Future of Generic Multi-ATC Surveillance Sensor Data Fusion

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Mr. Chanyut PHRUKKUMWONG
Mr. Paveen JUNTAMA

Air Traffic Service Engineering
Research & Development Department
Aeronautical Radio of Thailand Ltd. (AEROTHAI)
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Motivations

Objectives

Fusion Core Architecture

Summary

Future Work
MSDF has been considered to be one research modules of a future Thailand ATM Automation solution.
Motivations

A plurality of sensors

- Multiple sensors provide more reliable and accurate information.
- Increasing sensors leads to highly computational cost for processing.
- A central processing system requires more accurate multi-target tracking and fusion schemes.

Incoming of new sensors

- ADS-B, MLAT and WAM will be operated next few years.
- Possibility of introducing other surveillance technologies under R&D in the future, e.g., MSPSR (Multi-static Primary surveillance Radar), Holographic Radar, etc.
- New sensor models should be integrated into a central processing system.
Objectives

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The purposes of Multi Sensor Data Fusion System:

- **Surveillance Data Processing**
  - The system can process all data coming from various surveillance sensors for area, approach and aerodrome as well as ground traffic service.

- **New Sensor Registration**
  - The system can be adjustable for future surveillance sensors.

- **COTS-based software development**
  - Applying development and validation standards to be qualified as a COTS-based software.

- **Standardization**
  - The system will be based on compliance with international standards for ATM systems issued by ICAO, EUROCONTROL etc.
Objectives

Integration with Air Surveillance System

Multi-Sensor Data Fusion System

Surveillance Data Distribution Gateway

Airport/Airlines

Air Traffic Control

Aircraft Cockpit Display

SSR

WAM

ADS-B

TIS-B System
Objectives

Integration with Airport Surface Surveillance System

An A-SMGCS

SMR

Multi-Sensor Data Fusion System

Surveillance Data Distribution Gateway

Tower Control

ADS-B/MLAT

ADS-B/MLAT
Objectives

Contingency Purposes

A multi-level data fusion scheme

Independent sensors

SSR

SSR

plot

plot

track

Legacy Multi-target Processing

Multi-Sensor Data Fusion System

Fused track
Fusion Core Architecture

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Key Benefits:

- The architecture is based on JDL data fusion model.
- A new sensor model can be independently registered as a new extension as well as a modified configuration of Fusion Core.
- A processing track is updated on the fly as soon as sensor reports are received.
- Accurate fusion algorithms have been applied.
Fusion Core Architecture

Sensor Data Acquisition:

- Support ASTERIX sensors and non-ASTERIX sensors.
- ASTERIX sensor registration requires modified configuration.
- Non-ASTERIX sensor registration requires its extension.
- Coordinate Transformations.
- Transform ASTERIX messages to Metadata (Proprietary object).
- Data buffering
Fusion Core Architecture

Data Correlation:

- Creation of 2-D grid consisting of a plurality of deterministic cells containing measurements
- Selection of plot-track pairs using gating and likelihood computation
- Reduction of workloads before using an assignment algorithm in Data Association
Data Association:

- **Global Nearest Neighbor** approach is performed.
- **Murty's k-best assignment algorithm** is used to perform as a main plot-to-track association.
Track management and initiation:

- Generate new track using **Multi Hypothesis Testing (MHT)** algorithm.
- Track lifecycle management using M/N decision logic.
- Update associated track information from **DAPs**.
- Perform system track identification.
- Update tracks as outputs of system

**DAPs** - Downlink Aircraft Parameters
Fusion Core Architecture

State Estimation:

- Track-to-track fusion using **IMM-EKF** (Interacting Multiple Model - Extended Kalman Filter) or **IMM-UKF** (Interacting Multiple Model - Unscented Kalman Filter) tracker

- The IMM filter comprises 3 motion models by default:
  - Constant Velocity (CV)
  - Constant Acceleration (CA)
  - Coordinated Turn (CT)
Fusion Core Architecture

Example of 4-attribute sensor configuration
Fusion Core Architecture

Software Development Process: V-Model

1. User Requirement (major ATM Standards)
2. Functional Specification
3. Software Specification
4. Software Design (Fusion Core design)
5. Code
6. Unit Test Design
7. Unit Test
8. Integration Test Design
9. Integration Test
10. System Test Design
11. System Test
12. Acceptance Test Design
13. Acceptance Test
Fusion Core Architecture

Validation using ATM Standards & Guidance
Fusion Core Architecture

Key challenges - Software Development

- Thanks to **Task Parallel Library (TPL)**, Fusion Core is efficiently developed by using design patterns for parallel programming.
- Showing parallel workflows via activity diagrams is very useful.
- Sequence and class diagrams are used to complete the picture.
Summary

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Summary

- **Surveillance Data Processing**
  - Maximum number of sensors and concurrent processed tracks depend on performance of hardware and fusion algorithms.

- **New Sensor Registration**
  - A new sensor should be based on the use of global standards and uniform principles to ensure operational interoperability. If not, it must contain at least position-based information.

- **COTS-based software development**
  - V-Model is used to construct software development and validation processes of Fusion Core system.

- **Standardization**
  - The validation of system is complied with EUROCAE, EUROCONTROL standards and specifications, and ICAO guidance materials.
Future Work

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Future Work

- **Concept Evaluations**
  - Integration of all parts in the Fusion Core architecture will be evaluated by an end-to-end simulation approach.

- **Software Development**
  - Completion of software specification and design
  - Development of a first MSDF version will be started in 2016.

- **Test & Validation**
  - Finalization of test packages according to V-Model.
  - Non-functional testing design such as performance testing and load testing will be introduced.
Thank you for your attention