National Aeronautics and Space Administration

Integration and Testing of Safety Case Tool Support

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Abstract

Safety cases are a structured form of an argument that illustrate the safety of a system through the connections between claims and their evidence or justification. Ideally, they should provide for every possible instance in regards to safety of a system, and give proof through justifications and evidence that a system is indeed safe. The alternative to a safety case involves following a set of objectives that have been previously founded on standards or guidelines. Thus by following these objectives, the system or artifact is implicitly deemed as safe. The point of a safety case is to clearly demonstrate the safety of a system by going through thorough argumentation. The AdvoCATE tool provides support for the modeling and transformation of safety cases. Since conventional safety processes are based on spreadsheets, we want to integrate our tool with spreadsheet based artifacts, and then test it. In order to test the tool, we will be developing a test suite to assess functionality of the interface and transformations, so that it can be used for safety-critical applications.

Traditional Safety Processes Vs. Safety Cases

•Originally, safety verification procedures followed implicit argumentation, where systems were deemed safe when the standards and guidelines were followed.
•Alternatively, safety cases demonstrate explicit argumentation in terms of safety, going through each claim and evidence/justification.
•Traditional approaches to safety assurance record artifacts in tabular form, whereas safety cases can be presented in a graphical form.
•We have been working to develop a tabular model for our graphical data. The resulting table (Figure 2) provides a sample formatted version of the diagram

Background and Notation of Safety Cases

•A safety case is an evidence-based structured form of an argument to illustrate the safety of a system through claims and justifications. For example, Figure 1 is a safety case which argues that the auto pilot module accurately calculates the correct angle of attack and is justified by claims and evidence.

Elements and Notation:
•The notation used is Goal Structure Notation (GSN)
•Each structure represents a part of an argument (i.e. a claim or a strategy)
•Goal structures are: goal (claim): ▭ strategy(method to decompose goal): ▱
context: ▢ evidence: ◯ justification: ⬭ J assumption: ⬭ A
•Link structures are: IsSolvedBy: ▶ InContextOf: ▷

AdvoCATE

•AdvoCATE is the safety case transformation system.
•It allows for the application of transformations (i.e. creating CSV files, narratives , or computing metrics) to safety cases
•Edits to safety cases can also be made using this tool.
•Currently, we are working on implementing a Microsoft Excel Macro with the tool to format the outputted CSV file into an organized spreadsheet (like the one below in Fig. 2).

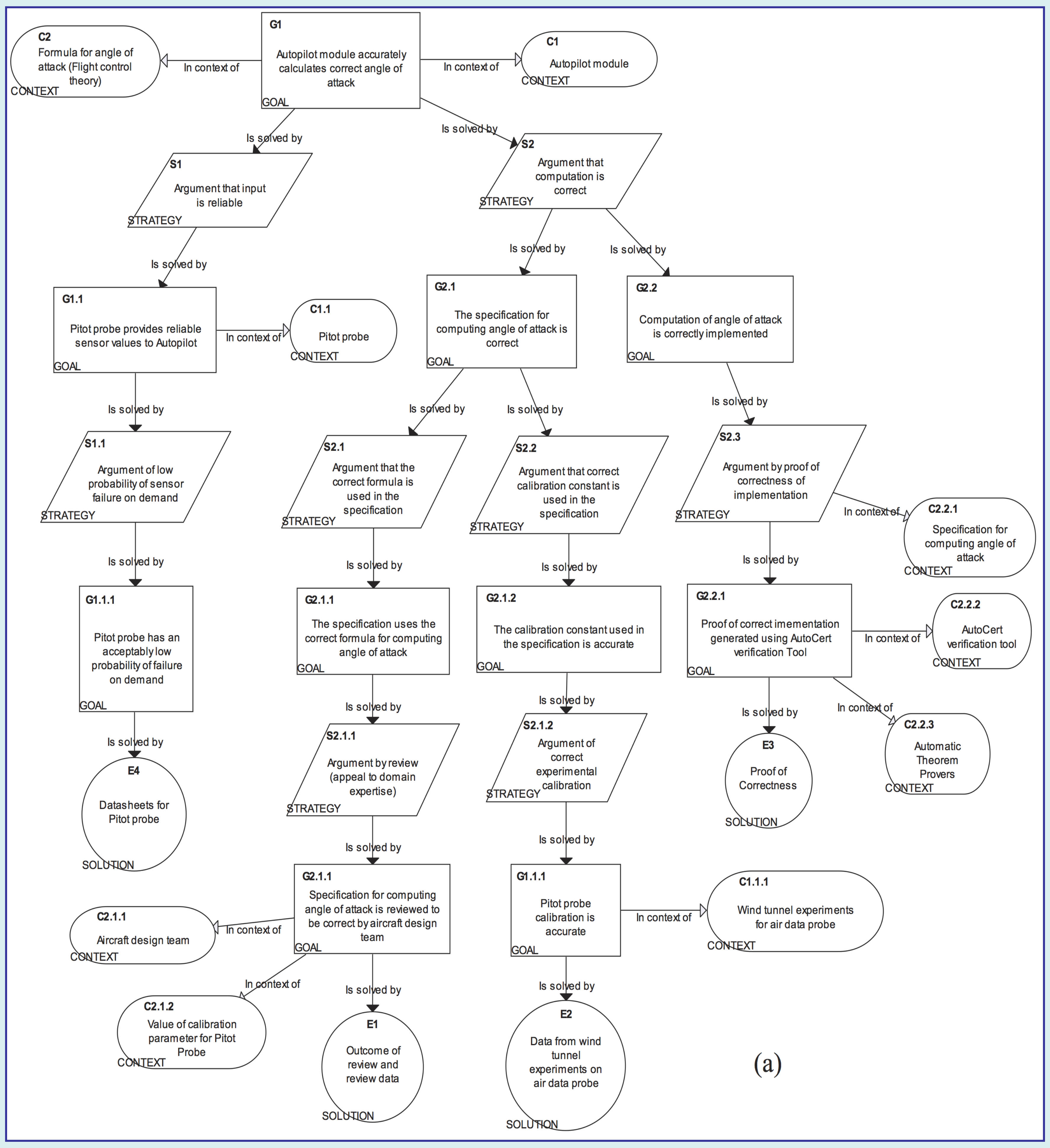
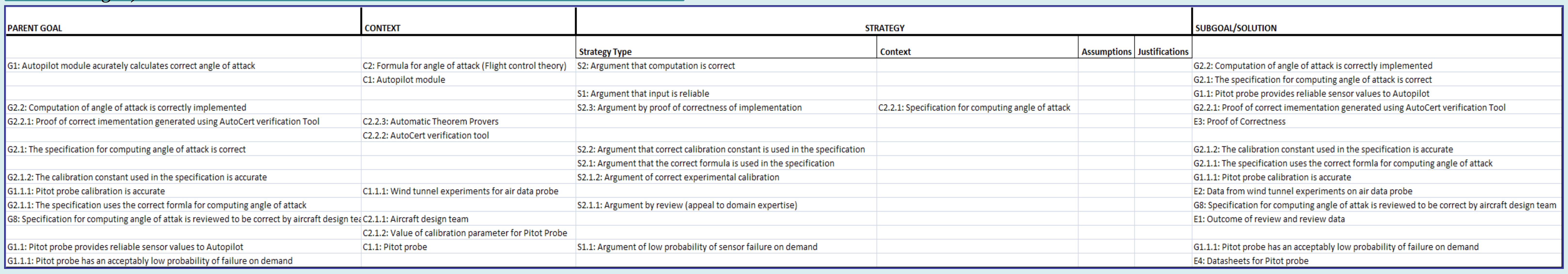

G1 Autopilot module accurately calculates correct angle of attack GOAL
C2 Formula for angle of attack (Flight control theory) CONTEXT
C1 Autopilot module CONTEXT
In context of
Is solved by
S1 Argument that input is reliable STRATEGY
S2 Argument that computation is correct STRATEGY
G1.1 Pitot probe provides reliable sensor values to Autopilot GOAL
C1.1 Pitot probe CONTEXT
G2.1 The specification for computing angle of attack is correct GOAL
G2.2 Computation of angle of attack is correctly implemented GOAL
S1.1 Argument of low probability of sensor failure on demand STRATEGY
S2.1 Argument that the correct formula is used in the specification STRATEGY
S2.2 Argument that correct calibration constant is used in the specification STRATEGY
S2.3 Argument by proof of correctness of implementation STRATEGY
C2.2.1 Specification for computing angle of attack CONTEXT
G1.1.1 Pitot probe has an acceptably low probability of failure on demand GOAL
G2.1.1 The specification uses the correct formula for computing angle of attack GOAL
G2.1.2 The calibration constant used in the specification is accurate GOAL
G2.2.1 Proof of correct imementation generated using AutoCert verification Tool GOAL
C2.2.2 AutoCert verification tool CONTEXT
E4 Datasheets for Pitot probe SOLUTION
S2.1.1 Argument by review (appeal to domain expertise) STRATEGY
S2.1.2 Argument of correct experimental calibration STRATEGY
E3 Proof of Correctness SOLUTION
C2.2.3 Automatic Theorem Provers CONTEXT
C2.1.1 Aircraft design team CONTEXT
G2.1.1 Specification for computing angle of attack is reviewed to be correct by aircraft design team GOAL
G1.1.1 Pitot probe calibration is accurate GOAL
C1.1.1 Wind tunnel experiments for air data probe CONTEXT
C2.1.2 Value of calibration parameter for Pitot Probe CONTEXT
E1 Outcome of review and review data SOLUTION
E2 Data from wind tunnel experiments on air data probe SOLUTION
(a)

Figure 1. A Sample Safety Case Diagram using Goal Standard Notation (GSN)

Denney, E., Habli, I., Pai, G.: Perspectives on Software Safety Case Development for Unmanned Aircraft. In: Proc. 42nd Annual IEEE/IFIP Intl. Conf. on Dependable Sys. and Networks. (Jun 2012)

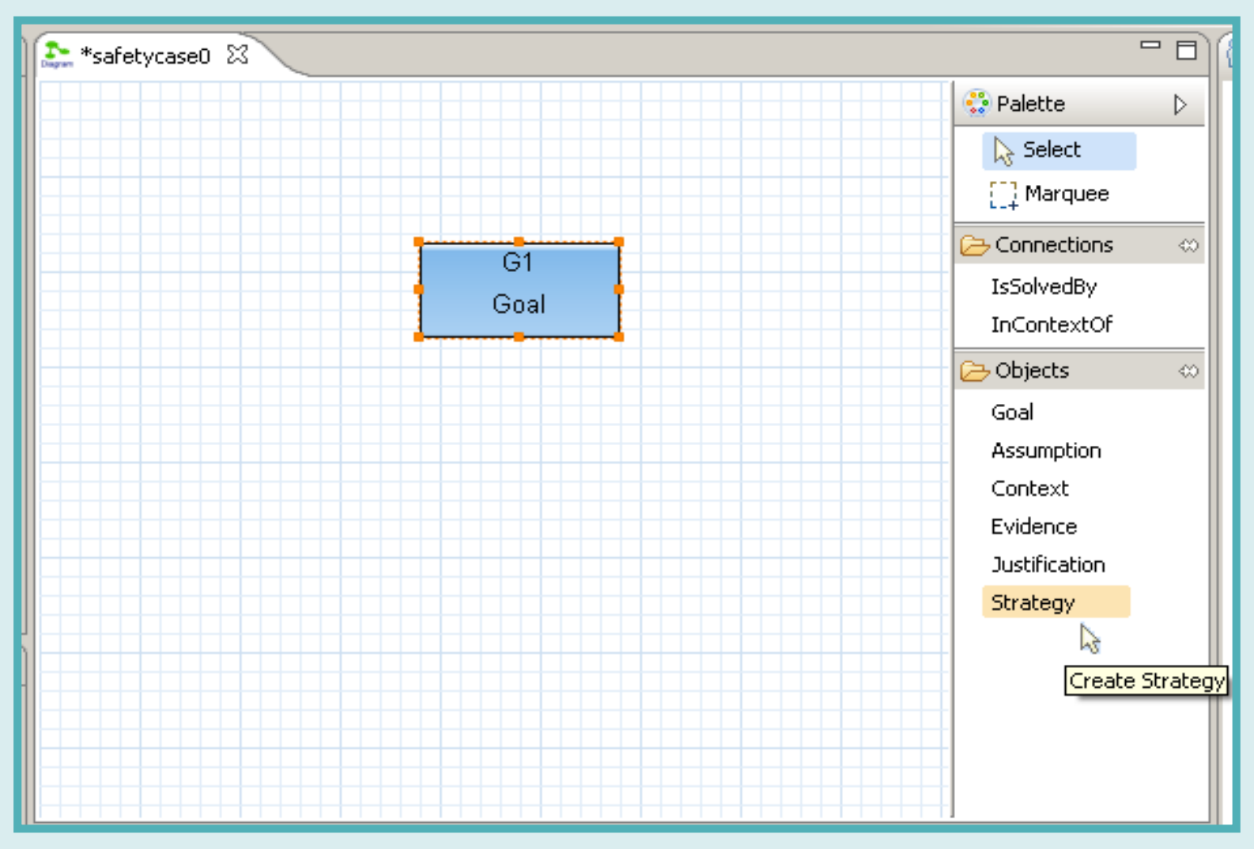


PARENT GOAL	CONTEXT	STRATEGY				SUBGOAL/SOLUTION
		Strategy Type	Context	Assumptions	Justifications	
G1: Autopilot module acurately calculates correct angle of attack	C2: Formula for angle of attack (Flight control theory)	S2: Argument that computation is correct				G2.2: Computation of angle of attack is correctly implemented
	C1: Autopilot module					G2.1: The specification for computing angle of attack is correct
		S1: Argument that input is reliable				G1.1: Pitot probe provides reliable sensor values to Autopilot
G2.2: Computation of angle of attack is correctly implemented		S2.3: Argument by proof of correctness of implementation	C2.2.1: Specification for computing angle of attack			G2.2.1: Proof of correct imementation generated using AutoCert verification Tool
G2.2.1: Proof of correct imementation generated using AutoCert verification Tool	C2.2.3: Automatic Theorem Provers					E3: Proof of Correctness
	C2.2.2: AutoCert verification tool					
G2.1: The specification for computing angle of attack is correct		S2.2: Argument that correct calibration constant is used in the specification				G2.1.2: The calibration constant used in the specification is accurate
		S2.1: Argument that the correct formula is used in the specification				G2.1.1: The specification uses the correct formla for computing angle of attack
G2.1.2: The calibration constant used in the specification is accurate		S2.1.2: Argument of correct experimental calibration				G1.1.1: Pitot probe calibration is accurate
G1.1.1: Pitot probe calibration is accurate	C1.1.1: Wind tunnel experiments for air data probe					E2: Data from wind tunnel experiments on air data probe
G2.1.1: The specification uses the correct formla for computing angle of attack		S2.1.1: Argument by review (appeal to domain expertise)				G8: Specification for computing angle of attak is reviewed to be correct by aircraft design team
G8: Specification for computing angle of attak is reviewed to be correct by aircraft design tea	C2.1.1: Aircraft design team					E1: Outcome of review and review data
	C2.1.2: Value of calibration parameter for Pitot Probe					
G1.1: Pitot probe provides reliable sensor values to Autopilot	C1.1: Pitot probe	S1.1: Argument of low probability of sensor failure on demand				G1.1.1: Pitot probe has an acceptably low probability of failure on demand
G1.1.1: Pitot probe has an acceptably low probability of failure on demand						E4: Datasheets for Pitot probe

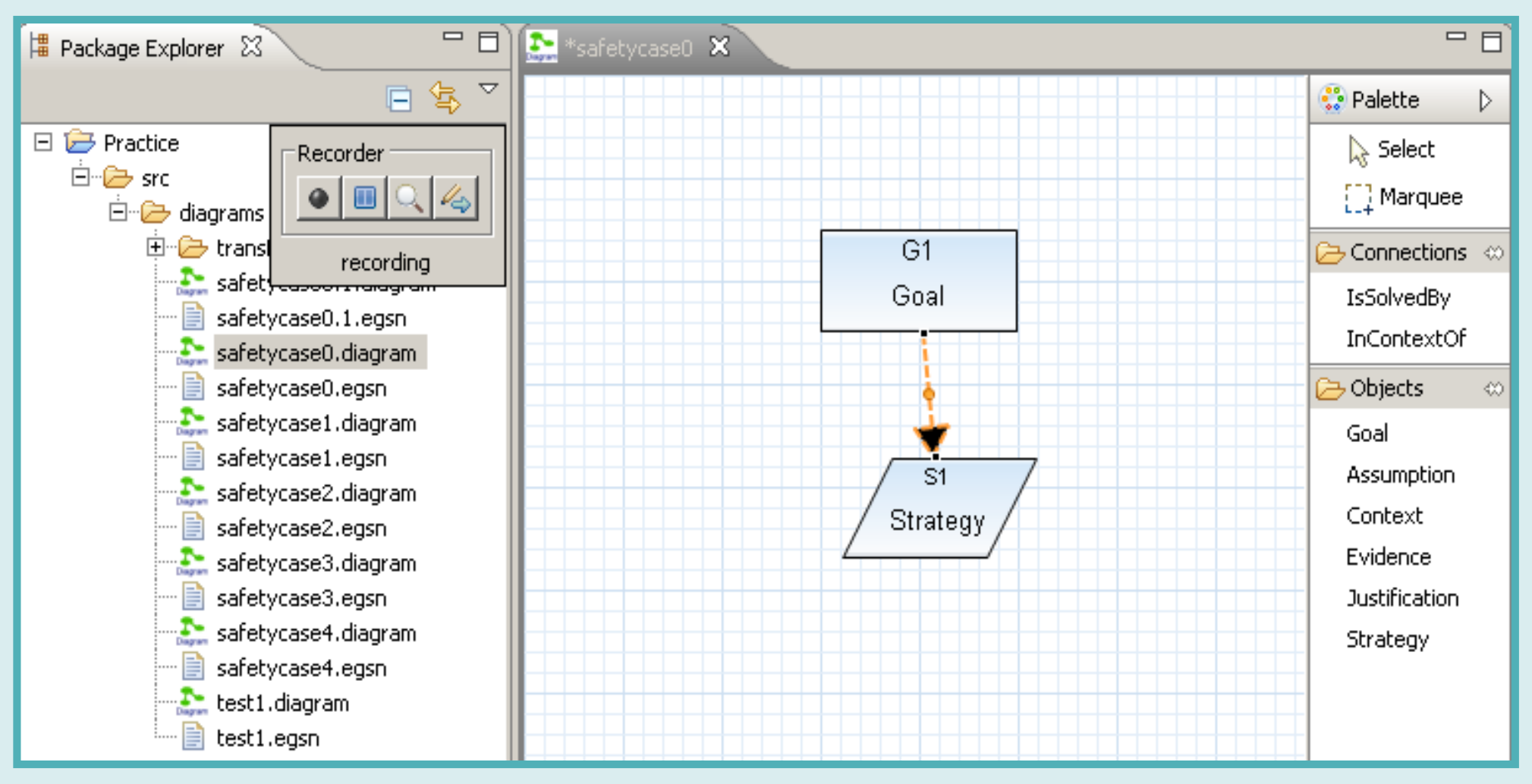
Figure 2. A sample Safety Case Spreadsheet of the Fig 1. diagram

Testing the Safety Case Editor

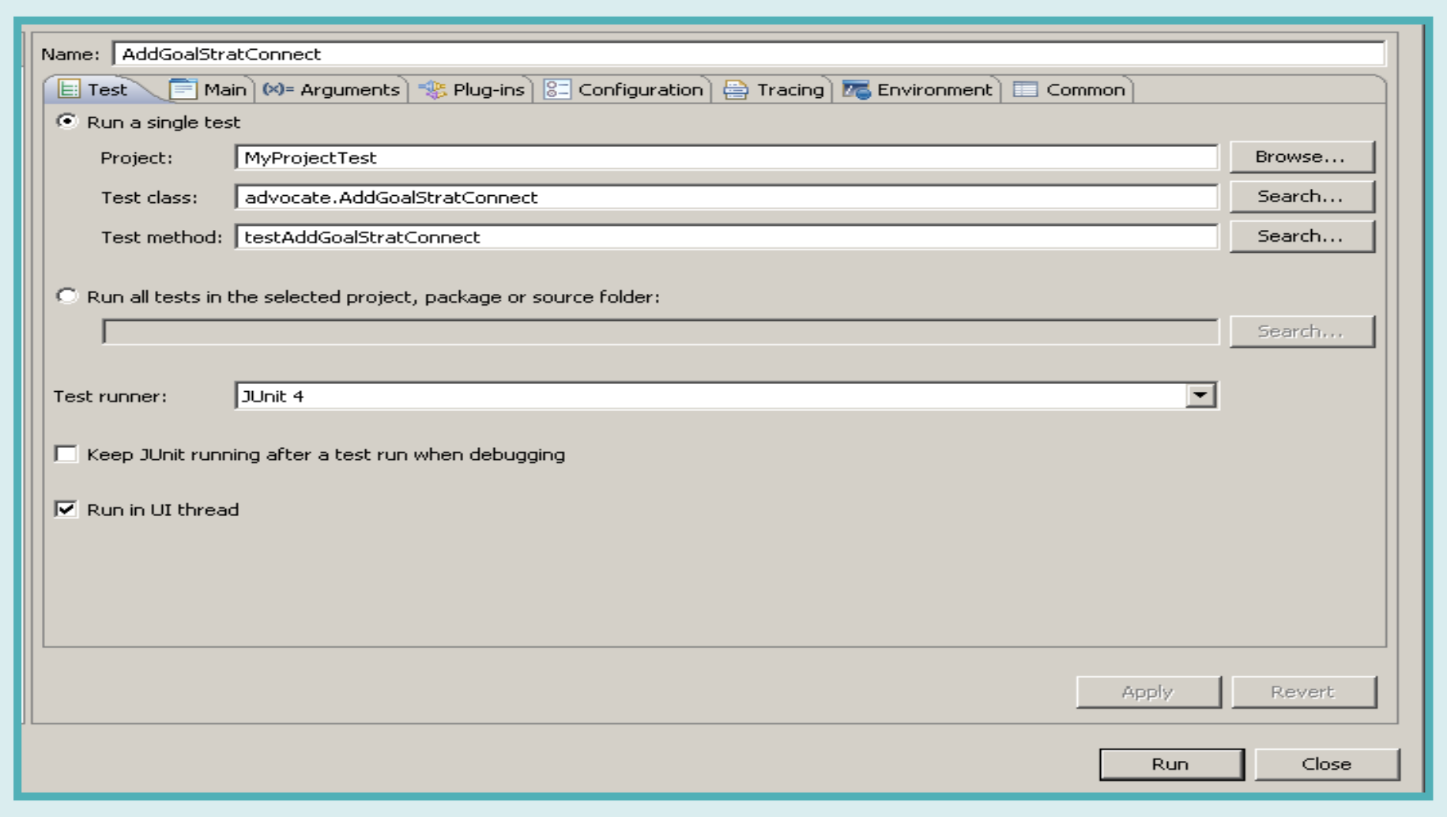
After changes have been made to the safety case editor, it's necessary to test the editor to make sure the changes have not negatively affected its functionality.



Testing the functionality of adding nodes and links using WindowTester Pro:



STEP 1: Record all keyboard clicks, mouse movements, and all changes made to the diagram, in this case a Goal and Strategy were added and then an IsSolvedBy link was added.


Name: AddGoalStratConnect
Test
Main
Arguments
Plug-ins
Configuration
Tracing
Environment
Common
Run a single test
Project: MyProjectTest
Test class: advocate.AddGoalStratConnect
Test method: testAddGoalStratConnect
Browse...
Search...
Run all tests in the selected project, package or source folder:
Test runner: JUnit 4
Keep JUnit running after a test run when debugging
Run in UI thread
Apply
Revert
Run
Close

STEP 2: Run the newly created junit plug-in test and view the results of the test. Edit the produced java code if necessary to make it run correctly.

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