The Evidence Pattern

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1 Introduction

The ability to present claims backed up by arguments that are supported by evidence, together with the ability to counter such claims in a similar manner, is a common need in systems engineering. While most often seen in areas such as testing, it applies equally to the establishment of traceability, definition of safety cases and even the presentation of business cases. Whatever the reason, such chains of evidence-arguments-claims should be presented in a consistent and rigorous manner.

1.1 Pattern Aims

This Pattern is intended to be used as an aid to the definition chains of evidence and arguments used to support claims made about a subject. The main aims of this Pattern are shown in the Architectural Framework Context View (AFCV) in Figure 1.
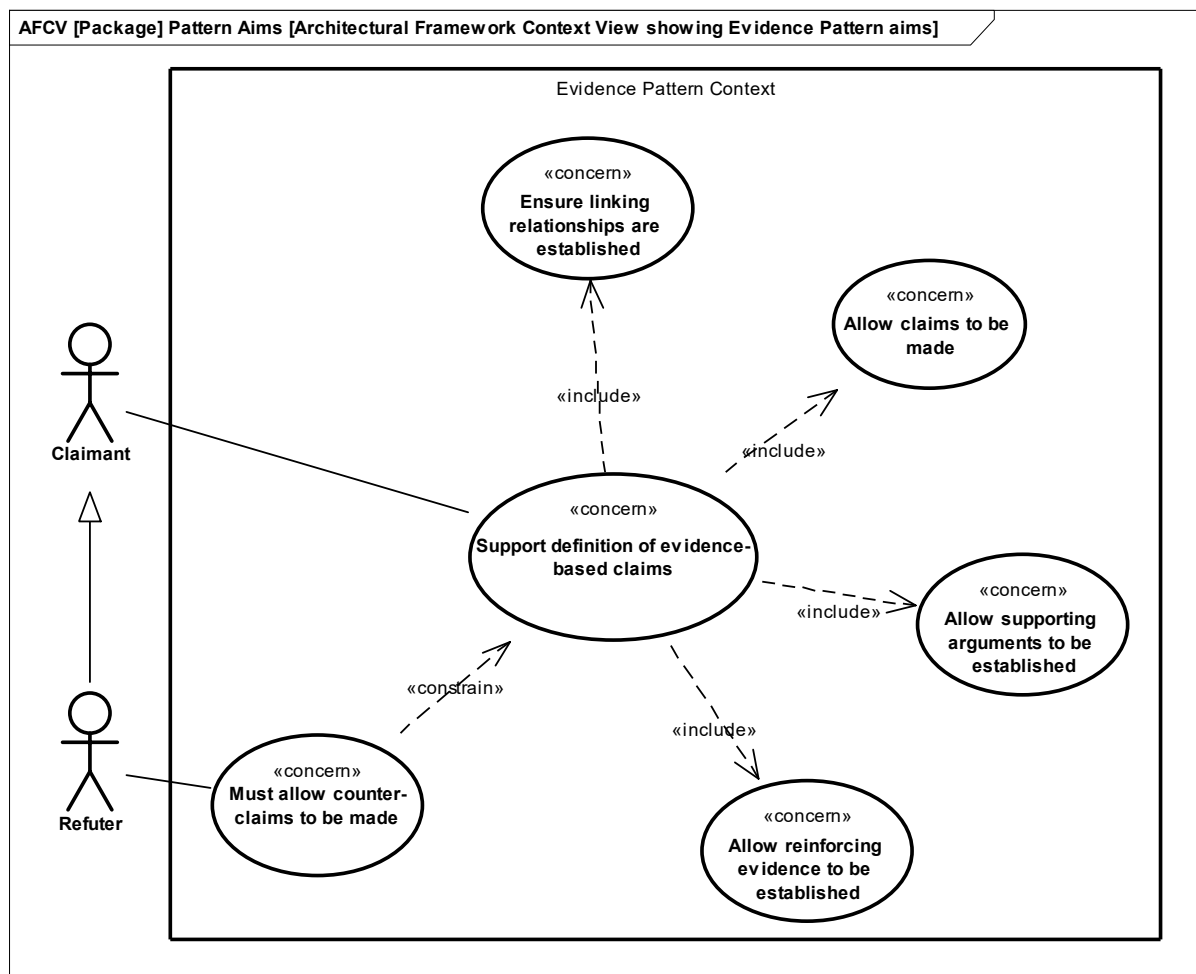

Figure 1 - Architectural Framework Context View showing Evidence Pattern aims

The main purpose of the Evidence Pattern is to 'Support definition of evidence-based claims' made by a 'Claimant'. This includes the Use Cases:

- 'Allow claims to be made' - allow claims to be made by a Claimant about a subject.
- 'Allow supporting arguments to be established' - allow the arguments that support a claim to be established.
- 'Allow reinforcing evidence to be established' - allow the evidence that reinforces an argument to be established.

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- 'Ensure linking relationships are established' - allow the linking relationships from evidence to arguments to claims to be clearly established.

The Use Case 'Support definition of evidence-based claims' is constrained by the need that the Evidence Pattern 'Must allow counter-claims to be made'. That is, it must allow counter-claims to be made against any aspect of a claim (the claim itself, the supporting arguments, the reinforcing evidence or the links between them).

2 Concepts

The main concepts covered by the Evidence Pattern are shown in the Ontology Definition View (ODV) in Figure 2.
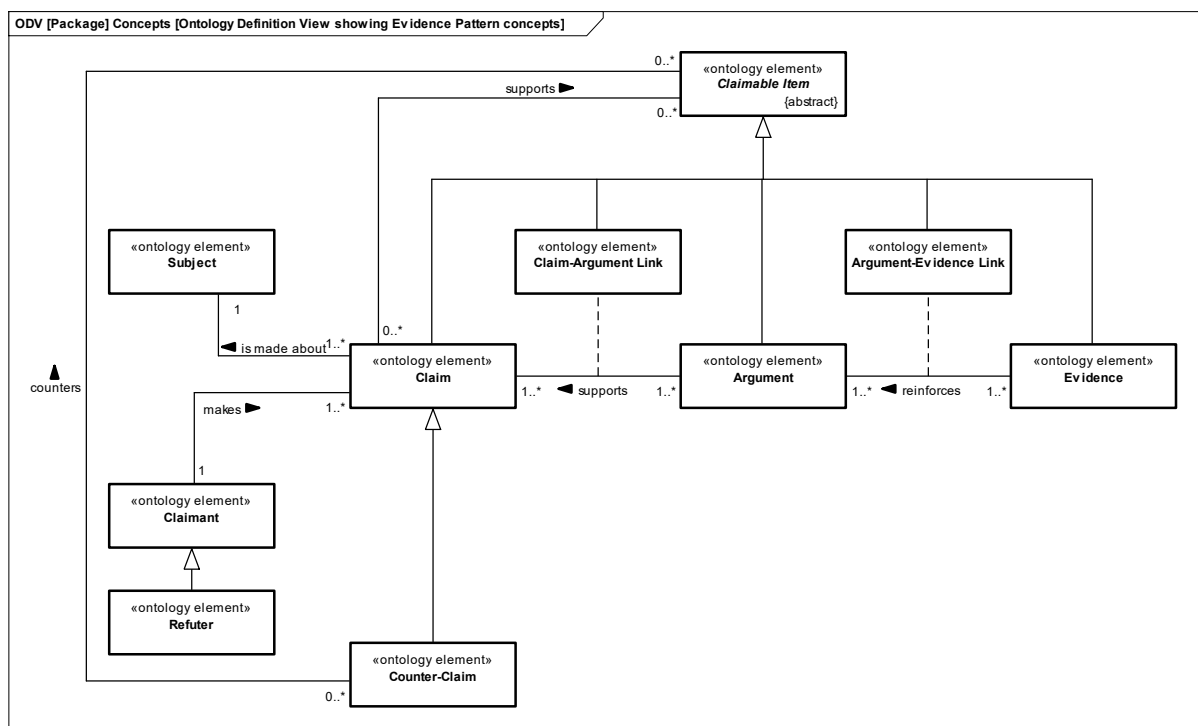

Figure 2 - Ontology Definition View showing Evidence Pattern concepts

Key to this Pattern is the concept of a 'Claim' that is made by a 'Claimant' about a 'Subject'. Such a 'Claim' is supported by one or more 'Argument' via a 'Claim-Argument Link'. Each 'Argument' is itself reinforced by one or more 'Evidence' via an 'Argument-Evidence Link'.

Note that a 'Claim', 'Argument', 'Claim-Argument Link', 'Evidence' and 'Argument-Evidence Link' are all types of the abstract concept of a 'Claimable Item'. This allows a 'Counter-Claim' (a special type of 'Claim') to be made about any type of 'Claimable Item' and a 'Claim' to support any type of 'Claimable Item'. Such a 'Counter-Claim' is made by a 'Refuter', a special type of 'Claimant'.

3 Viewpoints

This section describes the Viewpoints that make up the Evidence Pattern. It begins with an overview of the Viewpoints, defines Rules that apply to the Pattern and then defines each Viewpoint.

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3.1 Overview

The Evidence Pattern defines a number of Viewpoints as shown in the Viewpoint Relationship View (VRV) in Figure 3.
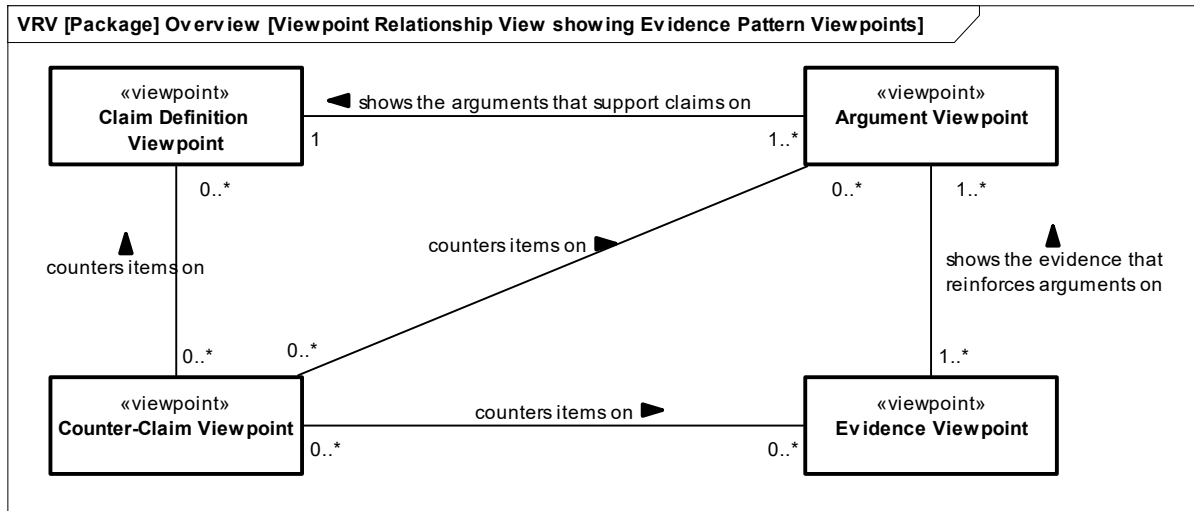

Figure 3 - Viewpoint Relationship View showing Evidence Pattern Viewpoints

The Evidence Pattern defines four Viewpoints for the definition of Evidence-Argument-Claim chains:

- The 'Claim Definition Viewpoint' is used to define Claims for a particular Subject and to show who made the Claims.
- The 'Argument Viewpoint' is used to show the Arguments that support a Claim.
- The 'Evidence Viewpoint' is used to show the Evidence that reinforces Arguments.
- The 'Counter-Claim Viewpoint' is used to make Counter-Claims (or supporting Claims) about Claimable Items.

Each of these Viewpoints is described in more detail in the following sections. For each Viewpoint an example is also given.

3.2 Rules

Seven rules apply to the four Evidence Viewpoints, as shown in the Rules Definition View (RDV) in Figure 4.

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RDV [Package] Rules [Rules Definition View showing Evidence Pattern Rules]

«rule» **Rule EP01**	«rule» **Rule EP02**	«rule» **Rule EP03**
notes *Every Claim must be supported by at least one Argument.*	*notes* *Every Argument must be reinforced by at least one Evidence.*	*notes* *Every Claim must be made by a defined Claimant.*

«rule» **Rule EP04**	«rule» **Rule EP05**	«rule» **Rule EP06**
notes *Every Claim must be made about an identified Subject.*	*notes* *As a minimum one Claim Definition View, one Argument View and one Evidence View must be produced.*	*notes* *A Counter-Claim View must have EITHER one Claim OR one Counter-Claim and at least one Claimable Item (Claim, Counter-Claim, Argument, Claim-Argument Link, Evidence or Argument-Evidence Link) that the Claim or Counter-Claim supports or counters.*

«rule» **Rule EP07**

notes
The Claimable Items that appear on a Counter-Claim View must appear on another relevant View. E.g. an Argument that appears on a Counter-Claim View must also appear on an Argument View etc.

Figure 4 - Rules Definition View showing Evidence Pattern Rules

These seven Rules are:

- 'Rule EP01: Every Claim must be supported by at least one Argument.' A Claim can not be made without some supporting Argument.
- 'Rule EP02: Every Argument must be reinforced by at least one Evidence.' An Argument is only valid if there is some Evidence to back it up.
- 'Rule EP03: Every Claim must be made by a defined Claimant.' For a Claim to be valid, there must be a Claimant associated with it who has made the Claim. Anonymous Claims are not permitted.
- 'Rule EP04: Every Claim must be made about an identified Subject.' Claims can not be generic, they have to be about something, that is they have to have a Subject.
- 'Rule EP05: As a minimum one Claim Definition View, one Argument View and one Evidence View must be produced.' This Rule establishes the minimum set of Views that have to be produced when using the Pattern for the use to be valid. If any are missing then all the necessary parts of the stated claim will not be present.
- 'Rule EP06: A Counter-Claim View must have EITHER one Claim OR one Counter-Claim and at least one Claimable Item (Claim, Counter-Claim, Argument, Claim-Argument Link, Evidence or Argument-Evidence Link) that the Claim or Counter-Claim supports or counters.' This Rule simply states that you can not have an "empty" Counter-Claim View i.e. one with no Claim in support of something else or Counter-Claim that refutes something else.
- 'Rule EP07: The Claimable Items that appear on a Counter-Claim View must appear on another relevant View. E.g. an Argument that appears on a Counter-Claim View must also appear on an Argument View etc.' This Rule simply states that if creating a Counter-Claim

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View, then that View must be making a Claim or Counter-Claim about something that has already been defined on one of the other Views; you can't counter or support something that hasn't already been claimed.

Note that the seven Rules shown in Figure 4 are the minimum that are needed. Others could be added if required.

3.3   Claim Definition Viewpoint (CDVp)

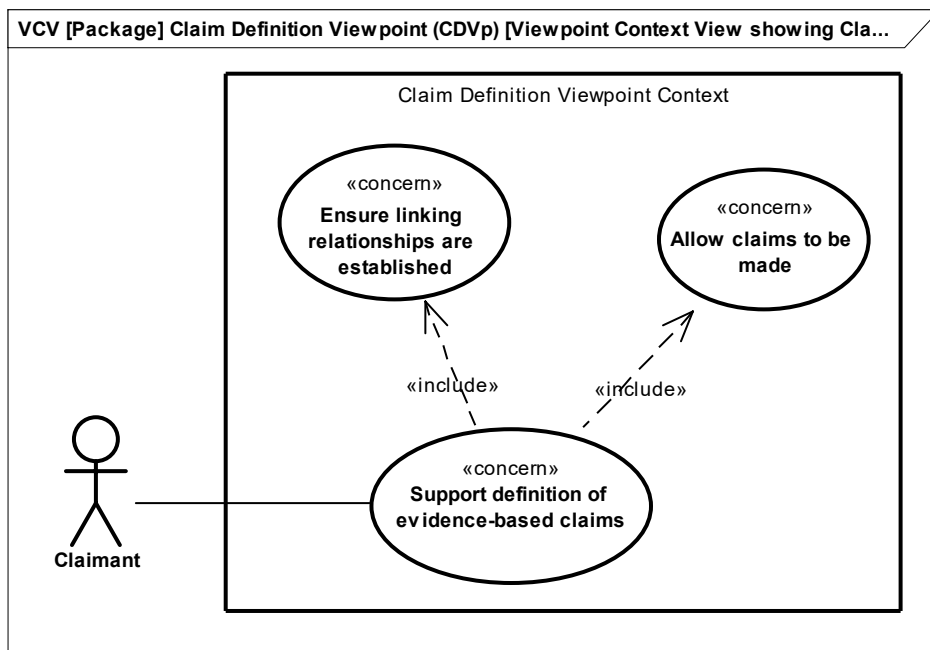The aims of the Claim Definition Viewpoint are shown in the Viewpoint Context View in Figure 5.

Figure 5 - Viewpoint Context View showing Claim Definition Viewpoint aims

The main aim of the Claim Definition Viewpoint is to 'Support definition of evidence-based claims' through the aims of 'Allow claims to be made' and 'Ensure linking relationships are established'. That is, its aim is to capture the Claims made by a Claimant about a Subject together with the relationships from Claimant to Claim to Subject.

3.3.1   Description

The Viewpoint Definition View (VDV) in Figure 6 shows the Ontology Elements that appear on a Claim Definition Viewpoint.
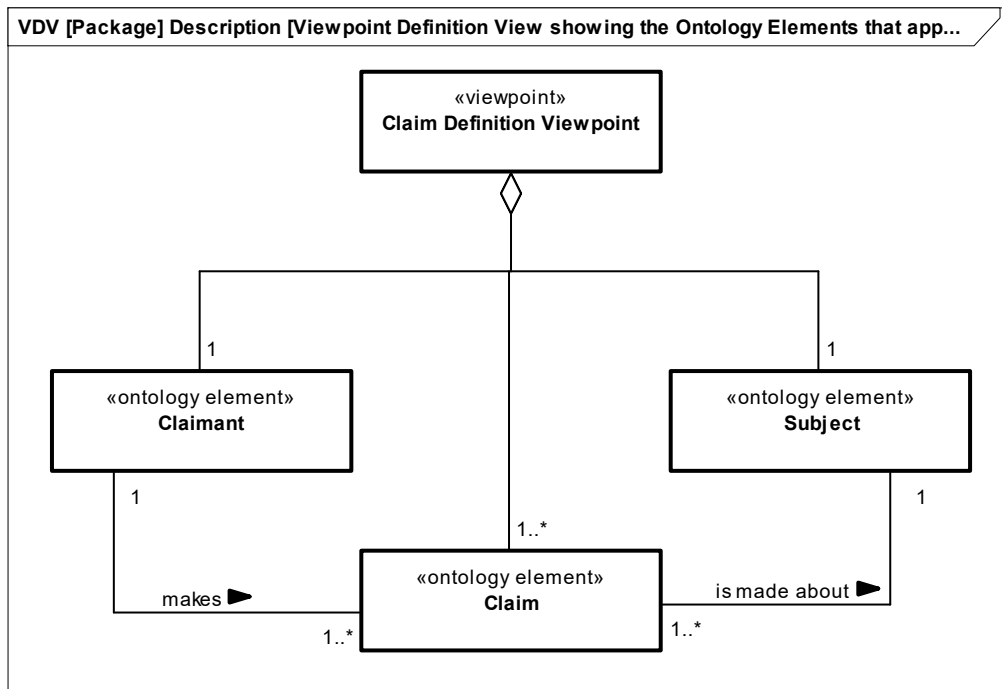
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Figure 6 - Viewpoint Definition View showing the Ontology Elements that appear on the Claim Definition Viewpoint (CDVp)

The Claim Definition Viewpoint identifies the Claims being made by a Claimant about a Subject.

As defined, the Claim Definition Viewpoint allows only a single Claimant and Subject to be shown, with any number of Claims made by that Claimant about the Subject. The definition could, of course, be extended to allow multiple Claimants and Subjects to be shown.

3.3.2 Example

An example View that conforms to the Claim Definition Viewpoint is shown in Figure 7.
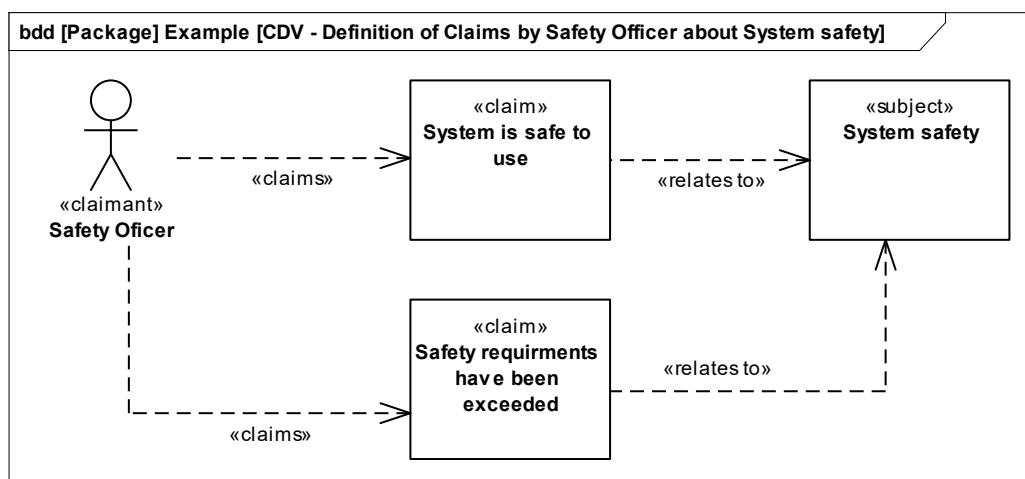

Figure 7 - CDV - Definition of Claims by Safety Officer about System safety

The Claim Definition View in Figure 7, realised as a SysML *block definition diagram*, shows the 'Safety Officer' Claimant making two Claims ('System is safe to use' and 'Safety requirements have been exceeded') about the Subject of 'System safety'.

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The Claim and Subject are realised using stereotyped *blocks* and the Claimant using a stereotyped *actor*. Stereotyped *dependencies* have been used to realise the relationships between Claimant, Claims and Subject.

This View conforms to Rules EP03 and EP04. With Figure 10 and Figure 13 it also conforms to Rule EP05.

3.4   Argument Viewpoint (AVp)

The aims of the Argument Viewpoint are shown in the Viewpoint Context View in Figure 8.
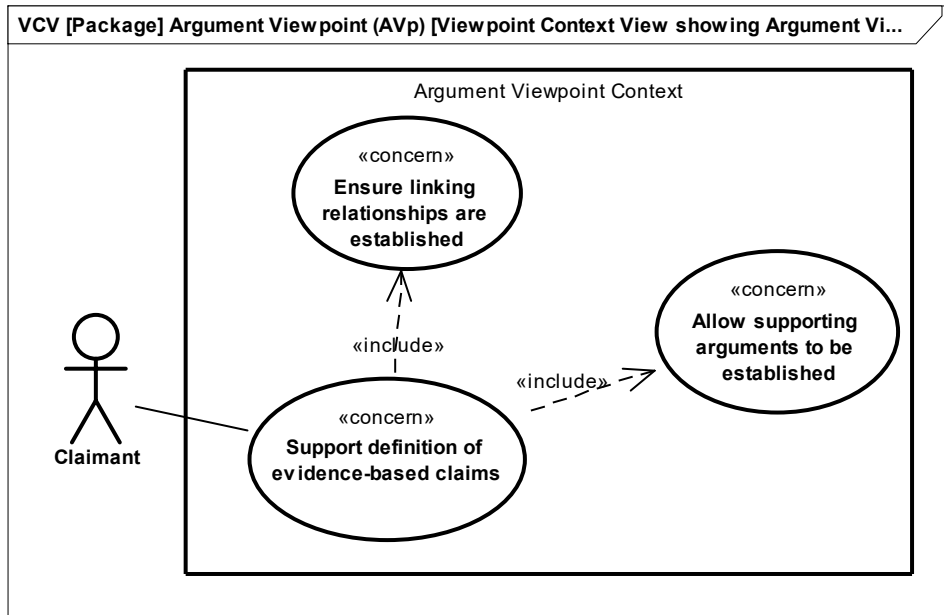

Figure 8 - Viewpoint Context View showing Argument Viewpoint aims

The main aim of the Argument Viewpoint is to 'Support definition of evidence-based claims' through the aims of 'Allow supporting arguments to be established' and 'Ensure linking relationships are established'. That is, its aim is to capture the Arguments that support a Claim together with the relationships from the Arguments to the Claim.

3.4.1   Description

The Viewpoint Definition View (VDV) in Figure 9 shows the Ontology Elements that appear on an Argument Viewpoint.
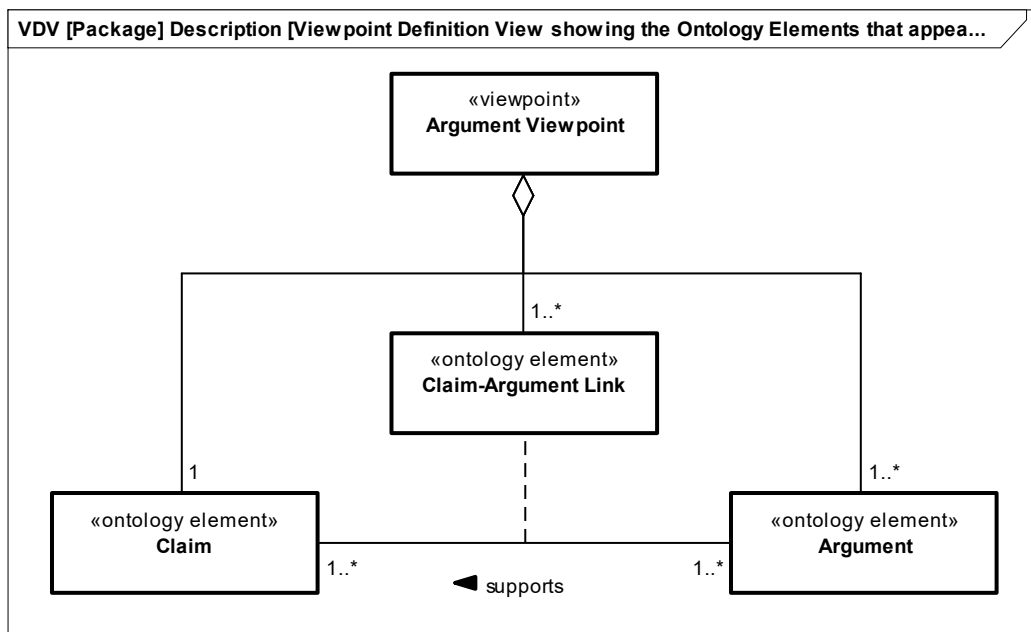
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Figure 9 - Viewpoint Definition View showing the Ontology Elements that appear on the Argument Viewpoint (AVp)

The Argument Viewpoint shows the Arguments that support a Claim.

As defined, the Argument Viewpoint only allows a single Claim to be shown. It could, of course, be extended to allow multiple Claims to be shown.

3.4.2 Example

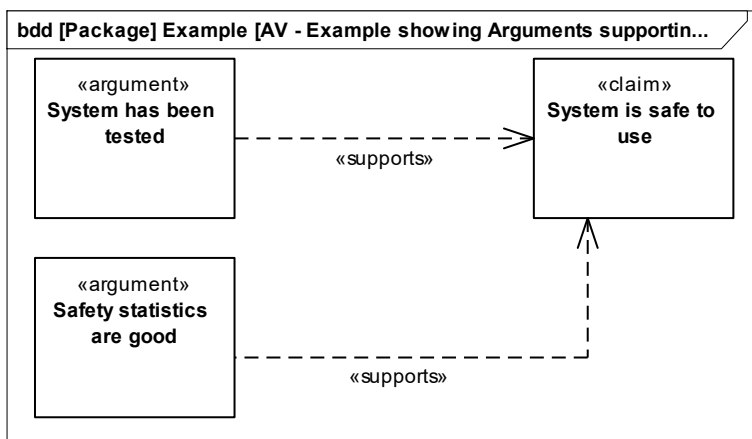An example View that conforms to the Argument Viewpoint is shown in Figure 10.

Figure 10 - AV - Example showing Arguments supporting "System is safe to use" Claim

The Argument View in Figure 10, realised as a SysML *block definition diagram*, shows two Arguments ('System has been tested' and 'Safety statistics are good') that support the Claim that 'System is safe to use'.

A stereotyped *block* is used to realise the Arguments, with stereotyped *dependencies* realising the Claim-Argument Links.

This View conforms to Rule EP01. With Figure 7 and Figure 13 it also conforms to Rule EP05.

3.5   Evidence Viewpoint (EVp)

The aims of the Evidence Viewpoint are shown in the Viewpoint Context View in Figure 11.
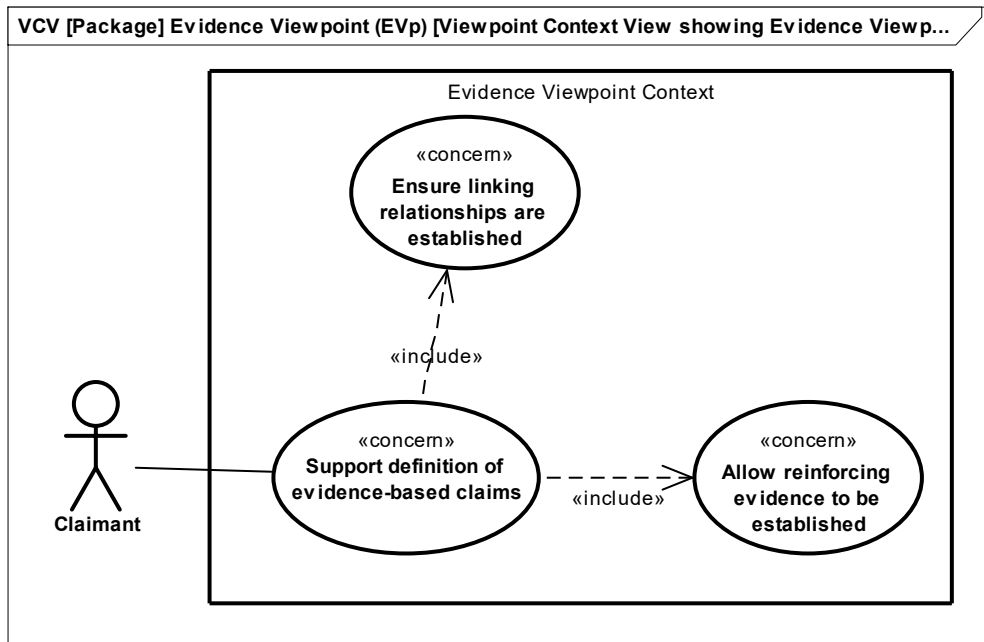

Figure 11 - Viewpoint Context View showing Evidence Viewpoint aims

The main aim of the Evidence Viewpoint is to 'Support definition of evidence-based claims' through the aims of 'Allow reinforcing evidence to be established' and 'Ensure linking relationships are established'. That is, its aim is to capture the Evidence that reinforces an Argument together with the relationships from the Evidence to the Argument.

3.5.1   Description

The Viewpoint Definition View (VDV) in Figure 12 shows the Ontology Elements that appear on an Evidence Viewpoint.
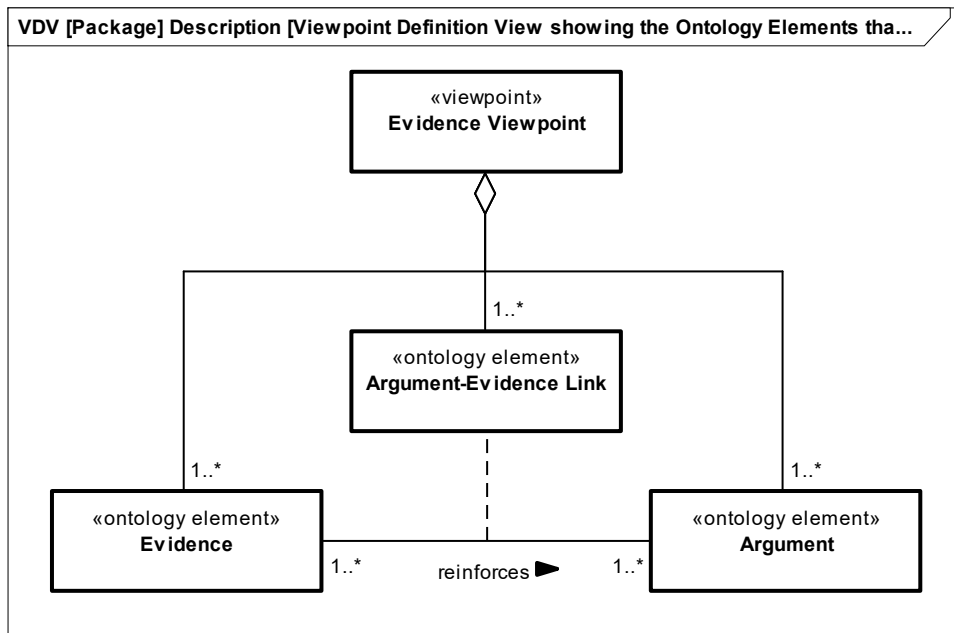
Figure 12 - Viewpoint Definition View showing the Ontology Elements that appear on the Evidence Viewpoint (EVp)

The Evidence Viewpoint shows the Evidence that reinforces one or more Arguments.

3.5.2   Example

An example View that conforms to the Evidence Viewpoint is shown in Figure 13.
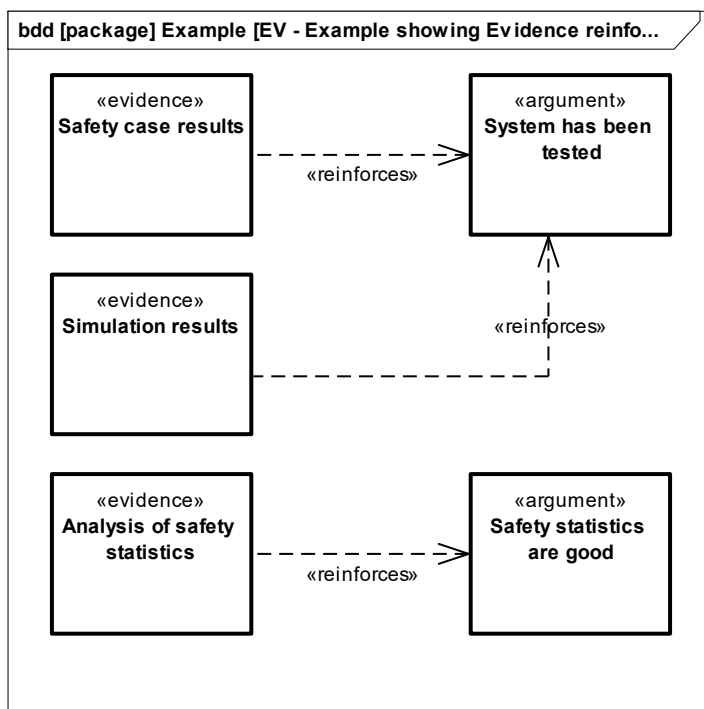

Figure 13 - EV - Example showing Evidence reinforcing the Arguments 'System has been tested' and 'Safety statistics are good'

The Evidence View in Figure 13, realised as a SysML *block definition diagram*, shows three pieces of Evidence reinforcing two Arguments. The Two pieces of Evidence 'Safety case results' and 'Simulation results' both reinforce the Argument that the 'System has been tested'. The Evidence 'Analysis of safety statistics' reinforces the Argument that 'Safety statistics are good.

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A stereotyped *block* is used to realise Evidence, with a stereotyped *dependency* used to realise each Argument-Evidence Link.

This View conforms to Rule EP02. With Figure 7 and Figure 10 it also conforms to Rule EP05.

3.6   Counter-Claim Viewpoint (CCVp)

The aims of the Counter-Claim Viewpoint are shown in the Viewpoint Context View in Figure 14.
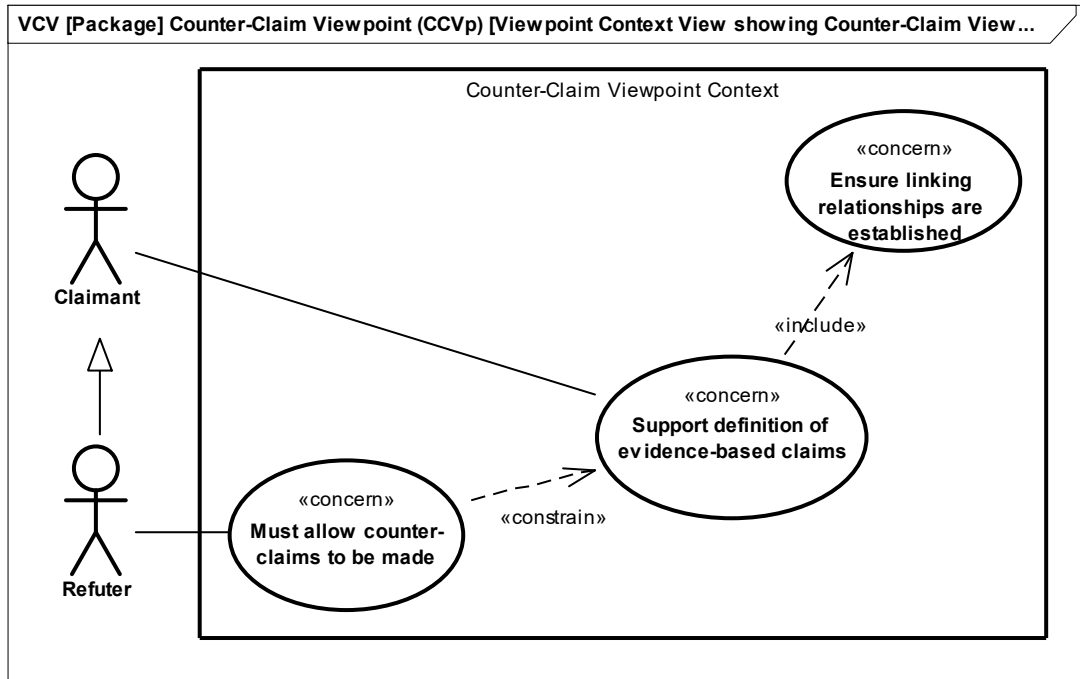

Figure 14 - Viewpoint Context View showing Counter-Claim Viewpoint aims

The main aim of the Counter-Claim Viewpoint is to 'Support definition of evidence-based claims' through the aims of 'Must allow counter-claims to be made' and 'Ensure linking relationships are established'. That is, its aim is to allow Counter-Claims to be made by a Refuter against any aspect of a claim (the Claim itself, the supporting Arguments, the reinforcing Evidence or the links between them). Similarly it can be used by a Claimant to make a Claim in support of any aspect ((the Claim itself, the supporting Arguments, the reinforcing Evidence or the links between them). The necessary links, for example from Refuter to Counter-Claim to item that the Counter-Claim counters, must also be captured.

3.6.1   Description

The Viewpoint Definition View (VDV) in Figure 15 shows the Ontology Elements that appear on a Counter-Claim Viewpoint.
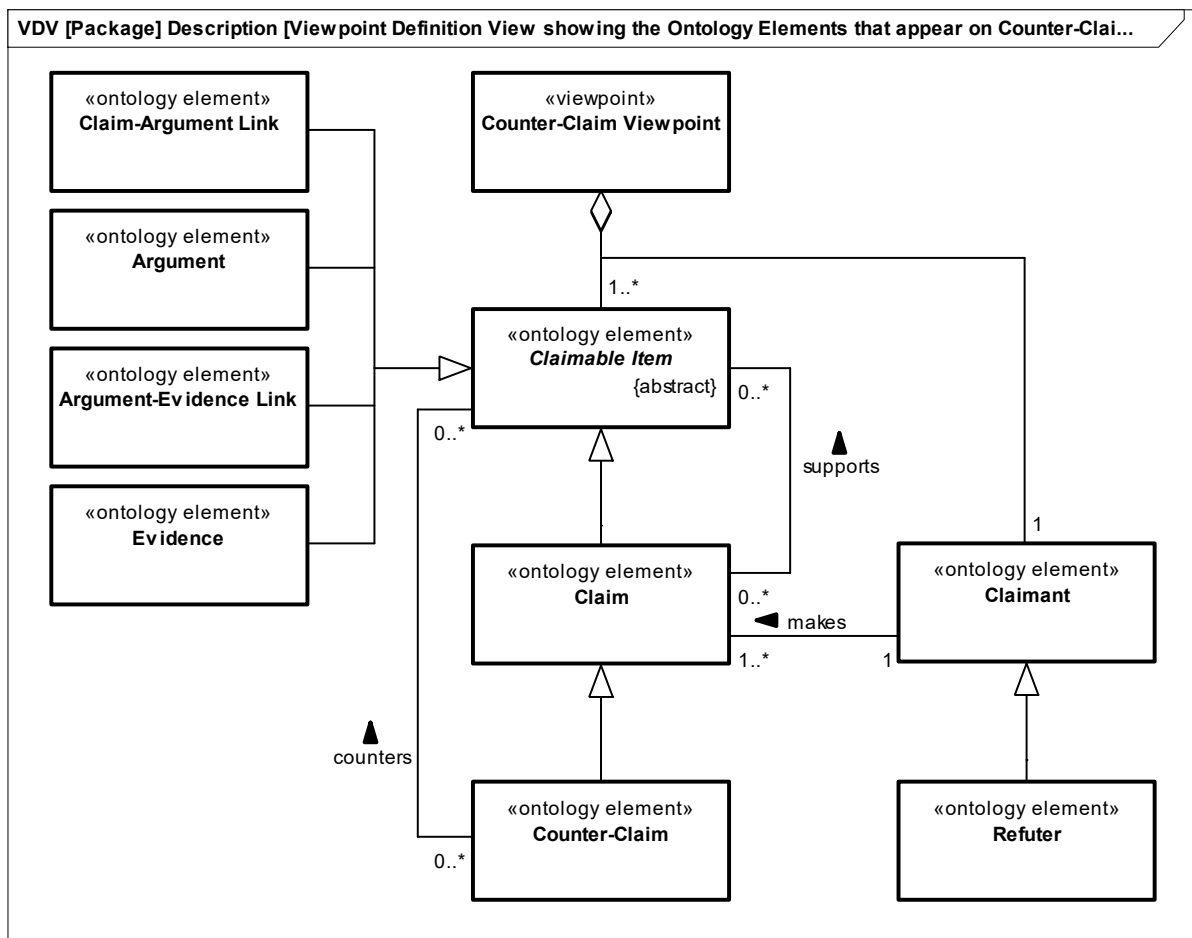
Figure 15 - Viewpoint Definition View showing the Ontology Elements that appear on Counter-Claim Viewpoint (CCVp)

The Counter-Claim Viewpoint is used to show a number of Counter-Claims and the Claimable Items that they counter OR a number of Claims and the Claimable Items that they support.

Although not made explicit in the VDV in Figure 15, only one Counter-Claim OR Claim can be shown on a CCV, as defined by Rule EP06. This rule also ensures that the Claimable Items that the Counter-Claims or Claims counter/support are also shown.

3.6.2 Example

An example View that conforms to the Counter-Claim Viewpoint is shown in Figure 16.
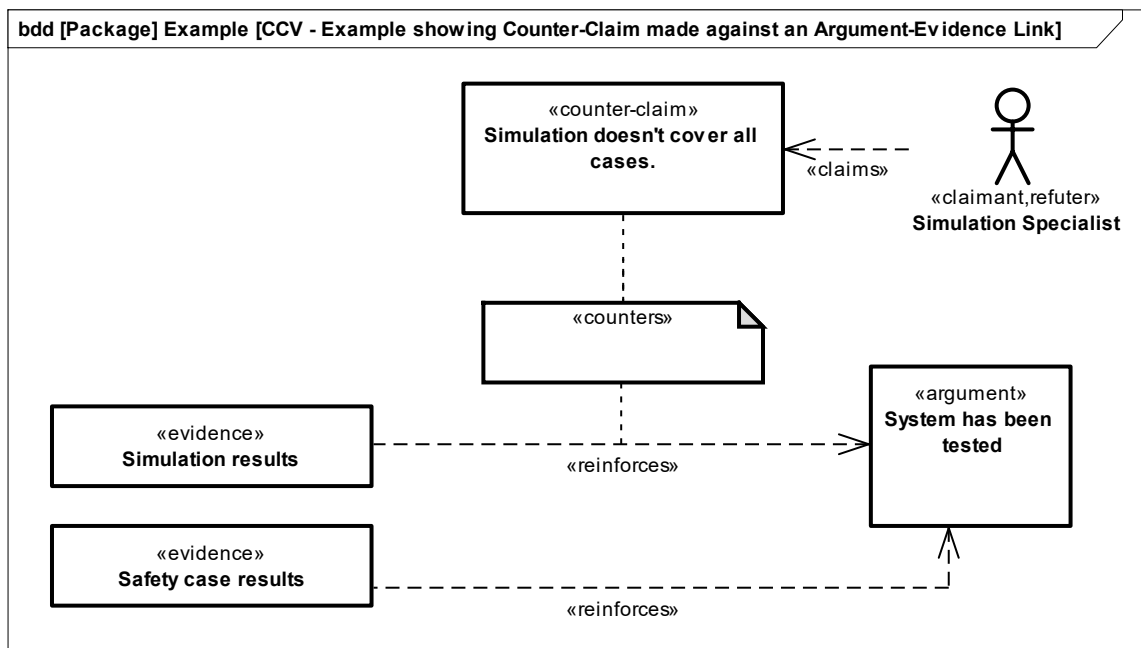
Figure 16 - CCV - Example showing Counter-Claim made against an Argument-Evidence Link

The Counter-Claim View in Figure 16, realised as a SysML *block definition diagram*, shows two pieces of Evidence ('Simulation results' and 'Safety case results') which reinforce, through the «reinforces» Argument-Evidence Links, the Argument that 'System has been tested'. These are all examples of Claimable Items.

The diagram also shows a Counter-Claim that 'Simulation doesn't cover all cases' made by the Claimant 'Simulation Specialist' against the Argument-Evidence Link between the 'Simulation results' Evidence and the 'System has been tested' Argument.

As with the other Views, stereotyped *blocks* and *dependencies* have been used to realise the various Ontology Elements and their relationships, with the exception of the 'counters' relationship from the Counter-Claim to the Argument-Evidence Link. In this case a stereotyped *note* has been used which connects the Counter-Claim to the Argument-Evidence Link. This has been done because the SysML tool used to produce this diagram does not allow a *dependency* to target another *dependency*. For Counter-Claims made against Ontology Elements realised as SysML *blocks* (such as Evidence, Arguments etc.). then a *dependency* stereotyped «counters» would be used. Note also the additional «refuter» stereotype applied to the *actor* representing the Claimant. This has been done to emphasise that this Claimant is playing a more specialised role of 'Refuter' (i.e. is a Claimant that is refuting something via a Counter-Claim).

This View conforms to Rule EP06. With Figure 13 it also conforms to Rule EP07.

4   Summary

The Evidence Pattern defines four Viewpoints for the definition of Evidence-Argument-Claim chains. The Claim Definition Viewpoint allows Claims to be defined for a particular Subject to show who made the Claims. The Argument Viewpoint allows the Arguments that support a Claim to be identified. The Evidence Viewpoint allows any supporting Evidence that reinforces Arguments to be identified. Finally, the Counter-Claim Viewpoint allows Counter-Claims (or supporting Claims) to be made about any type of Claimable Item.

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5 Related Patterns

If using the Evidence Pattern, the following Patterns may also be of use:

- Description
- Traceability
- Testing

6 References & Further Reading

Holt, J & Perry, S. SysML for Systems Engineering; 2nd Edition: A model-based approach. London: IET Publishing; 2013

Object Management Group. *SysML website* [online]. Available from http://www.omgsysml.org; Accessed February 2015

Holt, J. *UML for Systems Engineering - watching the wheels.* 2nd edn. London: IEE Publishing; 2004 (reprinted IET Publishing; 2007)

Rumbaugh, J., Jacobson, I. & Booch, G. *The Unified Modeling Language Reference Manual*. 2nd edition. Boston, MA: Addison-Wesley; 2005

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