**Global Navigation Satellite System (GNSS) Resilience  
System Requirements Specification**

**Version 2**

**11/25/2024**

# Document Control

## Distribution List

The following list of people will receive a copy of this document every time a new version of this document becomes available:

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## Change Summary

The following table details changes made between versions of this document:

|  |  |  |  |
| --- | --- | --- | --- |
| **Version** | **Date** | **Modifier** | **Description** |
| 1.1 | 10/24/2024 | Jonathan Legro | Initial document creation. Includes parts of the project introduction and general description. |
| 1.2 | 10/28/2024 | Jonathan Legro | Edited more of the project references and terminology. (1.4) |
| 1.3 | 11/10/2024 | Jonathan Legro | Remove developers from Intended Audience and Terminology in the Introduction. (1.1, 1.2) |
| 1.4 | 11/10/2024 | Jonathan Legro | Remove developers from Actors in the General Description (2.3.1) |
| 1.5 | 11/10/2024 | Jonathan Legro | Remove developers from Use Cases in the General Description. (2.3.2) |
| 1.6 | 11/15/2024 | Haskell Cappers | Remove all SRS template information for readability and consistency. (3, 4, 5, 6, 7, 8) |
| 1.7 | 11/15/2024 | Jonathan Legro | Edited Scenarios to include a description, precondition, trigger condition, and alt cases. (2.3.3) |
| 1.8 | 11/15/2024 | Cristina Arena | Added and edited the links within the Project References and User Documentation to display a title not a URL.(1.4, 2.6) |
| 1.9 | 11/20/2024 | Jonathan Legro | Added information into Functional within Behavioral Requirements. (5.5) |
| 1.10 | 11/20/2024 | Jonathan Legro | Added detailed information to General Constraints and Operating Environment. (2.4, 2.5) |
| 1.11 | 11/25/2024 | Tyler Lofton | Added figure number for figure 1, added figure 2. Added information in (7.1.3, 7.1.4, 7.1.5.) |
| 1.12 | 11/25/2024 |  |  |
| 1.13 | 11/25/2024 |  |  |

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# Introduction

## Purpose and Scope

The System Requirements Specification (SRS) outlines the development of a GPS display plugin for Microsoft Flight Simulator 2020 (MSFS 2020). The plugin’s primary purpose is to simulate real-world GPS navigation, providing pilots with a realistic tool for navigation practice. The scope includes the creation and integration of the GPS display within MSFS 2020’s instrument panel, using TypeScript and HTML. This project excludes any changes to the simulator’s core functions and does not involve real-world GPS data integration. The system, called the GNSS Resilience - GPS Display Plugin for MSFS 2020, addresses the absence of a GPS display in MSFS 2020 and establishes a foundation for future enhancements, such as geo-spoofing simulations. The plugin’s application benefits primary users, including pilots and researchers, by enabling realistic navigation practice, supporting future aviation vulnerability testing, and providing a stable GPS diagnostic tool within the simulator.

## Intended Audience and Reading Suggestions

This document is intended for:

1. **Primary Audience: Center for Aerospace Resilient Systems (CARS)** – CARS personnel can use this document to understand the project goals, scope, and technical requirements.
2. **Secondary Audience:**
   * **Federal Aviation Administration (FAA) & Commercial Airlines** – FAA and airline reps should review the Overview and System Features to assess how the plugin could support navigation training and GNSS resilience.
   * **MSFS 2020 Players** – Players may refer to the Overview and User Scenarios for insights into how the plugin enhances gameplay and navigation capabilities.

Suggested reading for:

1. **Center for Aerospace Resilient Systems (CARS)**
   * **Sections**: Review *1.1 Purpose and Scope* and *2. General Description* for an overview of project objectives, followed by *4. Behavioral Requirements* to understand functionality and performance criteria.
2. **Federal Aviation Administration (FAA) & Commercial Airlines**
   * **Sections**: Review *1.1 Purpose and Scope* and *2. General Description*, focusing on *2.2 Product Features* and *2.3 User Classes and Characteristics* to understand user scenarios and benefits.
3. **MSFS 2020 Players**
   * **Sections**: Review *1.1 Purpose and Scope*, *2.3 User Classes and Characteristics*, and *2.4 General Constraints* for purpose, user roles, and gameplay enhancements.

## Document Conventions

* **Emphasis**: Key terms are bolded; requirements are tagged (e.g., [REQ-101]).
* **Priorities**: Each requirement has an individual priority.
* **Formatting**: Standard headings and numbering for easy reference.

## Project References

1. **Microsoft Flight Simulator**
   * **Title**: *Microsoft Flight Simulator*
   * **Author**: Wikipedia Contributors
   * **Source**: Wikipedia
   * **Date**: Accessed 2024
   * **Location**: [Microsoft Flight Simulator Wiki](https://en.wikipedia.org/wiki/Microsoft_Flight_Simulator)
   * *Description*: Provides general information on Microsoft Flight Simulator, relevant for understanding the simulator’s framework and user environment.
2. **TypeScript Documentation**
   * **Title**: *TypeScript: JavaScript With Syntax for Types*
   * **Author**: Microsoft
   * **Version**: Latest
   * **Date**: Accessed 2024
   * **Location**: [TypeScript is JavaScript with syntax for types.](https://www.typescriptlang.org/)
   * *Description*: The official TypeScript documentation, useful for developers implementing the plugin within MSFS 2020.
3. **Federal Aviation Administration (FAA) - GNSS and GPS**
   * **Title**: *Global Navigation Satellite System (GNSS) and GPS*
   * **Author**: Federal Aviation Administration (FAA)
   * **Date**: Accessed 2024
   * **Location**: [Satellite Navigation - Global Positioning System (GPS)](https://www.faa.gov/about/office_org/headquarters_offices/ato/service_units/techops/navservices/gnss/gps)
   * *Description*: An FAA resource detailing GNSS and GPS functionality, supporting the project’s relevance to aviation resilience.
4. **Advanced Navigation - GNSS and Satellite Navigation Explained**
   * **Title**: *Global Navigation Satellite System (GNSS) and Satellite Navigation Explained*
   * **Author**: Advanced Navigation
   * **Date**: Accessed 2024
   * **Location**: [Global Navigation Satellite System (GNSS) and Satellite Navigation Explained](https://www.advancednavigation.com/tech-articles/global-navigation-satellite-system-gnss-and-satellite-navigation-explained/)
   * *Description*: An article on GNSS concepts, providing background information on satellite navigation relevant to GPS functionality in the plugin.
5. **Microsoft Flight Simulator SDK Documentation**
   * **Title**: *Microsoft Flight Simulator SDK Documentation*
   * **Author**: Microsoft
   * **Date**: Accessed 2024
   * **Location**: [SDK Documentation](https://docs.flightsimulator.com/html/Introduction/Introduction.htm)
   * *Description*: The official SDK documentation for MSFS 2020, essential for understanding development standards and integration guidelines.
6. **Microsoft Flight Simulator FAQ**
   * **Title**: *Minimum, Recommended, and Ideal PC requirements for Microsoft Flight Simulator*
   * **Author**: Microsoft
   * **Date**: April 23, 2020
   * **Location**: [General & Announcements](https://flightsimulator.zendesk.com/hc/en-us/articles/360013463459-Minimum-Recommended-and-Ideal-PC-requirements-for-Microsoft-Flight-Simulator)
   * *Description*: The official SDK Support Update for MSFS 2020, essential for understanding hardware constraints.

## Definitions, Acronyms, and Abbreviations

### Definitions

This section lists terms used in this document and their associated definitions.

**Table 1: Terms**

|  |  |
| --- | --- |
| **Term** | **Definition** |
| Spoofing | Mimicking signals to deceive a system, often used to mislead GPS navigation. |
| Display Plugin | Software component added to extend MSFS 2020 with GPS display functionality. |
| TypeScript | Typed JavaScript used for developing the GPS plugin in MSFS 2020. |
| Instrument Panel | Displays essential flight info in MSFS 2020, where the GPS plugin is integrated. |
| End User | Uses the GPS plugin in MSFS 2020 for navigation. |
| Researcher | Tests GNSS resilience using the plugin. |
| Simulator | Imitative representation of a process or system. |
| Actors | All users of the system. |

### Acronyms

This section lists the acronyms used in this document and their associated definitions.

**Table 2: Acronyms**

|  |  |
| --- | --- |
| **Term** | **Definition** |
| SDD | System Design Document |
| SRS | System Requirements Specification |
| GNSS | Global Navigation Satellite System |
| MSFS | Microsoft Flight Simulator |
| GPS | Global Positioning System |
| FAA | Federal Aviation Administration |
| CARS | Center for Aerospace Resilient Systems |
| HTML | HyperText Markup Language |

### Abbreviations

This section lists the abbreviations used in this document and their associated definitions.

**Table 3: Abbreviations**

|  |  |
| --- | --- |
| **Term** | **Definition** |
| e.g. | For example |

# General Description

## Product Perspective

The GNSS Resilience - GPS Display Plugin for Microsoft Flight Simulator 2020 (MSFS 2020) is a self-contained tool developed for the Center for Aerospace Resilient Systems (CARS). It adds realistic GPS navigation functionality to the simulator, allowing users to practice and test navigation as well as study GNSS resilience. This plugin supports CARS’ research on aviation resilience and provides the Federal Aviation Administration (FAA) and airlines with a tool to simulate navigation and test vulnerabilities. It fits within a larger initiative focused on aviation safety and resilience.

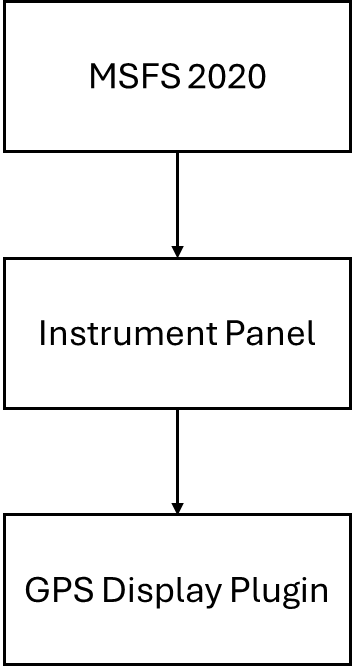


Figure 1: GPS Display Plugin Integration

## Product Features

The GNSS GPS Display Plugin for MSFS 2020 includes:

1. **GPS Navigation Display**: Shows realistic GPS data within MSFS 2020.
2. **Map View**: Displays location, route, and waypoints on a visual map.
3. **Waypoint Management**: Allows users to set waypoints for navigation.
4. **Navigation Data**: Shows essential data (altitude, speed, coordinates).

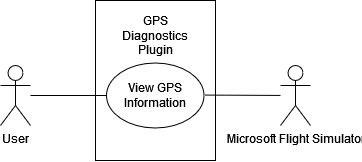


Figure 2: Use Case Diagram

## User Classes and Characteristics

### Actors

This section identifies the primary actors interacting with the GNSS GPS Display Plugin.

* **End User**
  + An End User is anyone who uses the plugin to enhance their flight simulation experience in MSFS 2020, such as pilots or aviation enthusiasts.
* **Researcher**
  + A Researcher uses the system to study GNSS resilience and conduct aviation safety testing, simulating potential vulnerabilities in a controlled environment.

### Use Cases

This section presents the primary use cases developed for the GNSS GPS Display Plugin.

* **Enhance Flight Simulation**
  + *Users* use the plugin to improve navigation in MSFS 2020, accessing GPS data, maps, and waypoints.
* **Conduct Research**
  + *Researchers* simulate GNSS vulnerabilities for aviation resilience studies.

### Scenarios

Scenario 1: Enhance Flight Simulation

* **Description:**
  + The GPS display plugin is used by an end user to enhance their flight simulation experience in MSFS 2020 by providing real-time navigation features such as waypoint management and map updates.
* **Precondition:**
  + The GPS display plugin is installed and correctly integrated into the simulator. The simulator is running, and the user has loaded a flight session.
* **Actors**:
  + End User
* **Trigger Condition**:
  + The user opens the GPS display within the instrument panel of MSFS 2020..
* **Steps**:
  + GPS interface loads.
  + User sets waypoints.
  + Map updates with navigation data.
* **Alt Cases:**
  + If the GPS interface fails to load, an error message is displayed, and the system provides a retry option.
  + If the map fails to update, the system displays a message prompting the user to reinitialize the GPS interface.

Scenario 2: Conduct Research

* **Description:** 
  + Researchers use the GPS display plugin to simulate GNSS vulnerabilities and test aviation resilience in controlled environments.
* **Precondition:** 
  + The GPS display plugin is installed and operational within MSFS 2020. The researcher has defined test parameters for GNSS simulations.
* **Actors**:
  + Researcher
* **Trigger Condition:**
  + The researcher initiates a resilience test using the GPS display interface.
* **Steps**:
  + GPS loads simulated data.
  + Researcher applies interference.
  + GPS display shows response to interference.
* **Alt Cases:**
  + If updates introduce compatibility issues, the system logs errors and reverts to the last stable version.
  + If tests fail, the maintainer reviews the error log and makes additional changes before deployment.

## General Constraints

1. **Organizational**: Must align with CARS’ requirements and MSFS 2020 compatibility.
2. **Hardware**: The GPS display plugin must operate within the following minimum hardware requirements, as dictated by MSFS 2020:
   * Minimum Specifications (AMD):
     1. Operating System: Windows 10 (November 2019 update, version 1909).
     2. CPU (Processor): AMD Ryzen 3 1200.
     3. GPU (Graphics Card): Radeon RX 570.
     4. VRAM (Video Memory): 2 GB.
     5. RAM (Memory): 8 GB.
     6. Storage: 150 GB HDD.
     7. Bandwidth: 5 Mbps internet connection.
   * Minimum Specifications (NVIDIA):
     1. Operating System: Windows 10 (November 2019 update, version 1909).
     2. CPU (Processor): Intel i5-4460.
     3. GPU (Graphics Card): NVIDIA GTX 770.
     4. VRAM (Video Memory): 2 GB.
     5. RAM (Memory): 8 GB.
     6. Storage: 150 GB HDD.
     7. Bandwidth: 5 Mbps internet connection.
3. **Interfaces**: Integrates with MSFS 2020 using TypeScript and HTML only.
4. **Technology**: Limited to TypeScript and HTML within MSFS 2020.
5. **Security**: Access restricted to authorized users only.
6. **Standards**: Follows MSFS 2020’s design and programming guidelines.

These constraints ensure compatibility, security, and stable performance within the simulator.

## Operating Environment

The GNSS GPS Display Plugin for MSFS 2020 will run on:

* **Operating System**: Windows 10 or higher.
* **Hardware Requirements (Minimum):**
  + **Processor:** AMD Ryzen 3 1200 or Intel i5-4460.
  + **Graphics Card:** Radeon RX 570 or NVIDIA GTX 770 with 2 GB VRAM.
  + **RAM:** 8 GB.
  + **Storage:** 150 GB HDD for MSFS 2020 and the plugin.
  + **Bandwidth:** Minimum 5 Mbps internet connection for MSFS 2020.
  + **Software**: Integrated within MSFS 2020, using TypeScript and HTML.
* **Display**: Standard monitor resolutions supported by MSFS 2020.

The plugin will operate smoothly alongside other MSFS 2020 components without affecting performance.

## User Documentation

1. **User Manual**: Guide for installation, setup, and usage.
   * [SDK Documentation](https://docs.flightsimulator.com/html/Introduction/Introduction.htm)
2. **Online Help**: In-app tips and troubleshooting.
   * [Microsoft Flight Simulator FAQ](https://flightsimulator.zendesk.com/hc/en-us)

**Formats**: Delivered in PDF and accessible online; in-app help follows MSFS 2020 standards.

## Assumptions and Dependencies

The project assumes:

* **Operating System**: Windows 10 or higher will be available.
* **Development Framework**: MSFS 2020 will continue supporting TypeScript and HTML integration.
* **Documentation Access**: MSFS 2020 documentation and tools will remain available and up to date.
* **Simulated Data**: Only MSFS 2020-provided simulated GPS data will be used.
* **Testing Environment**: MSFS 2020 and its instrument panel will be available for testing.

Changes to these assumptions may impact the requirements in this SRS.

# External Interface Requirements

## User Interfaces

N/A for now –

## Hardware Interfaces

**N/A for now** – This system is currently software-only; no hardware interfaces required.

## Software Interfaces

N/A for now –

## Communications Interfaces

N/A for now –

# Behavioral Requirements

## Same Class of User

N/A for now – No user access levels or privileges are defined yet. Requirements may be added later based on user roles.

## Related Real-world Objects

N/A for now – No specific real-world objects or models required. May be updated if user needs expand.

## Stimulus

N/A for now –

## Related Features

N/A for now –

## Functional

The GPS display plugin must meet the following functional requirements to ensure seamless user experience within MSFS 2020:

* **[REQ-001]:** The system shall process satellite data, GPS signal strength, and simulation data provided by MSFS 2020 to generate real-time navigation information.
* **[REQ-002]:** The system shall display the following data elements on the GPS interface:
  + Satellite status (e.g., visibility and availability).
  + Active GPS signal strength.
  + Constellation data (e.g., number of satellites in view).
  + Navigation details, such as waypoint coordinates, altitude, and speed.
* **[REQ-003]:** The system shall update all display windows at least once per second to ensure real-time accuracy during simulation.
* **[REQ-004]:** The system shall detect and respond to abnormal conditions, such as:
  + Signal degradation: Display an alert when satellite visibility or GPS signal strength drops below an operational threshold.
  + System failures: If the plugin fails to load or display data, the system shall notify the user and allow them to retry.
* **[REQ-005]:** The system shall log any GPS signal anomalies (e.g., degraded signal strength) for post-simulation review.
* **[REQ-006]:** The plugin shall interface seamlessly with MSFS 2020’s existing systems, including its data simulation and rendering engines, without affecting the simulator’s performance.
* **[REQ-007]:** The plugin shall be designed to accommodate future GNSS-related modules, such as geo-spoofing simulations, with minimal modifications to the existing codebase.

# Non-behavioral Requirements

## Performance Requirements

N/A – No specific requirements yet.

## Safety Requirements

N/A – No safety requirements currently.

## Qualitative Requirements

N/A for now –

### Availability

N/A – No availability needs defined.

### Security

N/A – No security requirements yet.

### Maintainability

N/A – No maintainability needs specified.

### Portability

N/A – No portability requirements for now.

## Design and Implementation Constraints

N/A – No constraints currently set.

# Other Requirements

## Database Requirements

N/A for now –

## Operations

N/A for now – No specific operational requirements defined at this stage. Operational guidelines may be added as the project develops.

# Analysis Models

## *Data Flow Model*

### *Data Sources*

N/A for now –

### *Data Sinks*

N/A for now –

### *Data Dictionary*

|  |  |  |
| --- | --- | --- |
| **Name** | **Description** | **Units** |
| GROUND\_VELOCITY | Speed relative to the earth’s surface. | Knots |

### *Context Diagram (Level 0 Data Flow Diagram)*

A diagram of a system

Description automatically generated

Figure 3: System Context Diagram

### *Level 1 Data Flow Diagram*

A diagram of a process

Description automatically generated

Figure 4: Level 1 Data Flow Diagram

### *Level 2 Data Flow Diagram*

N/A for now –

## *Class Model*

N/A for now – No class model defined. A class structure may be developed if the system requirements expand.

## *State Model*

N/A for now –

# To Be Determined List

N/A for now –