



Autonomous Cognitive Agent Flying Aircraft in X-Plane

Milestone 1

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Project Overview

Project Goal:

Extend the existing autonomous aircraft agent in X-Plane so it can:

- Detect supported equipment failures
- Evaluate the aircraft's remaining capabilities
- Determine an appropriate response
- Modify the flight route when necessary
- Continue operating when multiple failures occur

Existing System:

- X-Plane 12 simulation
- Java/CCAT communication layer
- Soar cognitive agent
- XPlaneConnect/DataRefs

Milestone 1 Goal:

- Understand the current system and tools
- Requirements Document
- Test Plan
- Design Document
- Existing system demos

Progress Matrix of Milestone 1

Task	Completion %	Avery Mackey	Dylan Ostolaza	Zachary Reese	Brianna Marshall	To do
Investigate Tools	100%	25%	25%	25%	25%	None
Demos	100%	0%	0%	100%	0%	None
Technical Challenges	100%	25%	25%	25%	25%	None
Requirement Document	100%	0%	0%	0%	100%	None
Design Document	100%	0%	0%	100%	0%	None
Test Plan	100%	0%	100%	0%	0%	None



Major Requirements

Main Functions:

1. Flight setup and initial route
 - Initiate flight and provide the route to the agent
2. Equipment failure detection
 - Recognize supported equipment failure
3. Equipment failure response
 - Determine an action from remaining aircraft capabilities
4. Multiple failure handling
 - Evaluate combined failure conditions
5. Dynamic route modification
 - Reroute when continued flight requires it
6. Flight status display
 - Show failures, responses, and route changes



Major Requirements cont.

Supported Failures:

- Uncharged battery
- Multi-engine failure
- Sensor failures caused by aircraft icing

Performance Targets:

- Detect/respond/reroute within 5 seconds
- $\geq 70\%$ failure identification accuracy
- $\geq 70\%$ correct response accuracy
- Support at least 3 simultaneous failures



Requirements → Test Plan

Function	Test Procedure	Expected Result
<i>Equipment Failure Initiation</i>	Select an equipment component, choose a failure type, and initiate the failure	The selected equipment enters a failed state, and the aircraft state reflects the change.
<i>Failure Detection</i>	Initiate a failure while the agent monitors equipment and flight data.	The agent identifies the failed component and failure type.



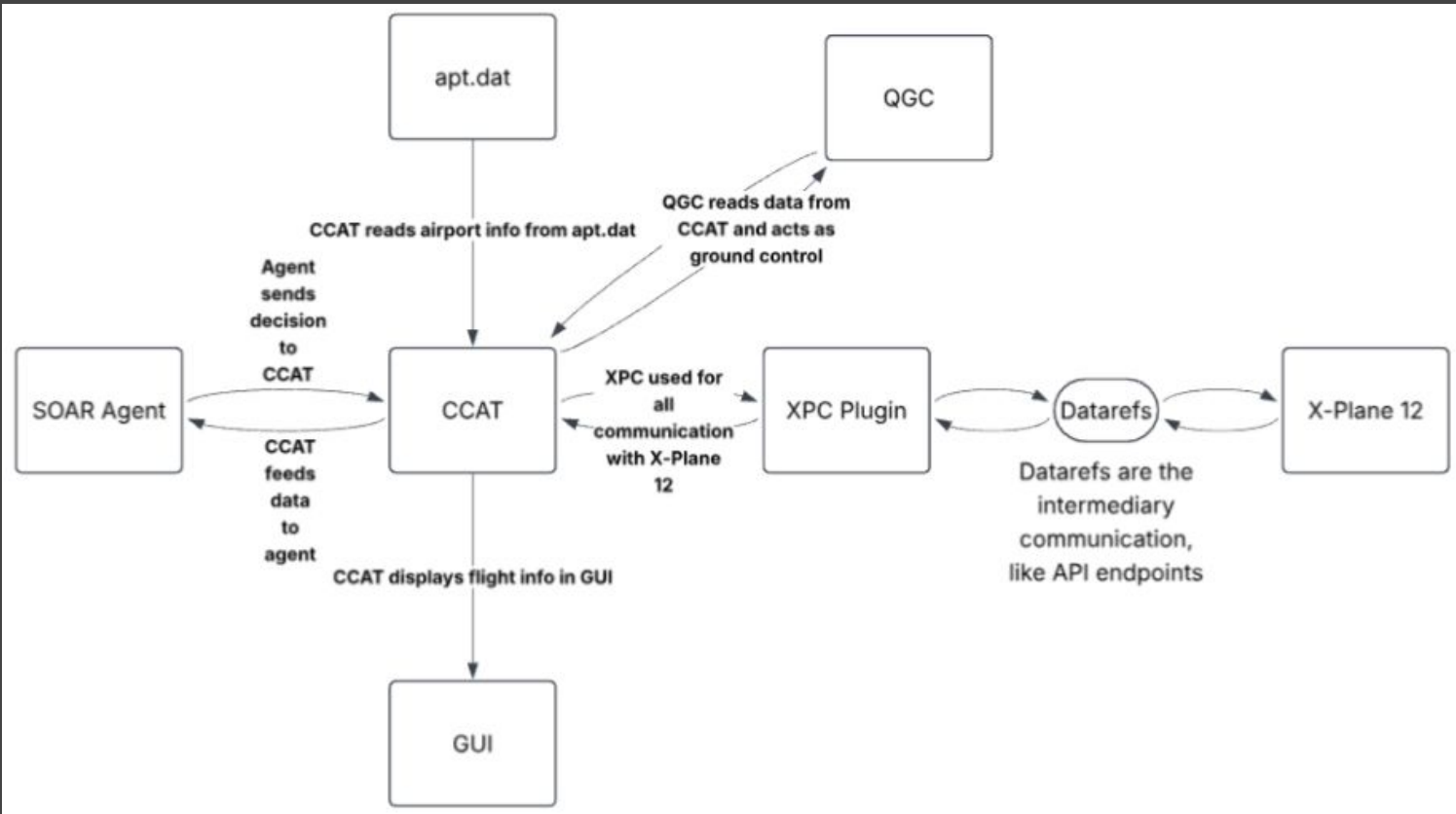
Requirements → Test Plan cont.

<i>Failure Response</i>	Have the agent detect a failure, evaluate available response options, and select a response.	The agent executes a response suited to the detected failure.
<i>Multiple Failure Handling</i>	Introduce a second failure or worsen the existing failure during flight.	The agent reevaluates the situation and updates its response.
<i>Dynamic Route Modification</i>	Trigger a failure requiring rerouting, calculate a modified route, and apply it.	A new route is generated and replaces the original flight plan.



System Design Approach

- **Reuse the existing architecture**
 - Extend the current CCAT/Soar/X-Plane system rather than rebuild it.
- **Use X-Plane DataRefs for failure simulation**
 - Equipment failures will be represented by manipulating X-Plane aircraft/sensor state.
- **Keep decision making in Soar**
 - The agent determines how to respond based on detected failures and remaining aircraft capabilities.
- **Use apt.dat for diversion airport lookup**
 - CCAT will read X-Plane airport data and identify the nearest airports.
- **Separate reasoning from command execution**
 - Soar determines the response.
 - The Java/CCAT side handles passing the resulting commands to X-Plane.



SOAR System Architecture

Demos and UI



Flight Data

Sensor Output:

GPS:

Position: 47°48'15", 12°59'48"

IMU:

Position: 47°48'15", 12°59'48"

Lidar:

Position: 47°48'15", 12°59'48"

Target Waypoint:

Position: 38°5'59", -115°10'11"
Distance to target: 9173.6941 Km

Initiate Landing

Testing UI:

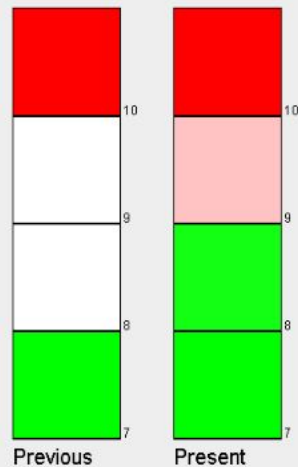
Altitude: 2100ft above Sea Level
Airspeed: -20kn

Sensor Display

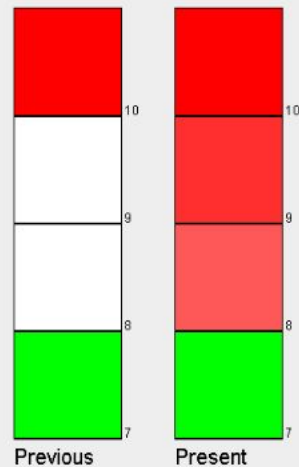
Warn Low -1.37	Do Not Warn Low -0.44
Warn High -0.02	Do Not Warn High -0.26

Warn Low 0.95	Do Not Warn Low 0.29
Warn High 1.11	Do Not Warn High 0.29

Warn Low -1.00	Do Not Warn Low -0.09
Warn High -1.04	Do Not Warn High -0.10



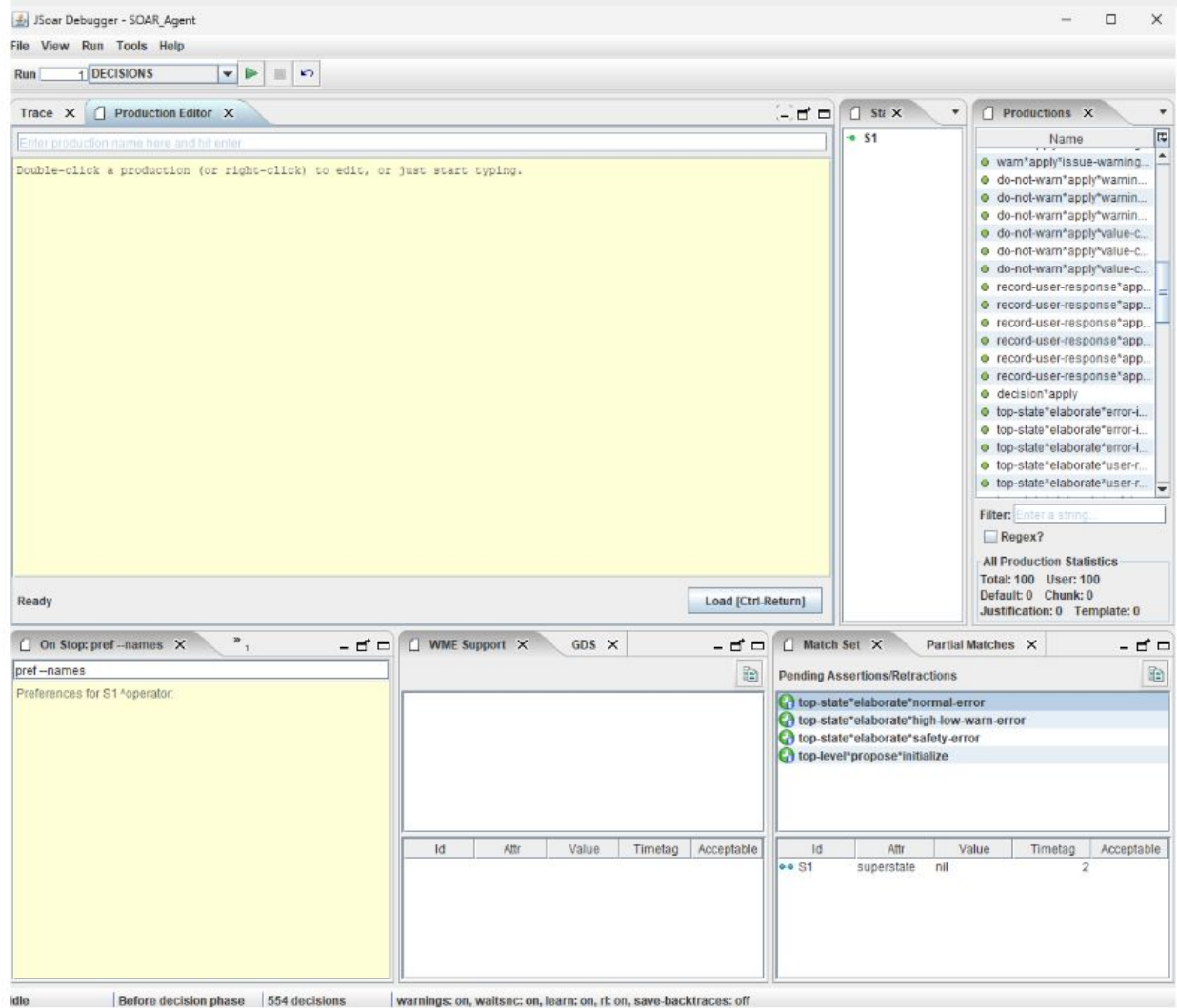
GPS Sensor



IMU Sensor



LIDAR Sensor





X-Plane in Operation



Next Milestone

1. Trigger and communicate at least one equipment failure from X-Plane to Soar
2. Complete a full nominal flight plan with no complications
3. Add Soar rules to recognize failures and choose responses based on remaining capabilities
4. Send the selected response commands back to X-Plane and verify execution

Any Questions?

