ARGEVIDE

Assurance Case Guide

Part 2. Argument Assessment

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1 Introduction

An assurance case is a structured and **compelling** argument, supported by evidence, **justifying** that a system has some postulated properties in a specific context and environment. When we develop an argument we should verify that it is “compelling” and that it “justifies” postulated properties. The way to achieve this goal is through the argument assessment mechanism.

Argument assessment is a systematic and documented process of an argument review, performed to verify its correctness and to guide the improvement process in order to produce an acceptably compelling argument.

The assessment process can be performed as self-assessment internally in the argument development team, by another division in the organization or by a third party, like a qualifier or certifier.

In this document we will describe:

- Main rules that drive the assessment process
- Activities of the assessment process
- Argument quality checklist

We recommend reading the first part of the Assurance Case Guide, which describes the structure of an assurance case, before continuing this text. Additionally you can use PREMIS while reading about the assessment and try the assessment process for yourself.

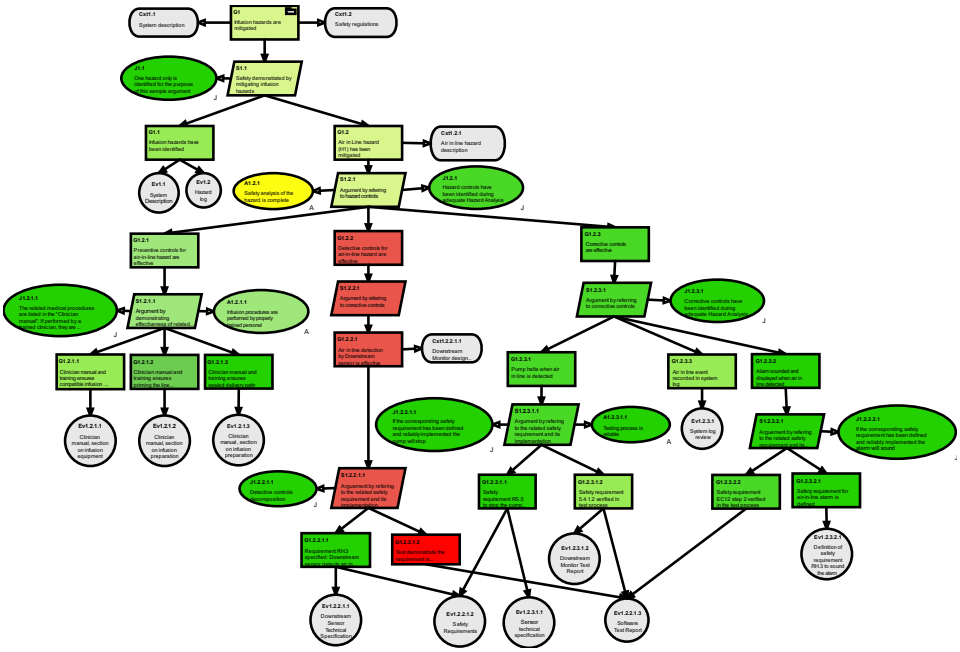


Figure 1. Visual presentation of the assessment in GSN diagram

2 What do we assess in the argument?

The main objective of the assessment is to determine whether the top claim is satisfied or not. The top claim, like all claims in the argument, is a proposition. Each proposition is a true-false statement. An example of a top claim is “the device is adequately safe to use”. Each proposition in the argument is a natural object for the assessment.

An argument is a composition of three base types of elements:

- Propositions (claims, assumptions, rationales)
- Inference rules (argumentation strategies)
- Information artefacts (references to evidence, context elements)

Propositions are the elements we are focused on in the assessment process. Propositions depend on each other in the argument structure and the assessment process should take these dependencies into account. A simplified argument structure is presented in Figure 2. To get more information about the argument structure and elements please refer to the first part of this Guide.

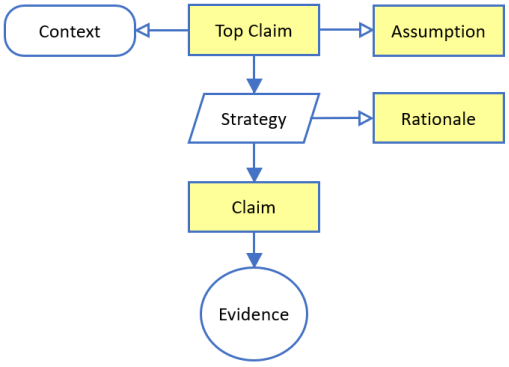


Figure 2. Main elements in the argument structure (rectangles are used for propositions in the argument)

The diagram presents a claim and other argument elements it depends on. There are three basic types of base argument structures that affect the overall assessment result:

- **Evidential steps** of the argument demonstrate that base claims are correctly supported by evidence
- **Reasoning steps** of the argument demonstrate that inferred claims are correctly supported by other claims
- **Assumptions** define conditions when the argument is valid

Note that TRUST-IT method advices defining an explicit strategy and rationale (justification) for each step of the reasoning in the argument. When higher confidence in the reasoning step is required a rationale can be supported with a confidence argument.

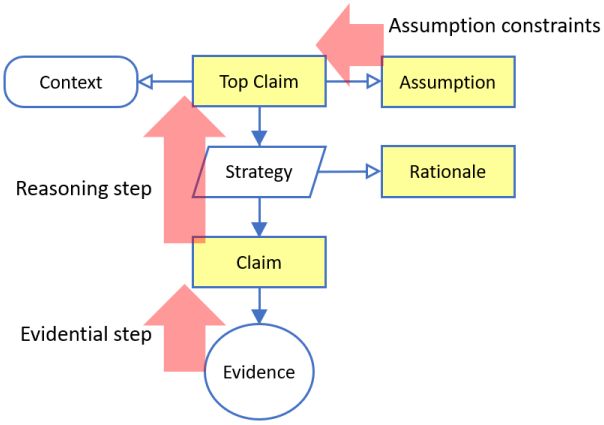


Figure 3. The main assessment points in the assurance case argument

3 What does the assessment mean?

The goal of the assessment is to give information whether a given proposition is true or false. It may happen that for some reason we are not able to make an assessment. To represent this situation we need “uncertain” value of the assessment. Assurance cases are often developed in parallel with system life cycle activities and uncertainty may correspond to tasks and work products which are not developed or not verified yet. Uncertainty is reduced with the progress in system development, verification and validation.

The base three values of the assessment are: “false”, “true” and “uncertain”. When the assessment is presented to the user we may use a colour code to represent the values: red for false, green for true and yellow for uncertainty.

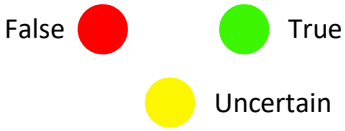


Figure 4. The main values of the assessment: false (red circle), true (green circle) and uncertainty (yellow circle)

The three-value assessment scale is useful but it does not give information on how many of the supporting premises are satisfied. This may be important when there are many premises or we want to identify separate issues in the assessment of one premise.

To represent the extent of achievement of a given proposition we extend the false/true values with a continuous scale from 0 (which denotes “false”) to 1 (“true”). The values can be represented with numbers (for example 0,85 or 85%) or graphically using a scale marked with values from 0 to 1. Another way of graphical representation is a colour bar with green, yellow and red segments corresponding to the assessment value. Both ways of assessment presentation are shown in Figure 5.

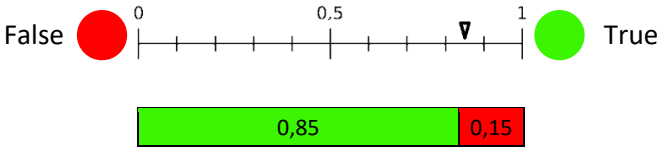


Figure 5. Assessment scale for a decision if proposition is true

Use of such a detailed scale raises some questions. What is the precise meaning of the assessment values? When a value like 0,85 should be used?

The assessment can be interpreted as a progress towards the goal. The value should not be interpreted as a metric for the goal. You cannot say that you have achieved 85% of system safety. The only reasonable statement is that according to the argument a given claim is true when it’s fully assessed to be true (assessment value 100%). Any assessment different from full acceptance (below 100%) means that the claimed system properties are not certain.

The scale presented in Figure 5 is using one dimension for the assessment from 0 (false) to 1 (true). Value 0,85 can be interpreted as an opinion that a given proposition is true at 85%, and it is false at 15%.

However we may need to extend this with uncertainty. Let’s consider a situation when we review twenty document. Fifteen of them are correct, three are wrong and two of them are missing, and our assessment of them is uncertain. To resolve the problem we need three values: to what extend a given proposition is true, is false and is uncertain. We need a way to combine these three values.

The solution is an opinion triangle[1].

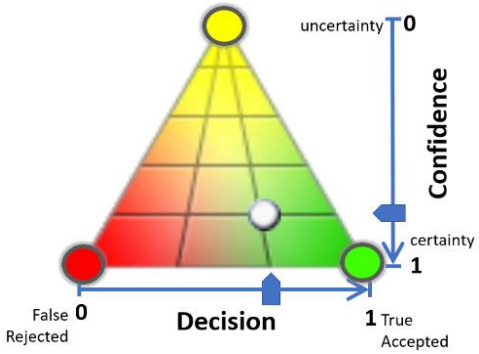


Figure 6. Opinion triangle used to represent proposition assessment

Any point in the triangle can be represented with two values which describe two dimensions of the assessor evaluation. The first dimension is used to say if a proposition is true or false. The second dimension is used to define the confidence level of the first assessment.

This way of the assessment representation with two values (decision, confidence) is formally defined by Dempster–Shafer theory as a pair (belief, plausibility).

Mathematical formulas are used to calculate the assessment point in the triangle depending on the assessor decision. The assessment can also be presented on the assessment bar where the width of green, red and yellow sections depends on the value of the assessment.

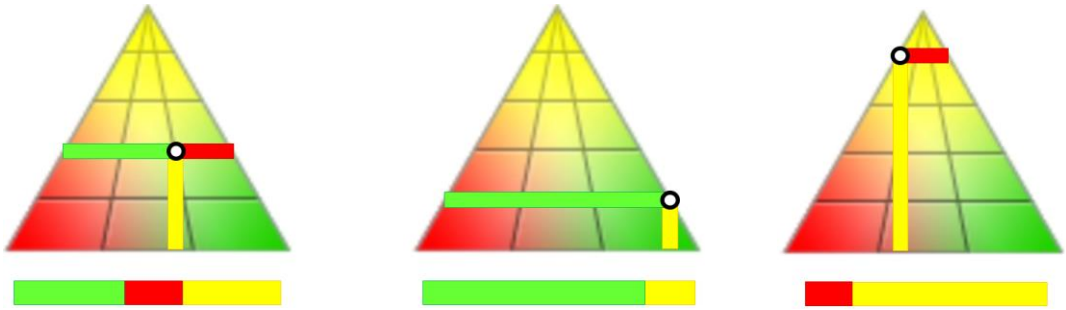


Figure 7. Examples of an assessment in the opinion triangle and presented in the assessment bar

The opinion triangle enables representation of uncertainty of the assessment, however simpler scales may also be used for the assessment of TRUST-IT assurance case. All scales use a subset of Dempster-Shafer assessment scale presented in Figure 6. Examples of simple assessment scales are:

- three-value assessment scale uses only three values as presented in Figure 4,
- SPICE scale defined by ISO 33000 standard with values from 0 to 100 divided into four ranges N-P-L-F: Not achieved (0–15%), Partially achieved (>15–50%), Largely achieved (>50–85%), Fully achieved (>85–100%).

[1] You can find description of the opinion triangle in: Josang A., Grandison T. Conditional inference in subjective logic. In: Proceedings of the 6th international conference on information fusion cairns, 2003, p. 471–8 (link)

4 Assessment in the argument structure

The argument assessment is a systematic process of reviewing of all evidential and reasoning steps on whether they provide sufficient support. The assessment of the top claim depends on the results of the review of the supporting argument steps according to the dependencies of the argument structure.

- Inferred claims are supported by **reasoning steps** and their assessment depends on the assessment of the inference rule and the premises. The inference rule for each reasoning step should be reviewed and assessed. The resulting assessment of the inferred claim can be calculated automatically.
- Base claims are supported directly by evidence. The **evidential steps** of the argument should be reviewed by the assessor to check if the available evidence satisfies the requirements specified by the base claim.
- The assessor should review and verify all **assumptions** in the argument on whether they apply.

The distinction between reasoning and evidential steps is the essential element of the assessment process. The assessment scenarios are different for these two types of argument steps.

- **Reasoning steps** contain claims supported by strategies and supporting premises. The premises are:
  - inferred claims supported by further reasoning steps
  - base claims supported by evidential steps
- **Evidential steps** contain base claims supported directly by evidence and are not supported by any other claims. They form the bottom layer of the argument

The argument steps are not separable and they share elements, usually claims, on their boundaries. Figure 8 presents three argumentation steps which share two base claims.

TRUST-IT methods requires the claim to be precisely defined. Each argumentation step can be examined and assessed in separation from other steps. The information that is shared by the argumentation steps is the inherited context and assumptions that apply to the whole branches of the argument.

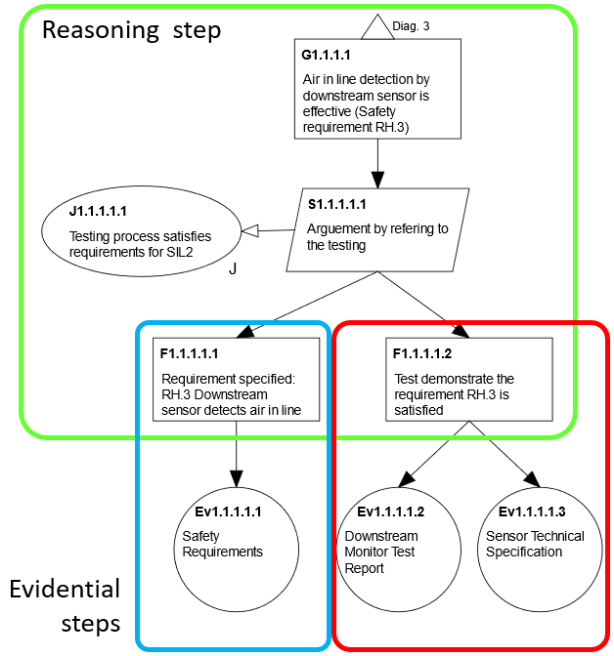


Figure 8. Boundaries of argumentation steps

Boundaries of an argumentation step are correctly defined when no other argument elements (except inherited context and assumption) are necessary to interpret the content of a given step. When you find any other information that has impact on the interpretation of an argument step then you should move this information into the scope of the argument step or define as an inherited context or assumption.

The logical separation of argumentation steps is useful for the assurance case change management process. This allows for automated change impact analysis and reduces the required effort of the re-assessment when the argument evolves.

5 Assessment of evidential steps

An evidential step consists of a base claim, supporting evidence and optionally direct or inherited context and assumptions.

There are to two main rules of the assessment of evidential steps:

1. The prerequisite is that the base claim provides a precise description of the required evidence and also acceptance criteria. The criteria should enable objective assessment if they are satisfied by the provided evidence.
2. The assessment of a base claim in manual. The assessor should review:
   a) The requirements defined by the base claim
   b) The direct and inherited context and assumptions when applicable
   c) Evidence and whether it satisfies the specified requirements in a given context

The scope of reviewed elements is presented in Figure 9.

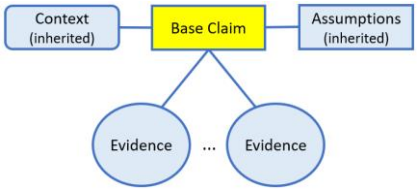


Figure 9. Elements that have impact on the assessment of an evidential step marked with light blue background

Precise specification of requirements in base claims is essential to develop unambiguous assurance case. When the requirements are not precise the assessor should give uncertain assessment and comments to point out the problem and possibly suggest improvement.

We will present a sample specification of acceptance criteria for a base claim. Base claim F1.1.1.1.2 presented in Figure 8 refers to the tests of safety requirements for a component named Downstream Monitor. The description of this base claim should provide criteria when the test report provided as evidence is sufficient to support the argument reasoning.

Element name	Tests demonstrate the requirement RH3 is satisfied
Label	F1.1.1.1.2
Description	Acceptance criteria for Downstream Monitor test reports: 1) The performed tests are based on the Test Plan, which includes requirement RH.3 2) The object of the test was the downstream monitor type according to the system definition 3) The results of all test cases related to the requirement RH.3 are positive 4) The test process was performed according to the approved development process 5) The tools used in the testing process had been approved.

The assessor should not forget to check what are the applicable inherited context and assumptions.

The assessment made by an assessor is valid as long as the related elements (Figure 9) are not modified. Evidence items are not a part of the argument but their modification should also invalidate assessment of all base claims that refer to them. The same problem relates to context documentation. When context elements refer to documents then their change should also invalidate assessment of the base claim. All documents referred as evidence or context information should be under the configuration management to enable change management.

6 Assessment of reasoning steps

A reasoning step consists of:

- An inferred claim and optionally its context and assumptions (including inherited)
- A supporting strategy and a rationale to justify that the reasoning step is valid
- The premises to support the reasoning that the inferred claim is satisfied

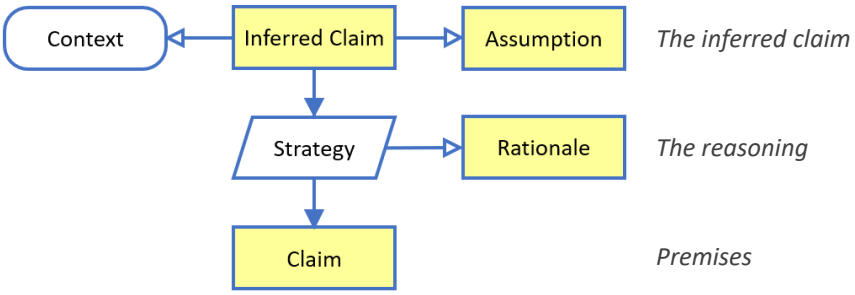


Figure 10. The scope of a reasoning step of the argument

Inferred claims are not assessed manually by the assessor but their assessment is calculated based on the assessment of other elements: assumptions, rationales and supporting claims. This can be performed manually by an assessor or automatically for element supported by further reasoning steps.

The assessment of the inferred claim is automatic and it is updated each time any assessment of the supporting elements changes. The algorithm of the automatic assessment calculation consists of four steps:

1. **Premises assessment aggregation** – The assessment of all premises under a strategy is merged into one aggregated assessment.
2. **Calculation of confidence of the reasoning** – The confidence of the aggregated assessment is to be adjusted depending on the assessment of the rationale of the reasoning step.
3. **Merging the assessment of alternative strategies** – If more then one strategy supports the inferred claim, their assessments strategies are to be merged.
4. **Assumption adjustment** – if an assumption is attached to the inferred claim it should be verified and possibly confidence of the inferred claim should be corrected.

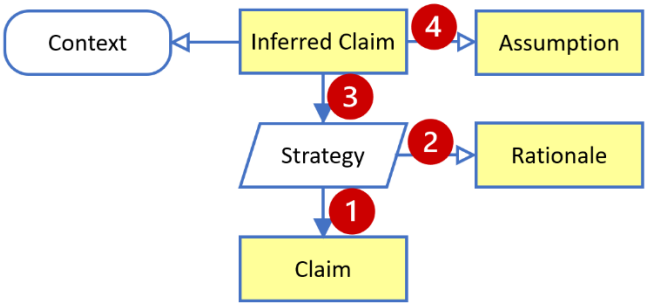


Figure 11. Steps to calculate the assessment of the inferred claim

The steps are performed automatically when any of the input elements are modified. When the inferred claim supports higher-level reasoning step, its assessment will also be used as in input for higher level claims. This process is be repeated up to the level of the top claim of the argument.

Depending on the assessment method used in the argument the details of the automatic steps may differ. The description in the following subsections presents the most advanced assessment calculation mechanism for Dempster-Shafer assessment method. Other assessment methods use simpler algorithms for the assessment aggregation.

6.1 Premises assessment aggregation

The step can be performed when the premises (sub-claims) are already assessed. The assessment is not complete when any of the premises is not assessed.

The goal of the step to combine the assessment of all premises for a single strategy. The aggregation algorithm depends on the relations between the premises.

The argument developer may choose of three types of relations between premises:

- Complementary premises
- Necessary and sufficient premises
- Sufficient premises

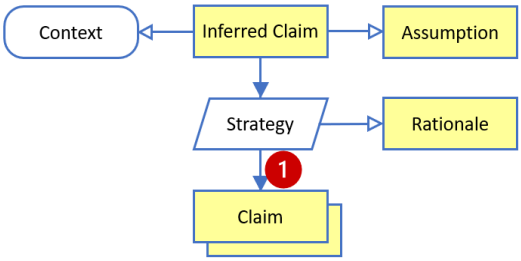
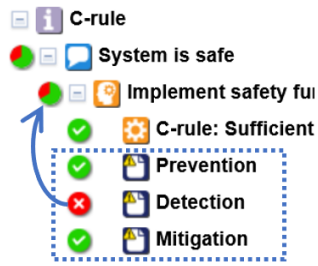
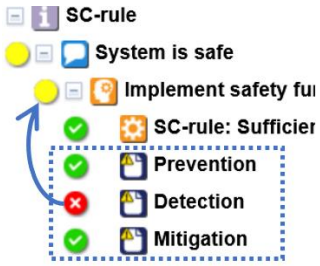


Figure 12. The step of assessment aggregation for multiple premises

The types of relations and corresponding calculation algorithms are presented in Table 1. Examples of a reasoning argumentation steps are presented with icons to present the assessment to illustrate how rejection of one premise affects the calculated result.

Table 1. Types of aggregation rules for multiple premises

Complementary premises	Necessary and sufficient premises	Sufficient premises
The premises support the conclusion in a complementary way. Every premise has its "share" in the conclusion assessment.	The set of premises is sufficient for the reasoning and every premise is necessary. When any of the premises is rejected, it entails rejection of the conclusion.	The set of premises is sufficient for the reasoning, but when any of them is rejected, we cannot say if the result is valid and leaves the conclusion uncertain.
		

6.2 Calculation of confidence of the reasoning

The next step is to verify if the strategy is valid for a given claim and if it was used in the right way. It should be rejected when:

- The strategy is not sufficient to support a given claim in its full context
- The set of premises if not complete or is inconsistent

These conditions are represented in the rationale of the reasoning. Rejection of the rationale causes uncertainty of the inferred claim (Figure 13 on the right).

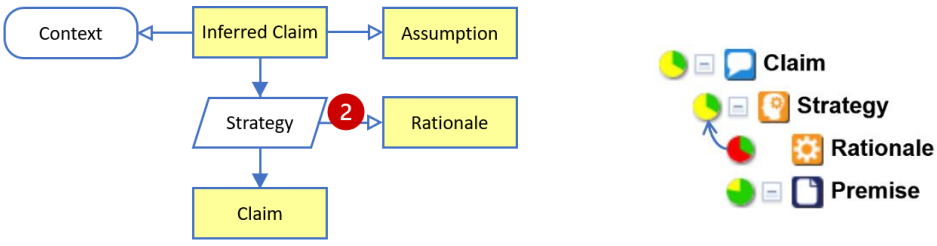


Figure 13. The step of the conclusion confidence assessment (left) and sample argument fragment (right)

6.3 Merging the assessment of alternative strategies

It may happen that several alternative strategies are defined to support the inferred claim.

Two strategies are alternative when two conditions are satisfied:

- they are independent of each other and
- each of them is sufficient itself to fully support a given claim.

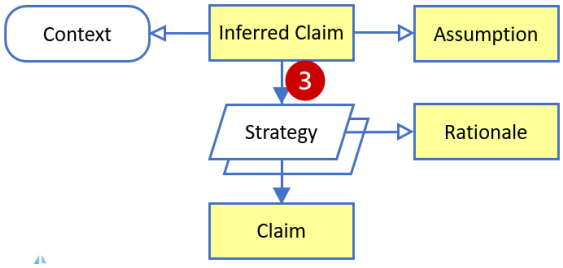


Figure 14. Use of alternative strategies

It should be checked if two strategies are alternative. In some cases two strategies may only seem to be alternative. For example static and dynamic testing may seem to be alternative approached but it should be demonstrated that each of them is sufficient to support the inferred claim. If you find out that there are some types of failures that cannot be detected by static testing then then this approach cannot be regarded an alternative strategy. The use of alternative strategies is to be considered individually for each claim.

When there are two alternative strategies the argument developer may select one of them to support it with evidence and ignore other strategies. This is presented in Figure 15 a).

Another approach is to implement both of them partially to achieve higher level of confidence. Figure 15 b) presents two strategies that are partially implemented. The resulting confidence in the inferred claim is higher than for each of the supporting strategies. This is a result of application of the belief matrix for alternative strategies shown in Figure 15 c).

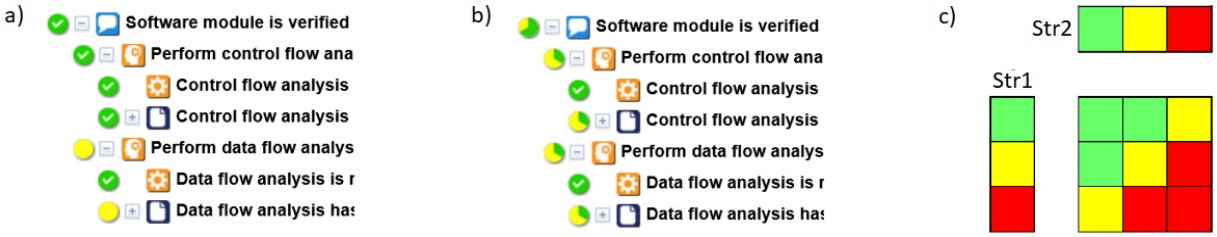


Figure 15. Use of alternative strategies (a and b), the belief matrix for alternative strategies (c)

6.4 Assumption adjustment

The last step is performed when an assumption is attached to the inferred claim. The assumption should be confirmed to be true. When the assumption is invalid then the whole argument may be also not valid and that causes uncertainty of the inferred claim.

Assumptions are generally assumed to be true but their verification is recommended for each assurance case, especially in case of argument reuse. It may happen that some assumptions are not valid when the argument is used in a different context.

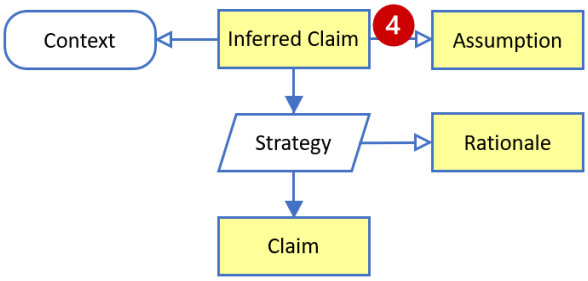


Figure 16. The step of assumption adjustment

7 Validity period of the assessment

Any assessment made in the argument is not valid indefinitely. Changes in the argument cause that some of the elements should be re-assessed. The assessment affected by argument changes becomes “outdated” in PREMIS. The user will know which elements needs to be assessed again.

The impact of a change on the argument assessment is determined based on the scope of argumentation steps. When any of the elements of an argumentation step is modified then the assessment of a given step becomes outdated. The scope of argumentation steps is presented in Figure 17.

- Assessment of a base claim becomes outdated when its context, assumptions, supporting evidence or the base claim itself is modified.
- Assessment of a rationale becomes outdated when the inferred claim, its context, assumptions, the strategy, premises or the rationale itself is modified.

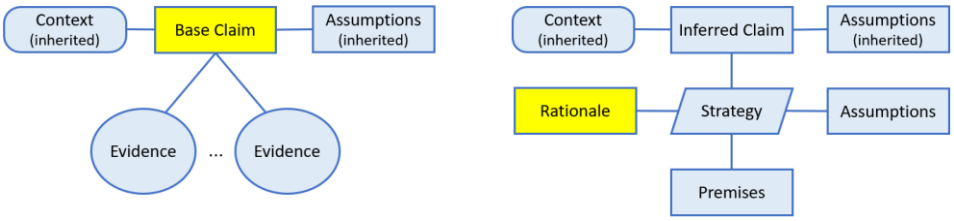


Figure 17. Scope for evidential step (left) and reasoning step (right)

The objective of tracking outdated assessment is to assist the assessor and alert them when a review is required to update the assessment.

It happens that during an assessment of a modified argumentation step the assessor finds any further inconsistencies or doubts caused by the change and to correct them next changes of the argument are required. These changes in turn cause other assessment to be outdated and the next argumentation steps have to be reviewed. This chain of argument and assessment changes will stop when a new consistent state of the argument is reached.

8 Argument quality checklist

Argument quality can be checked during the assessment process with the use of a checklist given below.

1. Clear and unambiguous assurance case
   a) Understandable – the goals, line of reasoning and context are clearly specified
   b) Precise – descriptions are clear and the terms used are defined
   c) Explicit – claims and argumentation strategies are explicitly defined
   d) Restricted – the context and boundaries are clearly specified
2. Convincing arguments
   a) Direct – reasoning should aim directly at the specific claim
   b) Defensible – capable of being justified and defended
   c) Comprehensive – reasoning should cover the full scope of the top claim, its context and the assumptions
   d) Complete – containing all elements required to reason the conclusion but not redundant elements
   e) Robust – not based on optimistic assessment and weak premises
3. Compelling evidence
   a) Veracious – representing the truth and being accurate
   b) Applicable – consistent with the goals and useful for the reasoning, adequate
   c) Unambiguous – not open to more than one interpretation
   d) Sufficient – containing all information required by the supported base claim
   e) Up to date – representing the current state adequate for the goals and context

Points 1 and 2 of the checklist apply to reasoning steps of the argument. Points 1 and 3 apply to evidential steps.