# WhizniumSBE Code Generation/Iteration Service

## Use Case: The BeamRelay Project

MPSI

## Quick facts

- BeamRelay is an example of a distributed medium-scale simulation project developed with the help of WhizniumSBE.
- The objective of the simulation is to gather statistics on the global reachability of commercial aircraft using multi-hop free-space optical communications.
- BeamRelay leverages the modeling capabilities of WhizniumSBE to generate a flight database from both timetable data and from real-time data provided by an external web-service, to establish a distributed compute environment e.g. for line of sight calculations, to express dynamic communication corridor equipment line-ups, and to visualize results in interactive SVG maps.

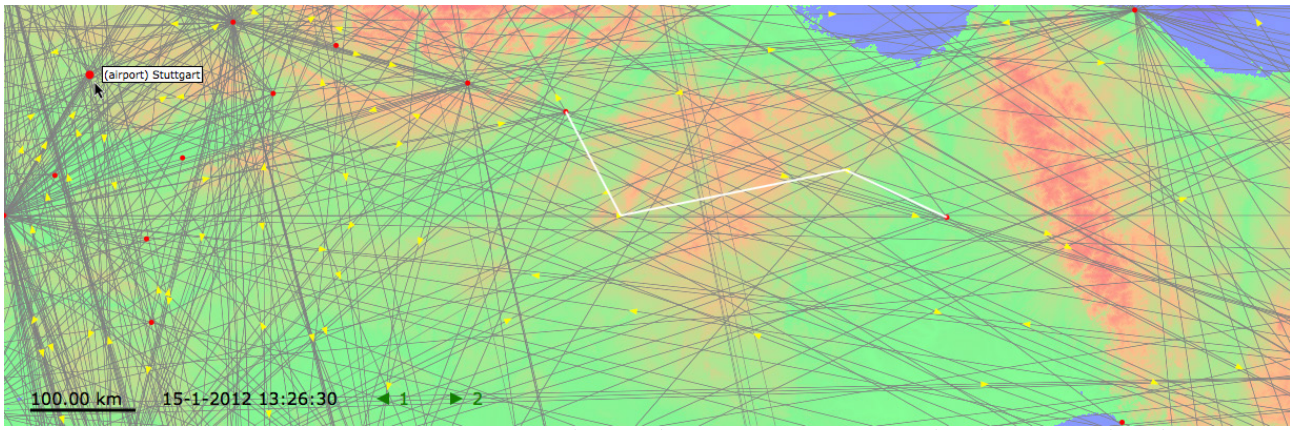


**Figure 1:** Interactive SVG map of a relay connection (in white) to a flight from Frankfurt (FRA) to Malaga (AGP). Red dots represent ground stations (airports), great circle flight paths are shown in gray, flights as yellow arrows

BeamRelay investigates a model scenario in which airports and commercial aircraft are equipped with optical transceivers for high-speed onboard internet access.

The core of the BeamRelay database is formed by tables of regions (hierarchical 1:N, granularity from continent to state), locations (airports and other ground stations), *legs* (routes), timetables and flights. Simple WhizniumSBE modeling features used include a double 1:N relation between location and *legs* (for begin and end), and *jumper* tables to the region table to store names in multiple languages and to account for time zone changes. DST and time zone information is relevant as timetables state local departure and arrival times. All data is accessible through the automatically generated UI shown in Figure 2.

The database receives its initial fill from timetable data published by major airline alliances. For the corresponding text-based import feature, an *import complex* for data extracted from .pdf timetable files is implemented.

Calculations start with the determination of ground station-to-flight path and mutual flight path lines of sight. As great circle routings are assumed, the results of this geometrical analysis, which is highly suitable for parallel execution, are time- and flight-independent. They are stored as M:N relations (locations to *legs*, *legs* to *legs*) with attributes (from/to angular coordinates).

**Table 1:** The project in numbers

| Metric | Value |
|---|---|
| database tables | 118 |
| ... of which model | 49 |
| ... of which query | 69 |
| UI modules | 3 |
| UI cards | 14 |
| operation packs | 5 |
| operations | 17 |
| source files | |
| database | 250 |
| [operation] engine | 828 |
| web-based UI | 1164 |
| API | 547 |
| binary sizes | |
| database library | 56.8 MB |
| engine | 108.7 MB |
| operation engine | 28.9 MB |
| API library | 134.3 MB |

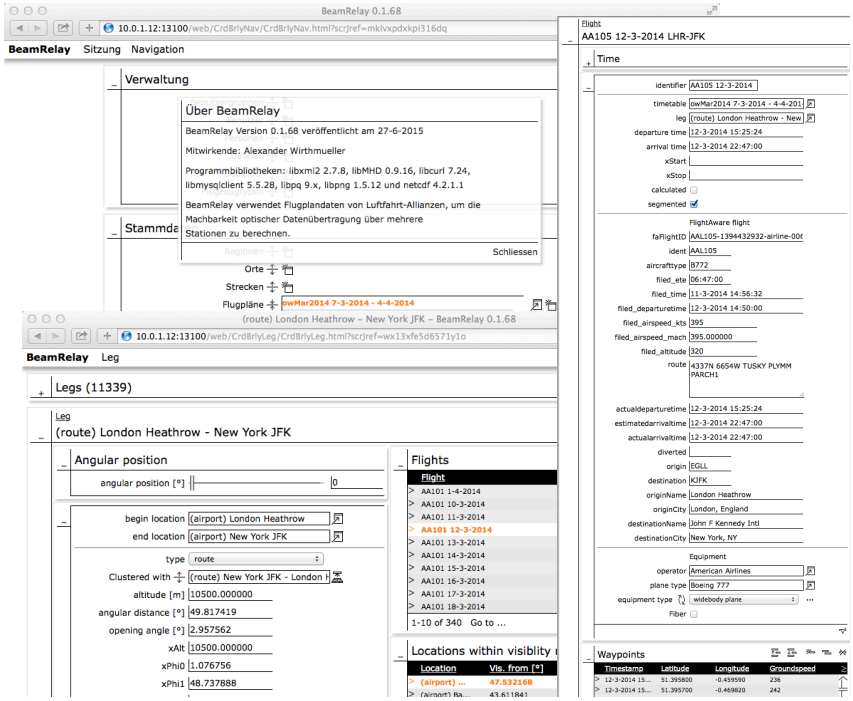


**Figure 2:** Navigation card in German, combined timetable and actual waypoint flight details, leg card with leg-related visibility data

The data is used for pre-filtering at the stage when ground station-to-flight and flight-to-flight visibilities are computed.

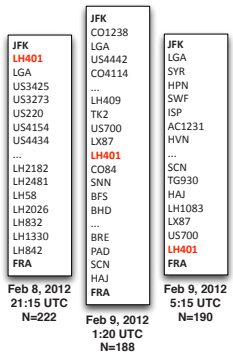


**Figure 3:** Corridor line-up evolution

Advanced WhizniumSBE modeling features are employed for the determination of relaying options: optical transceivers are modeled as *equipment* in the form of an *inclusion*, or optional 1:1 attachment, to either location or flight. For a specific flight, BeamRelay calculates the dynamic line-up of *equipment* along its flight path corridor. In Figure 3, this is shown for a flight from New York (JFK) to Frankfurt (FRA). Instead of snapshots, the list of all available *equipment* is stored, complemented by timestamped insert/swap/remove operations. WhizniumSBE offers methods to access the snapshot state for any given timestamp. Figure 1 is a visualization as animated SVG map, for which the geometry calculation is outsourced to a compute *operation*.

The local connection success rate is defined as the percentage of passenger-hours having internet access. Distributed evaluation of flights and their relaying options help accumulating statistics for the data grid of Figure 4.

Finally, actual flight paths vary on a daily basis due to guidance by air traffic control (ATC) and due to weather constraints. BeamRelay uses an online pay-per-use service, FlightXML, to retrieve waypoints upon specification of flight numbers of interest. The data is imported into the database and is used to refine simulation results, e.g. by breaking down flight paths into segments of constant altitude, velocity and heading.

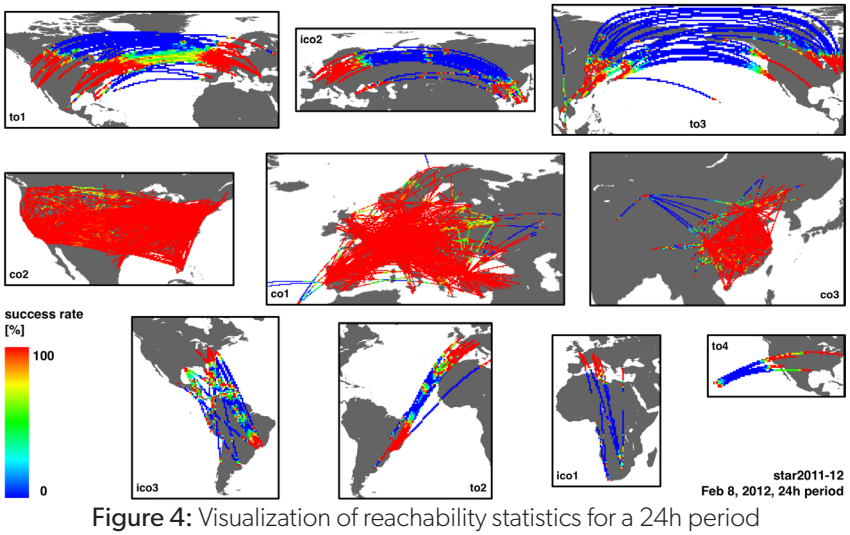


**Figure 4:** Visualization of reachability statistics for a 24h period

## Further reading


- Alexander Wirthmüller and Stefan Kalchmair: Global coverage of multi-hop free-space optical ground-to-airliner data links - ICNS Proceedings, IEEE 2014. DOI



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