

sUAS Safety Case Tool Software Requirements

TEAM: GRP_3_AERIAL

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Version History

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1 Introduction

1.1 Purpose

The purpose of this document is to establish the functional and non-functional requirements for the sUAS Safety Case Tool, a web-based application designed to automate the generation of safety cases for small Uncrewed Aerial Systems (sUAS). This document defines the problem, describes the system design, and provides details on the project's technical architecture.

1.2 Scope

The sUAS Safety Case Tool will reduce risks associated with operating sUAS by generating safety cases programmatically. The application will address hardware, software, and environmental risks, providing pilots with a formalized mechanism to evaluate the readiness of their vehicles for safe operation in shared airspace. It also supports compliance with potential regulatory requirements by maintaining safety assessment records.

1.3 Definitions, Acronyms, and Abbreviations

Term	Description
sUAS	Small Uncrewed Aerial Systems
GSN	Goal Structuring Notation, a framework for visualizing safety cases
YAML	A data serialization language used for safety case representation
NOTAM	Notice to Air Missions, real-time aviation information

1.4 References

- FAA's Flight Risk Assessment Tool (FRAT)
- MongoDB documentation: <https://www.mongodb.com/docs/>
- React.js documentation: <https://reactjs.org/>

1.5 Overview

The document includes the system's overall description, functional and non-functional requirements, technical architecture, and team contributions. It outlines the project's role in mitigating risks associated with operating sUAS.

2 Overall Description

2.1 Product Perspective

The sUAS Safety Case Tool is a web application combining a dynamic frontend interface, a robust backend server, and a database for persistent storage. The system automates safety case generation based on user inputs, such as vehicle condition, pilot credentials, and environmental conditions.

2.1.1 Concept of Operations

- Pilots create an account and answer dynamically generated questions about their flight plan.
- Safety cases are generated in YAML format and visualized using GSN diagrams.
- Risk assessments are performed to categorize flights as low-risk or high-risk.
- The system stores safety cases for future retrieval and regulatory compliance.

2.1.2 Major User Interfaces

The tool features a user-friendly React.js interface, with sections for answering questionnaires, viewing generated safety cases, and retrieving previous assessments. The interface is optimized for clarity and usability.

Screen Flow:

Question Form (Top) (Figure 1):

The screenshot displays the 'Flight Risk Evaluation' form. At the top, there are three buttons: 'Reset Form', 'View Previous Answers', and 'View Notams'. The form is organized into several sections, each with a blue header bar: 'Crew Characteristics', 'Airspace Characteristics', 'Wind', 'Density Altitude', and 'Precipitation'. The 'Crew Characteristics' section includes radio buttons for 'Pilot Certified' (Yes/No) and 'Spotter Present' (Yes/No). The 'Wind' section has input fields for 'Wind Gusts' and 'Wind Sustained' (both with a placeholder 'Enter Number (e.g. 125.6)') and a radio button for 'Wind Shear' (Yes/No). The 'Density Altitude' section contains three input fields: 'Max AGL Alt' (placeholder 'Enter an Integer (e.g. 25)'), 'Alt Above Sea Level At Takeoff (Feet)' (placeholder 'Enter an Integer (e.g. 25)'), and 'Pressure Alt At Takeoff (Feet)' (placeholder 'Enter an Integer (e.g. 25)'). Below these are three more input fields: 'Air Pressure At Takeoff' (placeholder 'Enter Number (e.g. 125.6)'), 'Air Temp at Takeoff (Celsius)' (placeholder 'Enter Number (e.g. 125.6)'), and 'Air Temp at Max Altitude (Celsius)' (placeholder 'Enter Number (e.g. 125.6)'). The 'Density Alt at Takeoff' field is currently set to 'N/A'. The 'Precipitation' section is at the bottom and is currently empty.

Figure 1:

Question Form (Bottom) (Figure 2):

Flight Characteristics

Mission_Location

Longitude Latitude

Zip Code

City Name

Location Longitude

Location Latitude

Enter Abbreviated ZIP Code (e.g. 50014)

Enter City of Operation

Enter Number (e.g. 125.6)

Enter Number (e.g. 125.6)

Mission_Area

Polygon List Of Points

Cylinder Radius

Add More

Enter an Integer (e.g. 25)

Mission Type

Max Mission Altitude

Mission Estimated Length

Select an option

Enter an Integer (e.g. 25)

Enter an Integer (e.g. 25)

Submit

Figure 2:

Generated Safety Cases (Safety Case Pass/Fail Tree) (Figure 3):

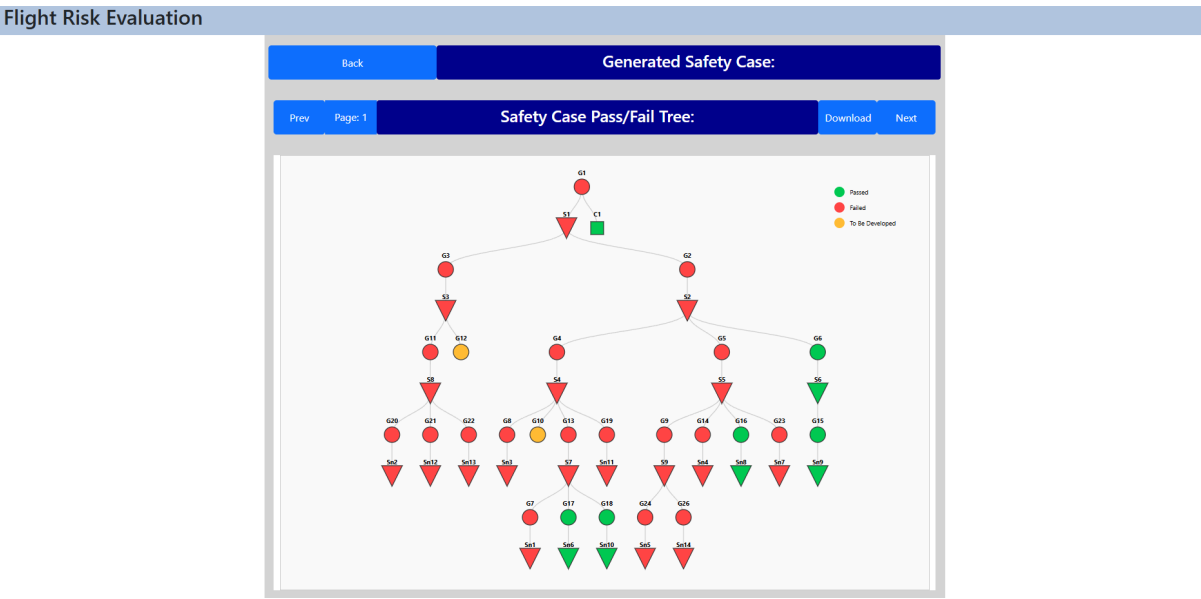


Figure 3:

Generated Safety Cases (Safety Case Pass/Fail Tree) (Figure 4):

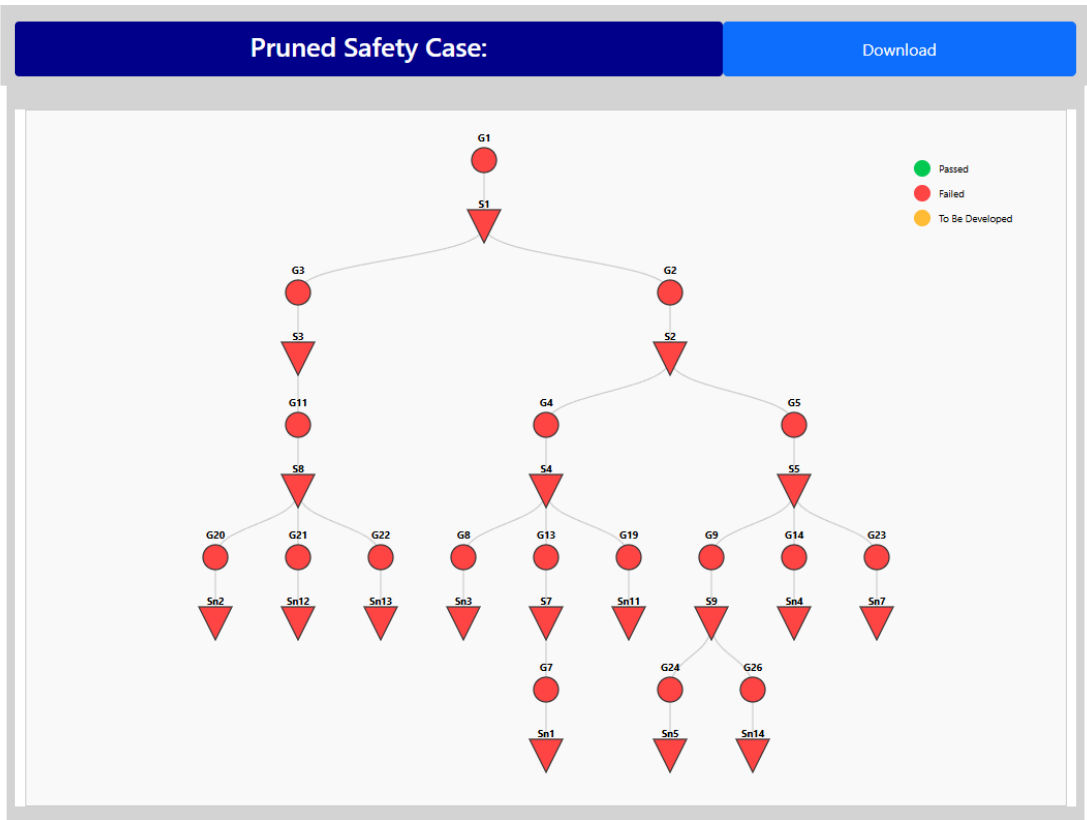


Figure 4:

Generated Safety Cases (YAML Versions/Argument File) (Figure 5):

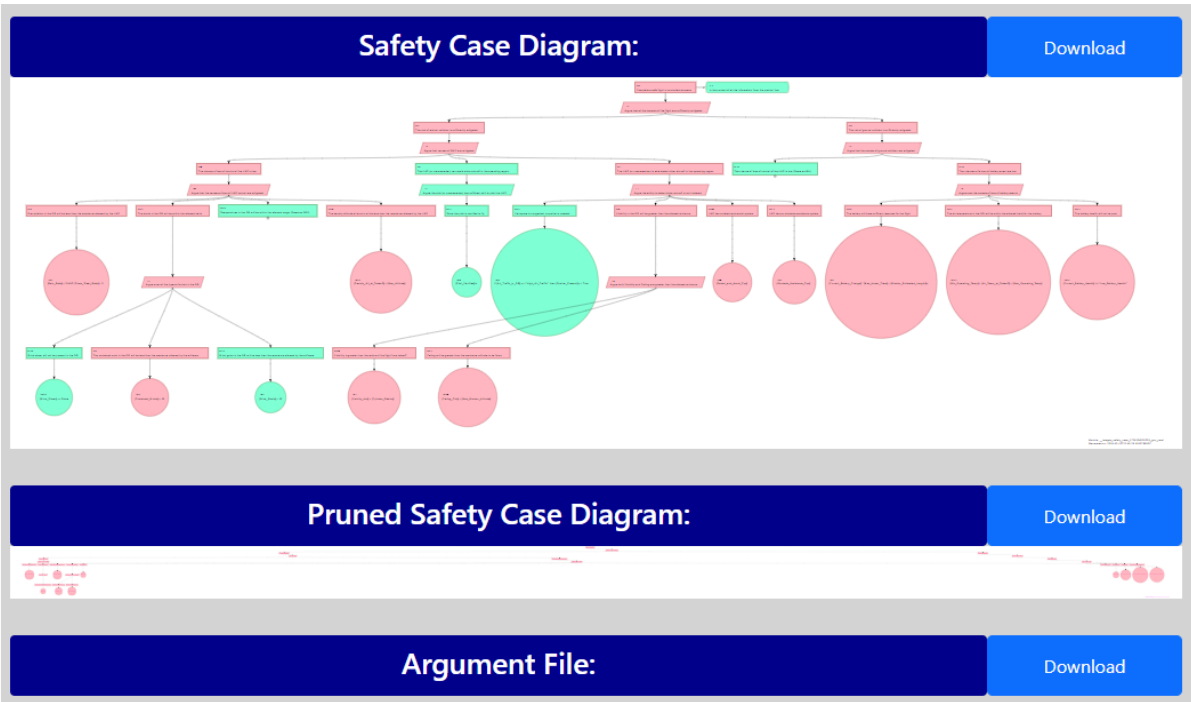


Figure 5:

Survey Results (Figure 6):

Survey Results

Wind Shear?
Answer: true

Select the appropriate option for Air Traffic in OR
Answer: Low_Air_Traffic

Select the appropriate option for Ground Traffic In OR
Answer: Low_Ground_Traffic

Select the appropriate option for Current Battery Health
Answer: Good_Battery_Health

Select the appropriate option for Mission Type
Answer: Recreation

Please provide details for City Name
Answer: Ames

Pilot Certified?
Answer: true

Spotter Present?
Answer: true

Figure 6:

NOTAMs (Figure 7):

Flight Risk Evaluation		
<div><div>Back</div><div>dimSearch for NOTAMS</div></div>		
Effective Start	Effective End	Condition
2022-11-28T18:59:00.000Z	PERM	TWY G CHANGED TO TWY H
2022-11-28T18:59:00.000Z	PERM	DSM TWY G CHANGED TO TWY H
2023-05-02T15:00:00.000Z	2023-05-09T21:41:00.000Z	DSM IAP DES MOINES INTL, DES MOINES, IA, VOR RWY 23, ORIG-C... PROCEDURE NA EXCEPT FOR ACFT EQUIPPED WITH SUITABLE RNAV SYSTEM WITH GPS, TNU DME OUT OF SERVICE.
2023-06-29T02:01:00.000Z	2025-06-29T01:49:00.000Z	DSM IAP DES MOINES INTL, DES MOINES, IA, ILS RWY 31 (SA CAT II), AMDT 24A... ILS RWY 31 (CAT II - II), AMDT 24A... PROCEDURE NA EXC FOR RED AIRMETER TOLERANT ACFT AND ACFT USING APPROVED ALTERNATIVE METHODS OF COMPLIANCE DUE TO 5G C-BAND INTERFERENCE PLUS SEE AIRWORTHINESS DIRECTIVE 2023-10-02 AND 5G C-BAND DOMESTIC NOTICES.
2023-08-18T18:46:00.000Z	2025-08-18T18:46:00.000Z	DSM IAP DES MOINES INTL, DES MOINES, IA, RNAV (GPS) RWY 5, AMDT 3... NOTE VGS AND RNAV GLIDEPATH NOT COINCIDENT.
2023-11-23T02:03:00.000Z	2023-11-29T20:00:00.000Z	DSM IAP DES MOINES INTL, DES MOINES, IA, ILS OR LOC RWY 13, AMDT 10... ILS OR LOC RWY 31, AMDT 24A... ILS OR LOC RWY 5, AMDT 1A... VOR RWY 23, ORIG-C... ILS RWY 31 (SA CAT II), AMDT 24A... ILS RWY 31 (CAT II AND III), AMDT 24A... ALTERNATE MINIMUMS NA EXCEPT FOR ACFT EQUIPPED WITH SUITABLE RNAV SYSTEM WITH GPS, DSM VORTAC UNMONITORED.
2023-11-23T02:06:00.000Z	2023-11-29T20:00:00.000Z	DSM IAP DES MOINES INTL, DES MOINES, IA, VOR RWY 23, ORIG-C... ALTERNATE MINIMUMS NA EXCEPT FOR ACFT EQUIPPED WITH SUITABLE RNAV SYSTEM WITH GPS, TNU VOR/DME UNMONITORED.
2023-11-28T15:52:00.000Z	2023-12-01T20:00:00.000Z	DSM NAV ILS RWY 31 GP US
2024-02-23T18:33:00.000Z	2026-02-23T18:33:00.000Z	IAP DES MOINES INTL, DES MOINES, IA, ILS OR LOC RWY 5, AMDT 1A... MSA SECTOR 090 CW 270 MINIMUM ALTITUDE 3200. 2402231803-2602231833EST
2024-02-23T18:40:00.000Z	2026-02-23T18:00:00.000Z	IAP DES MOINES INTL, DES MOINES, IA, ILS OR LOC RWY 13, AMDT 10... ILS OR LOC RWY 31, AMDT 24A... ILS RWY 31 (SA CAT II), AMDT 24A... ILS RWY 31 (CAT II AND III), AMDT 24A... MSA SECTOR 090 CW 330 MINIMUM ALTITUDE 3200. 2402231840-2602231800EST
2024-02-23T18:33:00.000Z	2026-02-23T18:33:00.000Z	DSM IAP DES MOINES INTL, DES MOINES, IA, ILS OR LOC RWY 5, AMDT 1A... MSA SECTOR 090 CW 270 MINIMUM ALTITUDE 3200.
2024-02-23T18:40:00.000Z	2026-02-23T18:00:00.000Z	DSM IAP DES MOINES INTL, DES MOINES, IA, ILS OR LOC RWY 13, AMDT 10... ILS OR LOC RWY 31, AMDT 24A... ILS RWY 31 (SA CAT II), AMDT 24A... ILS RWY 31 (CAT II AND III), AMDT 24A... MSA SECTOR 090 CW 330 MINIMUM ALTITUDE 3200.
2024-03-28T12:39:00.000Z	PERM	IAP DES MOINES INTL, DES MOINES, IA, RNAV (GPS) RWY 5, AMDT 4A... CHANGE NOTE TO READ: ASTERISK RWY 1800 AUTHORIZED WITH USE OF RED OR AP OR HUD TO DA. THIS IS RNAV (GPS) RWY 5, AMDT 4B.

Figure 7:

Administrative Page (Figure 8):



Figure 8:

2.1.3 Hardware Interfaces

Any device with a modern web browser supporting HTML5, CSS3, and JavaScript.

2.1.4 Software Interfaces

- Frontend: React.js with TypeScript
- Backend: Node.js with Express
- Database: MongoDB
- Parsing libraries: xml2js, js-yaml

2.1.5 Communication Interfaces

The application communicates with external APIs, such as NOTAM services, and performs client-server interactions over HTTP.

2.1.6 Memory Constraints

The system uses efficient in-memory operations for dynamic form generation and risk assessments.

2.1.7 Site Adaptation Requirements

The system supports multiple user roles (pilots, advisers, administrators) and accommodates localization for different regulatory environments.

2.2 Product Functions

- Dynamic questionnaire generation based on XML flight models.
- Safety case visualization using GSN diagrams.
- Risk assessments with color-coded diagrams.
- Storage and retrieval of historical safety case data.
- Integration with NOTAMs for real-time aviation updates.

2.3 User Characteristics

Target users include:

- Pilots: To assess flight safety and compliance.
- Advisers: To guide pilots in creating safe flight plans.
- Administrators: To manage system configurations and thresholds.

2.4 Constraints

- Real-time data retrieval from NOTAM APIs may be limited by external API access.
- The system must maintain compatibility with future aviation regulations.
- Memory usage must be optimized for large-scale XML and YAML files.

2.5 Assumptions and Dependencies

- Users have internet access and modern devices.
- MongoDB and Node.js are installed on the server.

3 Specific Requirements

3.1 Features

3.1.1 Dynamic Questionnaire Generation

- Parses XML flight models to generate tailored questions.
- Adapts dynamically to different sUAS configurations.

3.1.2 Risk Assessment and Safety Case Generation

- Assigns risk levels based on user input.
- Generates YAML files and visualizes safety cases using GSN.

3.1.3 NOTAM Integration

- Fetches real-time airspace updates.
- Displays NOTAM data within the application.

3.2 Performance Requirements

- Generate safety cases within 5 seconds for typical inputs.
- Support at least 100 simultaneous users.

3.3 Design Constraints

- The system must use MongoDB for database operations.
- Safety cases must adhere to GSN standards.

3.4 Software System Attributes

3.4.1 Reliability

- Ensure 99.9% uptime for critical features.

3.4.2 Availability

- The system should be accessible 24/7.

3.4.3 Maintainability

- Modular codebase for easier updates.

3.4.4 Portability

- Support deployment on cloud platforms like AWS or Azure.

Appendix

- Demonstration video: https://youtu.be/DIim2_m4Qaw?si=pD5d5uUXd5JJXZwp
- YAML template file: Available in the `templates/` directory.