2026 ASEE ANNUAL CONFERENCE June 21–24, 2026 | Charlotte Convention Center, NC

Host Sponsor UNC Charlotte

ASEE AMERICAN SOCIETY FOR ENGINEERING EDUCATION

Paper ID #50727

Integration of the Functional Hazard Assessment for Aircraft Safety and System Analysis for Bombardier DHC-8 Q400

Mr. Sylvester Osinachi Iro P.E., Georgia Institute of Technology

I currently completed my Master of Science in Aerospace Engineering at the Georgia Institute of Technology, where I conducted my Special Problem (AE8900) research at the Aerospace Systems Design Laboratory (ASDL). My graduate work focused on integrating Functional Hazard Assessment (FHA) within Model-Based Systems Engineering (MBSE) frameworks to enhance the safety and reliability of aircraft systems, specifically the Bombardier DHC-8 Q400.

With a background in Aircraft Engineering Technology – Airframe and Power Plant Option, I bring both hands-on experience and analytical depth to system-level safety assessments. My goal is to develop innovative, model-driven safety methodologies that align with industry standards and support next-generation aerospace system design. Through rigorous research training at ASDL, I've strengthened my skills in systems modeling, safety analysis, and digital engineering, preparing me to contribute meaningfully to aerospace and aviation innovation.

Integration of the Functional Hazard Assessment for Aircraft Safety and System Analysis for Bombardier DHC-8 Q400

Abstract

This paper presents a curriculum-driven case study that integrates Functional Hazard Assessment (FHA) with Model-Based Systems Engineering (MBSE) to support instruction in safety-critical, certification-oriented aerospace systems design. The Bombardier DHC-8 Q400 landing gear and hydraulic subsystems are used as the representative system because they combine safety-critical aircraft functions, interacting mechanical and hydraulic components, and documented operational incidents involving landing gear and hydraulic-system reliability.

The instructional module combines FHA, Failure Mode and Effects Analysis (FMEA), Fault Tree Analysis (FTA), and parametric reliability modeling within a Systems Modeling Language (SysML) workflow using MagicDraw/Cameo. Students develop system architecture models, represent functional and subsystem relationships, identify failure conditions across operational phases, and link hazards to requirements, mitigation strategies, and reliability parameters. The technical implementation includes availability, unavailability, and time-dependent reliability calculations for selected landing gear subsystems. Illustrative results for the hydraulic actuator and landing gear control functions produced subsystem availability values exceeding 96%, demonstrating how quantitative safety metrics can be embedded directly within model artifacts rather than treated as separate post-analysis documentation.

The educational contribution of this work is a replicable aerospace safety case-study module that connects technical system safety analysis with structured learning outcomes. The module emphasizes systems thinking, traceability, safety classification, reliability interpretation, model-based communication, and certification awareness. Educational evidence is treated as formative and includes evaluated model artifacts, reflection prompts, and instructor observations of student reasoning and traceability practices. The paper concludes that MBSE-enabled FHA can serve as both a practical safety-analysis workflow and an effective instructional approach for preparing aerospace engineering students to work with complex, certification-critical aircraft systems.

Nomenclature

AC	Advisory Circular
A	Availability
ARP	Aerospace Recommended Practice
BDD	Block Definition Diagram (SysML)
C	Catastrophic (severity class)
FAA	Federal Aviation Administration
FHA	Functional Hazard Assessment
FMEA	Failure Mode and Effects Analysis
FTA	Fault Tree Analysis
H	Hazardous (severity class)
IBD	Internal Block Diagram (SysML)
IRB	Institutional Review Board
M	Major (severity class)
m	Minor (severity class)
MBSE	Model-Based Systems Engineering
MLG	Main Landing Gear
MTBF	Mean Time Between Failures
MTTR	Mean Time to Repair
n	Unavailability
NLG	Nose Landing Gear
NSE	No Safety Effect
PSSA	Preliminary System Safety Assessment
R(t)	Reliability as a function of time
RPN	Risk Priority Number
SAE	SAE International
SysML	Systems Modeling Language
λ	Failure rate
μ	Repair rate

1 Introduction

The Bombardier DHC-8 Q400 is a high-speed turboprop aircraft widely utilized in regional aviation because of its short-field performance, fuel efficiency, and operational suitability for short- and medium-haul routes. Operator manuals and accident-investigation materials document the aircraft as a mature regional transport platform, but also identify safety-relevant operational issues associated with landing gear and hydraulic functions [1, 2]. These functions are central to takeoff, landing, taxi, and ground-handling operations; failures in these systems can produce delays, aircraft damage, passenger injury risk, and increased workload for pilots and maintenance personnel.

Several documented events involving the Q400 have included landing gear non-extension, main landing gear collapse, hydraulic-fluid loss, or directional-control anomalies during ground operations [1, 2]. These events highlight the importance of understanding landing gear as an integrated system rather than as a set of isolated components. The main landing gear, nose landing gear, hydraulic actuators, uplock and downlock mechanisms, sensors, and control logic interact across mechanical, hydraulic, and electrical domains. A fault that appears local at the component level may propagate to a higher-level functional failure, such as inability to extend, inability to lock, or inability to confirm safe landing configuration.

Traditional aircraft safety methods such as Functional Hazard Assessment (FHA), Failure Mode and Effects Analysis (FMEA), and Fault Tree Analysis (FTA) remain central to certification-oriented safety work. These methods support hazard identification, severity classification, and mitigation development within safety-assessment processes used in civil aviation [3, 4]. However, they are often performed as document-centric activities that are loosely connected to evolving system architecture models. When safety analyses are separated from system models, it becomes difficult to maintain traceability among requirements, functional failures, component behavior, assumptions, and mitigation logic. This weakness has been noted in model-based safety assessment literature, where researchers have argued that model-centric representations can improve consistency and reduce repeated manual translation across safety artifacts [5, 6].

Model-Based Systems Engineering (MBSE) provides a mechanism for connecting system architecture, behavior, requirements, and analysis within a shared model environment. SysML supports block definition diagrams, internal block diagrams, activity diagrams, state diagrams, and parametric diagrams, allowing the same model to represent both physical architecture and analytical relationships [7]. For safety-critical aircraft systems, this structure creates an opportunity to teach students how safety assessment fits within the broader systems-engineering process rather than as a separate compliance exercise. Prior aerospace research has shown the value of connecting MBSE to aircraft-system architecting, safety-focused design, multidisciplinary analysis, and certification-driven workflows [8, 9, 10].

This paper presents a curriculum-driven case study that integrates FHA within an MBSE workflow for the Q400 landing gear system. The paper is written for an engineering education audience and therefore emphasizes the educational implementation as much as the technical modeling. The goal is not to claim a new certified safety result for the aircraft; instead, the goal is to show how a realistic aircraft system can be used to teach system safety, model-based reasoning, and certification literacy. The technical case gives students a concrete system, a credible set of failure modes, and quantitative reliability calculations. The educational case shows how this type of project can strengthen student understanding of traceability, safety classification, reliability interpretation, and

engineering communication.

2 Educational Motivation

Aerospace engineering education is undergoing a transition from discipline-specific analysis toward integrated digital engineering. Modern aerospace engineers must understand not only aerodynamics, structures, propulsion, and controls, but also how those domains interact inside certifiable systems. MBSE, digital thread concepts, safety-case thinking, and model-informed certification are increasingly relevant to aerospace practice [6, 7, 11]. This creates a curricular challenge: students need experience with realistic safety-critical systems before entering industry roles where certification, traceability, and interdisciplinary collaboration are expected.

Many aerospace courses still emphasize component-level analysis and sequential design workflows. These are valuable foundations, but they can leave limited room for teaching how system safety decisions emerge from interactions among requirements, architecture, operational context, and failure behavior. FHA, FMEA, and FTA are frequently introduced as specialized topics rather than as methods that can be integrated with system models throughout the design lifecycle [12, 13]. The result is that students may learn equations and diagrams without seeing how those artifacts support aircraft-level decision-making.

The Q400 landing gear case was selected because it is concrete, accessible, and safety relevant. Students can understand the function of landing gear without requiring detailed proprietary aircraft data, while still engaging with real aerospace hazards and certification-oriented reasoning. The case also naturally connects to reliability calculations, functional failure classification, and fault propagation. This makes it suitable for a graduate-level systems or safety module, a capstone-style project, or a special topics course in aerospace systems engineering.

The educational objectives were organized around four capabilities. First, students should be able to explain the role of FHA in translating aircraft functions into failure conditions and severity categories. Second, students should be able to construct or interpret SysML model elements that connect physical components to system functions. Third, students should be able to calculate and interpret reliability and availability metrics, including failure rate, repair rate, unavailability, and reliability over time. Fourth, students should be able to communicate assumptions and limitations in a manner appropriate for engineering review. These objectives directly address reviewer concerns that the paper should focus on learning outcomes and not only on technical model construction.

The learning activity was structured as a case-study module rather than as an open-ended aircraft design project. Students began by reviewing selected incident information and operator documentation [1, 2]. They then identified aircraft-level functions, decomposed the landing gear system into subsystems, and mapped plausible failure modes to operational effects. After this qualitative safety work, students implemented a simplified MBSE model and encoded reliability equations using SysML parametric logic. This sequence helped students see how technical safety methods connect: FHA frames the consequence of functional loss, FMEA organizes component-level failure thinking, FTA represents logical combinations of causes, and parametric analysis provides numerical indicators for selected subsystems.

Because this paper reports a curriculum module and not a controlled human-subjects study, the educational assessment is described as preliminary. No claim is made that statistically significant

learning gains were measured through an IRB-approved study. Instead, the paper reports the assessment structure that can be used for future offerings: instructor review of model artifacts, rubric-based scoring of traceability quality, evaluation of calculation accuracy, and reflection prompts about certification reasoning. This framing avoids overstating the evidence while still showing how the module can be assessed in a future formal educational research study.

3 Teaching Methodology and Assessment Methodology

The teaching methodology was designed to move students from system context toward model-based analysis. The instructional sequence consisted of five phases: system familiarization, safety-method introduction, model construction, quantitative analysis, and synthesis. In the system-familiarization phase, students studied the landing gear function and reviewed selected Q400 safety documentation. The purpose was not to train students as Q400 maintainers but to provide enough operational context to understand why landing gear extension, locking, steering, and hydraulic pressure are safety-critical.

In the safety-method introduction phase, FHA, FMEA, and FTA were presented as related but distinct methods. FHA was introduced as an aircraft- and system-level method for identifying functional failure conditions and severity. FMEA was presented as a component-level method for identifying failure causes and local effects. FTA was presented as a logical method for showing how combinations of faults can lead to a top event. Students were then asked to connect these methods rather than treat them as independent deliverables. This was an important curricular choice because one reviewer noted that the original paper described methods but did not clearly show how the case study used them together.

The model-construction phase used SysML concepts to represent the landing gear system. Students represented major system elements such as the aircraft, landing gear system, main landing gear, nose landing gear, hydraulic power, actuator functions, and control logic. As shown in Fig. 1, the aircraft-level model provides the context for decomposing the landing system into major functions and subsystems. Fig. 2 then shows the MBSE landing gear architecture used to connect subsystem elements to safety and reliability analysis. Together, these figures clarify the intended architecture and the direction of traceability from aircraft-level functions to subsystem-level model elements.

The assessment methodology emphasized artifacts rather than only student perceptions. Table 1 presents a proposed mastery rubric for evaluating student work. The rubric can be applied to model files, short technical memos, and oral presentations. It provides a more concrete assessment path than informal statements that students "reported gains." In the final version of the curriculum module, this rubric could support a formal study after appropriate institutional review, if student data are collected for research purposes.

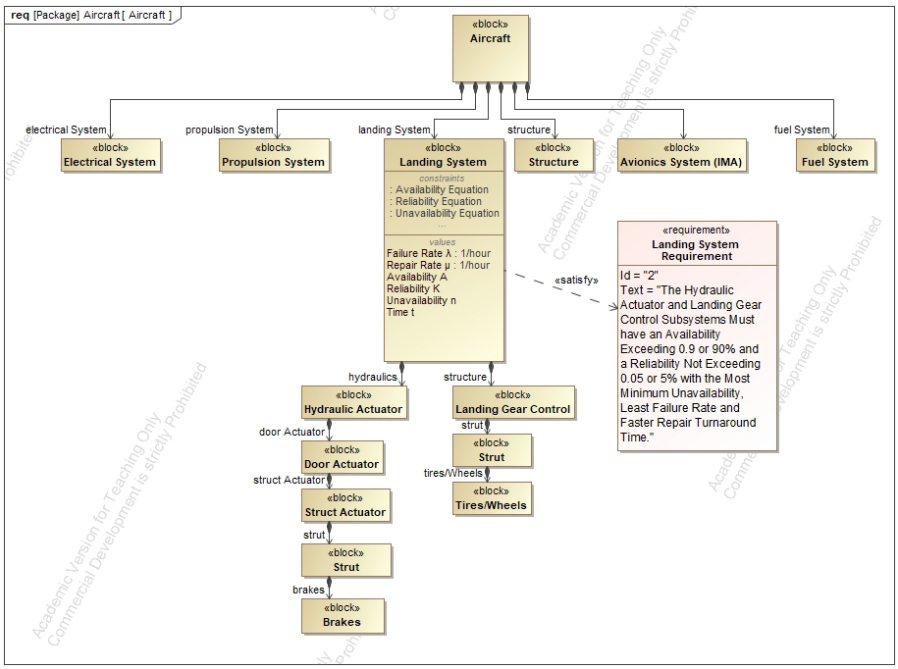

Figure 1: **Aircraft-level landing system view.** High-level decomposition of the aircraft landing system, showing the relationship among the Main Landing Gear (MLG), Nose Landing Gear (NLG), and supporting system components.

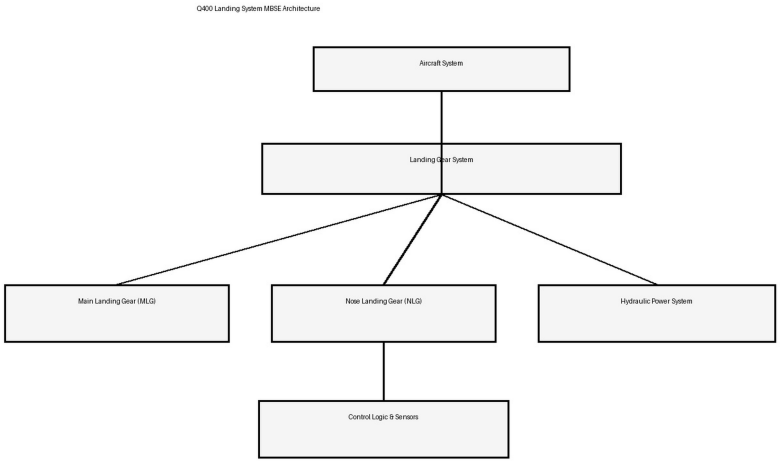

Figure 2: **MBSE landing gear architecture model.** SysML-based representation of structural and functional relationships among hydraulic actuation, control logic, and landing gear subsystem interfaces used for safety and reliability analysis.

Table 1: Proposed assessment rubric for the FHA–MBSE instructional module

Learning outcome	Emerging	Developing	Proficient
Safety classification	Identifies failures but assigns unclear severity.	Applies severity categories with partial rationale.	Justifies severity using operational phase and aircraft effect.
Model architecture	Lists components without clear relationships.	Represents major blocks and some interfaces.	Connects functions, components, and interfaces with traceability.
Reliability analysis	Uses equations with calculation errors.	Calculates availability but gives limited interpretation.	Calculates and interprets availability, unavailability, and reliability over time.
Traceability	Treats FHA, FMEA, and FTA as separate artifacts.	Links some failures to model elements.	Shows coherent links among hazards, causes, model elements, and metrics.
Communication	Provides results with limited assumptions.	States major assumptions.	Clearly explains assumptions, limitations, and implications for safety education.

The assessment is intentionally framed as work suitable for a final course project. It does not require proprietary data and can be adapted to other aircraft subsystems. If used for formal education research, the instructor should obtain IRB guidance before collecting or reporting student-performance data beyond normal course evaluation. In its present form, the paper reports the course-design logic, the assessment plan, and an illustrative technical case.

4 Technical Case Study: DHC-8 Q400 Landing Gear Safety Analysis

The technical case study demonstrates how each safety method contributes to the final reliability interpretation. The case begins with the aircraft-level function: provide safe landing gear extension, lock confirmation, steering, and ground support during landing and taxi. From this function, the FHA identifies potential functional failures such as failure to extend, failure to lock, false indication of locked gear, hydraulic pressure loss, and degraded steering. These failures are classified by severity depending on operational phase. A gear failure during landing is more severe than the same failure detected during maintenance because it affects aircraft controllability, structural integrity, and crew workload.

After the FHA identifies functional failures, the FMEA links those failures to component-level causes. For example, failure to extend may be caused by insufficient hydraulic pressure, actuator internal leakage, a blocked line, a command-signal fault, or a mechanical obstruction in the downlock linkage. The FTA then organizes these causes as logical paths to a top event. Fig. 3 shows the top event "MLG fails to extend or lock." The notation in the figure also clarifies a reviewer concern: probability labels such as 10^{-5} or 10^{-9}, when used in safety figures, should be interpreted as representative allowable failure-probability targets or severity-related thresholds, not as computed values unless the paper explicitly calculates them.

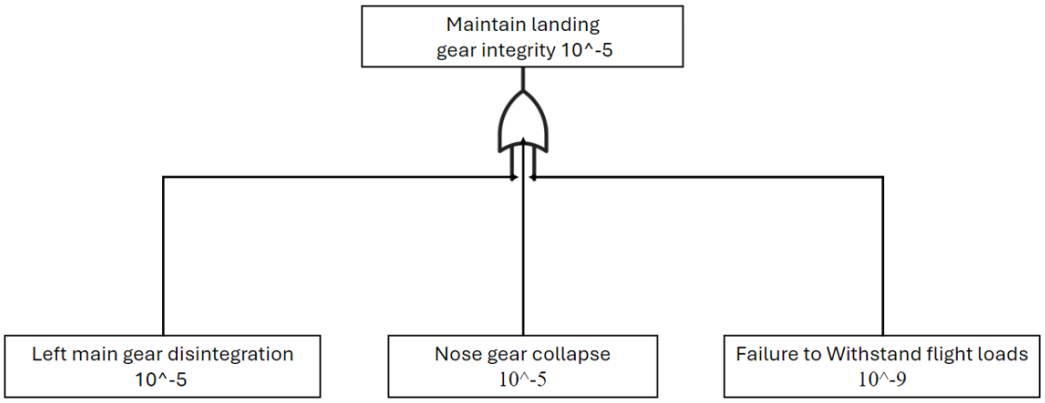

Figure 3: Representative fault-tree structure for the MLG failure-to-extend or failure-to-lock top event. Probability annotations such as 10^{-5} or 10^{-9} should be interpreted as target or threshold labels, not computed values from this case unless explicitly calculated.

The final step is parametric reliability modeling. The key point is that Table 2 is not intended to represent the entire aircraft landing gear safety case. It represents the quantitative portion of the example for two selected subsystems. The FHA and FMEA identify which subsystems are important to model. The FTA clarifies the causal path from component failures to the top event. The parametric equations then quantify availability for selected subsystem elements. In other words, the qualitative model flow determines what should be calculated, while the parametric model performs the calculation.

The availability equation used in this example is:

$$A = \frac{\mu}{\lambda + \mu} \tag{1}$$

where λ is the failure rate and μ is the repair rate. Unavailability is defined as:

$$n = 1 - A \tag{2}$$

The exponential reliability function is:

$$R(t) = e^{-\lambda t} \tag{3}$$

The time-dependent reliability expression was applied to illustrate how subsystem failure-rate assumptions can be translated into operational reliability estimates within the MBSE model. For

the hydraulic actuator, using a failure rate of $\lambda = 0.02$ failures/hour, the reliability after a 10-hour operating interval is:

$$R_{HA}(10) = e^{-0.02(10)} = e^{-0.20} = 0.8187 \tag{4}$$

For the landing gear control subsystem with $\lambda = 0.01$ failures/hour, the reliability after a 10-hour operating interval is:

$$R_{LGC}(10) = e^{-0.01(10)} = e^{-0.10} = 0.9048 \tag{5}$$

These values are illustrative and depend strongly on the assumed failure rates. The educational purpose is to show students how availability and time-dependent reliability describe different aspects of system behavior. Availability includes repair rate and represents readiness over a long operational period. Reliability over time represents probability of surviving a mission interval without failure.

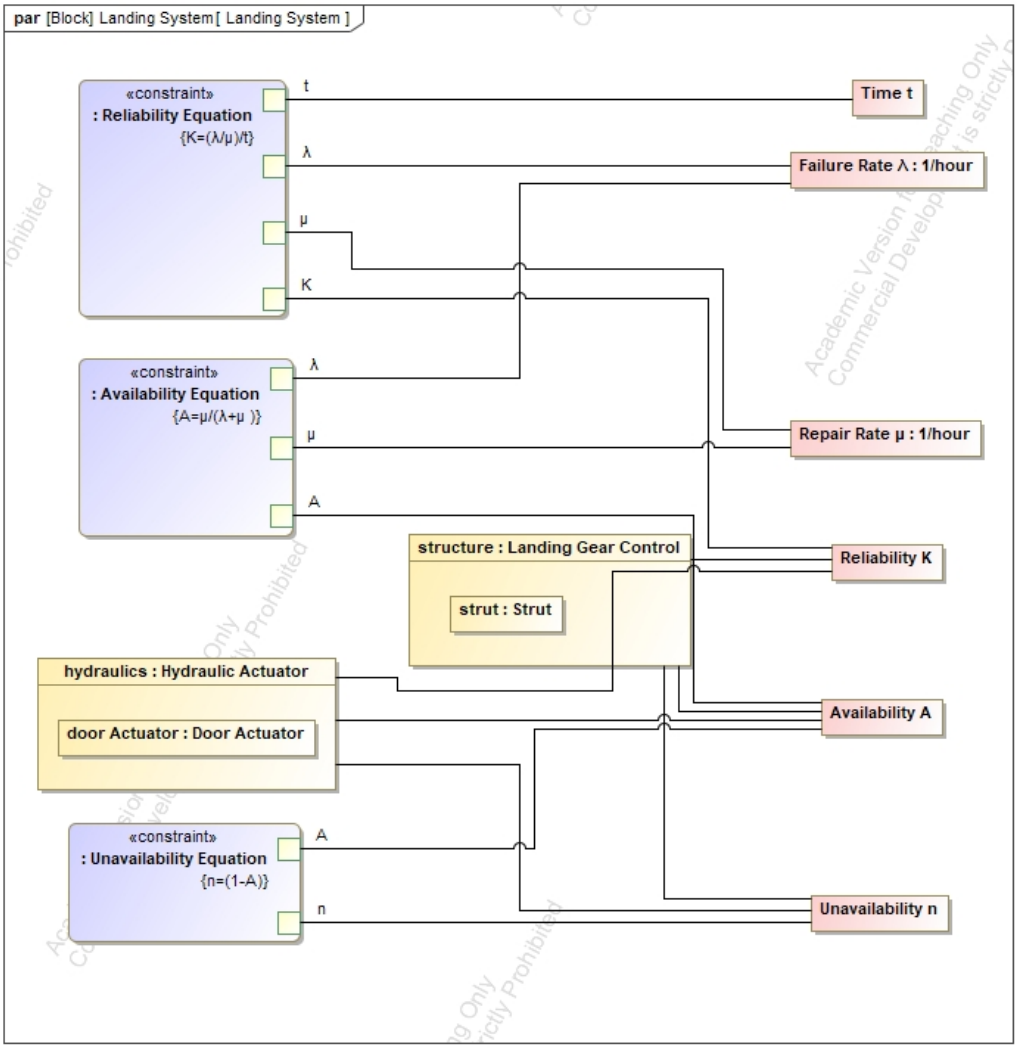

Figure 4: Representative SysML parametric diagram for reliability and availability modeling. The diagram links subsystem failure and repair rates to availability, unavailability, and time-dependent reliability.

Table 2: Subsystem reliability and availability results for the illustrative case

Metric	Hydraulic Actuator	Landing Gear Control
Failure Rate λ (1/hr)	0.02	0.01
Repair Rate μ (1/hr)	0.50	0.30
Availability A	0.9615	0.9677
Unavailability n	0.0385	0.0323
Reliability $R(10)$	0.8187	0.9048

The table shows that both subsystems have availability greater than 96% under the assumed rates. The landing gear control subsystem has slightly higher availability because its assumed failure rate is lower, while the hydraulic actuator benefits from a higher assumed repair rate. The time-dependent reliability values show a different comparison: over a 10-hour interval, the subsystem with the lower failure rate has the higher reliability. This distinction is useful pedagogically because students often conflate reliability and availability. The case therefore supports a discussion of how safety engineers interpret different metrics for maintenance planning, mission readiness, and hazard mitigation.

5 Educational Outcomes and Discussion

The most important contribution of the paper is the educational use of the safety case. The technical model provides an authentic context, but the primary engineering education relevance is the way the project can help students learn. The project requires students to move between narrative incident reports, safety classifications, system architecture, fault logic, and quantitative equations. This movement mirrors the work of systems and safety engineers more closely than a traditional homework problem focused on a single equation or isolated diagram.

The module also helps students understand traceability. In the case study, a functional failure such as "failure to extend landing gear" can be linked to operational phase, severity classification, candidate component causes, fault-tree logic, and reliability parameters. This traceability is difficult to communicate through a static document alone. In a model-based environment, students can see how changes to assumptions propagate through the analysis. For example, changing a failure rate changes $R(t)$ and may also motivate reconsideration of inspection intervals or mitigation strategies.

A second educational benefit is that the project strengthens certification literacy. Students are introduced to the idea that aerospace design is constrained not only by performance but also by safety evidence and regulatory logic. The project does not train students to perform a full certification program, but it exposes them to the vocabulary and reasoning patterns used in certification-oriented analysis. This is especially valuable for students who may later work in aircraft systems, maintenance engineering, safety assessment, or digital engineering roles.

A third benefit is that the module encourages clear communication of assumptions. In the educational framing, students are required to distinguish between assumed instructional values, values drawn from public incident documentation, and values that would require proprietary maintenance data. This distinction is a learning outcome in itself because it prevents students from treating

illustrative numerical results as certified aircraft performance data. Instead, students learn to interpret the results as evidence of the modeling workflow, the traceability logic, and the relationship between assumptions and safety conclusions.

The assessment evidence is presented conservatively because the study centers on a curriculum case study and illustrative technical implementation. The current work demonstrates the module design, student-facing artifacts, mastery rubric, and model-based safety workflow. Future offerings can strengthen the evidence base by collecting student learning data through pre/post concept inventories, rubric-based artifact scoring, and structured reflection analysis. If student data are collected for research purposes, appropriate institutional review or exemption determination should be completed before data collection.

6 Future Work

Future work will focus on three areas. The first is expansion of the technical model. The current case uses landing gear extension, locking, hydraulic pressure, and control indication as the primary example. Future versions can include right and left main gear symmetry, braking, steering, cockpit indication, maintenance inspection intervals, and emergency extension logic. Including both left and right main gear branches in the fault tree would also address the reviewer question about why one side appeared in the earlier model.

The second area is improvement of the educational assessment. The next implementation should use a defined assessment plan with a pre-module diagnostic, post-module artifact evaluation, and reflection prompts aligned to the learning outcomes. A mastery rubric can measure whether students can connect FHA, FMEA, FTA, and MBSE artifacts. A short survey can measure student confidence, but the primary evidence should come from artifact quality rather than self-report alone. Before collecting identifiable student data for research, the instructional team should seek IRB guidance.

The third area is dissemination and transferability. The module can be adapted to other safety-critical aerospace systems such as flight controls, avionics cooling, environmental control, electrical power, or unmanned aircraft systems. It can also be scaled for undergraduate capstone projects by reducing the number of diagrams and focusing on the traceability from one function to one failure condition. At the graduate level, the module can be expanded to include safety assurance cases, SysML v2, and digital thread integration.

7 Conclusion

This paper reframes FHA–MBSE integration as an educationally focused aerospace systems case study. The Q400 landing gear system provides a realistic and safety-relevant context for teaching how aircraft functions, hazards, component failures, and reliability metrics can be connected within a model-based workflow. The paper emphasizes curriculum design, assessment strategy, traceability, reliability modeling, and the use of safety-critical aircraft systems as instructional case studies for aerospace engineering education.

The technical example shows that the hydraulic actuator and landing gear control subsystems

exceed 96% availability under the assumed instructional parameters. The reliability calculations for a 10-hour interval further demonstrate the difference between availability and time-dependent reliability. These results are not presented as certified aircraft data; rather, they are used as instructional examples that show students how to connect safety reasoning with mathematical analysis.

The educational contribution is a structured module that can be used to teach systems thinking, traceability, certification awareness, and model-based safety assessment. The paper also establishes a future path for stronger educational research through rubric-based artifact assessment and IRB-guided collection of student-learning data. Overall, the work demonstrates that MBSE-enabled FHA can function as both a practical engineering workflow and a valuable instructional strategy for preparing aerospace students to work with safety-critical systems.

8 Appendix

8.1 Applicable Landing Gear Structural Standards

SAE ARP1311D addresses landing gear structures and mechanisms for civil and military aircraft. The standard covers structural and load-bearing elements such as axles, wheel forks, links, arms, shock struts, downlock assemblies, uplock assemblies, braces, trunnion beams, truck beams, and other elements not integral to the primary airframe. Hydraulic actuators used for retraction, extension, steering, positioning, and damping may also be considered within the broader landing gear mechanism context.

Several related SAE Aerospace Information Reports support landing gear design and evaluation. AIR1494 addresses verification of landing gear design strength, AIR1594 discusses plain bearing selection for landing gear applications, and AIR1752 addresses aircraft nose wheel steering and centering systems. These standards are referenced here to show how the technical case aligns with recognized landing gear engineering concerns, even though the instructional module does not attempt to perform a complete certification analysis.

8.2 Subsystem Reliability and Availability Parameters

The reliability and availability parameters used in the illustrative case are summarized in Table 3. These values were used to demonstrate the calculation workflow and should be replaced with validated operator or manufacturer data in an industrial application.

Table 3: Input parameters used for the illustrative reliability calculation

Subsystem	**Failure rate λ**	**Repair rate μ**	**Availability**
Hydraulic Actuator	0.02 failures/hour	0.50 repairs/hour	96.15%
Landing Gear Control	0.01 failures/hour	0.30 repairs/hour	96.77%

8.3 Implementation Notes for Instructors

Instructors implementing this module should provide students with a simplified system description, a small set of public incident summaries, and a starter SysML model or diagram template. Students can then complete the FHA table, identify major failure modes, construct a simplified FTA, and calculate availability and reliability. The instructor can evaluate the project using the rubric in Table 1. The module can be completed as a two- to four-week project depending on the depth of modeling expected.

Acknowledgments

The author gratefully acknowledges the guidance, technical feedback, and review support provided by faculty advisors and project reviewers during the development of this work.

References

[1] WestJet Encore Ltd., *Aircraft Operating Manual – DHC-8-400, Revision 016*, Aug. 31, 2018. Available through Transportation Safety Board of Canada investigation material: https://www.tsb.gc.ca/sites/default/files/rapports-reports/aviation/A19W0094/eng/a19w0094.pdf.

[2] Transportation Safety Board of Canada, "Aviation investigation reports involving Bombardier DHC-8 aircraft and landing gear or hydraulic system events," 2019. https://www.tsb.gc.ca/eng/rapports-reports/aviation/index.html.

[3] S. Maitrehenry, S. Metge, Y. Ait-Ameur, and P. Bieber, "Towards model-based functional hazard assessment at aircraft level," in *Proceedings of the European Safety and Reliability Conference (ESREL)*, 2011.

[4] K. Deb and P. Saxena, "A review of the literature on FHA integration with MBSE for aviation systems," in *AIAA Aviation Forum*, 2019.

[5] K. Lundqvist and D. Dixon, "Challenges in model-based safety assessment for aerospace systems," in *AIAA Modeling and Simulation Technologies Conference*, 2018.

[6] N. Tabesh, A. K. Jeyaraj, S. Liscouet-Hanke, and A. Tamayo, "Integration of the functional hazard assessment within a model-based systems engineering framework," *Journal of Aerospace Information Systems*, 2024. https://doi.org/10.2514/1.I011371.

[7] S. Friedenthal, A. Moore, and R. Steiner, *A Practical Guide to SysML: The Systems Modeling Language*, 2nd ed. Waltham, MA: Morgan Kaufmann, 2014.

[8] A. K. Jeyaraj, N. Tabesh, and S. Liscouet-Hanke, "Connecting model-based systems engineering and multidisciplinary design analysis and optimization for aircraft systems architecting," in *AIAA Aviation Forum*, 2021. https://doi.org/10.2514/6.2021-3077.

[9] A. K. Jeyaraj and S. Liscouet-Hanke, "A safety-focused system architecting framework for the conceptual design of aircraft systems," *Aerospace*, vol. 9, no. 12, p. 791, 2022. https://doi.org/10.3390/aerospace9120791.

[10] F. Torrigiani, P. D. Ciampa, B. Nagel, S. Deinert, M. Fioriti, and others, "MBSE certification-driven design of a UAV MALE configuration in the AGILE 4.0 design environment," in *AIAA Aviation Forum*, 2021. https://doi.org/10.2514/6.2021-3080.

[11] J. Xie, *Incorporating Airworthiness Certification Requirements into Unconventional Transport Aircraft Conceptual Design and Optimization*. Doctoral dissertation, School of Aerospace Engineering, Georgia Institute of Technology, 2024.

[12] K. Lai, *A Guideline for the Implementation of Model-Based Functional Hazard Assessment and its Integration with Model-Based Systems Engineering*. Master's thesis, University of Toronto, 2023. https://hdl.handle.net/1807/128100.

[13] S. M. Lübbe, M. Schäfer, and O. Bertram, "Coupling of model-based systems engineering and safety analysis in conceptual aircraft system design," in *Proceedings of the 33rd Congress of the International Council of the Aeronautical Sciences (ICAS 2022)*, Stockholm, Sweden, 2022.