Here's a draft for the purpose, scope, and identification sections for your SRS document:

### Purpose

The purpose of this Software Requirements Specification (SRS) document is to define the requirements and functionalities of the data association module for multi-target tracking. This module will facilitate accurate and efficient tracking of multiple targets by grouping radar plots into clusters, generating hypotheses, and computing probabilities to determine the best target plot associations. The implementation will utilize advanced data association techniques, including improved Joint Probabilistic Data Association (JPDA), Global Nearest Neighbor (GNN), and Probabilistic Data Association (PDA), ensuring high precision and reliability in target tracking.

### Scope

The scope of this SRS document encompasses the design, development, and implementation of the data association module for multi-target tracking systems. This includes:

- Receiving radar plots and organizing them into clusters.

- Performing clustering of plots with respect to existing tracks.

- Generating possible hypotheses for each cluster and computing joint and marginal probabilities for these hypotheses.

- Determining the best hypothesis for target plot association.

- Implementing and comparing various data association techniques such as improved JPDA, GNN, and PDA.

- Integrating with Human-Machine Interface (HMI) for configuration management.

- Generating visual plots to evaluate the performance of different data association techniques.

### Identification

This SRS document is identified by the following attributes:

- \*\*Title:\*\* Software Requirements Specification for Multi-Target Tracking Data Association Module

- \*\*Version:\*\* 1.0

- \*\*Author:\*\* [Your Name]

- \*\*Date:\*\* [Current Date]

- \*\*Document Number:\*\* SRS-MTT-DA-001

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### System Overview

The multi-target tracking data association module is a critical component of the overall tracking system, designed to enhance the accuracy and reliability of tracking multiple targets simultaneously. The module receives radar plots, processes them to form clusters, and associates these clusters with existing tracks using advanced data association techniques. By computing joint and marginal probabilities for various hypotheses, the system determines the most likely associations, thus improving target identification and tracking precision. The integration with a Human-Machine Interface (HMI) allows for dynamic configuration and visualization of tracking performance, facilitating real-time decision-making and system adjustments.

### Document Overview

This SRS document is structured to provide a comprehensive understanding of the requirements and functionalities of the multi-target tracking data association module. It includes the following sections:

1. \*\*Introduction:\*\* Defines the purpose, scope, and identification of the SRS document.

2. \*\*Overall Description:\*\* Provides a high-level overview of the system, including its context, user characteristics, and constraints.

3. \*\*Specific Requirements:\*\* Details the functional and non-functional requirements of the data association module.

4. \*\*System Features:\*\* Describes the key features and functionalities of the system.

5. \*\*External Interface Requirements:\*\* Outlines the interactions with other systems and interfaces.

6. \*\*Other Non-Functional Requirements:\*\* Specifies performance, security, and other quality attributes.

7. \*\*Appendices:\*\* Includes supplementary information and references.

### Overall Description

#### System Context

The data association module operates within a multi-target tracking system, which is part of a larger surveillance and monitoring infrastructure. The module interfaces with radar sensors to receive raw plot data, processes this data to identify and track multiple targets, and communicates with the HMI for configuration and visualization purposes.

#### User Characteristics

The primary users of this system are:

- \*\*System Operators:\*\* Responsible for monitoring and managing the tracking system, interpreting results, and making operational decisions based on the output of the data association module.

- \*\*System Engineers:\*\* Tasked with configuring and maintaining the system, including adjusting parameters and updating algorithms as needed.

- \*\*Analysts:\*\* Utilize the generated plots and tracking data for analysis, reporting, and further research.

#### Constraints

The development and deployment of the data association module must adhere to the following constraints:

- \*\*Real-Time Processing:\*\* The system must process radar plots and update track associations in real-time to ensure timely and accurate tracking.

- \*\*Scalability:\*\* The module must be capable of handling varying numbers of targets and radar plots without significant degradation in performance.

- \*\*Compatibility:\*\* The system must integrate seamlessly with existing radar sensors, HMI systems, and other components of the tracking infrastructure.

- \*\*Accuracy:\*\* The data association techniques employed must achieve a high level of accuracy to minimize false associations and missed targets.

This SRS document serves as a guide for the design, development, and implementation of the multi-target tracking data association module, ensuring that all requirements are clearly defined and met.

### 4. Product Perspective

#### 4.1 System Interfaces

The data association module interacts with several external systems and interfaces to achieve its functionality:

##### 4.1.1 Radar Sensors

- \*\*Interface Type:\*\* Data Input

- \*\*Description:\*\* The module receives raw radar plot data from radar sensors. This data includes the range, azimuth, and elevation of detected objects.

- \*\*Protocol:\*\* Standard data communication protocols (e.g., TCP/IP, UDP).

##### 4.1.2 Tracking System Database

- \*\*Interface Type:\*\* Data Storage and Retrieval

- \*\*Description:\*\* The module stores processed track data and retrieves historical data to enhance tracking accuracy.

- \*\*Protocol:\*\* Database query languages (e.g., SQL).

##### 4.1.3 Human-Machine Interface (HMI)

- \*\*Interface Type:\*\* User Interaction

- \*\*Description:\*\* The module interfaces with the HMI to receive configuration inputs and display tracking results and visual plots.

- \*\*Protocol:\*\* Web-based interfaces or custom GUI frameworks.

##### 4.1.4 Configuration Management System

- \*\*Interface Type:\*\* Configuration Input

- \*\*Description:\*\* The module receives system configuration and parameter settings from a centralized configuration management system.

- \*\*Protocol:\*\* Configuration files, APIs.

#### 4.2 Product Functions

The data association module performs several critical functions:

1. \*\*Radar Plot Reception:\*\* Continuously receives radar plots from radar sensors.

2. \*\*Plot Clustering:\*\* Groups received plots into clusters based on spatial and temporal proximity.

3. \*\*Track Association:\*\* Associates clusters with existing tracks using data association techniques.

4. \*\*Hypothesis Generation:\*\* Generates possible hypotheses for each cluster-track association.

5. \*\*Probability Computation:\*\* Computes joint and marginal probabilities for each hypothesis.

6. \*\*Best Hypothesis Selection:\*\* Identifies the best hypothesis for target plot association.

7. \*\*Data Association Techniques:\*\* Implements various techniques such as improved JPDA, GNN, and PDA for accurate tracking.

8. \*\*Configuration Management:\*\* Receives and applies configuration settings from the HMI and configuration management system.

9. \*\*Visualization:\*\* Generates and displays visual plots of tracking data and performance metrics.

#### 4.3 User Characteristics

The primary users of the data association module include:

- \*\*System Operators:\*\* Monitor and manage the tracking system, interpret tracking data, and make operational decisions.

- \*\*System Engineers:\*\* Configure and maintain the system, adjust parameters, and update algorithms.

- \*\*Analysts:\*\* Analyze tracking data and generate reports for further research and operational improvements.

Users are expected to have a technical background in radar systems, tracking technologies, and data analysis.

#### 4.4 Constraints

The development and operation of the data association module must consider the following constraints:

- \*\*Real-Time Processing:\*\* The system must process incoming radar plots and update track associations in real-time to ensure timely and accurate tracking.

- \*\*Scalability:\*\* The module must handle varying numbers of targets and radar plots without significant performance degradation.

- \*\*Compatibility:\*\* The module must integrate seamlessly with existing radar sensors, databases, HMIs, and other system components.

- \*\*Accuracy:\*\* The data association techniques must achieve high accuracy to minimize false associations and missed targets.

- \*\*Security:\*\* The module must ensure the security and integrity of data, preventing unauthorized access and modifications.

#### 4.5 Assumptions and Dependencies

The development and deployment of the data association module rely on several assumptions and dependencies:

- \*\*Reliable Radar Data:\*\* Assumes that radar sensors provide accurate and timely plot data.

- \*\*Stable Communication:\*\* Assumes that the communication between the module and external systems (sensors, databases, HMI) is stable and reliable.

- \*\*Adequate Processing Power:\*\* Assumes that the underlying hardware provides sufficient processing power to handle real-time data processing and probability computations.

- \*\*System Configuration:\*\* Assumes that the configuration settings provided via the HMI and configuration management system are correct and appropriate for the operational environment.

- \*\*Interoperability:\*\* Assumes that the module can seamlessly integrate with existing systems and interfaces without major compatibility issues.

These sections outline the key aspects of the data association module, ensuring that all requirements are clear and feasible for implementation.

### 5. Specific Requirements

#### 5.1 Required States and Modes

The data association module for multi-target tracking will operate in several distinct states and modes to ensure proper functionality and flexibility. These states and modes define how the module handles incoming data, processes it, and interacts with other system components.

##### 5.1.1 Initialization Mode

- \*\*Description:\*\* This mode is active when the system starts up. It involves loading initial configuration settings, initializing data structures, and establishing connections with external interfaces (radar sensors, database, HMI).

- \*\*Key Activities:\*\*

- Load configuration settings.

- Initialize data structures.

- Establish connections with radar sensors, databases, and HMI.

##### 5.1.2 Data Reception Mode

- \*\*Description:\*\* In this mode, the system continuously receives radar plots from connected radar sensors.

- \*\*Key Activities:\*\*

- Continuously receive and buffer radar plot data.

- Preprocess incoming data for clustering.

##### 5.1.3 Clustering Mode

- \*\*Description:\*\* This mode groups radar plots into clusters based on spatial and temporal proximity.

- \*\*Key Activities:\*\*

- Apply clustering algorithms to group radar plots.

- Update internal data structures with clustered plots.

##### 5.1.4 Track Association Mode

- \*\*Description:\*\* In this mode, the system associates clustered plots with existing tracks using data association techniques.

- \*\*Key Activities:\*\*

- Generate possible hypotheses for plot-track associations.

- Compute joint and marginal probabilities for each hypothesis.

##### 5.1.5 Hypothesis Evaluation Mode

- \*\*Description:\*\* This mode evaluates generated hypotheses to determine the best plot-track associations.

- \*\*Key Activities:\*\*

- Evaluate hypotheses based on computed probabilities.

- Select the best hypothesis for each track.

##### 5.1.6 Configuration Mode

- \*\*Description:\*\* This mode allows system operators and engineers to configure system parameters via the HMI.

- \*\*Key Activities:\*\*

- Receive configuration inputs from the HMI.

- Apply new configuration settings to the system.

##### 5.1.7 Visualization Mode

- \*\*Description:\*\* In this mode, the system generates and displays visual plots of tracking data and performance metrics.

- \*\*Key Activities:\*\*

- Generate visual plots based on current tracking data.

- Display plots and metrics via the HMI.

##### 5.1.8 Error Handling Mode

- \*\*Description:\*\* This mode is activated when the system encounters errors or anomalies.

- \*\*Key Activities:\*\*

- Detect and log errors.

- Attempt to recover from errors or switch to a safe state.

- Notify operators via the HMI.

#### 5.2 CSCI Capability Requirements

The Computer Software Configuration Item (CSCI) capability requirements detail the specific functionalities that the data association module must provide.

##### 5.2.1 Radar Plot Reception

- \*\*Requirement ID:\*\* CSCI-001

- \*\*Description:\*\* The system shall continuously receive radar plots from radar sensors.

- \*\*Performance:\*\* The system must handle a minimum of 100 radar plots per second.

- \*\*Interface:\*\* Radar sensor interface (e.g., TCP/IP, UDP).

##### 5.2.2 Plot Clustering

- \*\*Requirement ID:\*\* CSCI-002

- \*\*Description:\*\* The system shall group received radar plots into clusters based on spatial and temporal proximity.

- \*\*Performance:\*\* Clustering must be completed within 10 milliseconds of receiving new plot data.

- \*\*Algorithm:\*\* K-means, DBSCAN, or similar clustering algorithm.

##### 5.2.3 Track Association

- \*\*Requirement ID:\*\* CSCI-003

- \*\*Description:\*\* The system shall associate clustered plots with existing tracks using data association techniques.

- \*\*Performance:\*\* Track association must be performed within 20 milliseconds.

- \*\*Techniques:\*\* Improved JPDA, GNN, PDA.

##### 5.2.4 Hypothesis Generation

- \*\*Requirement ID:\*\* CSCI-004

- \*\*Description:\*\* The system shall generate possible hypotheses for each plot-track association.

- \*\*Performance:\*\* Hypothesis generation must be completed within 10 milliseconds.

- \*\*Details:\*\* Generate at least 5 hypotheses per cluster.

##### 5.2.5 Probability Computation

- \*\*Requirement ID:\*\* CSCI-005

- \*\*Description:\*\* The system shall compute joint and marginal probabilities for each hypothesis.

- \*\*Performance:\*\* Probability computations must be completed within 20 milliseconds.

- \*\*Algorithm:\*\* Bayesian probability computation.

##### 5.2.6 Best Hypothesis Selection

- \*\*Requirement ID:\*\* CSCI-006

- \*\*Description:\*\* The system shall select the best hypothesis for target plot association.

- \*\*Performance:\*\* Selection must be performed within 10 milliseconds.

- \*\*Criteria:\*\* Based on highest marginal probability.

##### 5.2.7 Configuration Management

- \*\*Requirement ID:\*\* CSCI-007

- \*\*Description:\*\* The system shall receive and apply configuration settings from the HMI.

- \*\*Performance:\*\* Configuration changes must take effect within 5 seconds.

- \*\*Interface:\*\* HMI configuration interface.

##### 5.2.8 Visualization

- \*\*Requirement ID:\*\* CSCI-008

- \*\*Description:\*\* The system shall generate and display visual plots of tracking data and performance metrics.

- \*\*Performance:\*\* Visualization updates must occur within 100 milliseconds of data changes.

- \*\*Interface:\*\* HMI visualization interface.

##### 5.2.9 Error Handling

- \*\*Requirement ID:\*\* CSCI-009

- \*\*Description:\*\* The system shall detect, log, and handle errors, attempting to recover or notify operators.

- \*\*Performance:\*\* Error detection and handling must occur within 1 second of error occurrence.

- \*\*Interface:\*\* HMI error notification interface.

These specific requirements ensure that the data association module will function correctly, efficiently, and reliably, providing accurate multi-target tracking and seamless integration with external systems and interfaces.

### 5.2.2 Performance Requirements

The performance requirements detail the expected performance metrics that the data association module must meet to ensure it functions efficiently and effectively in a real-time environment.

##### 5.2.2.1 Latency

- \*\*Requirement ID:\*\* PER-001

- \*\*Description:\*\* The system shall process each radar plot and update the tracking information with minimal delay.

- \*\*Metric:\*\* End-to-end latency from plot reception to track update must not exceed 50 milliseconds.

##### 5.2.2.2 Throughput

- \*\*Requirement ID:\*\* PER-002

- \*\*Description:\*\* The system shall handle a high volume of radar plots to support real-time tracking.

- \*\*Metric:\*\* The system must process at least 1000 radar plots per second without performance degradation.

##### 5.2.2.3 Accuracy

- \*\*Requirement ID:\*\* PER-003

- \*\*Description:\*\* The system shall maintain high accuracy in plot-track association.

- \*\*Metric:\*\* The probability of correct track association must be greater than 95%.

##### 5.2.2.4 Scalability

- \*\*Requirement ID:\*\* PER-004

- \*\*Description:\*\* The system shall scale to handle an increasing number of targets and plots without significant performance loss.

- \*\*Metric:\*\* The system must support up to 500 simultaneous tracks and 5000 plots per second.

##### 5.2.2.5 Resource Utilization

- \*\*Requirement ID:\*\* PER-005

- \*\*Description:\*\* The system shall utilize system resources efficiently.

- \*\*Metric:\*\* CPU usage must not exceed 80% under peak load, and memory usage must not exceed 70% of available memory.

##### 5.2.2.6 Real-Time Processing

- \*\*Requirement ID:\*\* PER-006

- \*\*Description:\*\* The system shall process radar data in real-time.

- \*\*Metric:\*\* Data processing and track updating must be completed within 10 milliseconds for each radar plot.

### 5.2.3 Operational Requirements

The operational requirements define the conditions under which the data association module will operate and the necessary operational capabilities.

##### 5.2.3.1 Availability

- \*\*Requirement ID:\*\* OPR-001

- \*\*Description:\*\* The system shall be available for operation 24/7.

- \*\*Metric:\*\* System uptime must be at least 99.9%.

##### 5.2.3.2 Reliability

- \*\*Requirement ID:\*\* OPR-002

- \*\*Description:\*\* The system shall reliably perform its functions under normal operating conditions.

- \*\*Metric:\*\* Mean Time Between Failures (MTBF) must be greater than 1000 hours.

##### 5.2.3.3 Maintainability

- \*\*Requirement ID:\*\* OPR-003

- \*\*Description:\*\* The system shall be easy to maintain and update.

- \*\*Metric:\*\* Mean Time to Repair (MTTR) must be less than 2 hours.

##### 5.2.3.4 Environmental Conditions

- \*\*Requirement ID:\*\* OPR-004

- \*\*Description:\*\* The system shall operate effectively under specified environmental conditions.

- \*\*Metric:\*\* The system must operate within a temperature range of -10°C to 50°C and humidity range of 10% to 90% non-condensing.

##### 5.2.3.5 Security

- \*\*Requirement ID:\*\* OPR-005

- \*\*Description:\*\* The system shall ensure data security and integrity.

- \*\*Metric:\*\* The system must implement encryption for data transmission and storage, and must adhere to relevant cybersecurity standards.

##### 5.2.3.6 Interoperability

- \*\*Requirement ID:\*\* OPR-006

- \*\*Description:\*\* The system shall integrate seamlessly with other components of the tracking infrastructure.

- \*\*Metric:\*\* The system must support standard communication protocols and data formats used by radar sensors, databases, and HMIs.

##### 5.2.3.7 User Interface

- \*\*Requirement ID:\*\* OPR-007

- \*\*Description:\*\* The system shall provide a user-friendly interface for configuration and visualization.

- \*\*Metric:\*\* User tasks such as configuration changes and plot visualizations must be completed within 5 seconds of user input.

##### 5.2.3.8 Backup and Recovery

- \*\*Requirement ID:\*\* OPR-008

- \*\*Description:\*\* The system shall support data backup and recovery processes.

- \*\*Metric:\*\* Data recovery must be completed within 30 minutes of a failure event.

These performance and operational requirements ensure that the data association module will meet the necessary performance standards and operate effectively under the expected conditions.

### 5.3 CSCI Interface Requirements

The Computer Software Configuration Item (CSCI) interface requirements detail the interactions between the data association module and other components, both internal and external. These requirements ensure seamless communication and functionality across the system.

#### 5.3.1 Internal Interfaces

Internal interfaces describe the interactions between various components within the data association module.

##### 5.3.1.1 Plot Reception Component

- \*\*Interface ID:\*\* INT-001

- \*\*Description:\*\* The component responsible for receiving radar plots from the sensor interface.

- \*\*Interaction:\*\* Provides radar plot data to the clustering component.

- \*\*Protocol:\*\* In-memory data transfer.

##### 5.3.1.2 Clustering Component

- \*\*Interface ID:\*\* INT-002

- \*\*Description:\*\* The component responsible for grouping radar plots into clusters.

- \*\*Interaction:\*\* Sends clustered plot data to the track association component.

- \*\*Protocol:\*\* In-memory data transfer.

##### 5.3.1.3 Track Association Component

- \*\*Interface ID:\*\* INT-003

- \*\*Description:\*\* The component responsible for associating clustered plots with existing tracks.

- \*\*Interaction:\*\* Sends hypotheses and associated data to the hypothesis evaluation component.

- \*\*Protocol:\*\* In-memory data transfer.

##### 5.3.1.4 Hypothesis Evaluation Component

- \*\*Interface ID:\*\* INT-004

- \*\*Description:\*\* The component responsible for evaluating and selecting the best hypothesis for plot-track associations.

- \*\*Interaction:\*\* Updates track data and sends it to the data storage and visualization components.

- \*\*Protocol:\*\* In-memory data transfer.

##### 5.3.1.5 Configuration Management Component

- \*\*Interface ID:\*\* INT-005

- \*\*Description:\*\* The component responsible for applying configuration settings received from the HMI.

- \*\*Interaction:\*\* Updates configuration settings for other components.

- \*\*Protocol:\*\* In-memory data transfer.

#### 5.3.2 External Interfaces

External interfaces describe the interactions between the data association module and other systems or components outside the module.

##### 5.3.2.1 Radar Sensors

- \*\*Interface ID:\*\* EXT-001

- \*\*Description:\*\* Interface for receiving radar plots from radar sensors.

- \*\*Interaction:\*\* Receives raw radar plot data.

- \*\*Protocol:\*\* Standard data communication protocols (e.g., TCP/IP, UDP).

##### 5.3.2.2 Tracking System Database

- \*\*Interface ID:\*\* EXT-002

- \*\*Description:\*\* Interface for storing and retrieving tracking data.

- \*\*Interaction:\*\* Stores processed track data and retrieves historical data.

- \*\*Protocol:\*\* Database query languages (e.g., SQL).

##### 5.3.2.3 Human-Machine Interface (HMI)

- \*\*Interface ID:\*\* EXT-003

- \*\*Description:\*\* Interface for user interaction and configuration management.

- \*\*Interaction:\*\* Receives configuration inputs and displays tracking results and visual plots.

- \*\*Protocol:\*\* Web-based interfaces or custom GUI frameworks.

##### 5.3.2.4 Configuration Management System

- \*\*Interface ID:\*\* EXT-004

- \*\*Description:\*\* Interface for receiving system configuration and parameter settings.

- \*\*Interaction:\*\* Receives and applies configuration settings.

- \*\*Protocol:\*\* Configuration files, APIs.

#### 5.3.3 Hardware Interfaces

Hardware interfaces describe the physical connections and interactions between the data association module and hardware components.

##### 5.3.3.1 Radar Sensor Hardware

- \*\*Interface ID:\*\* HW-001

- \*\*Description:\*\* Physical connection to radar sensor hardware for data acquisition.

- \*\*Interaction:\*\* Receives radar plot data from radar sensors.

- \*\*Protocol:\*\* Standard data communication protocols (e.g., Ethernet).

##### 5.3.3.2 Server Hardware

- \*\*Interface ID:\*\* HW-002

- \*\*Description:\*\* Physical servers or computing hardware hosting the data association module.

- \*\*Interaction:\*\* Executes the data association algorithms and stores data.

- \*\*Protocol:\*\* Standard server interfaces (e.g., PCIe, SATA).

##### 5.3.3.3 Network Hardware

- \*\*Interface ID:\*\* HW-003

- \*\*Description:\*\* Network infrastructure supporting data transmission between components.

- \*\*Interaction:\*\* Transmits data between radar sensors, the data association module, and external systems.

- \*\*Protocol:\*\* Standard network protocols (e.g., TCP/IP).

#### 5.3.4 Software Interfaces

Software interfaces describe the software interactions between the data association module and other software systems.

##### 5.3.4.1 Operating System

- \*\*Interface ID:\*\* SW-001

- \*\*Description:\*\* The underlying operating system on which the data association module runs.

- \*\*Interaction:\*\* Provides necessary system resources and services.

- \*\*Protocol:\*\* OS-specific APIs and system calls.

##### 5.3.4.2 Database Management System (DBMS)

- \*\*Interface ID:\*\* SW-002

- \*\*Description:\*\* Software for managing and querying the tracking system database.

- \*\*Interaction:\*\* Stores and retrieves tracking data.

- \*\*Protocol:\*\* Database query languages (e.g., SQL).

##### 5.3.4.3 HMI Software

- \*\*Interface ID:\*\* SW-003

- \*\*Description:\*\* The software component of the HMI for user interaction.

- \*\*Interaction:\*\* Receives configuration inputs and displays tracking data.

- \*\*Protocol:\*\* Web-based interfaces or custom GUI frameworks.

##### 5.3.4.4 Configuration Management Software

- \*\*Interface ID:\*\* SW-004

- \*\*Description:\*\* Software for managing system configuration and parameters.

- \*\*Interaction:\*\* Provides configuration settings to the data association module.

- \*\*Protocol:\*\* Configuration files, APIs.

These interface requirements ensure that the data association module can effectively communicate and function with both internal and external components, providing a comprehensive and seamless multi-target tracking system.

### 5.3.5 Communication Interfaces

Communication interfaces describe how the data association module interacts and communicates with other systems, components, and users.

#### 5.3.5.1 Radar Sensor Communication

- \*\*Interface ID:\*\* COM-001

- \*\*Description:\*\* Communication interface for receiving radar plot data from radar sensors.

- \*\*Protocol:\*\* Standard data communication protocols (e.g., TCP/IP, UDP).

- \*\*Details:\*\* Handles incoming radar plot streams and ensures data integrity during transmission.

#### 5.3.5.2 Database Communication

- \*\*Interface ID:\*\* COM-002

- \*\*Description:\*\* Communication interface for storing and retrieving tracking data from the database.

- \*\*Protocol:\*\* Database query languages (e.g., SQL).

- \*\*Details:\*\* Executes queries to store processed track data and retrieve historical data for analysis and reporting.

#### 5.3.5.3 HMI Communication

- \*\*Interface ID:\*\* COM-003

- \*\*Description:\*\* Communication interface with the Human-Machine Interface (HMI) for user interaction and system configuration.

- \*\*Protocol:\*\* Web-based interfaces or custom GUI frameworks.

- \*\*Details:\*\* Receives configuration inputs from users, displays tracking results, and visualizes tracking data for operators and analysts.

#### 5.3.5.4 Configuration Management Communication

- \*\*Interface ID:\*\* COM-004

- \*\*Description:\*\* Communication interface for receiving configuration settings from the configuration management system.

- \*\*Protocol:\*\* Configuration files, APIs.

- \*\*Details:\*\* Updates system configuration parameters based on inputs received from the configuration management system.

### 5.3.6 User Interfaces

User interfaces describe how users interact with the data association module for configuration, monitoring, and operational purposes.

#### 5.3.6.1 Graphical User Interface (GUI)

- \*\*Interface ID:\*\* UI-001

- \*\*Description:\*\* Graphical interface for system operators and engineers to interact with the data association module.

- \*\*Functionality:\*\* Allows users to view tracking results, configure system parameters, and monitor system performance.

- \*\*Details:\*\* Provides intuitive controls and visualizations to facilitate efficient operation and decision-making.

#### 5.3.6.2 Command Line Interface (CLI)

- \*\*Interface ID:\*\* UI-002

- \*\*Description:\*\* Command-line interface for advanced system configuration and debugging.

- \*\*Functionality:\*\* Enables direct input of commands and parameters for system configuration and troubleshooting.

- \*\*Details:\*\* Provides flexibility for technical users to perform specific tasks and access detailed system information.

#### 5.3.6.3 API Interface

- \*\*Interface ID:\*\* UI-003

- \*\*Description:\*\* Application Programming Interface (API) for programmatic access to system functions and data.

- \*\*Functionality:\*\* Allows integration with external systems, automated data processing, and custom application development.

- \*\*Details:\*\* Defines methods and endpoints for data retrieval, configuration updates, and system status queries.

These communication and user interface requirements ensure that the data association module can effectively communicate with external systems and provide intuitive interfaces for users to configure, monitor, and interact with the multi-target tracking system.

### 5.4 Fault Tolerance and Exception Handling Requirements

Fault tolerance and exception handling requirements ensure that the data association module can detect and recover from errors, ensuring continuous operation and data integrity.

#### 5.4.1 Fault Detection

- \*\*Requirement ID:\*\* FT-001

- \*\*Description:\*\* The system shall detect faults and errors in radar data reception, clustering, track association, and probability computation.

- \*\*Details:\*\* Implement error checks and validation mechanisms at each processing stage.

#### 5.4.2 Error Logging

- \*\*Requirement ID:\*\* FT-002

- \*\*Description:\*\* The system shall log detected faults and errors, including timestamped details and severity levels.

- \*\*Details:\*\* Maintain error logs for analysis and troubleshooting.

#### 5.4.3 Exception Handling

- \*\*Requirement ID:\*\* FT-003

- \*\*Description:\*\* The system shall handle exceptions gracefully to prevent system crashes and data loss.

- \*\*Details:\*\* Implement try-catch blocks and recovery routines for critical operations.

#### 5.4.4 Redundancy

- \*\*Requirement ID:\*\* FT-004

- \*\*Description:\*\* The system shall incorporate redundancy in critical components to ensure continuous operation.

- \*\*Details:\*\* Implement backup mechanisms for data storage and processing.

#### 5.4.5 Failover Mechanism

- \*\*Requirement ID:\*\* FT-005

- \*\*Description:\*\* The system shall have a failover mechanism to switch to redundant components in case of primary component failure.

- \*\*Details:\*\* Automate failover processes to minimize downtime and maintain system availability.

### 5.5 Apportioning Requirements

Apportioning requirements specify how system functionalities and capabilities may be phased or prioritized during development and deployment phases.

#### 5.5.1 Phase 1: Basic Functionality

- \*\*Requirement ID:\*\* APP-001

- \*\*Description:\*\* Implement basic data reception, clustering, and track association functionalities.

- \*\*Priority:\*\* High

- \*\*Details:\*\* Focus on core functionalities to achieve initial operational capability.

#### 5.5.2 Phase 2: Enhanced Performance

- \*\*Requirement ID:\*\* APP-002

- \*\*Description:\*\* Improve system performance for handling increased plot volumes and enhancing probability computations.

- \*\*Priority:\*\* Medium

- \*\*Details:\*\* Optimize algorithms and data processing pipelines.

#### 5.5.3 Phase 3: Advanced Features

- \*\*Requirement ID:\*\* APP-003

- \*\*Description:\*\* Introduce advanced features such as real-time visualization, advanced data analytics, and adaptive configuration management.

- \*\*Priority:\*\* Low

- \*\*Details:\*\* Enhance user interface and incorporate machine learning techniques for predictive analytics.

#### 5.5.4 Phase 4: Integration and Scalability

- \*\*Requirement ID:\*\* APP-004

- \*\*Description:\*\* Ensure seamless integration with external systems and scalability to support future expansion.

- \*\*Priority:\*\* Medium

- \*\*Details:\*\* Validate interoperability with diverse radar sensors and database systems.

### 6) Design Constraints

Design constraints specify limitations and restrictions that must be considered during the design and implementation of the data association module.

#### 6.1 Memory Constraints

Memory constraints define the limits on memory usage that the system must adhere to for efficient operation.

- \*\*Constraint ID:\*\* DC-001

- \*\*Description:\*\* The system must operate within a maximum memory footprint of 2 GB RAM.

- \*\*Rationale:\*\* Ensures compatibility with typical server configurations and minimizes resource overhead.

These requirements, apportioning considerations, and design constraints ensure that the data association module is robust, adaptable, and capable of meeting operational needs while maintaining reliability and performance standards.

Here are the software quality factors and associated requirements for the data association module:

### 7 Software Quality Factors

#### 7.1 Reliability

- \*\*Requirement:\*\* The system shall maintain a probability of correct plot-track association of at least 95% under normal operating conditions.

- \*\*Details:\*\* Implement fault tolerance mechanisms to ensure continued operation despite component failures.

#### 7.2 Availability

- \*\*Requirement:\*\* The system shall be available for operation 24/7, with an uptime of at least 99.9%.

- \*\*Details:\*\* Implement redundancy and failover mechanisms to minimize downtime and ensure continuous data processing.

#### 7.3 Security

- \*\*Requirement:\*\* The system shall implement encryption for data transmission and storage, following industry-standard cybersecurity protocols.

- \*\*Details:\*\* Ensure secure access control and data integrity measures to protect sensitive tracking information.

#### 7.4 Maintainability

- \*\*Requirement:\*\* The system shall have a mean time to repair (MTTR) of less than 2 hours for software updates and maintenance tasks.

- \*\*Details:\*\* Use modular and well-documented code, facilitate easy debugging and updating processes.

#### 7.5 Portability

- \*\*Requirement:\*\* The system shall support deployment across multiple operating systems, including Windows and Linux distributions.

- \*\*Details:\*\* Ensure compatibility with different hardware configurations and provide clear installation instructions.

#### 7.6 Verification Requirements

- \*\*Requirement:\*\* The system shall undergo rigorous testing, including unit testing, integration testing, and system testing, to verify functionality and performance.

- \*\*Details:\*\* Define test cases for each module and conduct validation against specified requirements and use cases.

#### 7.7 Acceptance Requirements

- \*\*Requirement:\*\* The system shall meet all specified performance metrics and functional requirements as defined in the SRS document.

- \*\*Details:\*\* Conduct acceptance testing with stakeholders to ensure the system meets user expectations and operational needs.

#### 7.8 Safety Requirements

- \*\*Requirement:\*\* The system shall not compromise the safety of personnel or equipment during operation.

- \*\*Details:\*\* Implement fail-safe mechanisms and adhere to safety standards in data processing and decision-making algorithms.

#### 7.9 Precedence and Criticality of Requirements

- \*\*Requirement:\*\* Critical requirements related to real-time processing and data accuracy shall take precedence over non-critical functionalities during system operation.

- \*\*Details:\*\* Prioritize system resources and processing cycles for mission-critical tasks such as plot association and track update.

These software quality factors ensure that the data association module not only performs its intended functions effectively but also meets high standards of reliability, availability, security, maintainability, and portability. Verification, acceptance, and safety requirements further guarantee that the system operates safely and efficiently in diverse operational environments.

### 8 Operations

#### 8.1 Periods of Interactive Operation and Periods of Unattended Operation

##### 8.1.1 Periods of Interactive Operation

- \*\*Description:\*\* During interactive operation, system operators and analysts interact with the data association module through the user interface to monitor tracking results, configure system parameters, and respond to alerts or anomalies.

- \*\*Activities:\*\* Operators view real-time plots, adjust configuration settings based on operational needs, and manually intervene as required for decision-making.

##### 8.1.2 Periods of Unattended Operation

- \*\*Description:\*\* During unattended operation, the data association module operates autonomously without direct human interaction.

- \*\*Activities:\*\* Continuously receives radar plots, processes data according to predefined algorithms, performs plot clustering, track association, and hypothesis evaluation automatically. It monitors system health, detects faults, and initiates failover procedures if necessary.

#### 8.2 Data Processing Support Functions

##### 8.2.1 Real-Time Data Reception

- \*\*Description:\*\* Receive radar plot data from multiple sensors in real-time.

- \*\*Functionality:\*\* Handle data streams efficiently, validate incoming data, and ensure synchronization with system time.

##### 8.2.2 Plot Clustering

- \*\*Description:\*\* Group radar plots into clusters based on spatial and temporal proximity.

- \*\*Functionality:\*\* Implement clustering algorithms to identify potential targets and reduce data complexity for subsequent processing stages.

##### 8.2.3 Track Association

- \*\*Description:\*\* Associate clustered plots with existing tracks or create new tracks based on kinematic and probabilistic models.

- \*\*Functionality:\*\* Perform hypothesis testing and evaluation to determine the most probable plot-track associations.

##### 8.2.4 Hypothesis Evaluation

- \*\*Description:\*\* Evaluate multiple hypotheses generated during track association to identify the best plot-track associations.

- \*\*Functionality:\*\* Compute joint probabilities, consider historical data, and update track states based on measurement updates.

##### 8.2.5 Data Visualization

- \*\*Description:\*\* Present tracking results, including plot clusters, track states, and associated probabilities.

- \*\*Functionality:\*\* Provide real-time visualization tools for operators to monitor and analyze tracking performance.

### 9 Qualification Provision

#### 9.1 Qualification Testing

- \*\*Description:\*\* The data association module shall undergo comprehensive qualification testing to validate compliance with specified requirements and performance criteria.

- \*\*Activities:\*\* Conduct unit testing, integration testing, system testing, and acceptance testing as per defined test cases and scenarios.

- \*\*Documentation:\*\* Maintain test plans, test cases, and test reports to demonstrate adherence to qualification criteria.

#### 9.2 Qualification Criteria

- \*\*Description:\*\* Qualification criteria shall include functional requirements, performance metrics, reliability, security measures, and operational capabilities.

- \*\*Validation:\*\* Ensure the module meets or exceeds specified reliability, availability, security, and performance benchmarks.

#### 9.3 Qualification Documentation

- \*\*Description:\*\* Document all qualification activities, results, and findings to support certification and regulatory compliance.

- \*\*Deliverables:\*\* Provide a qualification report detailing test results, compliance with standards, and any identified issues or corrective actions.

### 10 Requirements Traceability

#### 10.1 Traceability Matrix

- \*\*Description:\*\* Maintain a requirements traceability matrix (RTM) to link each requirement to design elements, test cases, and verification activities.

- \*\*Purpose:\*\* Ensure that each requirement is adequately addressed through design, implementation, testing, and validation phases.

- \*\*Documentation:\*\* Update the RTM throughout the project lifecycle to track changes, verify completeness, and support auditing and certification processes.

#### 10.2 Traceability Alignment

- \*\*Description:\*\* Align traceability across system components, interfaces, and operational scenarios to ensure comprehensive coverage.

- \*\*Verification:\*\* Verify traceability links during reviews, audits, and validation activities to confirm that all requirements are verified and validated.

#### 10.3 Traceability Tools

- \*\*Description:\*\* Utilize traceability tools and management systems to facilitate tracking, reporting, and analysis of requirement relationships.

- \*\*Integration:\*\* Integrate traceability tools with project management and documentation systems to streamline traceability maintenance and reporting.

#### 10.4 Traceability Maintenance

- \*\*Description:\*\* Regularly update and maintain traceability links as requirements evolve, design changes are implemented, and testing outcomes are documented.

- \*\*Accuracy:\*\* Ensure accuracy and consistency of traceability information to support decision-making, change management, and system evolution.

These provisions for qualification and requirements traceability ensure that the data association module meets specified standards, adheres to regulatory requirements, and maintains comprehensive documentation of its development, testing, and validation processes.

#### 8.3 Site Adaptation Required

##### 8.3.1 Environmental Adaptation

- \*\*Description:\*\* Adapt the data association module to different environmental conditions and operational settings.

- \*\*Requirements:\*\* Ensure compatibility with varying radar sensor configurations, network infrastructures, and geographical locations.

##### 8.3.2 Integration with Existing Systems

- \*\*Description:\*\* Integrate seamlessly with existing radar systems, databases, and human-machine interfaces (HMIs).

- \*\*Requirements:\*\* Support standard communication protocols and data formats to facilitate interoperability and data exchange.

##### 8.3.3 Configuration Flexibility

- \*\*Description:\*\* Allow configuration adjustments to accommodate site-specific requirements and operational preferences.

- \*\*Requirements:\*\* Provide configurable parameters for data processing algorithms, system thresholds, and user interface layouts.

These operational considerations ensure that the data association module can operate effectively in diverse scenarios, maintain high-performance standards during interactive and unattended periods, and adapt to specific site requirements and integration needs.