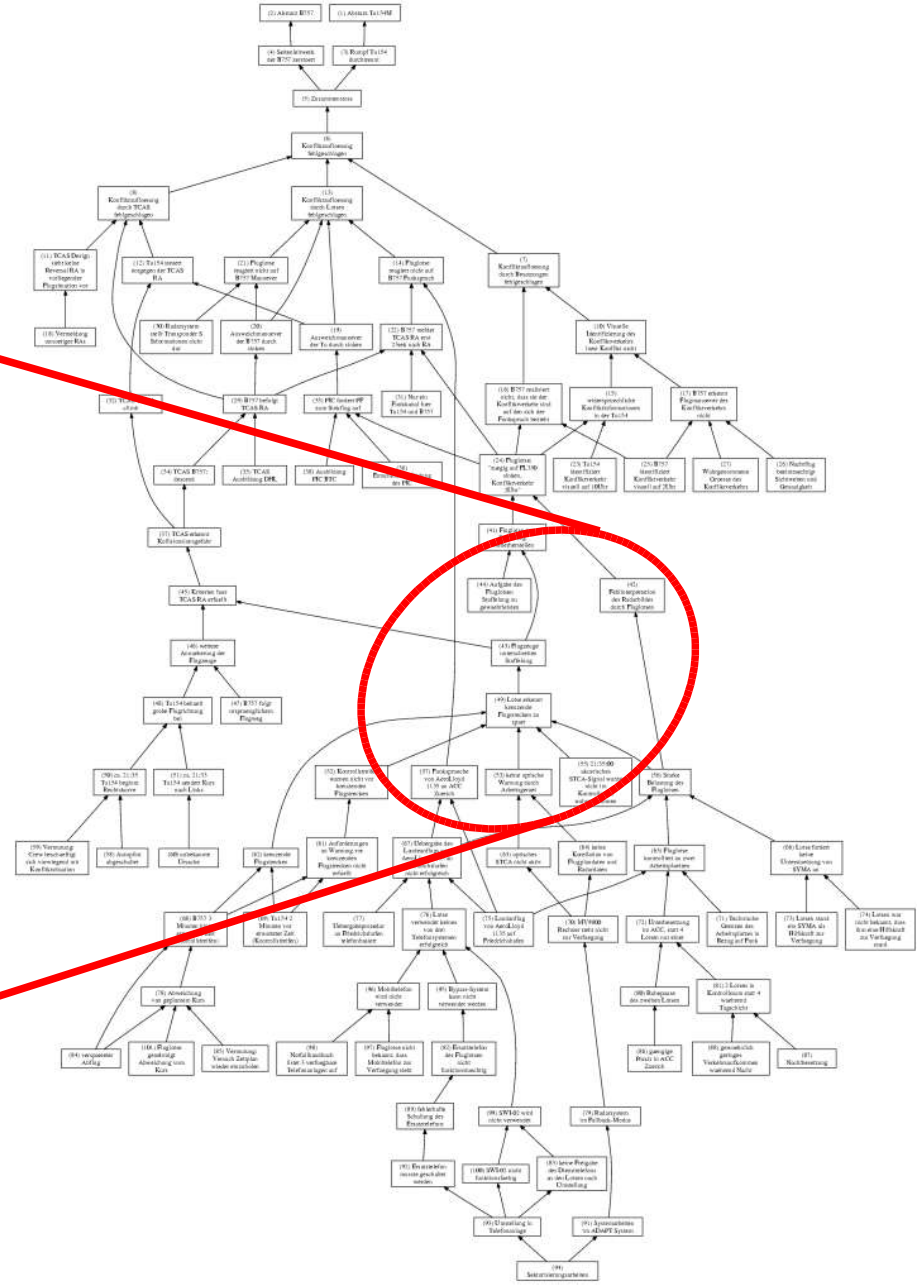
- Factors leading to mistake in radio message



Interesting Points (3)

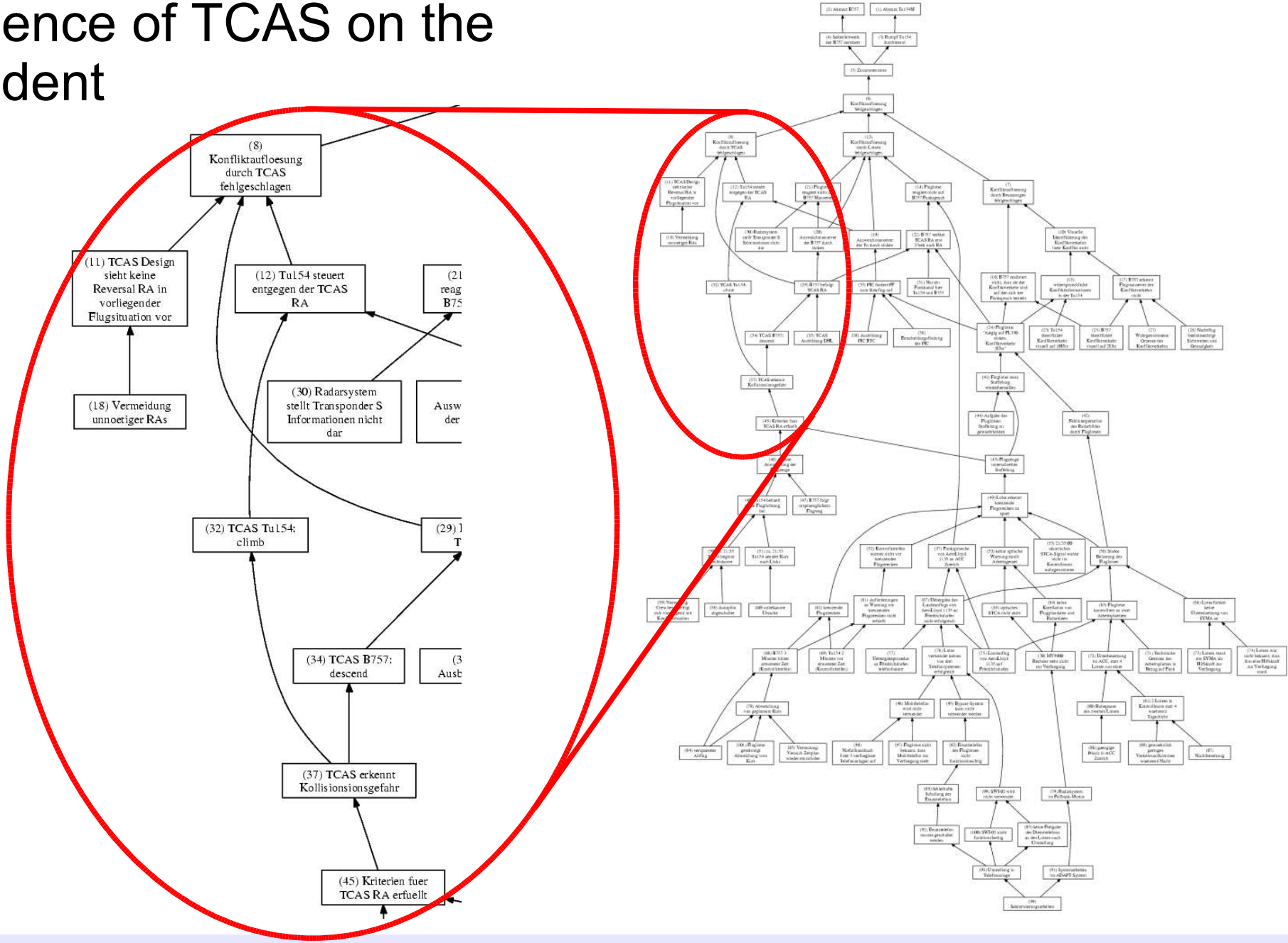
- "Waist" in Graph
  - Width = 3





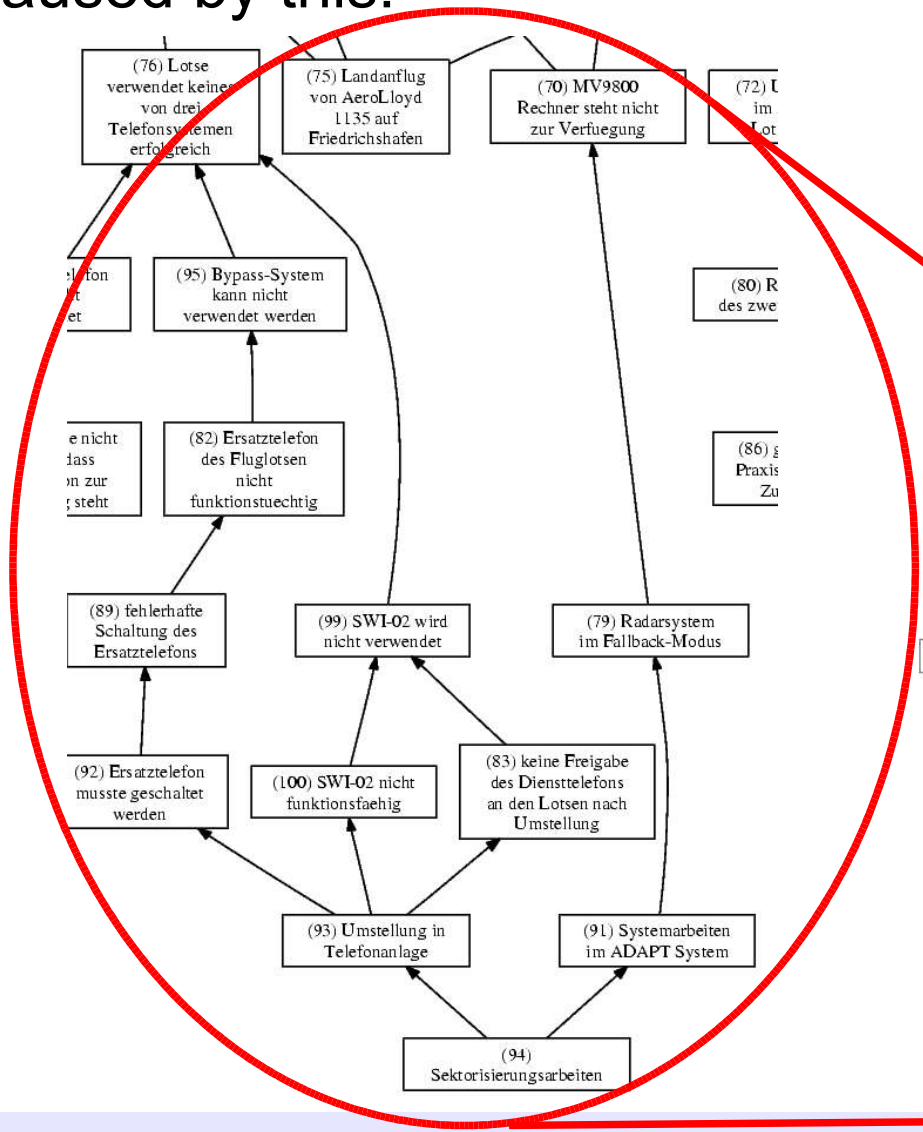
Interesting Points (4)

- Influence of TCAS on the Accident



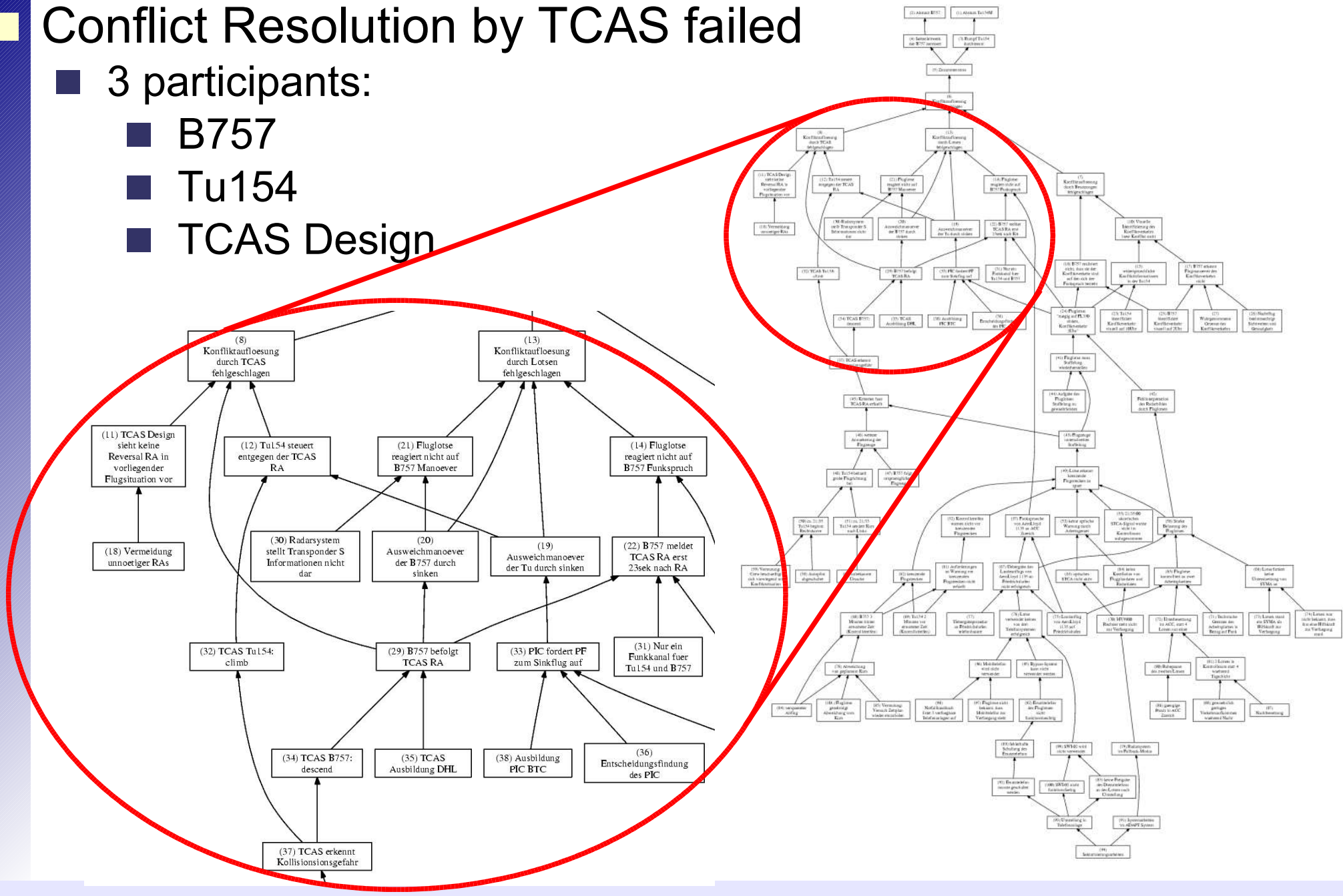
Interesting Points (5)

- Rearrangement of Sectors
  - only part of events in ACC are caused by this!



Interesting Points (6)

- Conflict Resolution by TCAS failed
  - 3 participants:
    - B757
    - Tu154
    - TCAS Design

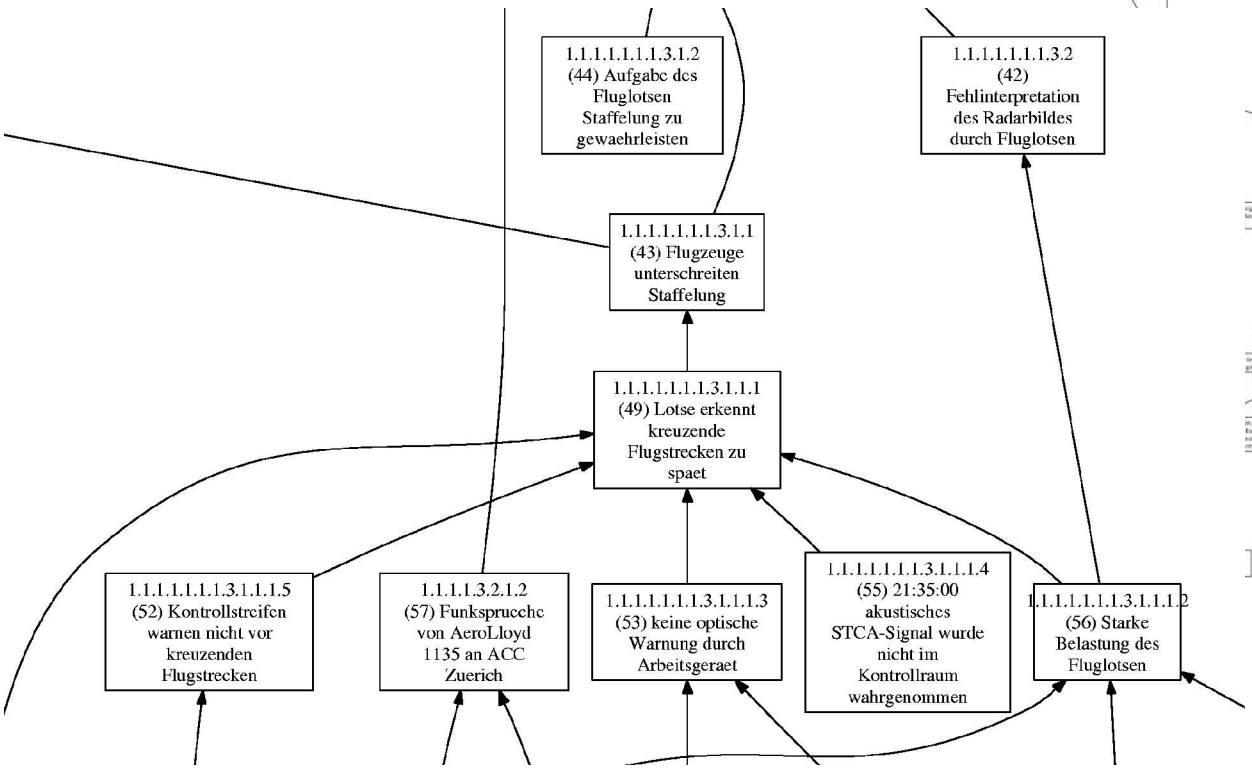


Causes identified by BFU

- 2 Immediate Causes
  - Seperation infringement not noted in time
  - Tu154 followed ATC instruction instead of TCAS advisory
- 3 Systematic Causes
  - Insufficient integration of ACAS/TCAS II into the system aviation
  - Management of ACC did not ensure that during night open workstations were staffed by controllers
  - Management tolerated that only one controller worked during times of low traffic
- 19 Safety Recommendations

Immediate Cause 1

- Immediate Cause:
  - ATC didn't note separation infringement in time. Instruction to Tu154M was given at time, when separation couldn't be ensured anymore



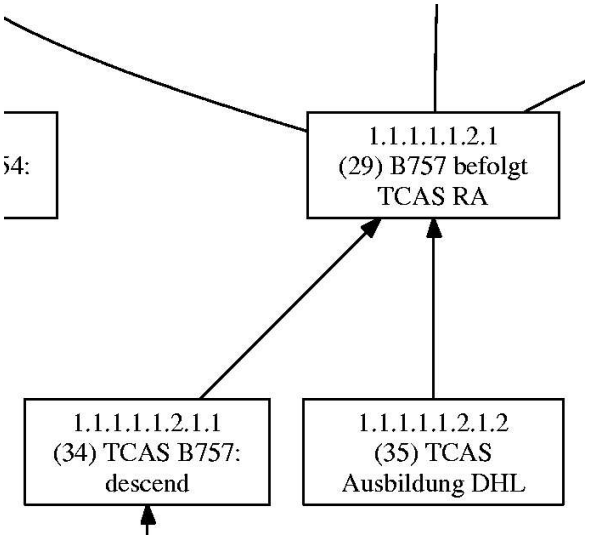
Immediate Cause 1 - Comments

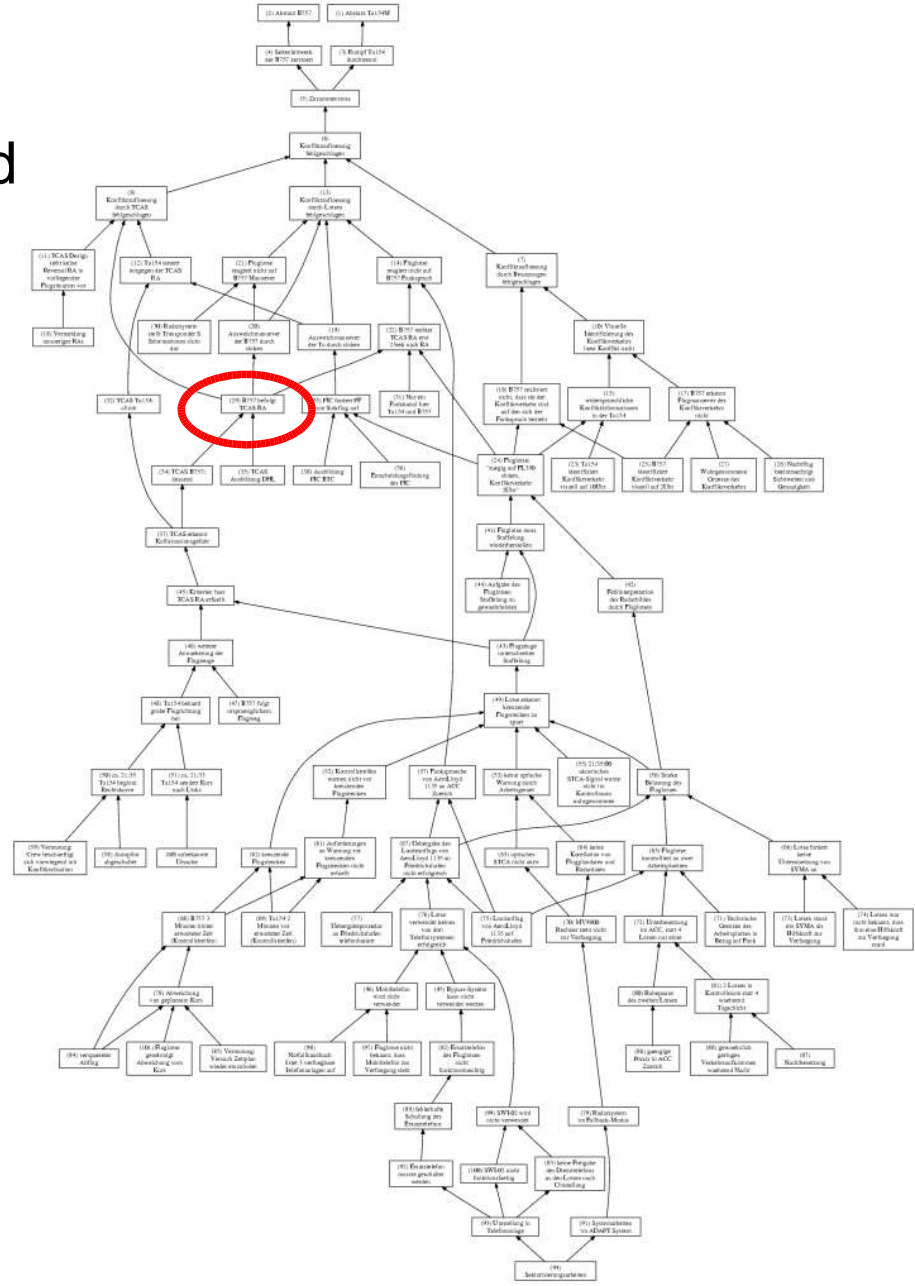
- The first systemic cause is very interesting as it states,
  - that the ACAS/TCAS II system was not only insufficiently integrated in the system aviation but
  - that it did not correspond in all points with the system philosophy
  - ICAO regulations were not standardised and partially incomplete

- These findings are present in the WBG
  - (30) identifies that the ATCs' radar system does not represent the TCAS informations
  - (11) identifies that design had prevented a possible Reversal RA
  - The regulations are included in (35), (36) and (38).

Immediate Cause 2

- Immediate Cause:
  - The Tu154M crew followed the ATC instruction to descend and continued to do so even after TCAS advised them to climb



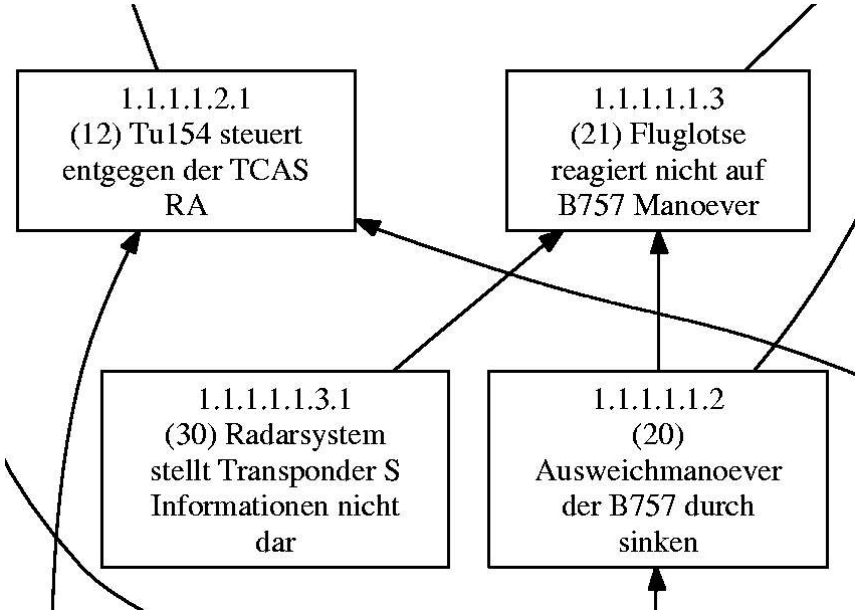


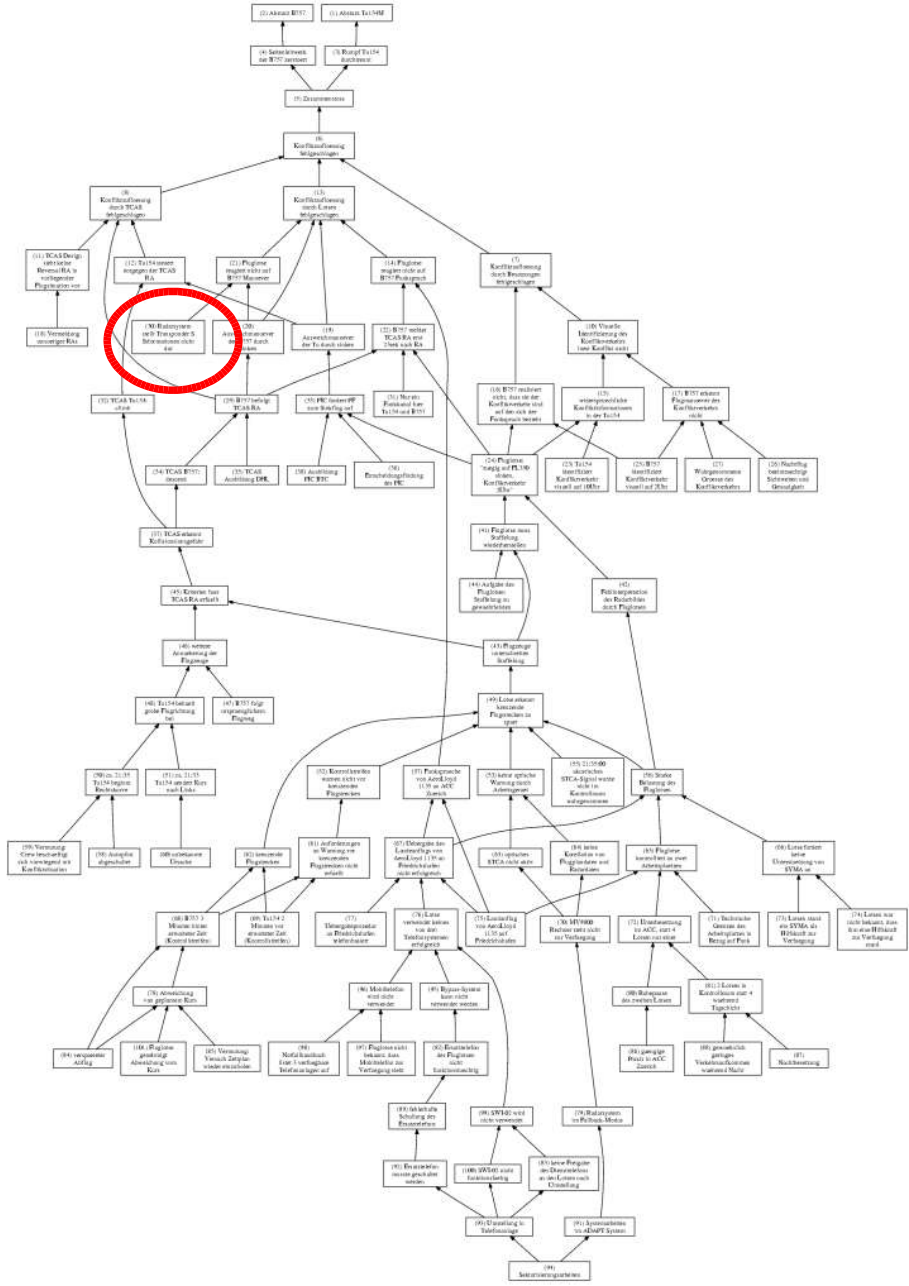
Immediate Cause 1 - Comments

- The second and third systematic cause concerning the Management of ACC Zurich concern only the number of controllers present in the controlroom.
  - These correspond with (81) respectively (80).
- It is interesting that concerning the causes BFU does not identify the execution of the rearrangement of the sectors at ACC Zurich to be a direct cause to the accident.
- Individual mistakes of the Controller that could possibly result out of deficiency in training or information are not listed under the direct causes.

Systematic Cause 1

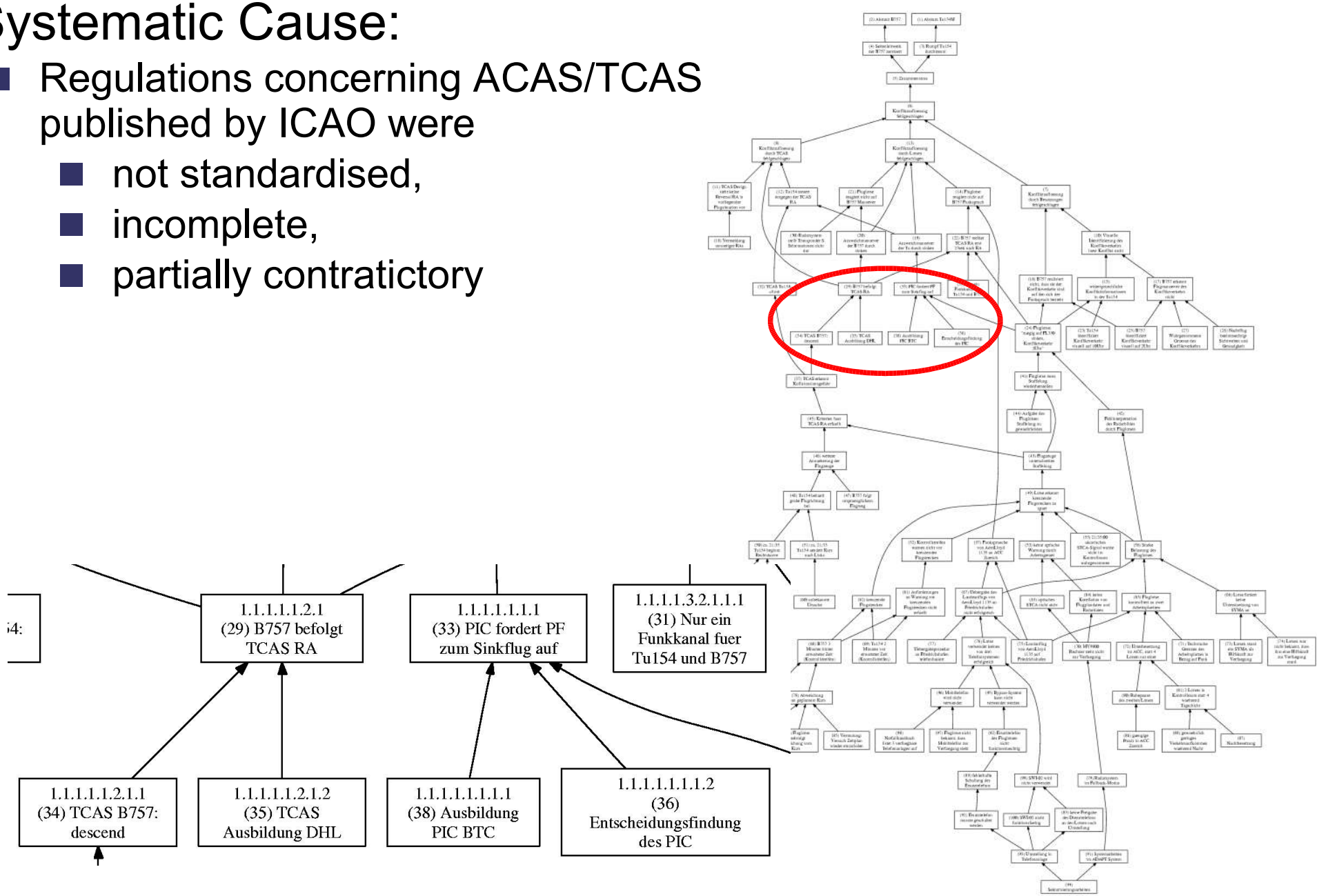
- Systematic Cause:
  - ACAS/TCAS II not sufficiently integrated into the system aviation





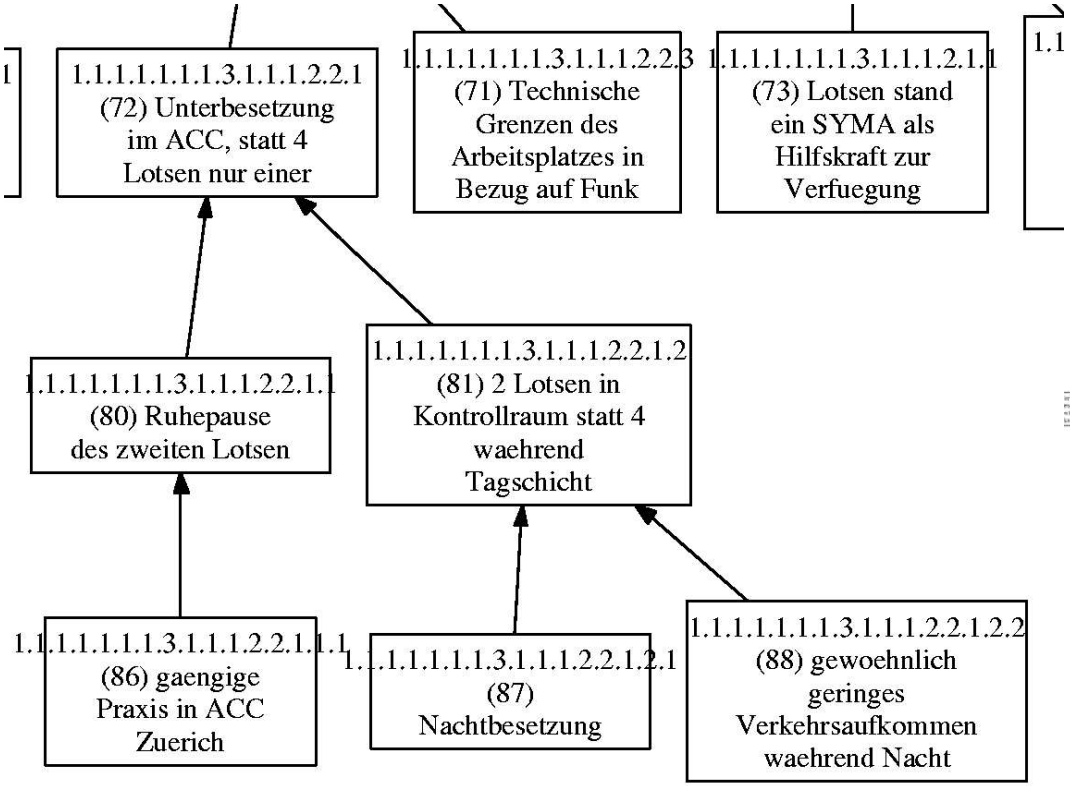
Systematic Cause 2

- Systematic Cause:
  - Regulations concerning ACAS/TCAS published by ICAO were
    - not standardised,
    - incomplete,
    - partially contratictory



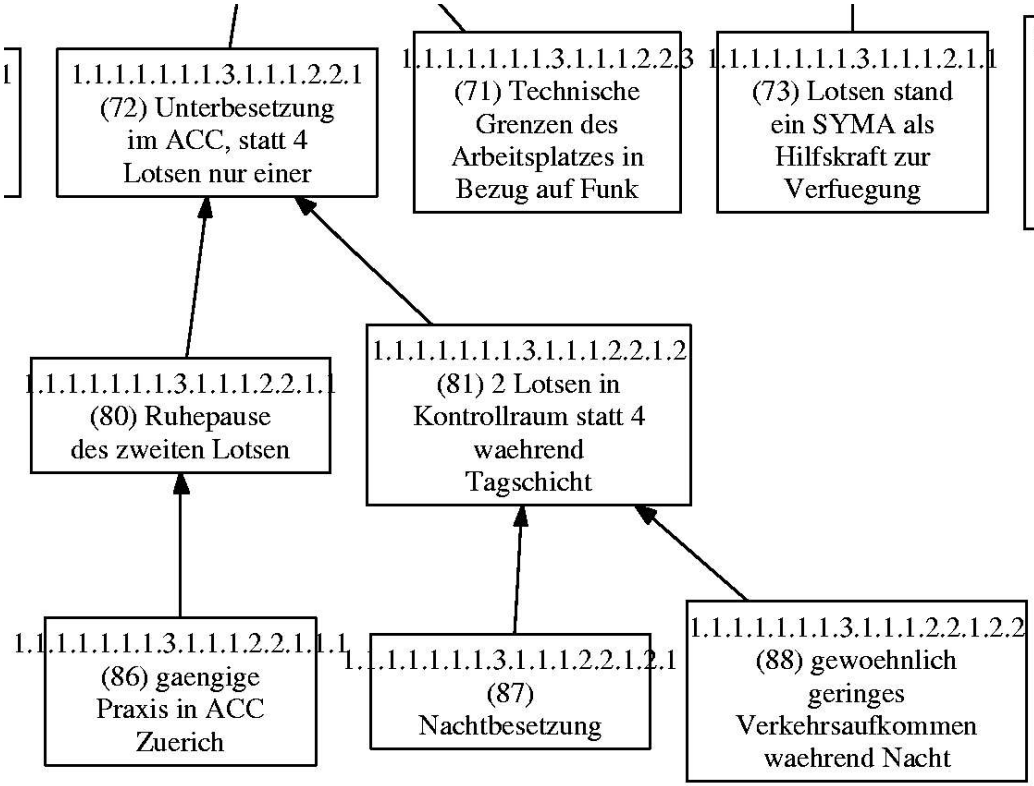
Systematic Cause 3

- Systematic Cause:
  - Management of air navigation service did not ensure that by night all open workstations were staffed by controllers



Systematic Cause 4

- Systematic Cause:
  - Management of air navigation service tolerated that during times of low traffic flow only one controller worked



Comments on Causes

- All causes identified by BFU are important in the WBG
- The first immediate cause was essential for this accident
  - It represents one of the strands in the waist of the graph.
- The second immediate cause could also be identified
  - Causally, the fact of the B757 following the TCAS advisory is equally important but left out of the BFU finding.
- Not identified as causes:
  - Influences of the TCAS implementation
  - Insufficient knowledge of ATC on telephone systems and available staff
  - Execution of restructuring at ACC Zurich

Safety Recommendations - Comments

- Recommendations apply to more fields than Causes
- Main fields are
  - Procedures
    - following of TCAS advisory should be obligatory
  - Training
    - ACAS system philosophy for pilots
    - Emergency procedures for controllers
  - Organisational
    - Documents concerning ACAS should be clarified and identical in their statement
    - ACC Zurich should be manned with minimum 2 controllers
  - Technical
    - TCAS RAs should be relayed to ATC
    - Telephone systems at ACC should automatically use bypass system in case of failure

Safety Recommendations - Comments

- The recommendations focus mostly on the following of the TCAS RA
  - Currently, a TCAS RA is an advisory, not an order
  - Making it mandatory shifts the responsibility from the crew to the TCAS manufacturer
- Both, the folloing and the not following of the TCAS RA were causes
  - Had the Tu154M followed the TCAS RA the collision would not have happened
  - Had the B757 not followed the TCAS RA the collision would not have happened
- The TCAS implementation itself was a cause
  - Had the TCAS system formulated a „reversal“ the collision might have been averted

Thank you.