A Practical Guide to the Why-Because Analysis Method

# Performing a Why-Because Analysis

Thilo Paul-Stüve

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This guide to the Why-Because Analysis (WBA) method concentrates on the detailed steps necessary to perform a WBA. The data to create this guide and the flow charts were determined by Hierarchical Task Analysis [Paul-Stüve 05]. The flow charts follow the IBM Flowcharting Techniques guide, which complies with the requirements of the ISO standard [IBM 69].

## Overview

A Why-Because Analysis (WBA) [Ladkin 01, Ladkin 02] starts with gathering information about the incident (Figure 1). This information is then used to construct either a *List of Facts* (facts listed alone) or a *Why-Because List*.

The construction of the *Why-Because Graph* (WB Graph, WBG) starts with determining the mishap (the "top node"). Then the necessary causal factors (NCF) that finally led to the mishap are determined, using the Why-Because List, until a chosen level of detail is reached. Finally, the quality (correctness and explanatory completeness) of the WBG is assured by detecting and correcting errors. A report can then be written using the WBG.

The WBA process is factored here into eight subprocesses, explained using flowchart notation.

## Gather Information

As shown in Figure 2, the first step is information gathering. First, the sources of information must be identified. These can be, for example, witness reports, responsible authorities, or applicable documentation. (It has proven useful to get printed copies of the material.)

The quality of the information must be assessed. Checking the sources and doing some background research helps. If a team is performing the WBA, the information material can be discussed. Finally, the useful information material is selected.

## Determine the Facts

The selected information material is read again in-depth to identify the statements that concern the course of events. These statements are split into single events. Presumptions must also explicitly be identified in order to extract the facts! (Figure 3) There are at least two ways to arrange the facts, both shown in Figure 4: one may apply the Counterfactual Test earlier (to form a Why-Because List) or later (one creates then a List of Facts).

## Create a List of Facts

A List of Facts is a collection of all the facts that might be relevant to the incident. Every fact determined is written down with (at least) a serial number, a brief description suitable for a title, and a reference to its origin.

## Create a Why-Because List

A Why-Because List incorporates information about the facts and their relations to each other. These relations are expressed in Why-Because pairs of facts. First, every fact is noted with a serial number, a description, and its reference. When all facts have been recorded this way, the **Counterfactual Test** is applied to every pair. If there are any discrepancies, the Why-Because List has to be corrected. Finally the List is checked for completeness and consistency and again corrected if necessary.

## Create an Auxiliary List of Facts

An Auxiliary List of Facts is optional, but often helpful to an understanding of the incident (see Figure 5). After having created a List of Facts or a Why-Because List, a classification system, such as selection according to time (to create later a *Timeline*) or according to the actors involved (to create later a *Time-Actor Diagram*, or TAD), is chosen. Then every fact is filed under its class. Again, every fact is noted with a serial number, a description, and its reference. If there are facts that do not fit the classification system, the classification must be adapted.

## Determine the Mishap / Top Node

The first task in creating a WB Graph is to determine the unwanted event that constitutes the incident, the mishap. This will be the top node of the WB Graph. To determine the mishap, the facts collected in the List of Facts or Why-Because List are reviewed and assessed (Figure 6). Often, the mishap will be obvious, especially in transportation system accidents. But in some cases, for example in computer security incidents in which many interests are involved, it may not be so easy to identify the mishap event.

The mishap is the event or circumstance that most directly caused the loss of resources, e.g., lives or money, that constitute the accident. These facts can be as obvious as "AC impacts mountain", but it can often become difficult to tell what makes up the accident. If working in a team, discussing the facts in the group is helpful.

The mishap is inserted as the top node in the WB Graph with a descriptive label and a reference to the List of Facts or Why-Because List.

## Determine the Necessary Causal Factors

Determining the Necessary Causal Factors (NCFs) is an iterative process starting with the mishap, the top node of the WBG (see Figure 7).

The following procedure is iterated until done. For every fact that is represented by a node **N** already in the WB Graph, the “child nodes”, the *necessary causal factors* (NCFs) are determined either from the facts found in the List of Facts or from the pairs of facts found in the Why-Because List, as follows:

- the List of Facts is reviewed and the Counterfactual Test is applied between **N** and each other node in the List of Facts; or
- all pairs in the Why-Because List are selected which have **N** as the first item. The second item of the pair is then an NCF of **N**.

When working in a team, discussing the selection in the group is helpful.

The NCFs are added as child nodes of the node representing the examined fact with a descriptive label and a reference to the List of Facts or Why-Because List.

This procedure is iterated until the desired level of detail is reached, or until every node appears in the graph.

## Quality Assurance and Correction of the WB Graph

After having determined all NCFs to reach the desired level of detail, the *Causal Completeness Test* is applied. The graph is thoroughly inspected to ensure that the incident is described sufficiently, and that there are no errors. This step is most successful if carried out in a face-to-face team meeting (see Figure 8).

If inadequacies or errors are found, they are corrected by changing or adding causal relations, removing nodes, or adding nodes. Adding nodes requires carefully extending the List of Facts / Why-Because List and then returning to the process of determining NCFs (Figure 9).

If it is determined that the quality of the WBG must be improved, the Counterfactual Test should be applied once again to check the causal relations. When the entire WB Graph has been checked in this manner, it is finished.

## Glossary

**Auxiliary List of Facts (auxLoF)** Auxiliary List of Facts are optional. The facts are arranged according to a classification system, such as *timestamp* or *actor involved*. Auxiliary List of Facts help to gain a better understanding of an incident. The facts are notated with a serial number, a short description, their class, and a reference to their source.

**Causal Completeness Test (CCT)** A technical criterion for determining sufficiency of causal explanation. The CCT applies between a collection $A_1, A_2, ....., A_n$ of facts and a fact **B**. The CCT is satisfied when (a) each $A_k$ is an NCF of **B**; and (b) the Causal Sufficiency Criterion holds between the set $A_1, A_2, ....., A_n$ and **B**. The technical definition may be found in [Ladkin 01].

**Causal Sufficiency Criterion** The Causal Sufficiency Criterion between a set of facts $A_1, A_2, ....., A_n$ and a fact **B** is that, given the world as it more or less is, it is impossible for **B** not to have happened if all of the $A_k$ have happened. That is, had the world been just sufficiently different that **B** did not happen, then at least one of the $A_k$ (not necessarily the same one for each different circumstance) would not have happened either. The technical definition may be found in [Ladkin 01].

**Counterfactual Test (CT)** The criterion for determining a *Necessary Causal Factor*. Given two facts, **A** and **B**, CT asks whether, if the world had been just sufficiently different that **A** had not happened, whether **B** would have happened anyway. If **B** would not have happened in this situation in which **A** did not happen, the Counterfactual Test is passed, and **A** is a *Necessary Causal Factor* of **B**.

**List of Facts (LoF)** The List of Facts contains the significant facts that are causal factors of the incident. The facts are notated with a serial number, a short description, and a reference to their source.

**Necessary Causal Factor (NCF)** A fact that causally affects the occurrence of another fact in the course of events of the incident. This is determined by applying the Counterfactual Test. In Why-Because Graphs, NCFs are represented by child nodes.

**Topnode** The top node of the Why-Because Graph represents the failure of the examined system (mishap).

**Why-Because Graph (WB Graph, WBG)** The Why-Because Graph shows as edges the causal relations between the facts, shown as nodes, that led to the failure of a system.

**Why-Because List (WB List)** The Why-Because List contains the facts that are causal factors of the incident, arranged in pairs consisting of a necessary causal factor and its effect. Every single fact is notated with a serial number, a short description, and a reference to its source.

## References


[IBM 69] IBM. *Flowcharting Techniques*, GC20-8152-1 edition, 1969. Available from *http://www.fh-jena.de/~kleine/history/*, accessed 20 September 2005.

[Ladkin 01] Peter B. Ladkin. Causal system analysis, volume RVS-Bk-05-01. RVS Group, University of Bielefeld, 2001. Available at *www.rvs.uni-bielefeld.de → Why-Because Analysis*.

[Ladkin 02] Peter B. Ladkin. *WBA Home Page*. Available at *www.rvs.uni-bielefeld.de → Why-Because Analysis*, June 2002.

[Paul-Stüve 05] Thilo Paul-Stüve. *Formal Task Analysis of Graphical System Engineering Software Use*. Rapport technique, RVS Group, Faculty of Technology, University of Bielefeld, March 2005. Available at *www.rvs.uni-bielefeld.de → Publications → Theses Written in the Group*.

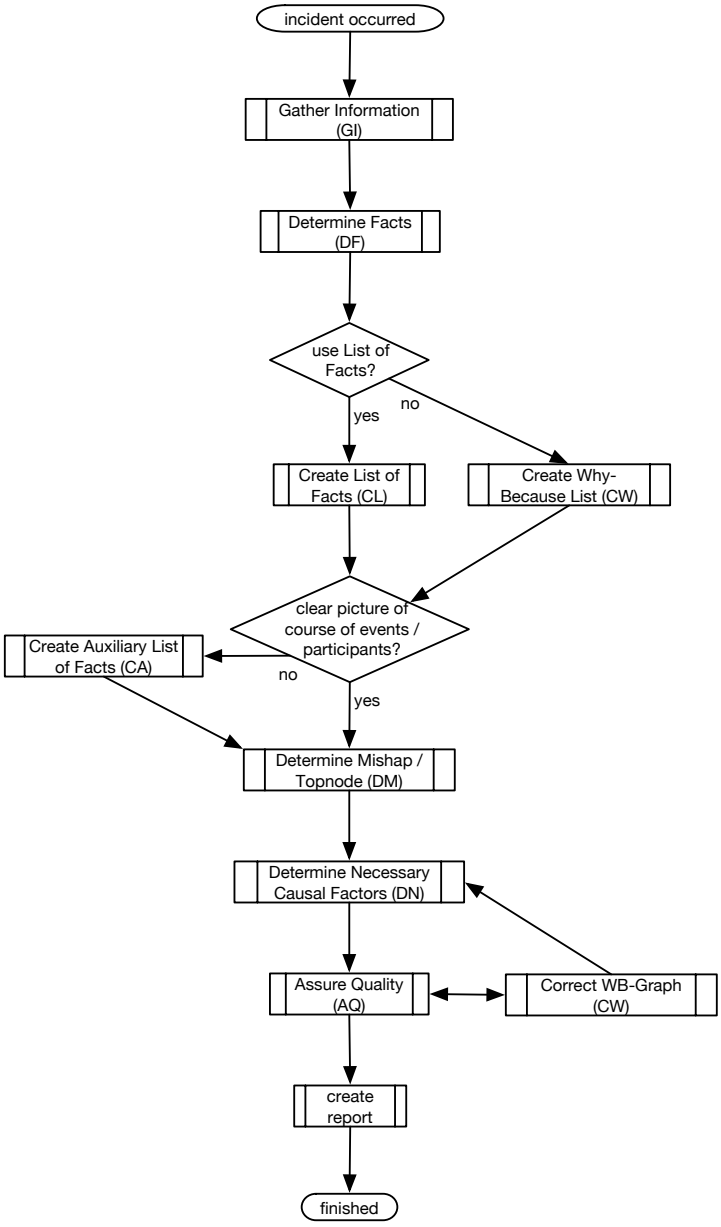


Figure 1: Why-Because Analysis Overview

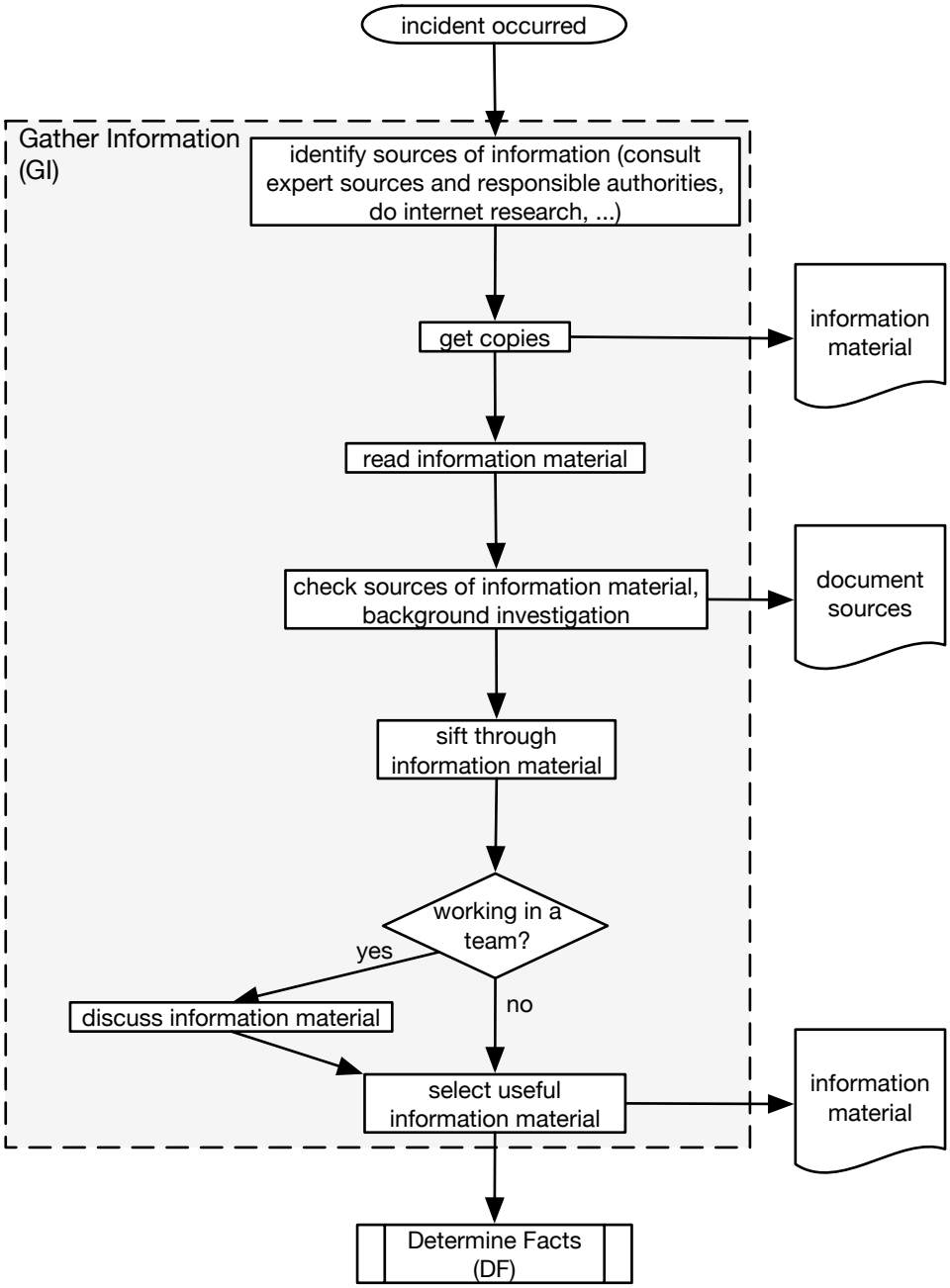


Figure 2: Gather Information

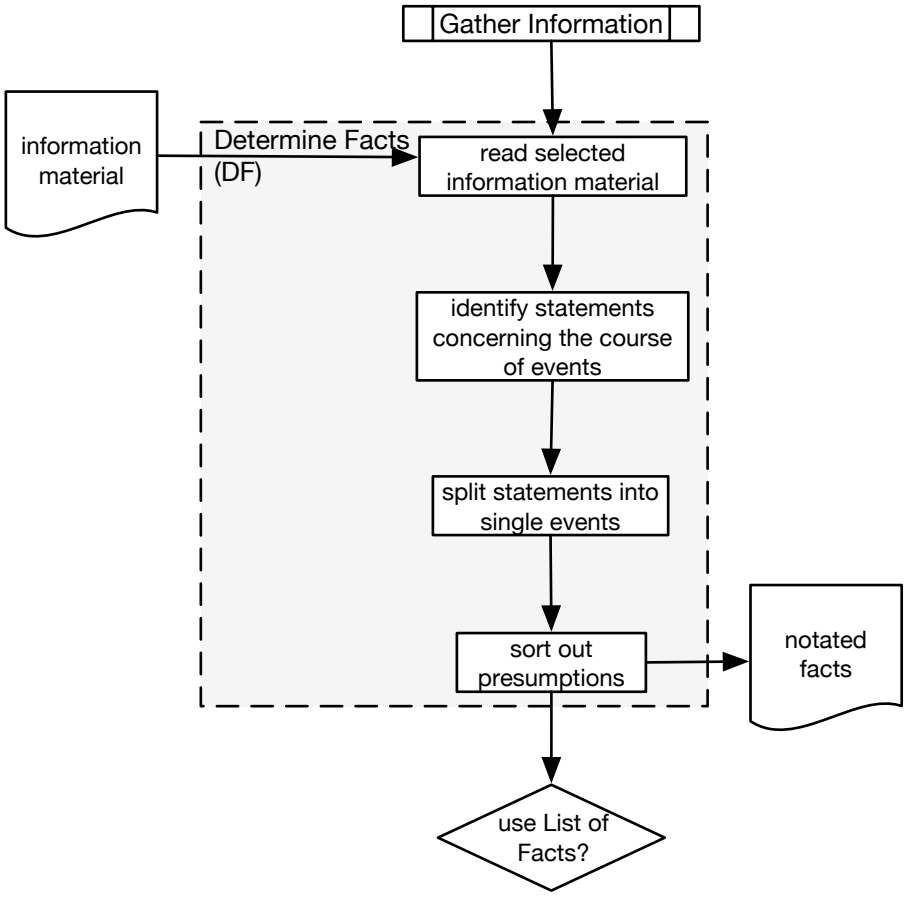


Figure 3: Determine the Facts

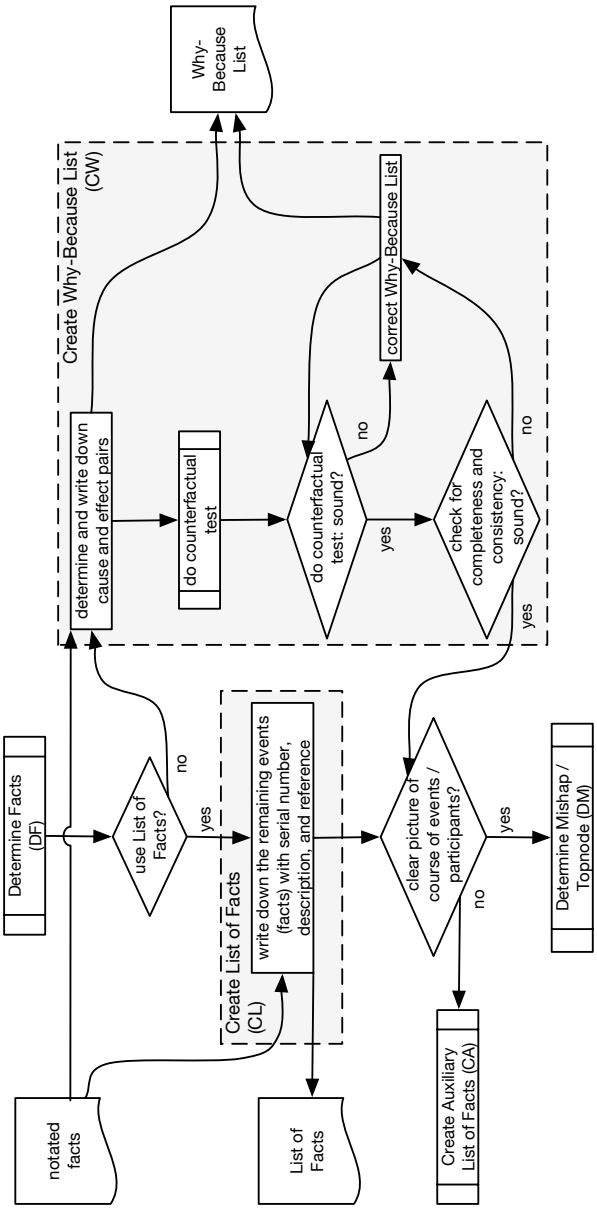


Figure 4: Create List of Facts / Why-Because List

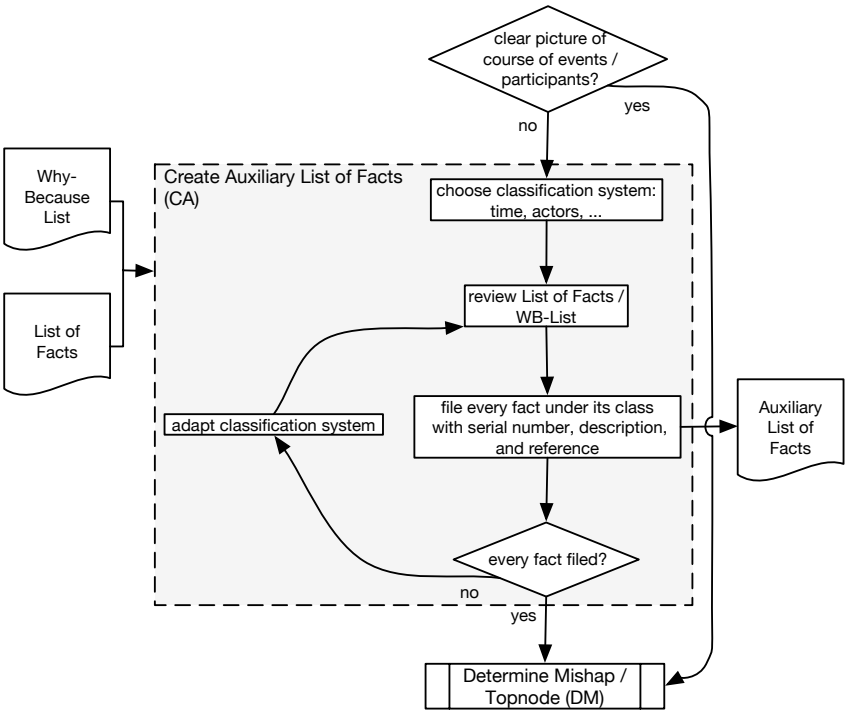


Figure 5: Create auxiliary List of Facts

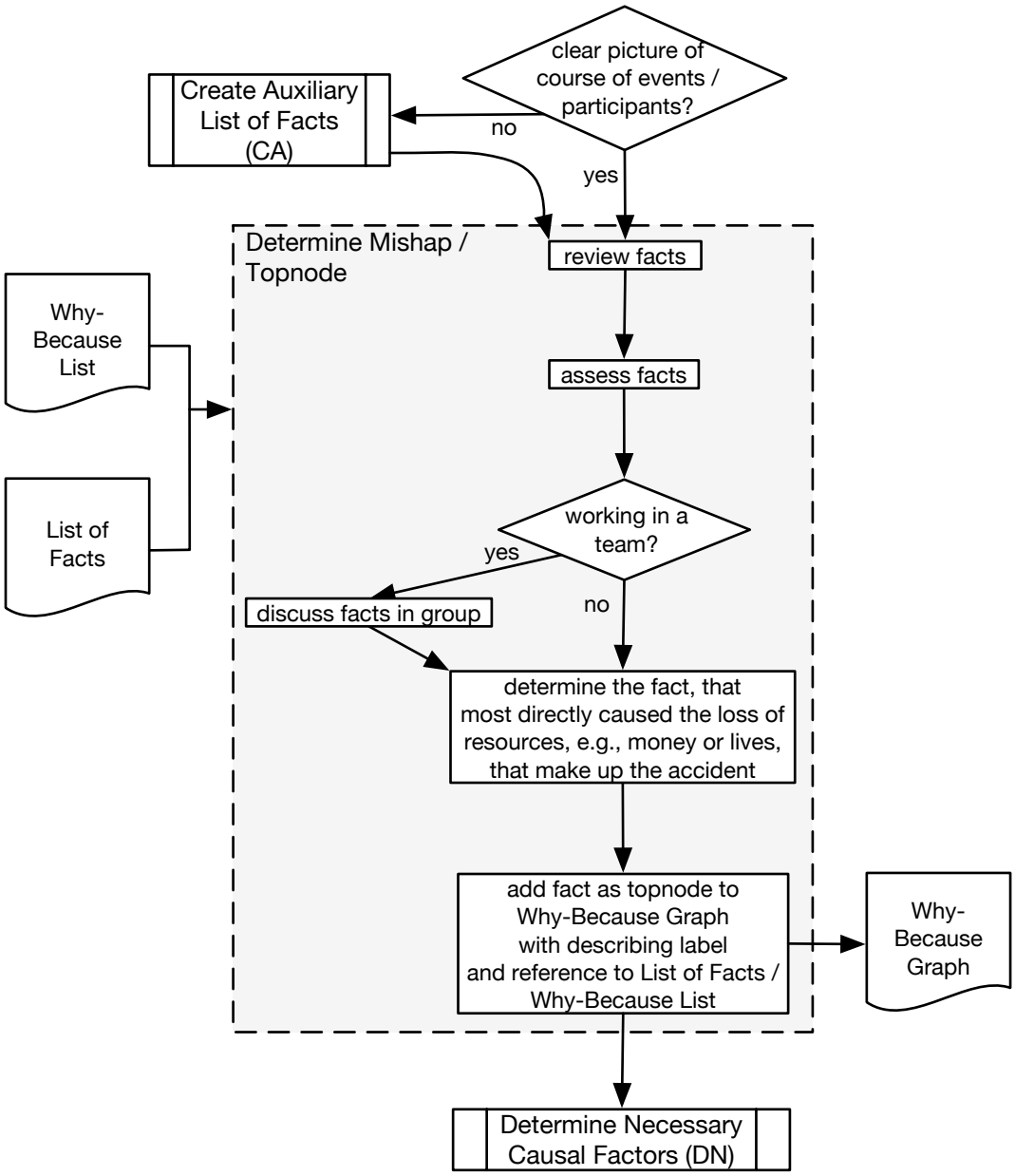


Figure 6: Determine the Mishap / Top node

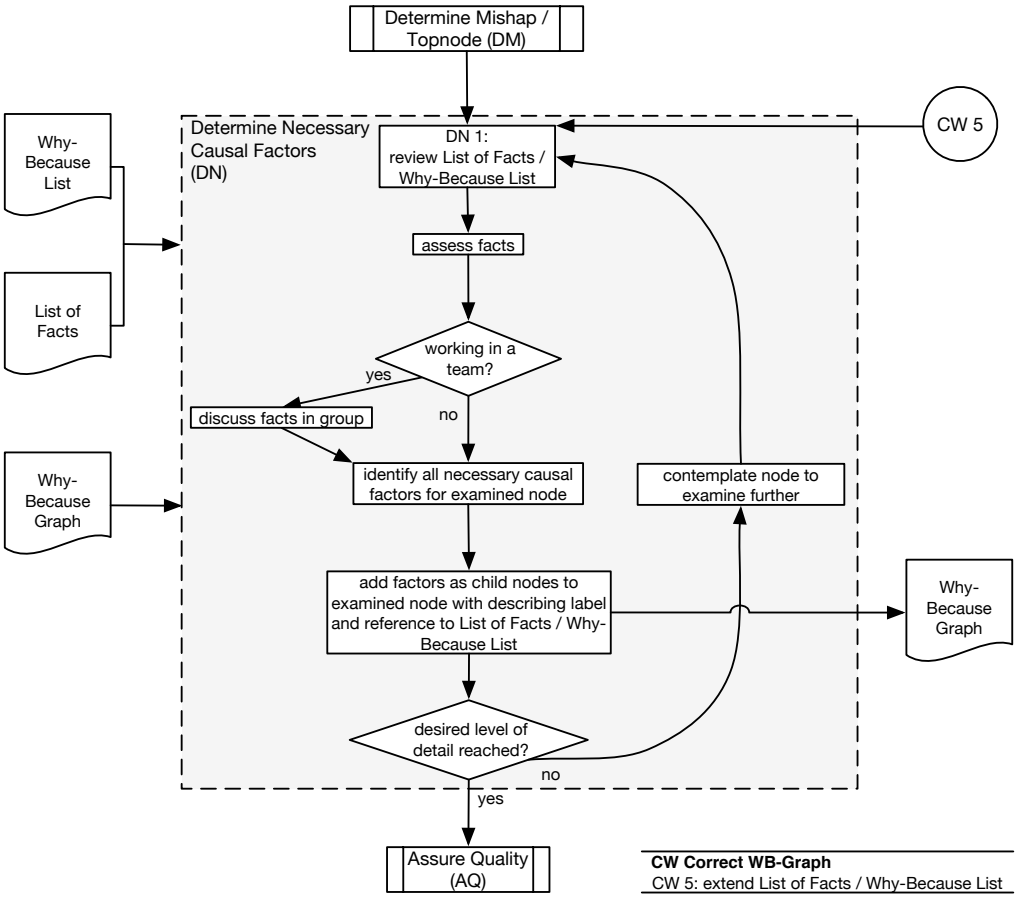


Figure 7: Determine the Necessary Causal Factors

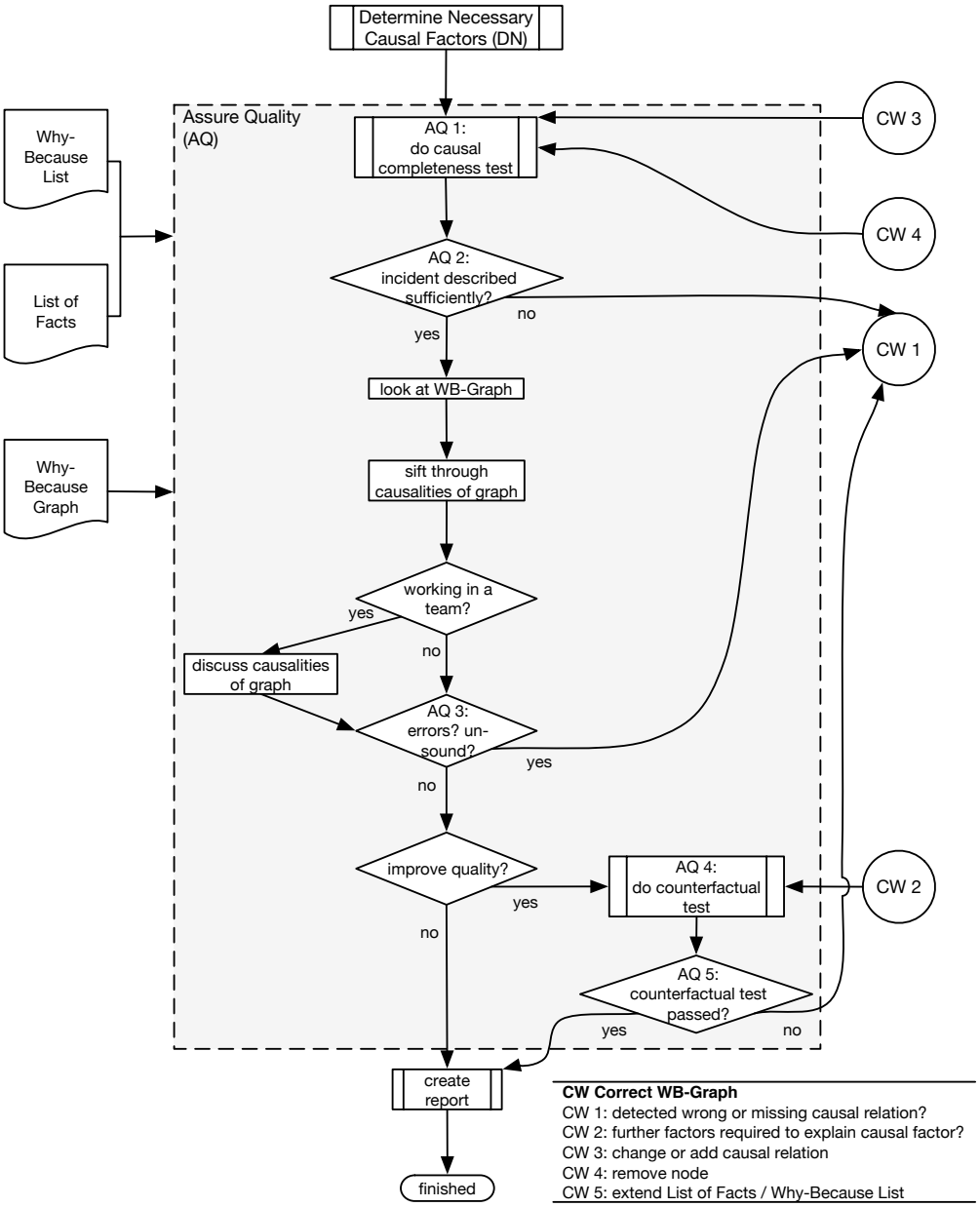


Figure 8: Assure the Quality

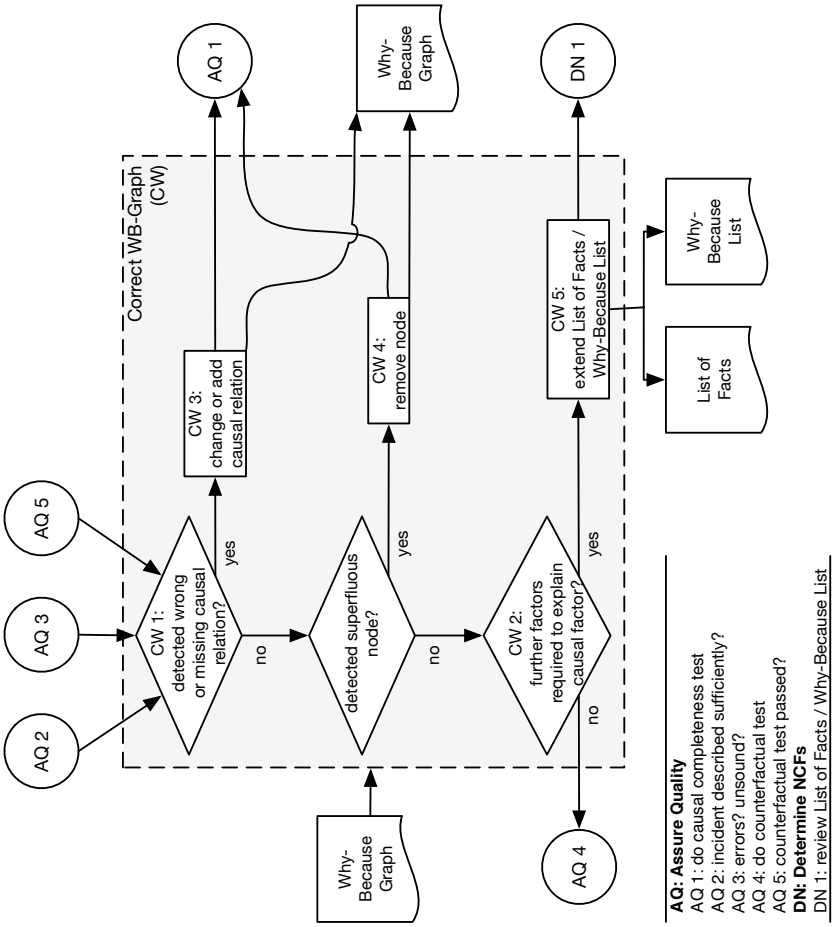


Figure 9: Correct the WB Graph