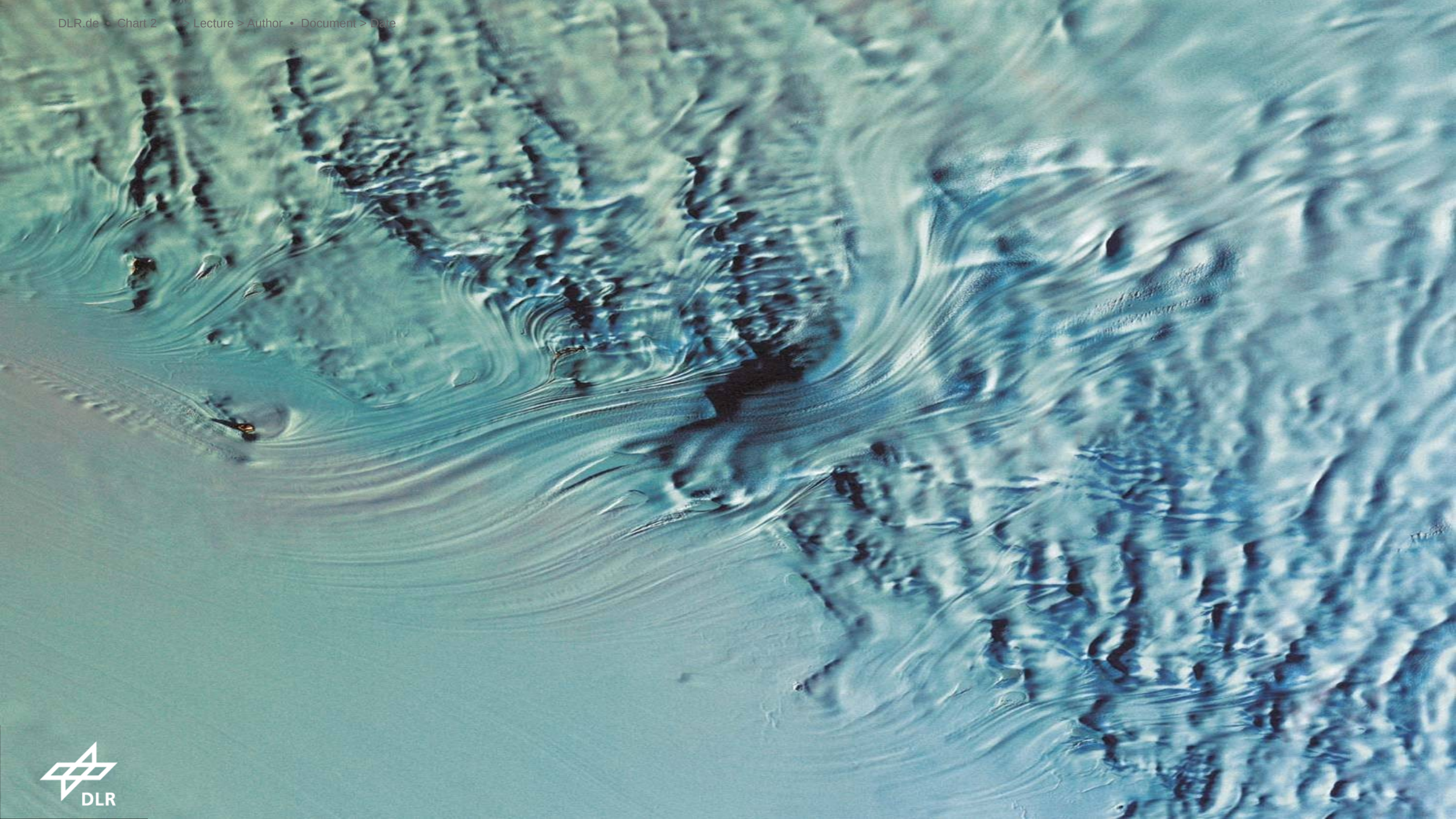
SWIMming in Tcl

Frank Morlang



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**)

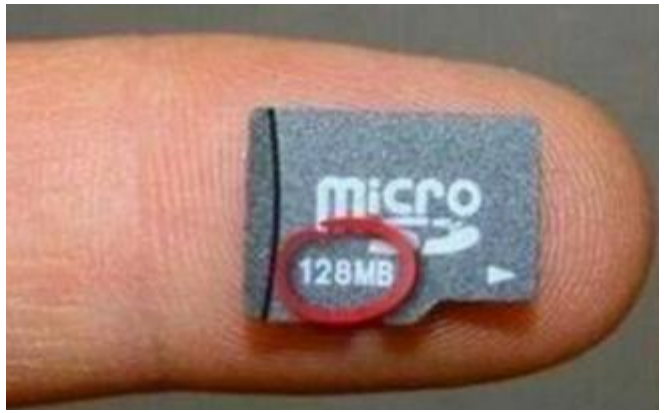
Provocation

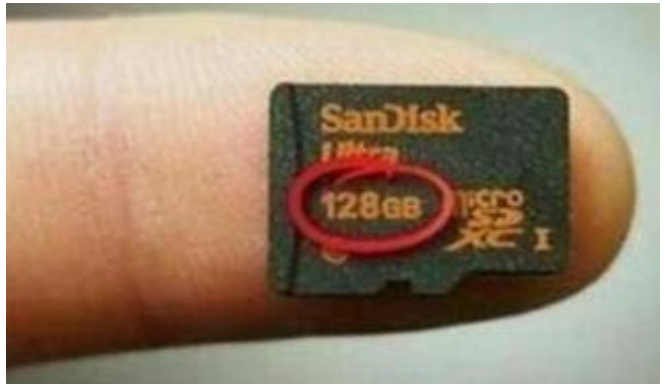
- **Commercial Space Traffic**
  - *Only a few movements per year = research + entertainment for private super millionaires = no air traffic integration considerations needed = If ever relevant, in the very far future !*

⇨ Really ?

Motivation

- 10 years between

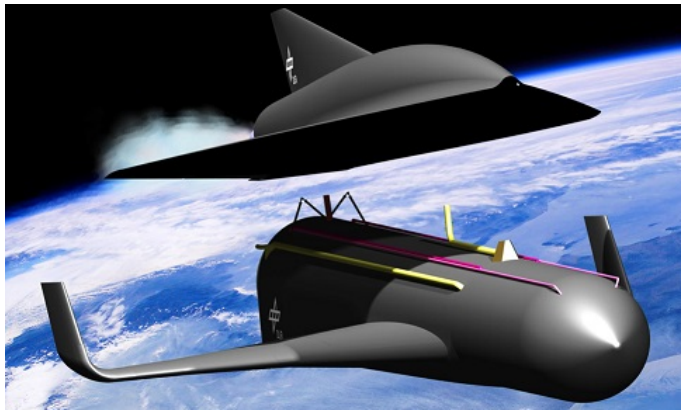




Motivation

- Now

- Future (Who knows when ?)



Motivation

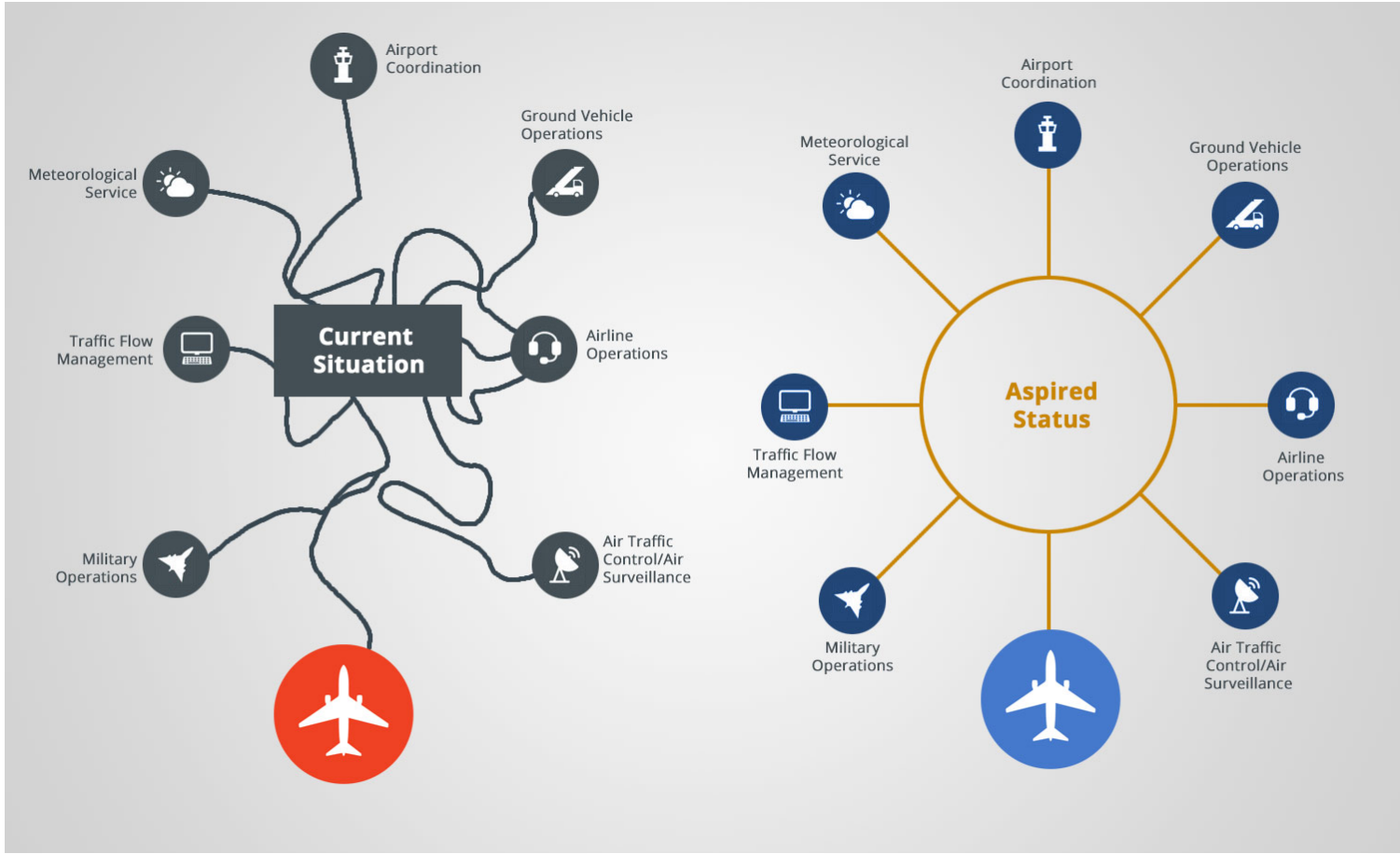
SWIM

= **S**ystem **W**ide **I**nformation **M**anagement

Motivation

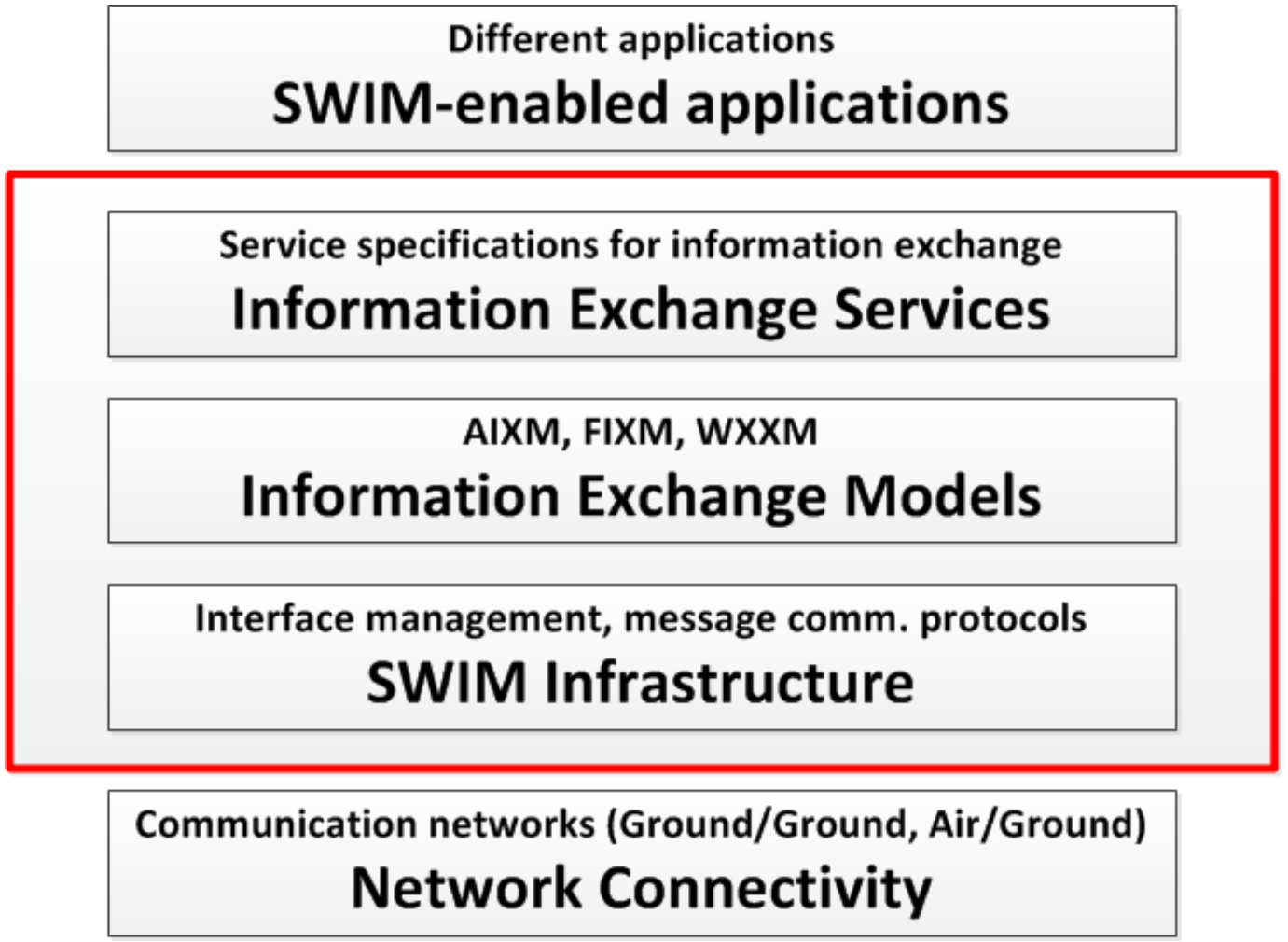
SWIM "Intranet for ATM" concept requests **all** the future air traffic participants acting as communicating sub-systems.

Motivation SWIM ⊔ Why ?



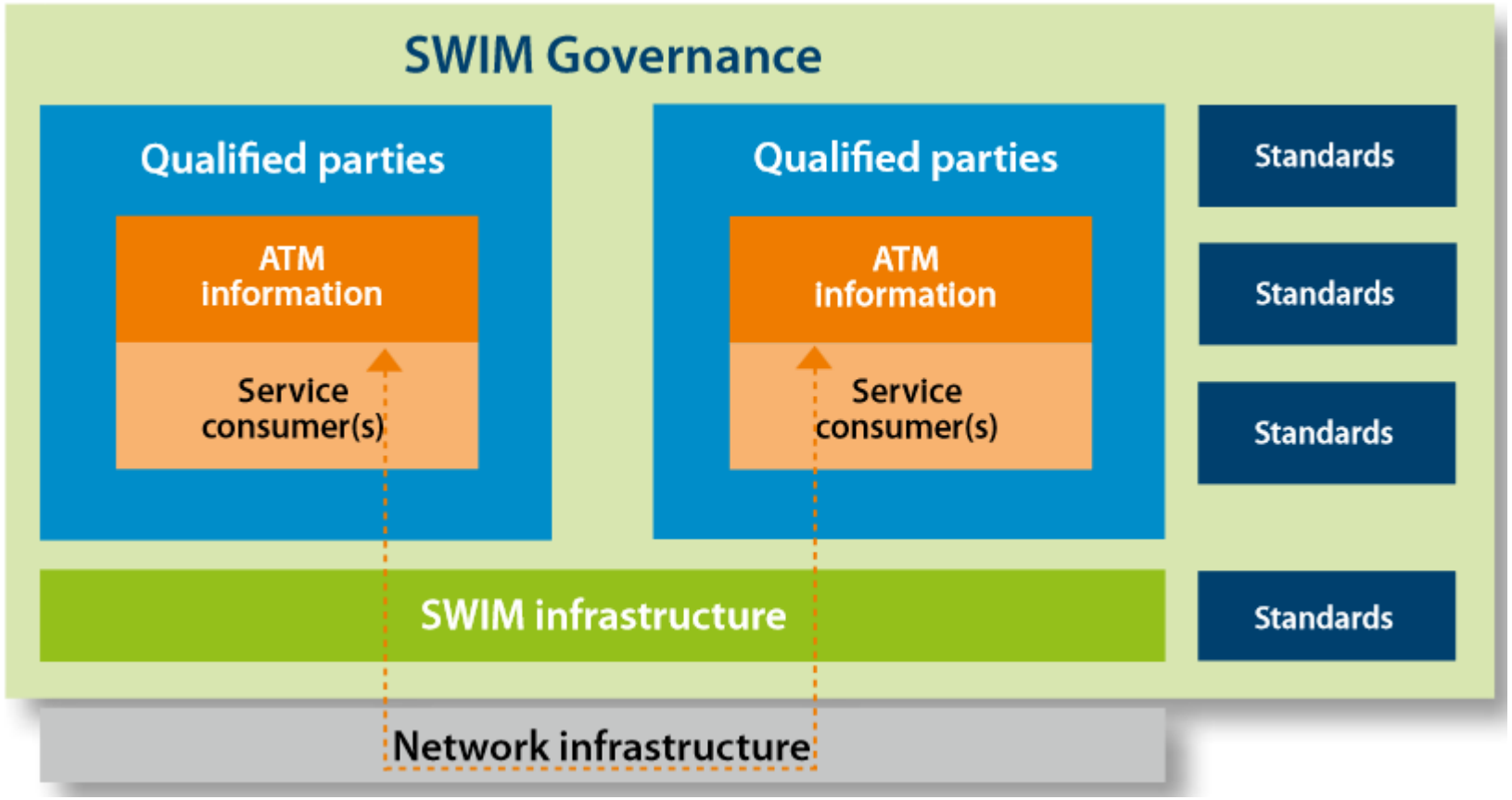
Source: https://www.einfochips.com/blog/k2-categories/aerospace/iot-in-aviation-with-system-wide-information-management.html

Motivation SWIM ␣ What ?



SWIM Scope

Motivation SWIM ⊔ What ?



Source: http://www.sesarju.eu/sites/default/files/documents/wac/SWIM_Becoming_a_reality_Brochure.pdf

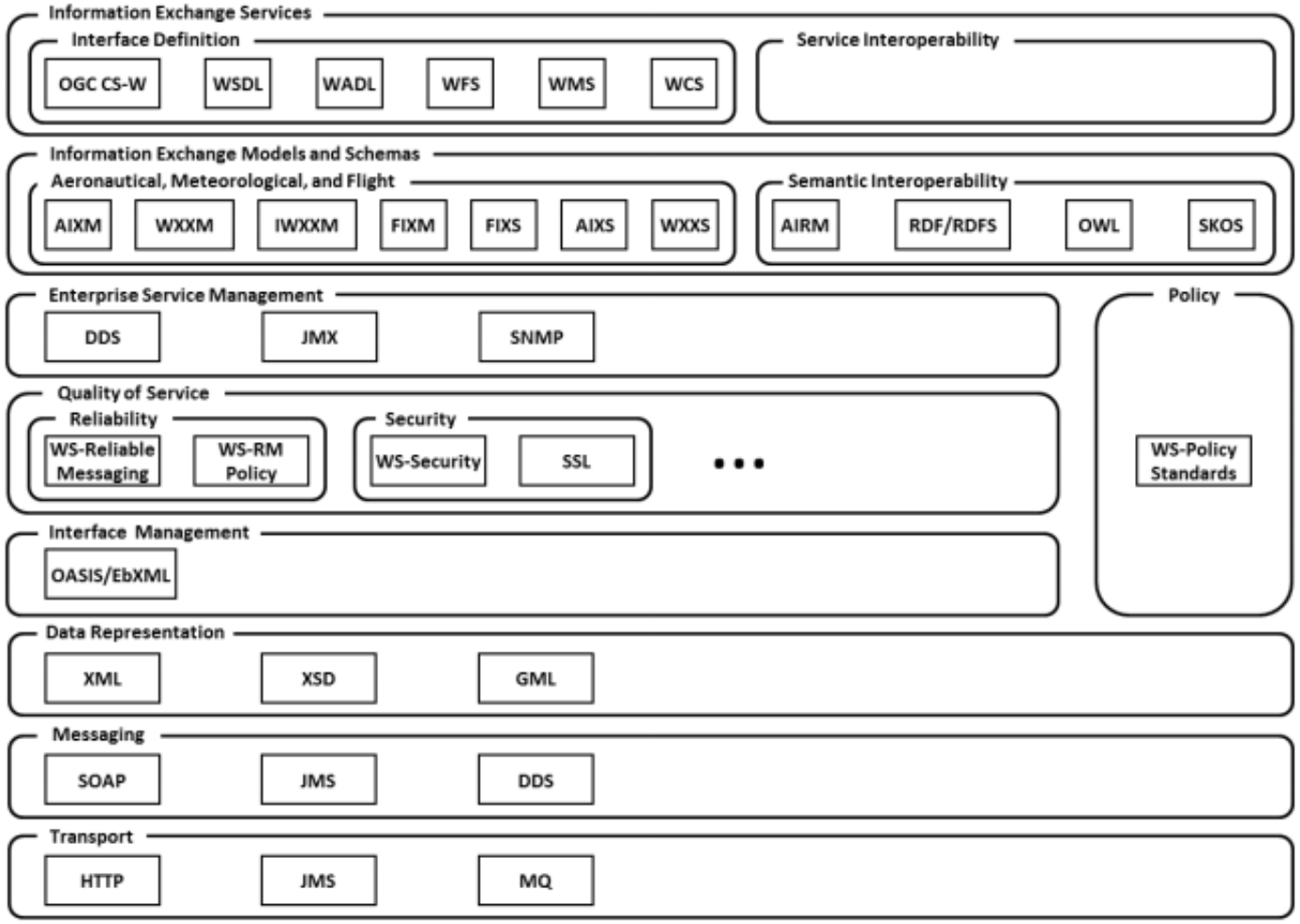
SWIM ▭ What ?

Motivation

- Technical profiles:
  - Yellow ▭ non critical information
  - Blue ▭ critical information
  - Purple ▭ Air / Ground info exchanges

SWIM ␣ What ?

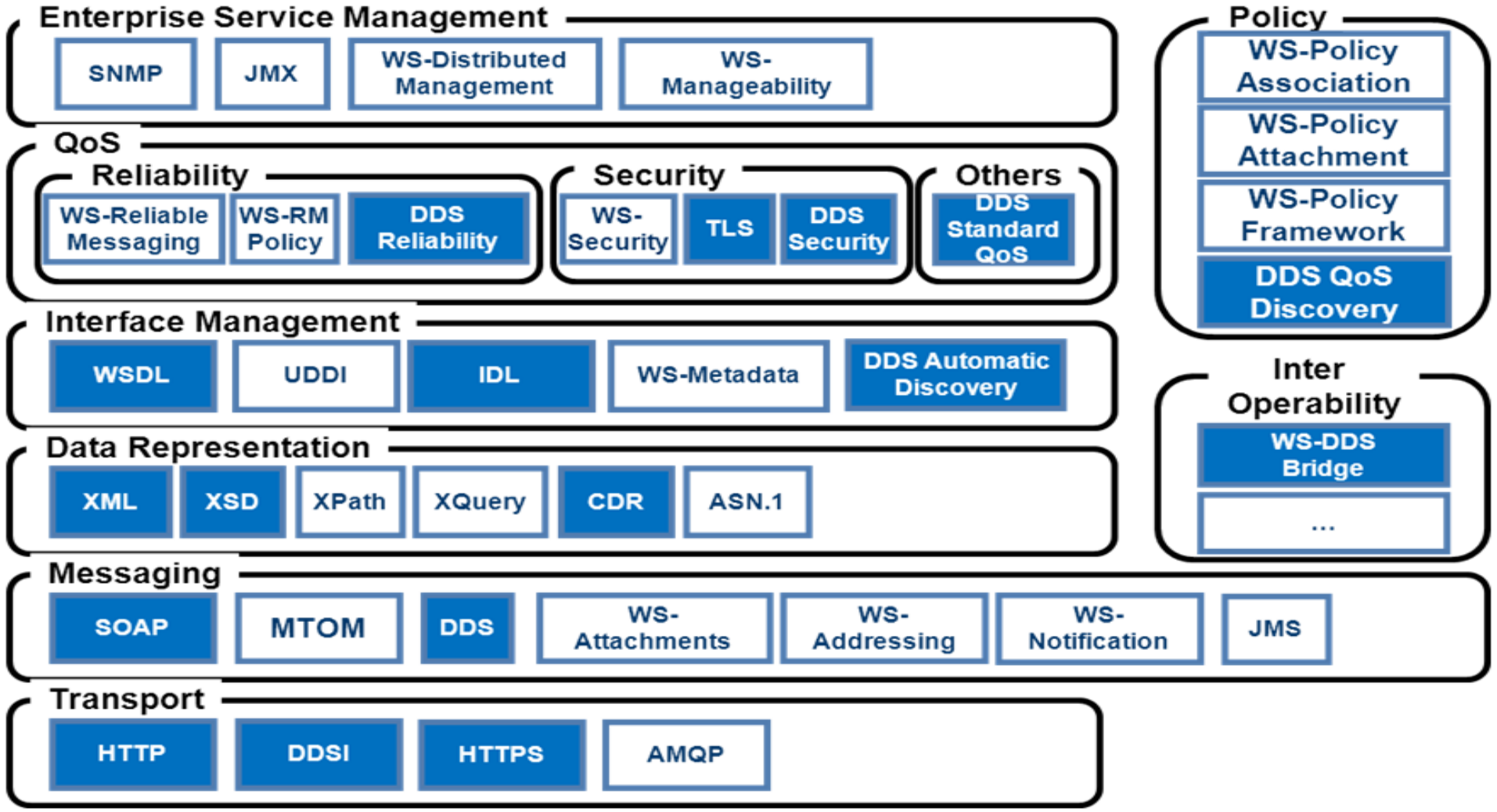
Motivation



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

Motivation

SWIM ⊔ What ?



Motivation

Benefits of acting SWIM compliant

- **Access to real-time, relevant aeronautical, flight, and weather information ⇨ <u>faster dedicated response possibilities</u>**

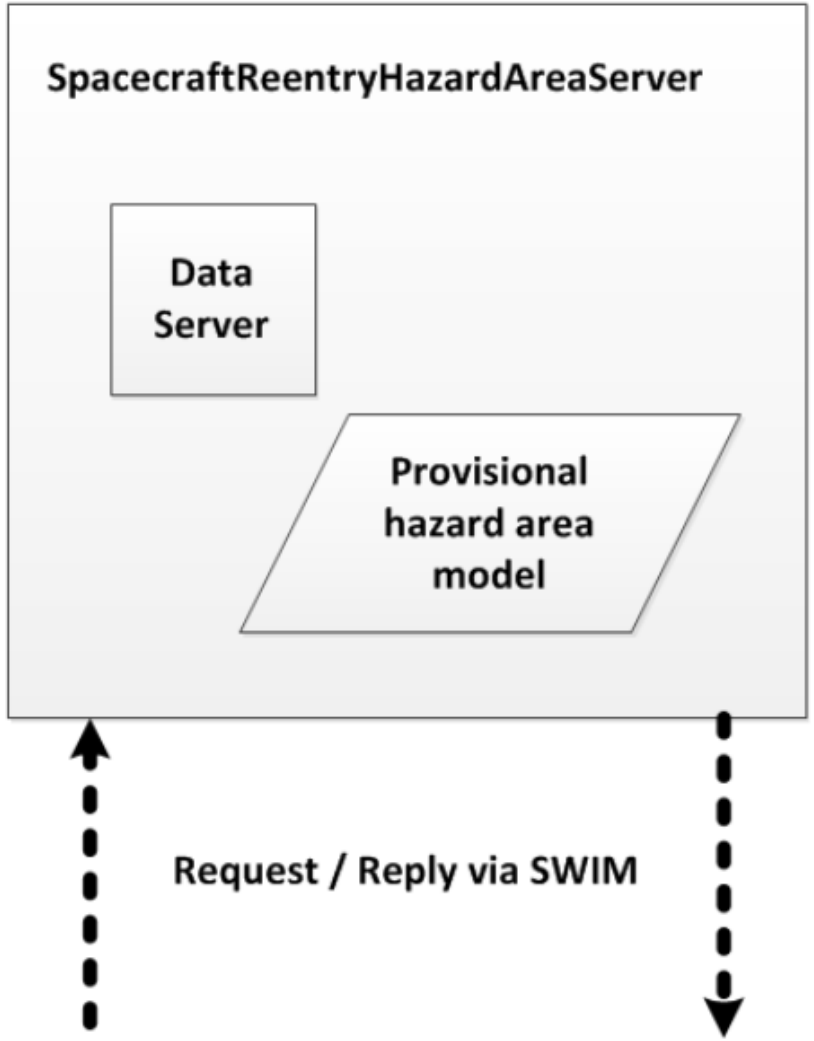
- **<u>Reduced implementation, operating and extension costs</u> because of SWIM's standardized character**

- **SWIM = <u>requested fundament of the future</u> for info based collaboration in ATM (Air Traffic Management) ⇨ <u>being prepared for the future</u>**

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

FIXM

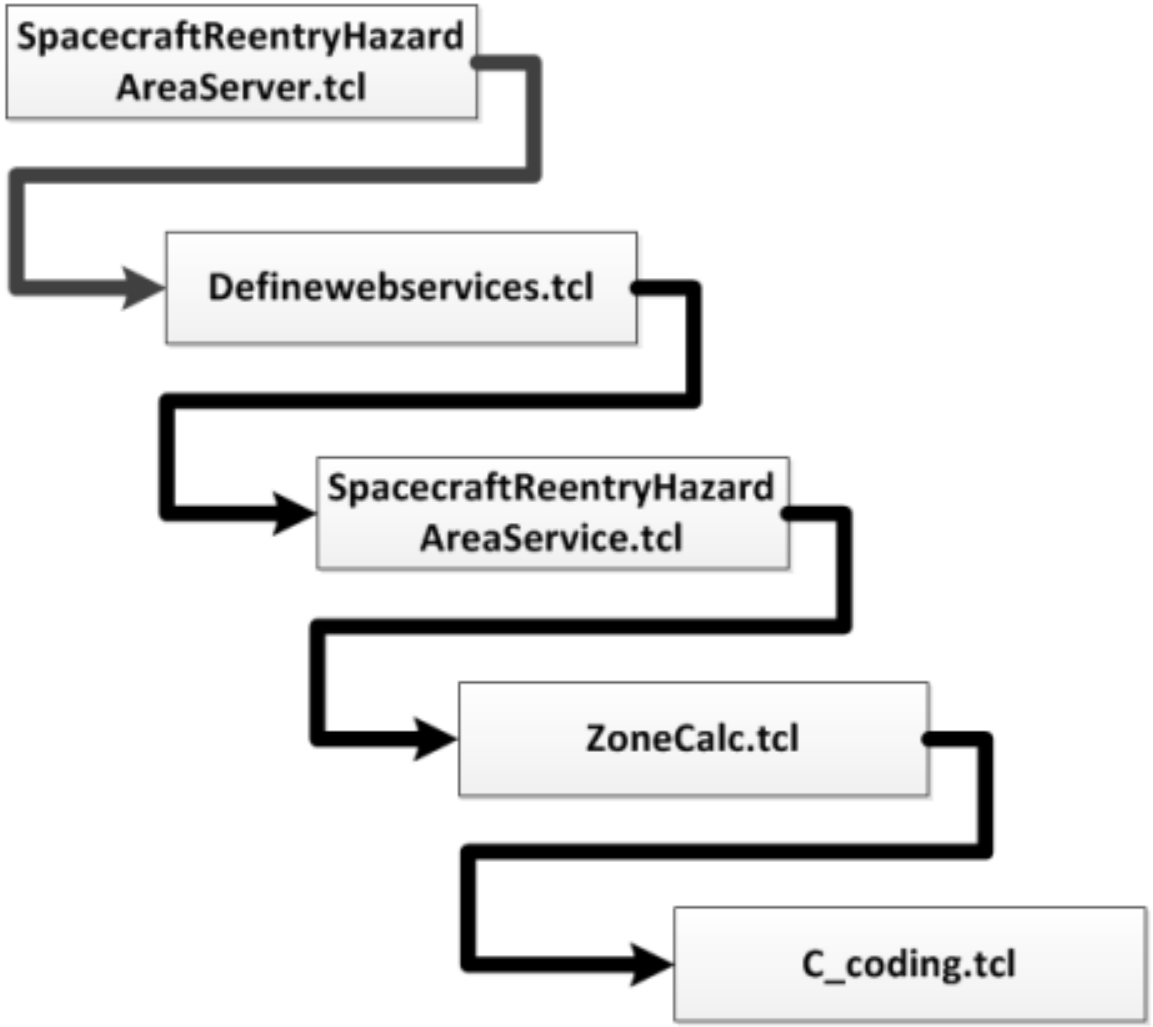
Output:
Lat_lon of 4-point-HazardZonePolygon

TFR airspace in AIXM

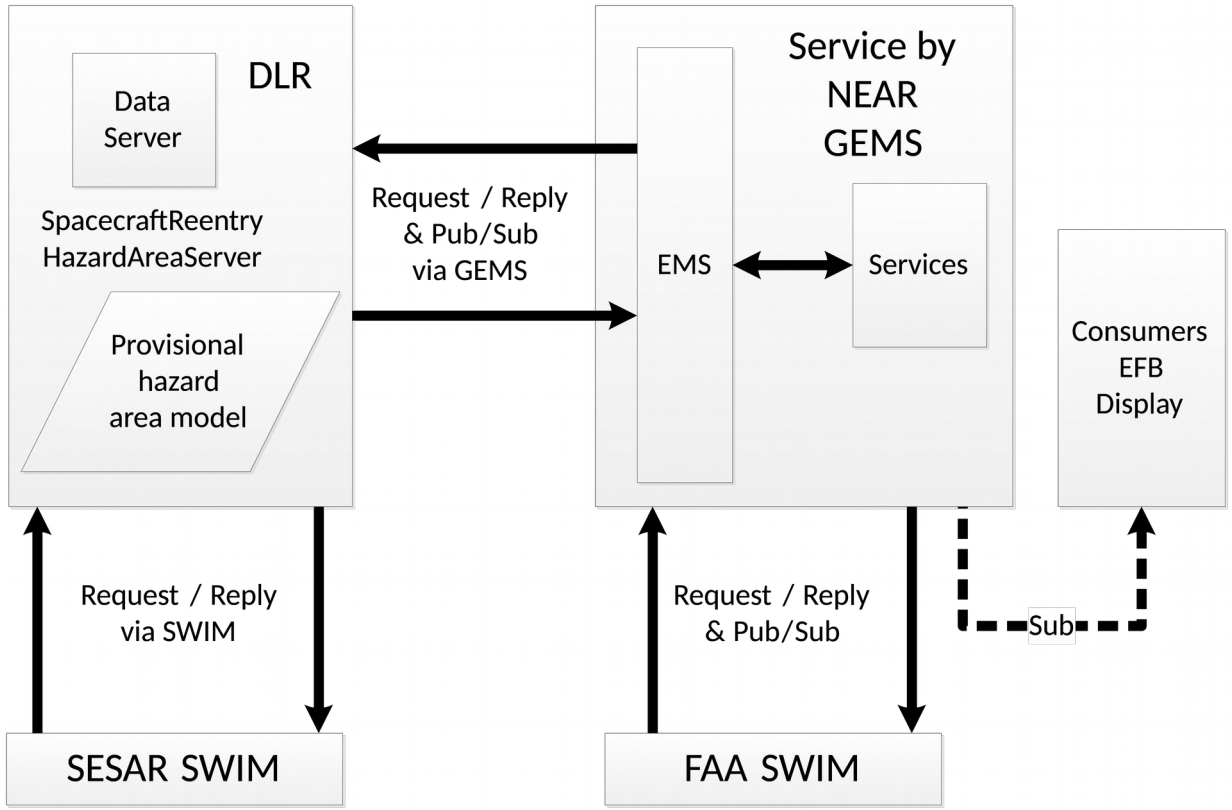
Solution using:

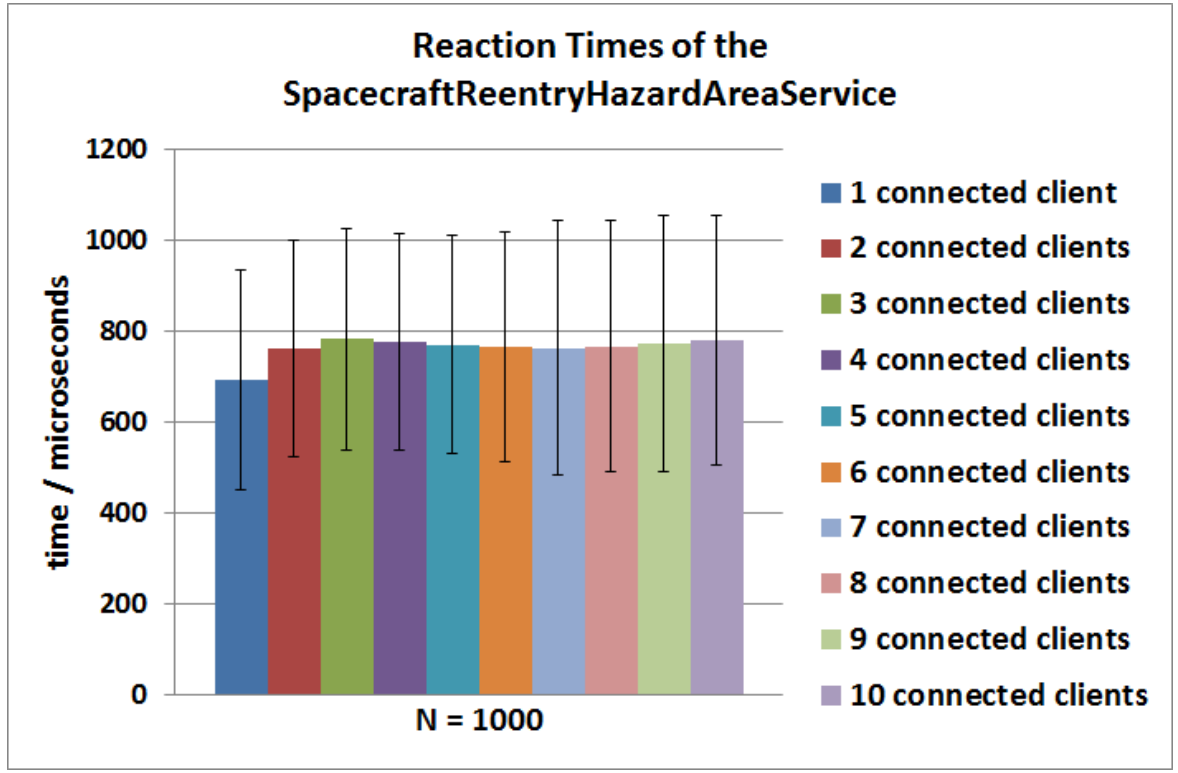
- **TclHttpd** as the web server
- **Web Services for Tcl** for the server side web service creation on top of TclHttpd
- **TclTLS** for using HTTPS
- **Rpcvar** for complex data type definitions
- **CriTcl** for improved performance by the usage of C code runtime embedding
- **BaseXClient-Tcl** for using the BaseX server protocol to communicate with the hazard area model database server

Solution structure:



Solution

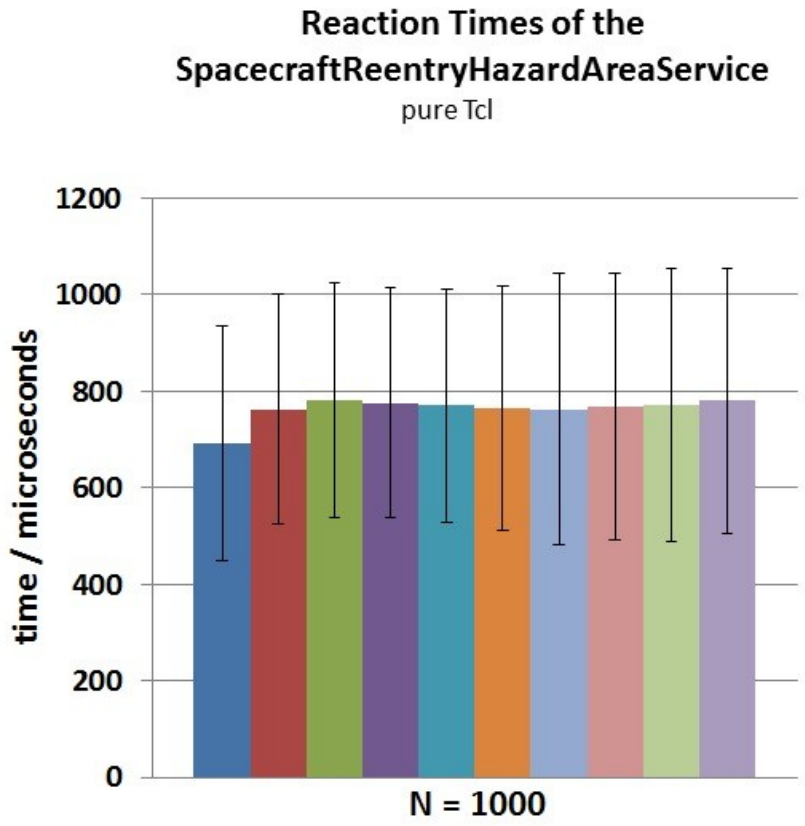

DLR
Data Server
SpacecraftReentry HazardAreaServer
Provisional hazard area model
Request / Reply & Pub/Sub via GEMS
Service by NEAR GEMS
EMS
Services
Consumers EFB Display
Request / Reply via SWIM
Request / Reply & Pub/Sub
Sub
SESAR SWIM
FAA SWIM

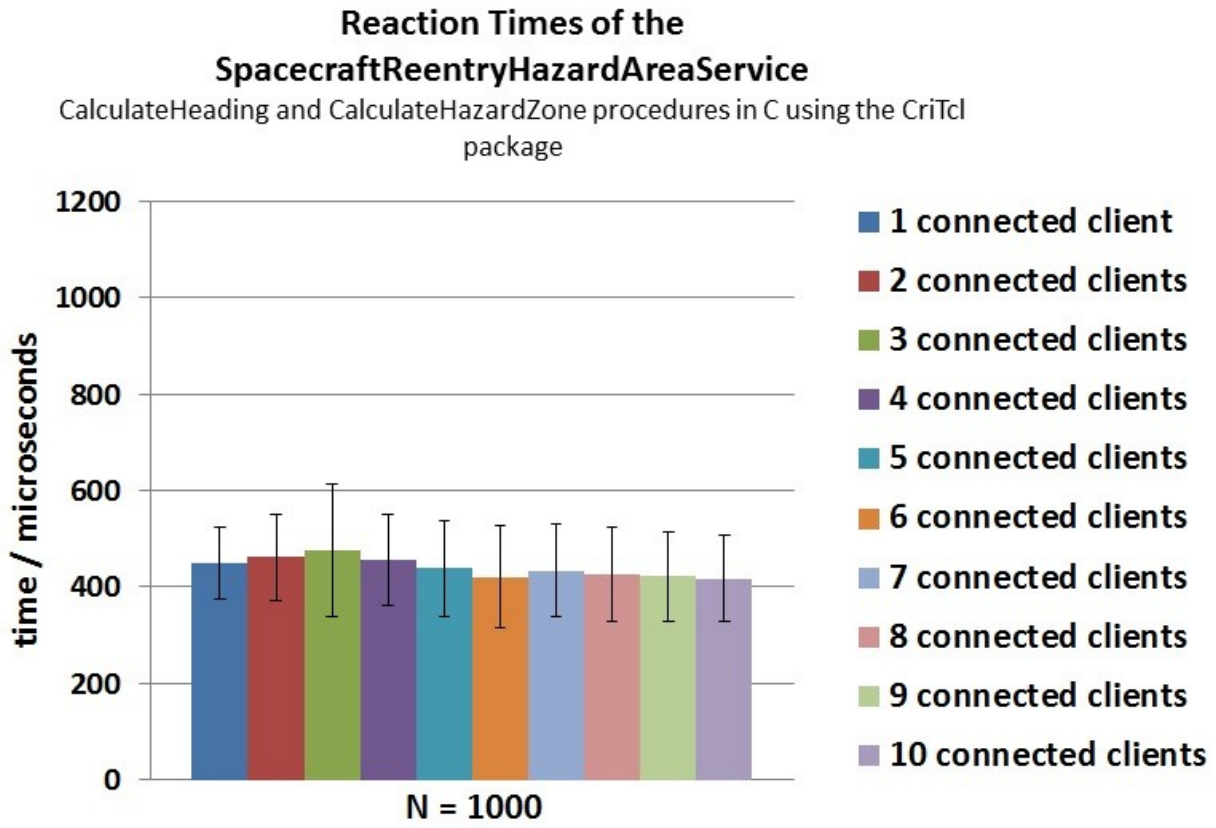

Reaction Times of the SpacecraftReentryHazardAreaService
time / microseconds
1200
1000
800
600
400
200
0
N = 1000
1 connected client
2 connected clients
3 connected clients
4 connected clients
5 connected clients
6 connected clients
7 connected clients
8 connected clients
9 connected clients
10 connected clients

Solution CriTcl usage (excerpt):

```
critcl::cproc c_calcheading {double lat1in double lon1in double lat2in double lon2in} double {
    /* this is C code */
    double localoperator1;
    double localoperator2;
    double localheading;
    localoperator1 = cos(torad(lat2in)) * sin((torad(lon2in)) -  (torad(lon1in)));
    localoperator2 = cos(torad(lat1in)) * sin(torad(lat2in)) - sin(torad(lat1in))
    * cos(torad(lat2in)) * cos((torad(lon2in)) - (torad(lon1in)));
    localheading = atan2(localoperator1, localoperator2) * (180 / pi);
    if (localheading < 0)
    localheading += 360.0;
    return localheading;
}
```

Solution (performance enhancement)

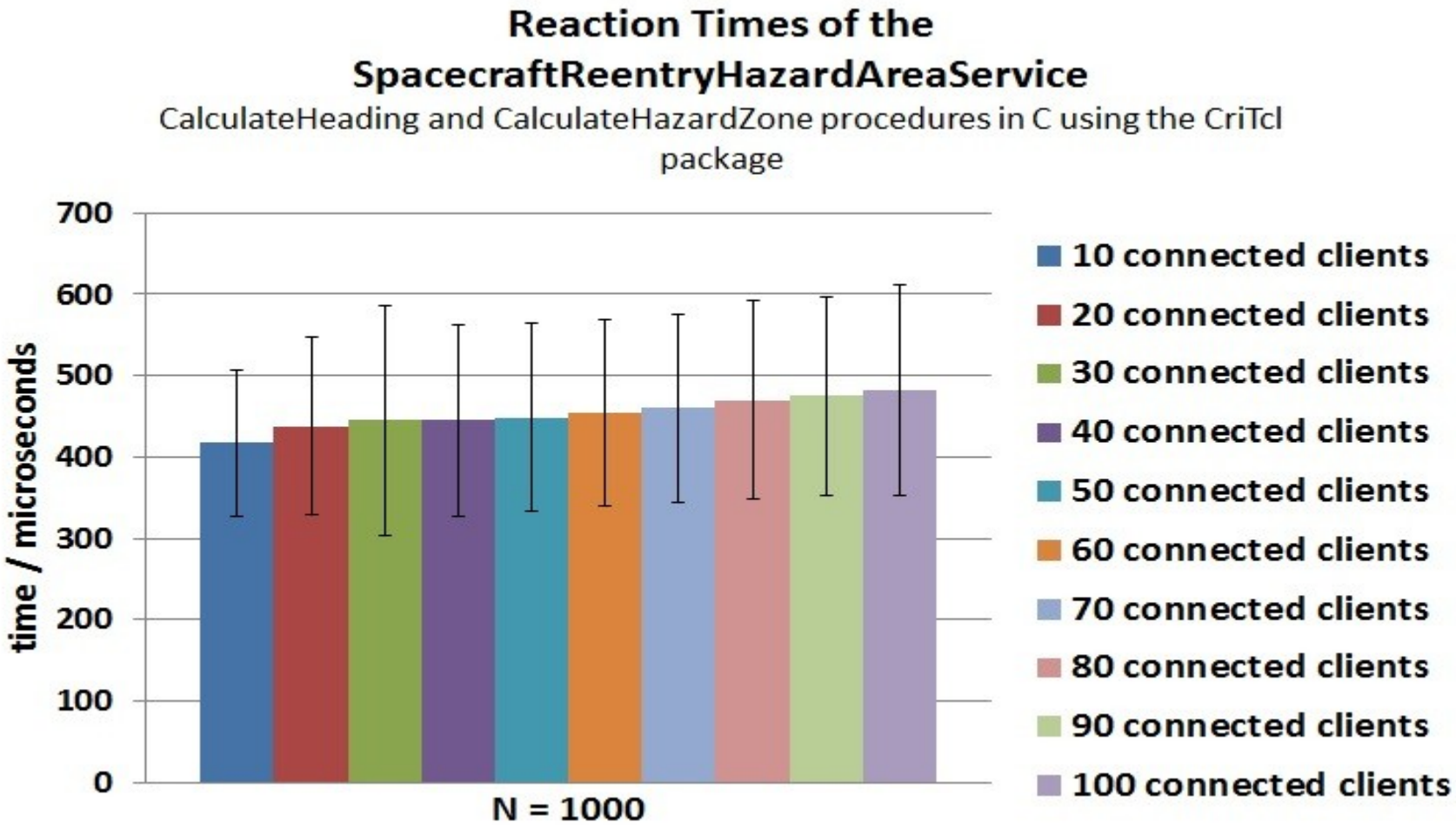




Solution (scalability)

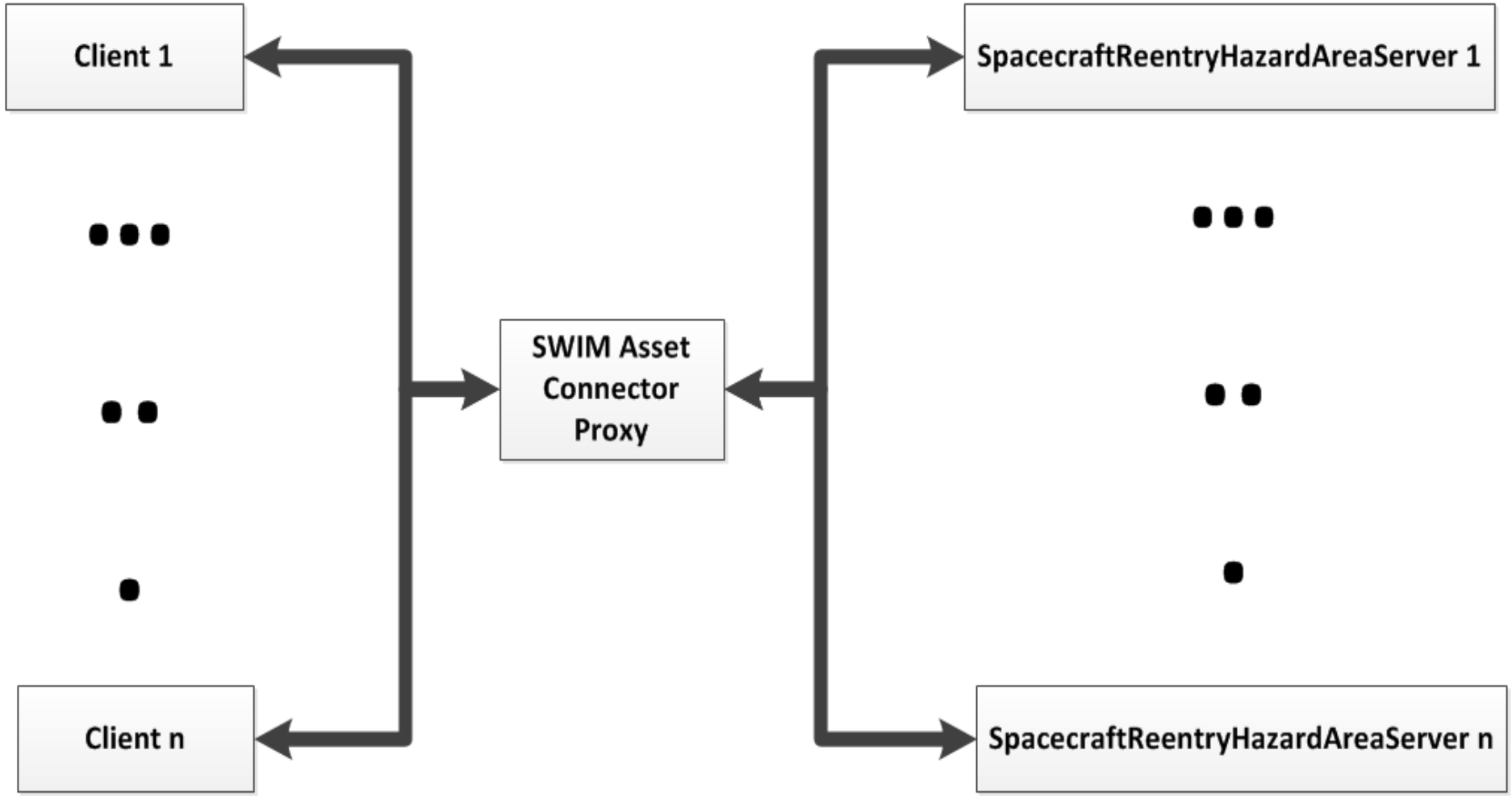
Sufficient for most small and medium sized cases !

Anyhow ….

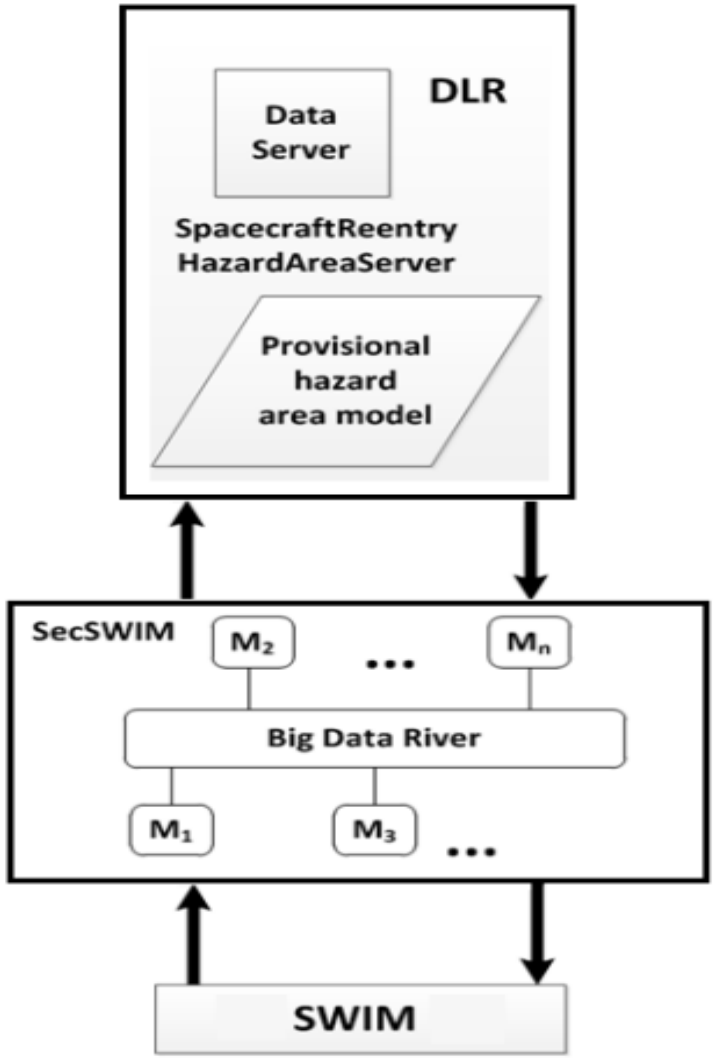


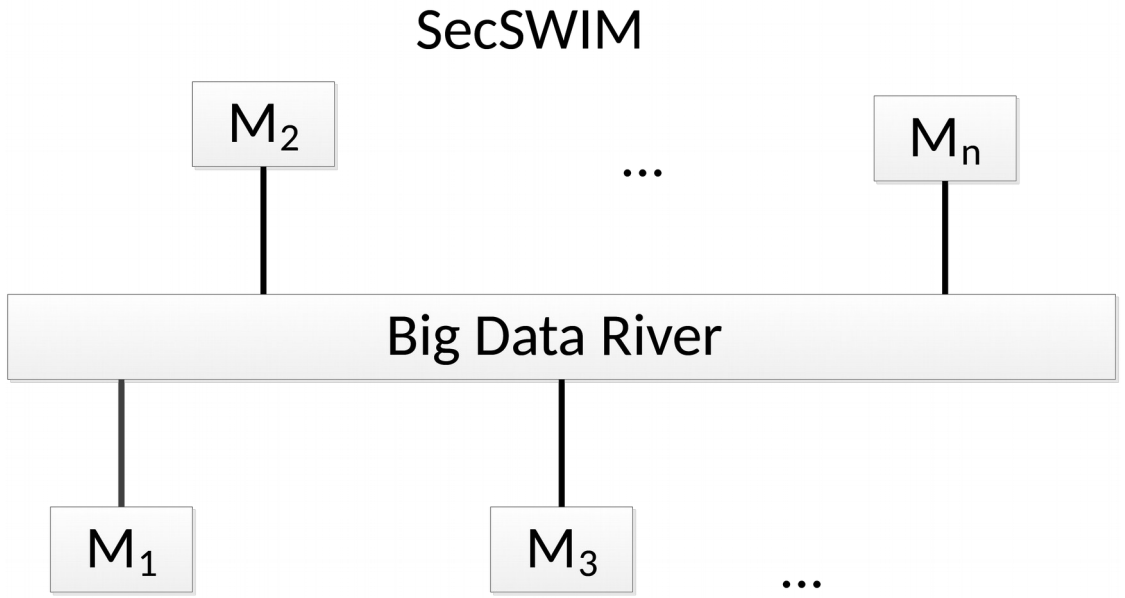
Solution (scalability)

Anyhow ….



Outlook


DLR
Data Server
SpacecraftReentry HazardAreaServer
Provisional hazard area model
SecSWIM
M2
...
Mn
Big Data River
M1
M3
...
SWIM


SecSWIM
M2
...
Mn
Big Data River
M1
M3
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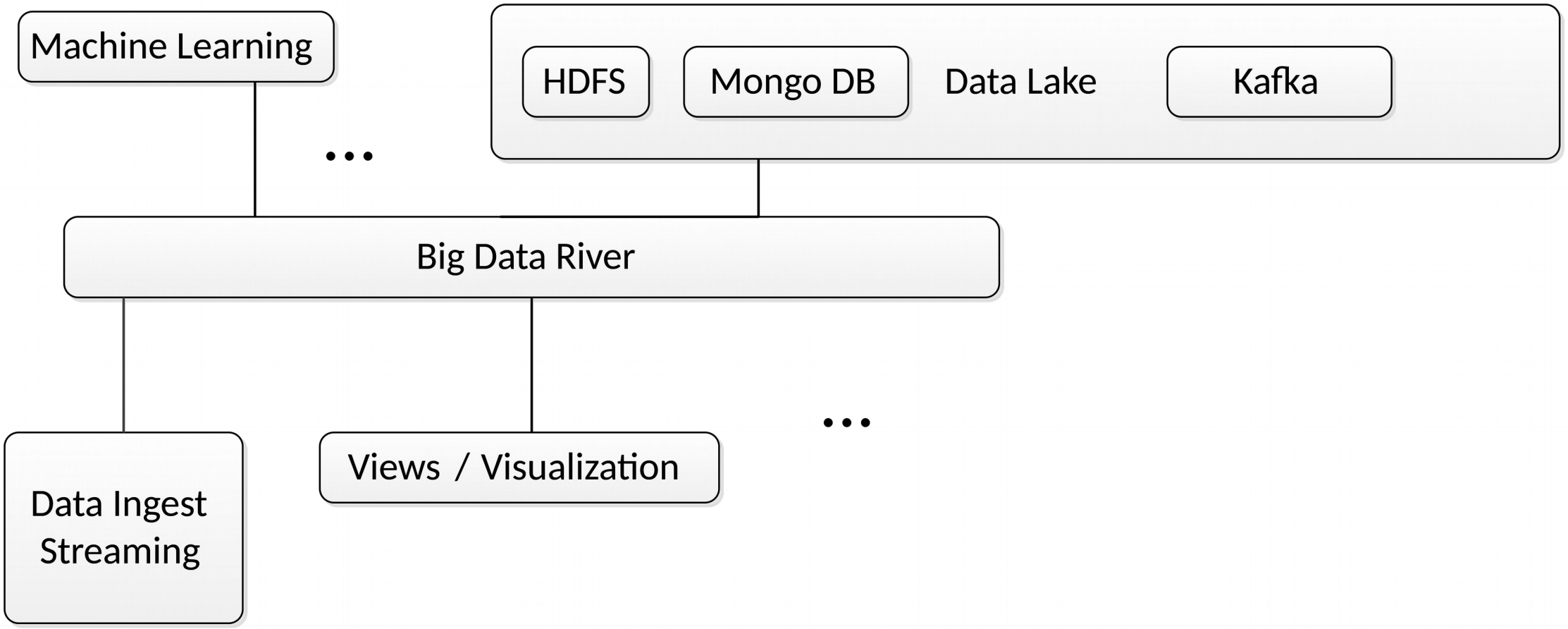
Outlook


Machine Learning
HDFS
Mongo DB
Data Lake
Kafka
Big Data River
Data Ingest
Streaming
Views / Visualization

Outlook

SecSWIM ␣ foreseen to be developed in ?

␣Make an educated guess… ᵐ

- Kafkatcl
- TensorFlow (C++ API used inside Critcl)