ATM & STM Integration enabler - SWIM in Space

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Overview

• INTRODUCTION
• PROVOCATION 😊
• MOTIVATION
• CHALLENGE
• SOLUTION
• OUTLOOK
Introduction

• Future Commercial Space Traffic assumption:
  • Will return as a hypersonic glider
  • What does a (Columbia comparable) fatal break up event (ca. 231000 ft. Alt., speed > Mach 20) mean?
    • Debris raining down on conventional air traffic will cover a footprint of about 300 by 35 nm
    • No collision of Columbia debris with air traffic was just luck (Casualty propability for passengers was about 0.3)
Provocation

• Commercial Space Traffic

• Only a few movements per year = research + entertainment for private super millionaires = no air traffic integration considerations needed = If ever relevant, in the very far future!

→ Really?
Motivation

• 10 years between
Motivation

• **Now**

• **Future (Who knows when ?)**
Motivation

SWIM

= System Wide Information Management
Motivation

SWIM "Intranet for ATM" concept requests all the future air traffic participants acting as communicating sub-systems.
Motivation  SWIM → Why?

Motivation

SWIM → What?

SWIM Scope

- Different applications
  - SWIM-enabled applications
- Service specifications for information exchange
  - Information Exchange Services
- AIXM, FIXM, WXXM
  - Information Exchange Models
- Interface management, message comm. protocols
  - SWIM Infrastructure
- Communication networks (Ground/Ground, Air/Ground)
  - Network Connectivity
Motivation

SWIM → What?

Motivation

• Technical profiles:
  • Yellow $\rightarrow$ non critical information
  • Blue $\rightarrow$ critical information
  • Purple $\rightarrow$ Air / Ground info exchanges
Motivation

SWIM \rightarrow What?

Source: Manual on System Wide Information Management (SWIM) Concept, ICAO Doc 10039 AN/511
Motivation

SWIM → What?

Enterprise Service Management
- SNMP
- JMX
- WS-Distributed Management
- WS-Manageability

QoS
- Reliability
  - WS-Reliable Messaging
  - WS-RM Policy
  - DDS Reliability

Security
- WS-Security
- TLS
- DDS Security

Others
- DDS Standard QoS
- DDS QoS Discovery

Policy
- WS-Policy Association
- WS-Policy Attachment
- WS-Policy Framework

Interface Management
- WSDL
- UDDI
- IDL
- WS-Metadata
- DDS Automatic Discovery

Data Representation
- XML
- XSD
- XPath
- XQuery
- CDR
- ASN.1

Messaging
- SOAP
- MTOM
- DDS
- WS-Attachments
- WS-Addressing
- WS-Notification
- JMS

Transport
- HTTP
- DDSI
- HTTPS
- AMQP
Motivation

Benefits of acting SWIM compliant

- Access to real-time, relevant aeronautical, flight, and weather information → faster dedicated response possibilities

- Reduced implementation, operating and extension costs because of SWIM’s standardized character

- SWIM = requested fundament of the future for info based collaboration in ATM (Air Traffic Management) → being prepared for the future
Challenge

Safe global space traffic integration by taking into account data distribution of its changing debris (= hazard) area during reentry!
Solution

**Input:**
Hypothetical spacecraft’s (returning) runtime data:
- id
- lat
- lon
- alt
- heading
- path_velocity

**Output:**
Lat_lon of 4-point-HazardZonePolygon

**TFR airspace in AIXM**
Solution

Chart 19

Data Server

Service by NEAR GEMS

EMS

Service

Consumers EFB Display

Request / Reply & Pub/Sub via GEMS

Provisional hazard area model

Spacecraft Reentry Hazard Area Server

Request / Reply via SWIM

SESAR SWIM

FAA SWIM

Reaction Times of the Spacecraft Reentry Hazard Area Service

N = 1000

1 connected client
2 connected clients
3 connected clients
4 connected clients
5 connected clients
6 connected clients
7 connected clients
8 connected clients
9 connected clients
10 connected clients
Solution (performance enhancement)

**Reaction Times of the SpacecraftReentryHazardAreaService**
- Pure Tcl

![Bar chart showing reaction times for different numbers of connected clients.](image)

**Reaction Times of the SpacecraftReentryHazardAreaService**
- CalculateHeading and CalculateHazardZone procedures in C using the CritTcl package

![Bar chart showing reaction times for different numbers of connected clients.](image)
Solution (scalability)

Sufficient for most small and medium sized cases!

Anyhow ....
Solution (scalability)

Anyhow ....
Outlook

1.: Continuous position information of spacecraft  
2.: Continuous air traffic position information  
3.: Fatal breakup identification  
4.: Affected aircraft that have to leave hazard zone asap
Outlook

1. Get edge coordinates of the hazard zone
2. Identify smallest and biggest latitude and longitude
3. Use biggest latitude / smallest longitude and smallest latitude / biggest longitude as request zone parameters for ADS-B traffic info fetching
Outlook

- Purple Profile (Air↔Ground Information)