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Table of Contents

List of Figures

3.1 INTRODUCTION

This chapter is an introduction to the generic Small Modular Reactor (SMR)-300 Claims, Arguments, Evidence (CAE) process. It links the CAE process to the Safety, Security and Environmental Case (SSEC), which comprises the Preliminary Safety Report (PSR), Preliminary Environmental Report (PER), Generic Security Report (GSR) and Preliminary Safeguards Report (PSgR).

The SSEC and supporting documents have been prepared with the CAE concept in mind; the CAE approach is embedded in the way these documents are structured. Holtec SMR Master Document Submission List (MDSL) [1] contains all substantive documents related to the SSEC and is structured into a tiered hierarchy to reflect the controlling influence of CAE thinking, see PSR Part A Chapter 1 Introduction [2].

This chapter is informed by the CAE Methodology for the Holtec SMR-300 [3] (which provides a literature review of CAE) and is concerned with describing and justifying the CAE approach used for the generic SMR-300 SSEC.

3.1.1 Purpose

The primary purpose of a CAE approach is to capture the golden thread of a SSEC narrative demonstrating how plant and operational evidence is brought together to justify that a high-level or fundamental claim is true. The fundamental Claim, referred to here as the Fundamental Purpose, of the generic SMR-300 SSEC is:

> *"The generic SMR-300 can be constructed, commissioned, operated, and decommissioned on a generic site in the United Kingdom (UK) to fulfil the future licensee's legal duties to be safe, secure and protect people and the environment."*

A subsidiary purpose and one of the main drivers for the development of CAE methodology has been a desire to make the complex safety, security (including safeguards) and environmental justification narratives in modern nuclear SSECs more comprehensible and visible.

The claims architecture has been decomposed to a level which supports demonstration of the fundamental adequacy of the design and the SSEC. The Claims presented throughout the SSEC are supported by associated prose (Arguments) to connect the claims to the supporting documentation (Evidence).

This chapter presents the high-level route map which links the Claims made throughout the SSEC to the Fundamental Purpose.

3.1.2 Definitions

For this Generic Design Assessment (GDA) the following definitions apply:

- **Claims:** A [true/false] statement or assertion with respect to the intent of the generic SMR-300 SSEC, e.g., “Risks from external hazards and their combinations are demonstrated to be tolerable and As Low As Reasonably Practicable (ALARP).”
- **Sub-claims:** A logical decomposition of a “parent” Claim into as many levels as required, e.g., “A comprehensive set of external hazards are identified and screened for assessment.”
- **Arguments:** The reasoning as to why a Claim is satisfied. An argument acts as a bridge between a Claim and Evidence, e.g., “External hazards are identified and screened using UK and international relevant good practice and operational experience.”
- **Evidence:** Facts that establish the truth of the Claim according to the logic of the Argument, e.g., “Generic Site Envelope Report”.

A master list of definitions and abbreviations relevant to all PSR Chapters can be found in PSR Part A Chapter 2 General Design Aspects and Site Characteristics [4].

3.1.3 Interfaces with other PSR Chapters

The CAE route map interfaces with all chapters in the PSR and wider SSEC. This chapter interfaces with PSR Part A Chapter 1 [2], which introduces the SSEC Fundamental Purpose. It also interfaces with the wider SSEC, namely the PER, GSR and PSgR.

This chapter defines the overall approach to CAE and describe the methodology being used. The high-level overarching Claims presented in this chapter cross-reference to the relevant SSEC chapters, where further decomposition of the Claims is presented in the appendices of the respective chapter in the form of a table. Demonstration of Claims is made in the corresponding chapters.

3.1.4 Assumptions

There are no assumptions that have been made with regard to the CAE methodology.

3.2 CODES, STANDARDS AND METHODOLOGY

3.2.1 Codes and Standards

Codes and standards related to CAE methodology are sparse and do not necessarily relate specifically to nuclear applications. Nevertheless, the following documentation has been reviewed as part of the development of the CAE route map and is considered to represent a mixture of Relevant Good Practice (RGP) and industry norms:

- Office for Nuclear Regulation (ONR):
  - Safety Assessment Principles (SAP) for Nuclear Facilities [5].
  - Security Assessment Principles (SyAP) [6].
  - Technical Assessment Guide (TAG) 51 [7].
  - Nuclear Material Accountancy, Control and Safeguards Assessment Principles (ONMACS) [8].
- International Atomic Energy Agency (IAEA) – Nuclear Energy Series No. NP-T-3.27 Dependability Assessment of Software for Safety Instrumentation and Control Systems at Nuclear Power Plants (NPP) [9].
- Best Available Techniques (BAT) for the Management of the Generation and Disposal of Radioactive Wastes Good Practice Guide [10].
- Industry practice:
  - Claims Arguments Evidence – Information, studies and research results on CAE [11].
  - Understanding, assessing and justifying Instrumentation & Control (I&C) systems using Claims, Arguments and Evidence [12].
  - Using Structured Assurance Case Approach to Analyse Security and Reliability of Critical Infrastructures [13].
- Previous GDA submissions:
  - Rolls-Royce SMR Step 1 PSR [14].
  - China General Nuclear (CGN) UK HPR1000 Step 4 GDA Project Pre-Construction Safety Report (PCSR), Chapter 1 [15].

Further New Nuclear Power Plants: Generic Design Assessment Technical Guidance [16] has been reviewed to understand lessons learnt from previous GDAs with regards to topic area approach to CAE.

Whilst a CAE approach is not prescribed by the ONR, TAG 51 [7] states, *“CAE can be useful for planning a safety case because it can describe the purpose and requirements of evidence that has yet to be produced”.*

3.2.2 Principles

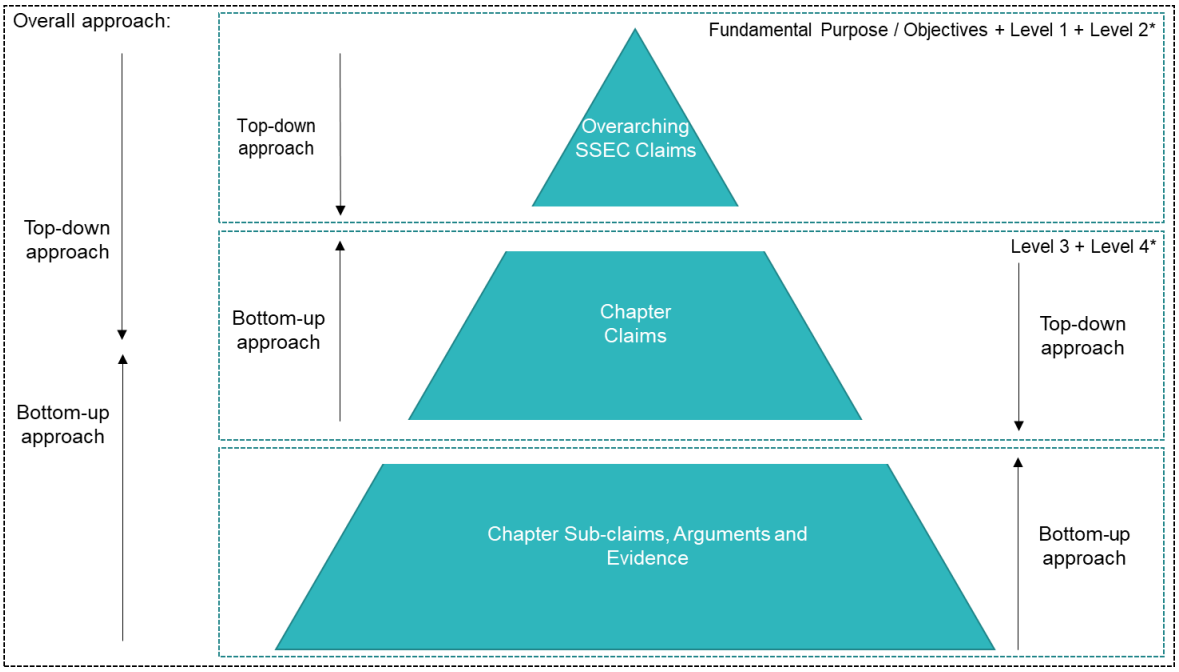
The following principles are applied to the development of the CAE route map specifically for the generic SMR-300; their intent is to codify what constitutes an adequate CAE approach:

- **Principle 1**: Claims, Arguments and Evidence that are linked in a CAE tree form a golden thread. Each route through the tree from the highest-level claim to the lowest level evidence forms a separate partial golden thread.
- **Principle 2**: Claims are organised into a hierarchy from high level general statements about a plant quality to lower level increasingly specific statements about that quality.
    - The intent of high-level claims is that they express the highest-level qualities expected by the public, regulators, etc.
    - The intent of low-level claims is that they can be unambiguously linked to specific plant evidence for support.
- **Principle 3**: An argument should be used to demonstrate why a particular claim decomposition has been used, unless it is self-evident from the context of its use. If the claim decomposition is simple, then single arguments should separate successive levels of sub-ordinate claims. If the decomposition is complex, then multiple arguments can be used to support a claim decomposition. The following approaches suggested in industry practice [11] are used to decompose claims:
    - Refine (into more specific and precise terminology).
    - Substitute (with different but equivalent claims).
    - Divide (into lower-level constituents).
    - Calculate (based on contributing values).
    - Terminate (with evidence).
- **Principle 4**: It should be clear how an item of evidence supports the claim it pertains to. Evidence should be related to relevant observable facts, or to analysis of factual data (see industry practice [11]).
- **Principle 5:** Where evidence is not available to support a claim at this step in GDA (to a maturity which would be expected for a PSR), a commitment will be acknowledged and methodologies, philosophies and future evidence to address these gaps proposed. Further details on how commitments are managed is provided in PSR Part A Chapter 4 [17].

3.2.3 Methodology

CAE implementation in nuclear safety cases is traditionally presented as a tree-like representation in a top-down bifurcating (or branching) structure, starting with a single high-level or fundamental purpose and working down to multiple examples of evidence to support that single claim. This basic morphology has been adopted for the generic SMR-300. Figure 1 presents the overall high-level approach to decomposition of the fundamental purpose.

A primary top-down approach from the fundamental purpose is applied to identify appropriate sub-claims where evidence is readily producible and understood. A secondary bottom-up approach is applied whereby the extent of the claims are validated against any available evidence produced, following established codes, standards or other RGP.



*Note: Claim "levels" are approximate with some variation throughout the CAE route map.

Figure 1: High-level CAE approach

3.2.4 Decomposition

The SSEC Fundamental Purpose can be achieved through the PSR Objective, PER Objective, GSR Objective and PSgR Objective (detailed in PSR Part A Chapter 1 [2]). The PSR Objective together with the PER Objective, GSR Objective and PSgR Objective then diverges to the individual overarching Claims, which have sub-claims, arguments and evidence trails in the respective chapters of each report that forms the SSEC. This is visualised in a simple hierarchy in Figure 2.

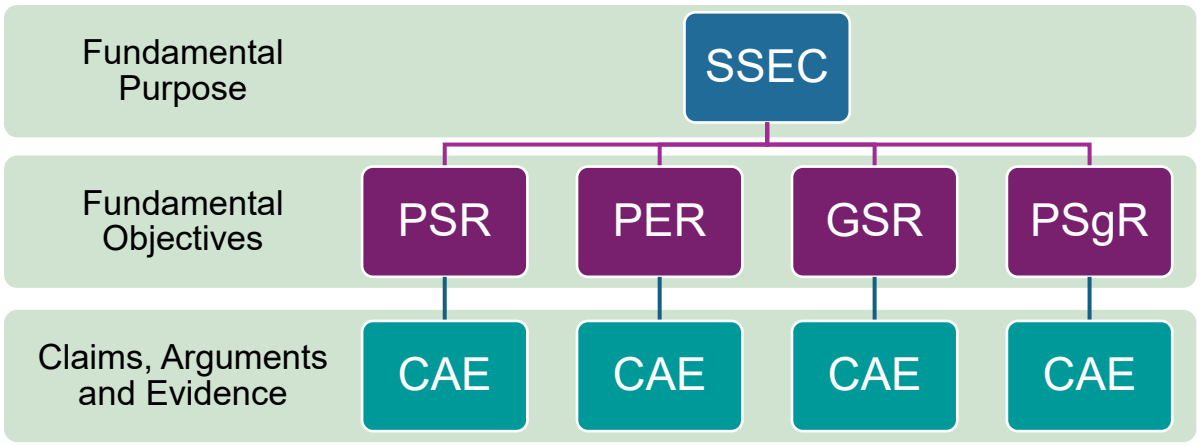


Figure 2: The Fundamental Purpose, Objective and CAE Hierarchy

Further decomposition of the fundamental objectives takes inspiration from systems development process lifecycle. A "V-model" has been used to derive claims throughout the SSEC development lifecycle. The V-model applies to all areas of the SSEC but it is illustrated here for nuclear safety.

As per Figure 3 the SSEC development process lifecycle has been divided into the following phases:

- **Safety Analysis:** This is where the safety requirements and system architecture are defined and demonstrate that the design reduces risk to a level which is tolerable and ALARP.
- **Design:** This is where the Systems, Structures and Components (SSC) that form the design are developed to ensure they meet the relevant safety requirements and appropriate adopted codes and standards to ensure risks are reduced to ALARP.
- **Construct, install and commission:** This is where the overall design is verified and validated against the requirements placed on the systems/processes.
- **Operation:** Operational arrangements are developed to ensure the operation of the plant remains within the identified limits and conditions. This includes ongoing maintenance of the installed design so that substantiation of requirements remains verified and valid, and safety performance is maintained.
- **Decommission:** This is where the operational activities are no longer undertaken and the plant is decommissioned. Consideration should be given in the preceding phases as to the requirements for, and design for future decommissioning.

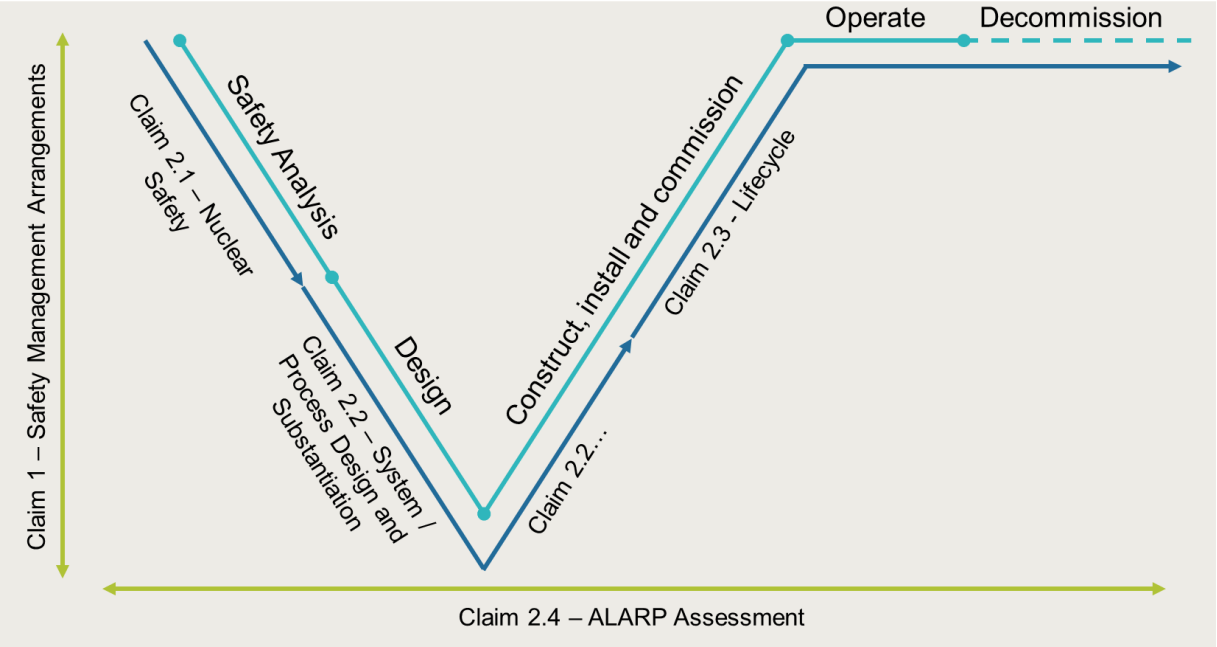


Figure 3: CAE "V-model"

3.2.5 Notation

A simple multi-level sequential numbering system has been applied. For example, Claim 2.1 is the first claim under Claim 2 and subsequently Claim 2.1.3 is the third claim under Claim 2.1. Note that as per Principle 3 (see Subchapter 3.2.2), Claims are decomposed as necessary into Sub-claims. As such, there is no significance as to the "level" of claim, e.g., a level 3 claim could in principle contain the same level of detail as a level 5 claim.

A simple numbering system has also been applied to all arguments. For example, if Claim 2.1.3 has two arguments associated with it, they are displayed as 2.1.3 – A1 and 2.1.3 – A2.

3.3 CAE TRAIL

3.3.1 Overarching SSEC Claims

The resultant overarching SSEC Claim route map to relevant SSEC chapters[1] is presented in Appendix A.

3.3.2 Chapter Claims

This chapter links out to the relevant SSEC chapters that satisfy the "Overarching SSEC Claims" and the fundamental purpose. Chapter claims have been further decomposed (where necessary). Further rationale for the decomposition of chapter claims is provided in the Part B Chapters and the full CAE route map can be found in the Generic SMR-300 CAE Model Report [18].

Every claim within the CAE route map, by nature of its decomposition from the PSR fundamental objective, can be considered as contributing to the overall ALARP demonstration. However, not every claim/sub-claim uses terminology of '*and reduces risk to ALARP'* within the claim wording, for brevity of presentation and readability. PSR Part A Chapter 5 [19] provides further details on how the overarching ALARP demonstration is provided across the PSR.

Each chapter defines how the high-level claims are linked to that chapter so that the evidence provided within can be argued to support these claims. Some claims will be supported entirely from evidence within a single chapter, but some will require support from multiple chapters. Chapters have been structured to highlight the claims narrative with cross-references to arguments and evidence explicitly included.

It is recognised that there are several elements/topics covered in the SSEC for NPPs that are cross-cutting in nature and therefore may result in chapter claims under multiple areas of the "Overarching SSEC Claims". Where this is the case, this has been clearly articulated within the main body of the chapter.

For example, radiological protection can be considered as a "safety analysis" discipline on the basis that exposure assessments are required to drive design requirements. Alternatively, radiological protection can be considered as an "engineering" or "systems-based" discipline with respect to shielding or containment design to meet requirements identified during the safety analysis. This is demonstrated in the CAE Model (see Appendix A) with Radiological Protection claims being presented under both Claim 2.1 (Nuclear Safety) and Claim 2.2 (System/Process Design and Substantiation).

The CAE model report [18] at SSEC v1 currently only presents claims and sub-claims. The arguments and evidence for each claim are within the relevant Chapters of the SSEC where the claims are demonstrated as met.

[1] The SSEC comprises the PSR chapters, PER chapters, GSR and PSgR.

3.4 SUMMARY

This chapter of the SSEC introduces the CAE approach to be used for the generic SMR-300 and presents the high-level route map that links the claims, throughout the SSEC to the fundamental purpose.

A systematic approach has been used for top-down decomposition of claims which considers the entire development process lifecycle. The approach taken is consistent with UK nuclear industry RGP and draws on learning from previous GDA submissions. A secondary bottom-up approach has been used to ensure that the resulting claims are comprehensive and reflect all aspects of a NPP.

The full CAE route map is presented in the CAE model report [18].

3.5 REFERENCES

[1] Holtec Britain, “HI-2240061, SMR-300 GDA Master Document Submission List for GDA,” Revision 10, Feb 2025.

[2] Holtec Britain, “HI-2240332, Holtec SMR GDA PSR Part A Chapter 1 Introduction,” Revision 1, July 2025.

[3] Holtec Britain, “HI-2240670, Claims, Argument, Evidence Methodology for the Holtec SMR-300 Project,” Revision A, May 2024.

[4] Holtec Britain, “HI-2240333, Holtec SMR GDA PSR Part A Chapter 2 General Design Aspects and Site Characteristics,” Revision 1, July 2025.

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[6] Office for Nuclear Regulation, “Security Assessment Principles for the Civil Nuclear Industry,” Version 1, March 2022.

[7] Office for Nuclear Regulation, “NS-TAST-GD-051 - The Purpose, Scope, and Content of Safety Cases,” Issue 7.1, 2022.

[8] Office for Nuclear Regulation, “ONR Nuclear Material Accountancy, Control and Safeguards Assessment Principles (ONMACS),” Issue 6, February 2025.

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[12] S. Guerra, “Understanding, assessing and justifying I&C systems using Claims, Arguments and Evidence,” Revision 5, March 2015.

[13] Netkachova K, et al, “Using Structured Assurance Case Approach to Analyse Security and Reliability of Critical Infrastructures,” 2014.

[14] Rolls-Royce SMR, “E3S Case PSR Version 2, Tier 1, Chapter 1: Introduction,” May 2024.

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[16] Office for Nuclear Regulation, “ONR-GDA-GD-007 - New Nuclear Power Plants: generic Design Assessment Technical Guidance,” Revision 0, May 2019.

[17] Holtec Britain, “HI-2240335, Holtec SMR GDA PSR Part A Chapter 4 Lifecycle Management of Safety and Quality Assurance,” Revision 1, July 2025.

[18] Holtec Britain, “HI-2241013, Holtec SMR-300 GDA CAE Model Report,” Revision 1, April 2025.

[19] Holtec Britain, “HI-2240336, Holtec SMR-300 GDA PSR Part A Chapter 5 Summary of ALARP and SSEC,” Revision 1, July 2025.

3.6 LIST OF APPENDICES

Appendix A Overarching SSEC Claims

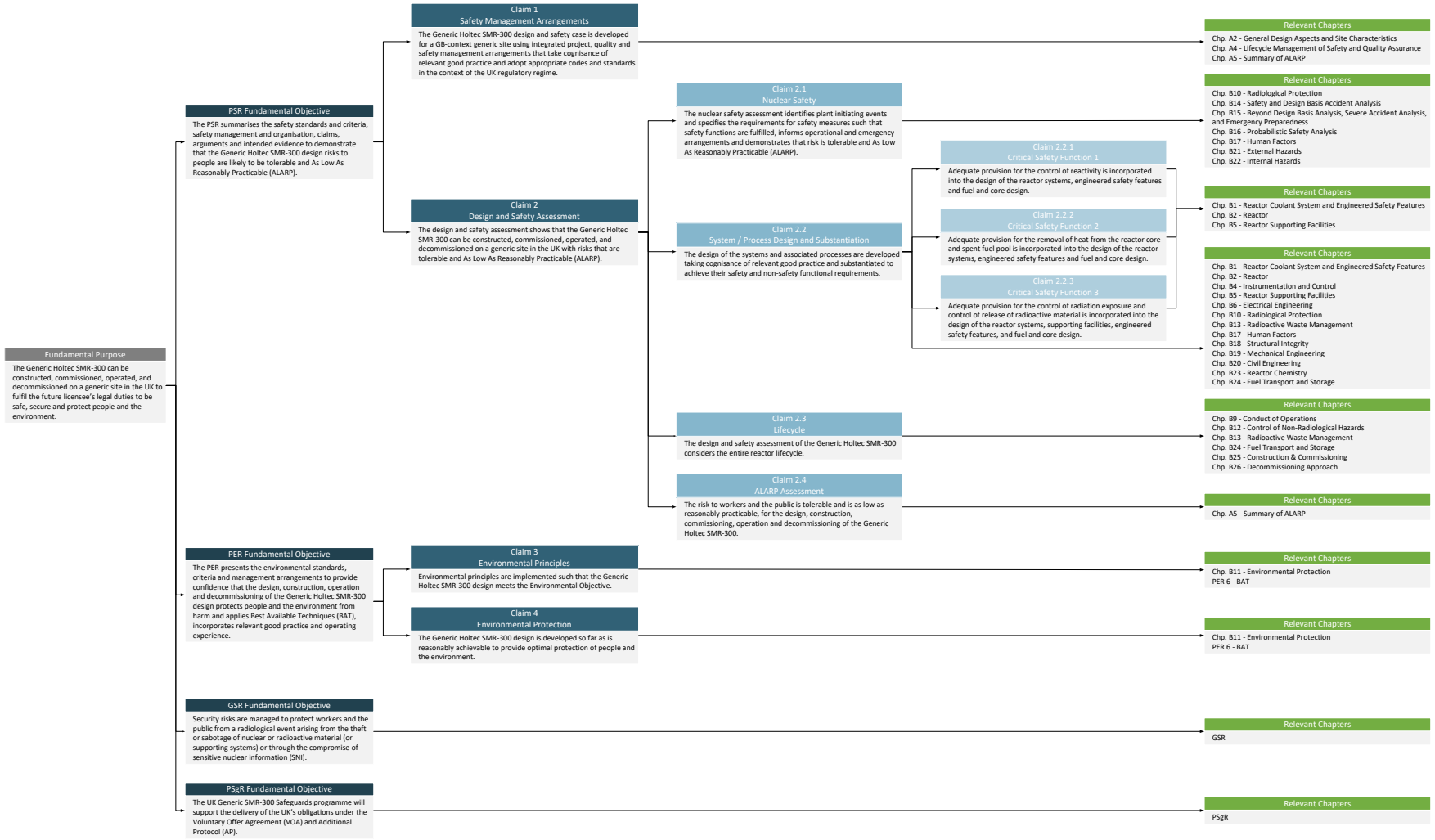

Figure 4: Generic SMR-300 Overarching SSEC Claim Route Map