Evolving Air Traffic Management towards an efficient integration of hypersonic air transportation

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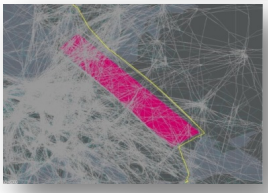
PARTNER OF SESAR JOINT UNDERTAKING

ATM Integration of Space Vehicles

Flight phases to be considered:
- Launch operation
- Suborbital flight trajectories
- Reentry operation

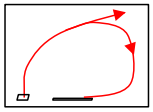
Ensure separation between a/c and
- Space vehicle
- Boosters / 1st stage / returning launch systems
- Debris in case of mishap

Research topic:
ATM Integration of Space Vehicles
- Analysis and optimization of spaceflight scenarios and concepts regarding air traffic impacts
- Improved ATC procedure design, Integration of Hazard Areas
- Efficient and sustainable Spaceport Operations
- Provision of adequate evaluation and validation capabilities

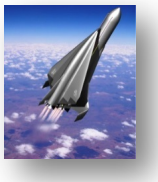


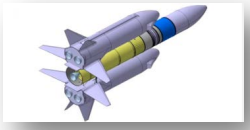
Goal: Seamless, efficient, and safe integration of air traffic and spaceflight

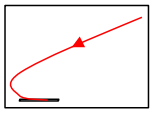
Categories of ATM relevant Space Vehicle Operations



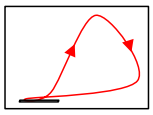
Launch Operations



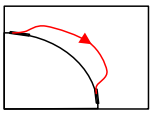




De-orbiting Space Vehicles

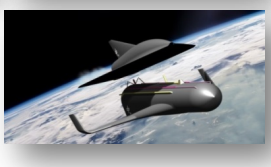


Suborbital Flights



Suborbital Point-2-Point Travel

↳ Hypersonic Air Transport



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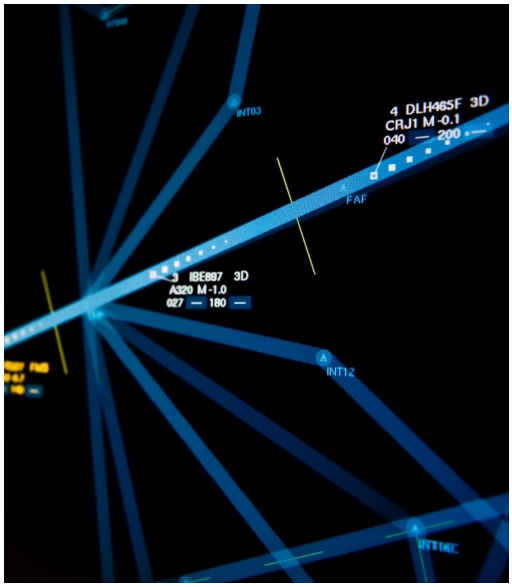
Differences in handling aircraft vs. spacecraft in ATM

Space Vehicles - current situation

- do not file a flight plan,
- trajectories are predictable but far away from 4D-contracts,
- provide limited capabilities to avoid other traffic, therefore have to be prioritized, therefore need restricted airspace,
- often have to delay launch / landing operations,
- will operate internationally - e.g. hypersonic intercontinental flights,

are not (yet) fully integrated into ATS !

International Intraoperability is required !



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Limiting the Impact of Spaceflights on ATM

Current operational practice, as far as applicable, e.g.

- Launch & reentry operation window as short as possible
- Avoid peak traffic times
- Optimize launch & reentry trajectories as far as possible
- Optimize air space usage alongside restricted areas
- Ensure real time monitoring and direct communication, connecting all involved stakeholders with ANSP managers and ATC facilities

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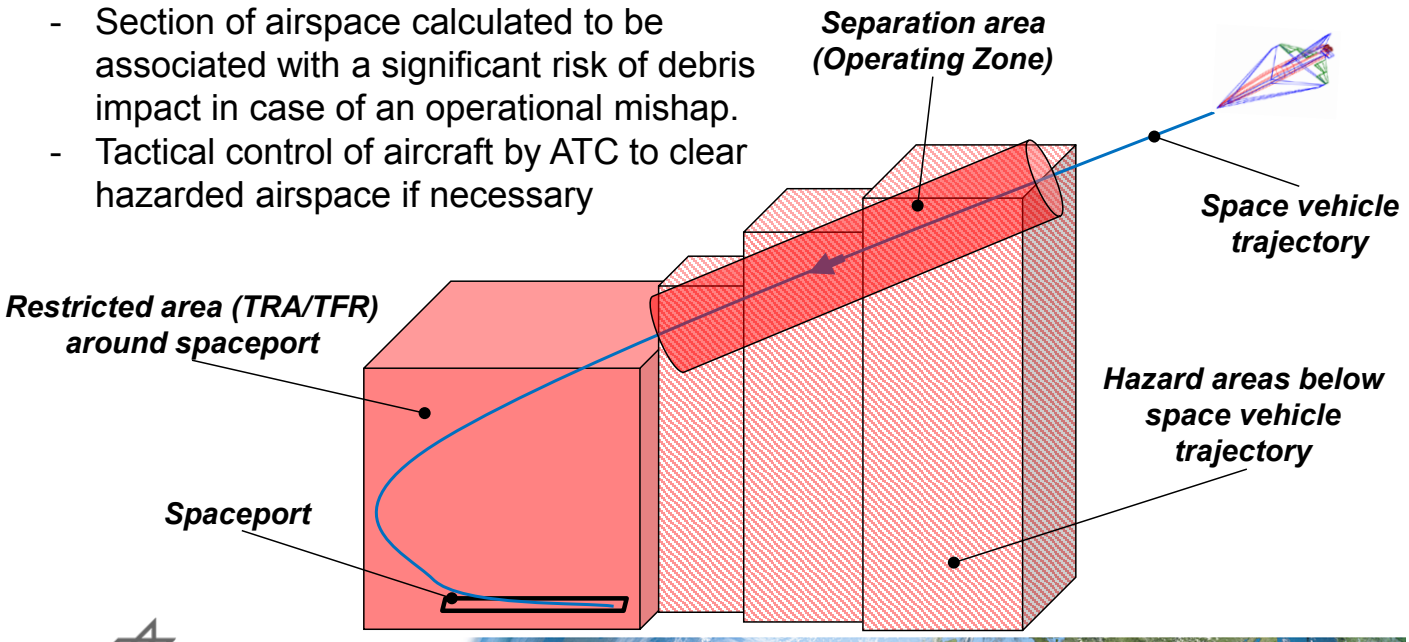
Hazard Area definition

- Section of airspace calculated to be associated with a significant risk of debris impact in case of an operational mishap.
- Tactical control of aircraft by ATC to clear hazarded airspace if necessary

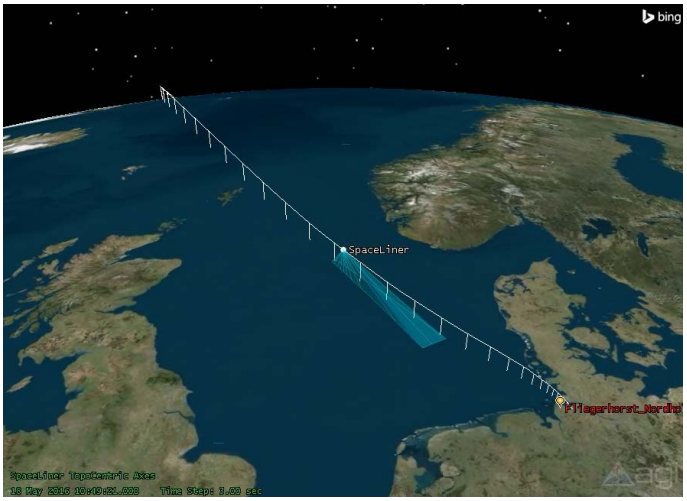


Hazard Area calculation

- Prediction of extend of airspace that could contain falling debris hazardous to aircraft
- Planning mode and realtime mode
- Use of debris catalog / model and input wind characteristics
- Output of hazard area / debris foot-prints for each received state vector

Existing tools: e.g. FAA Shuttle Hazard Area to Aircraft Calculator SHAAC

- **So far, there is no integrated & interoperable solution available!**



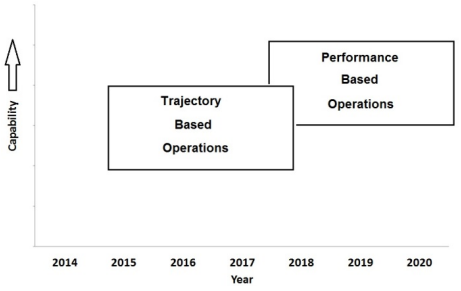
Hazard Area footprint visualisation for DLR SpaceLiner

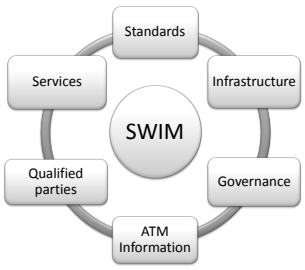
- example for a flight Australia - Europe;
- visualisation from MECO to entry into spaceport TMA;
- trajectory data generated by DLR SART,
- provisional Space Shuttle based Hazard Area model

SESAR Requirements

Single European Sky ATM Research Programme SESAR

- From Business trajectory to Performance based trajectory
- System Wide Information Management SWIM
  - "Intranet for ATM"
  - Pilots, Airport Operations Centers, Airline Operations Centers, Air Navigation Service Providers, Meteorology Service Providers, Military Operations Centers
  - Includes Controller-Pilot Data Link Communication (CPDLC)

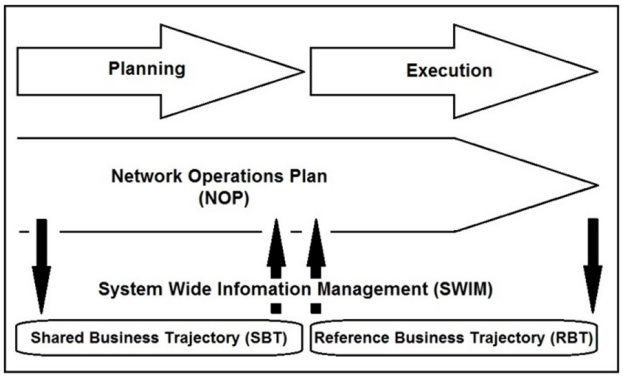




SWIM in SESAR

From Planning to Sharing to Execution

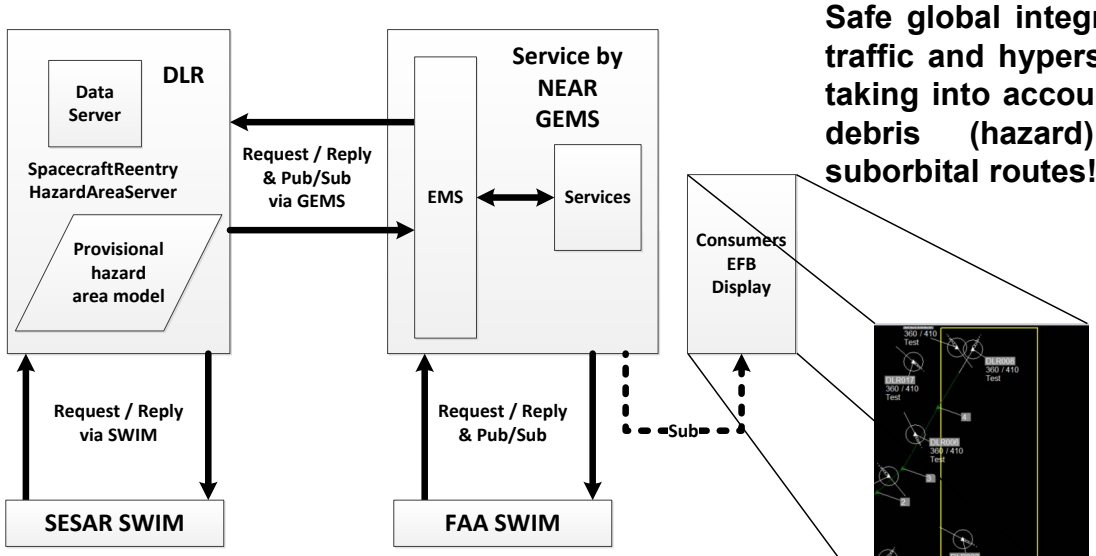
- Business Development Trajectory BDT
- Shared Business Trajectory SBT
- Reference Business Trajectory



SESAR SWIM concept requests all the future air traffic participants acting as communicating sub-systems!

SWIM SpacecraftReentryHazardAreaServer

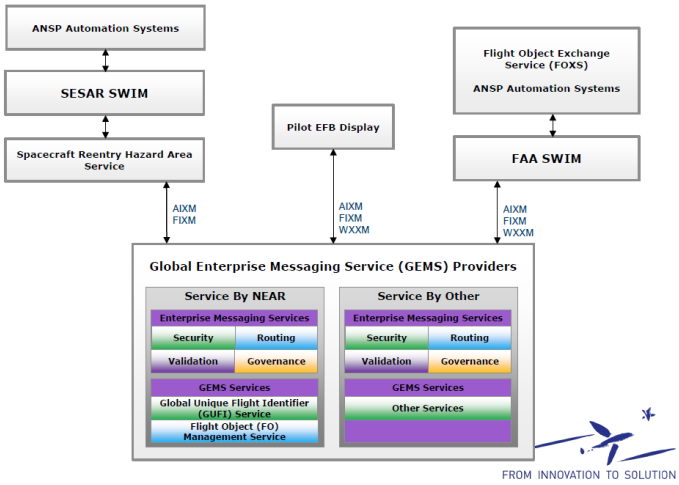
Safe global integration of space traffic and hypersonic flights by taking into account its changing debris (hazard) areas along suborbital routes!



2015 SESAR SWIM Master Class contribution by DLR in cooperation with Embry Riddle University (ERAU)

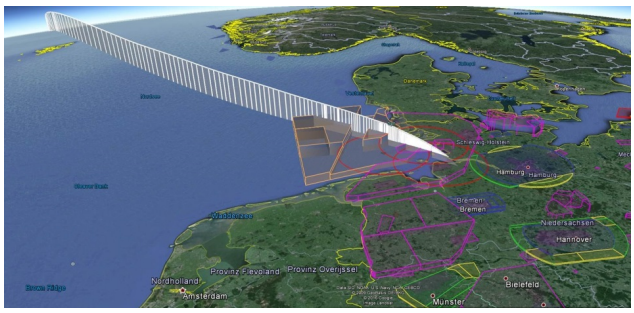
Spacecraft Flight Planning and Execution

1. Checking potential hazard areas by making the IFPS Validation System a SpacecraftReentryHazardAreaServer consumer
2. ANSP Automation Systems consume the SpacecraftReentry-HazardAreaServer, Air traffic controller issuing associated voice commands to other aircraft
3. Standard http requests for pre-formatted web charts to a chart web server
4. EFB software as a GEMS subscriber or an AMQP subscriber to the gate way server

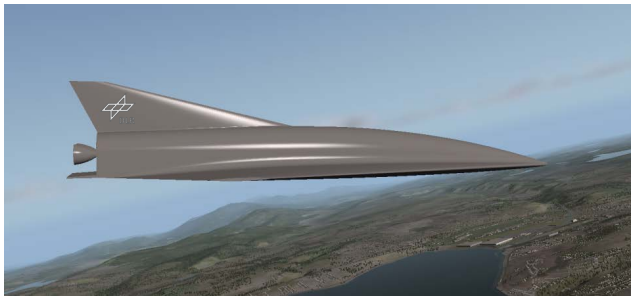


Next Steps

- Operational ATM impact analysis of hypersonic DLR SpaceLiner concept (Fast-time simulation study)
- Integrated SWIM Evaluation of SpacecraftReentryHazardArea Service, ATC procedures and possible Air Traffic Controller HMI design (HIL real-time simulation study)
- <u>Achieved Milestone:</u> Implementation of SpaceLiner 7-1 Orbiter flight dynamic for fasttime and realtime ATC simulation (DLR Air Traffic Validation Center)



SpaceLiner trajectory modelling and airspace interaction



SpaceLiner Orbiter real-time flight simulation model

Thank you very much for your attention !

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