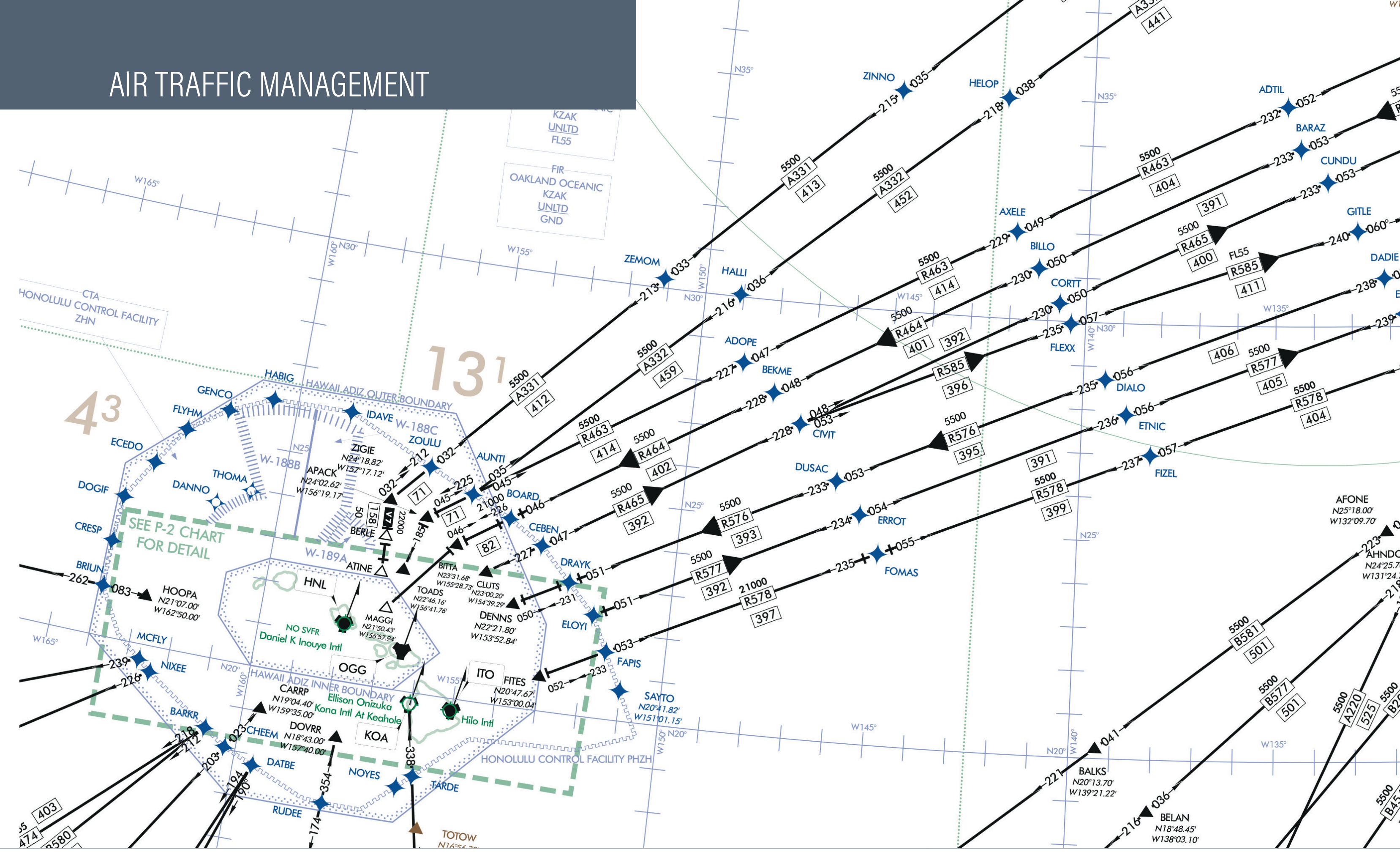


IMPROVING OCEANIC COORDINATION

ADS-B is enabling surveillance and efficiencies for oceanic traffic to a much greater extent than ever before

By Alexander Suchkov, OpenSky-Avia, and Pier Ferraris, Airtopsoft

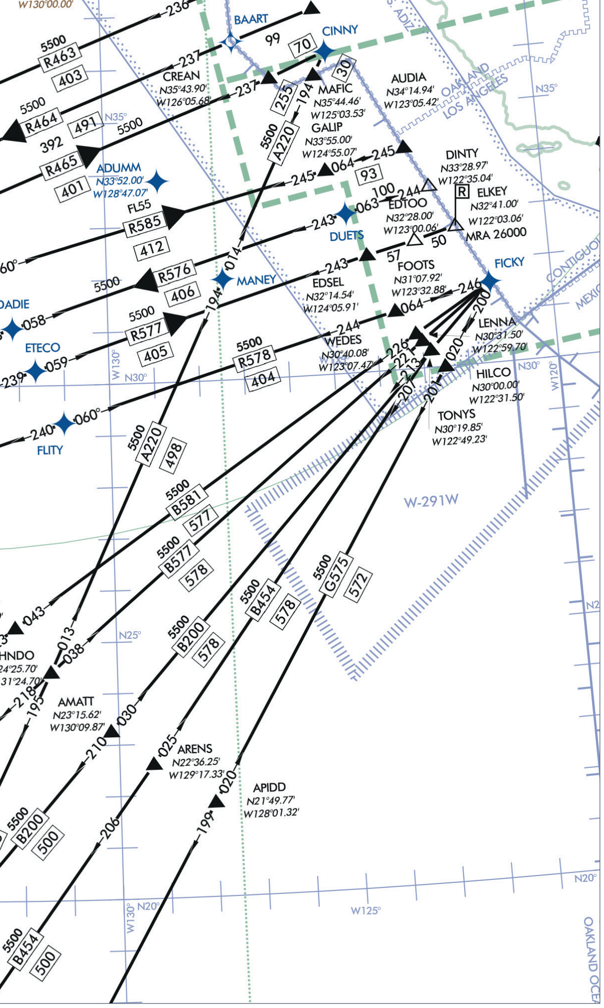
While air traffic operations in the terrestrial portion of the United States National Airspace System are optimised for the highest efficiencies, oceanic operations are unoptimised. With the emergence of space-based Automatic Dependent Surveillance-Broadcast, Air Traffic Services surveillance is now available in areas where it was not previously provided. OpenSky-Avia recently chose AirTOP from Airtopsoft, a Transoft Solutions company, to study the operational effects of this new technology on specific airspace routes.

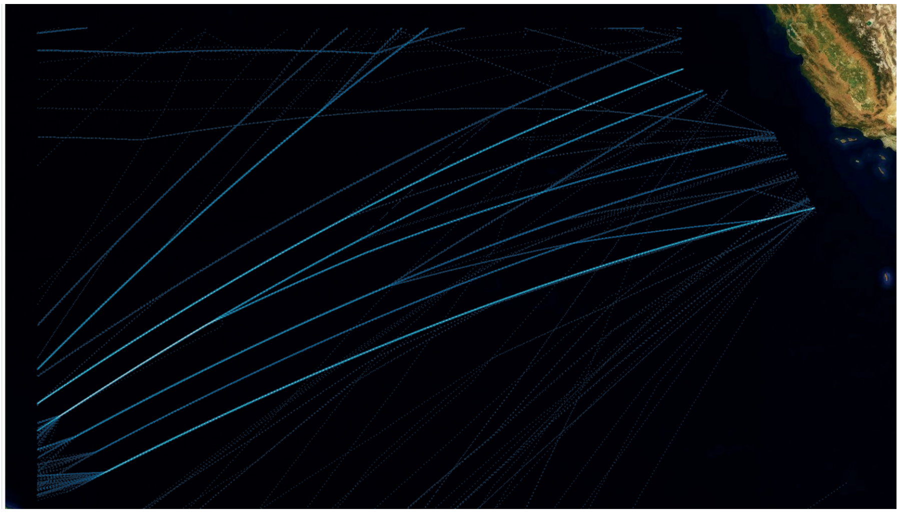
In terrestrial airspace with monopulse secondary surveillance radars (MSSR) or ground-based Automatic Dependent Surveillance-Broadcast (ADS-B) antennas, Air Traffic Controllers (ATC) can see where the aircraft are and communicate with them in real-time. In contrast, air traffic operations in oceanic and remote airspace are conducted according to "procedural" airspace rules, with large traffic separations and rigid route structures in areas where traffic demand is high. In these areas, it is impossible or not feasible to have ground-based surveillance and communication infrastructure and, consequently, the traffic is managed with larger separations that provide higher margins of safety. "Oceanic operations are probably the least efficient operations in the NAS" explains Dr Vitaly Guzhva, Professor at Embry-Riddle Aeronautical University, who worked on modeling oceanic operations with OpenSky-Avia, a provider of aviation research and consulting services to government and commercial customers. The company has expertise in aerospace infrastructure, airport and airspace planning and development services and airport and airspace modelling and simulation.

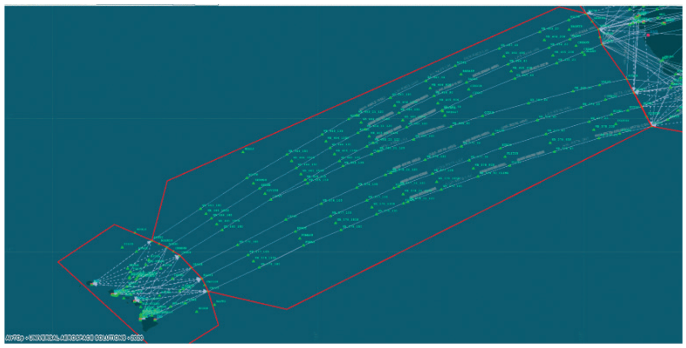
"Large traffic separations in oceanic airspace prevent oceanic flights from reaching the most efficient altitudes and flying the most efficient routes," adds Dr Guzhva. The effect is more pronounced in busy regions, such as North Atlantic, West Atlantic Route System or Central East Pacific routes.

In airspace with real-time surveillance and communication capabilities, the required longitudinal (in-trail) separation between two aircraft is 5 nautical miles en route and 3 nm in Terminal Radar Approach Control (TRACON) airspace. Traffic separations in procedural airspace depend on aircraft equipage and the specifics of the particular airspace. In most US-controlled oceanic airspace, minimum traffic separations are 10 minutes (approximately 80 nm) in trails and 50-60 nm lateral for non-Performance Based Communications and Surveillance (PBCS) traffic, and 30 nm in trail and 30 nm lateral for PBCS traffic.

The ICAO PBCS framework addresses new technologies in navigation, communication, and surveillance and ensures the safety of their implementation and operations. The PBCS framework







Left (figure 1): CEP Routes
Above (figure 2): Traffic heatmap on July 26, 2019
Right (figure 3): Modelled Airspace and Operations

defines Required Navigation Performance (RNP), Required Surveillance Performance (RSP), and Required Communication Performance (RCP). RNP refers to the level of performance required for a specific airspace, air route, or flight procedure and the lateral navigation accuracy is expressed in nautical miles. The expressed accuracy level is expected to be achieved at least 95% of the flight time by the population of aircraft operating within the airspace, route, or procedure (ICAO Performance-based Navigation Manual). RSP refers to surveillance data delivery, which specifies how often (to a maximum number of seconds) the aircraft updates its position with ATC. RCP indicates the maximum number of seconds taken for the controller to issue an instruction to the crew and receive a response.

The standards relevant to the oceanic operations are RNP4 and RNP10, RSP180 and RSP240, and RCP240 and RCP400. To be able to operate in the PBCS airspace, on the PBCS tracks, and with the PBCS separations, an aircraft needs to be RNP4, RSP180, and RCP240 compliant and approved. RNP10, RSP240, and RCP400 aircraft are not PBCS compliant and operate on non-PBCS routes and with non-PBCS separations. For example, FANS1/A would satisfy RNP4, Controller Pilot Data Link Communication (CPDLC) would satisfy RCP240, and Automatic Dependent Surveillance - Contract (ADS-C) would satisfy RSP180 requirements. Besides the equipage, PBCS aircraft should have demonstrated and have statements of compliance for RNP, RSP, and RCP.

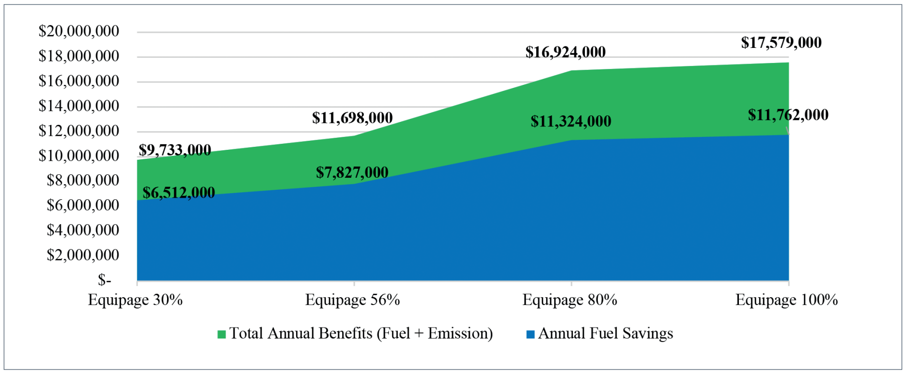
With the emergence of space-based ADS-B, ATS surveillance is now available in areas where it was not previously provided, including oceanic and remote airspace, enabling ANSPs to introduce more fuel and cost-efficient profiles while reducing safety risks. Recognizing the safety benefits of real-time ATS surveillance in oceanic airspace, ICAO recently amended its PANS-ATM, Doc 4444, concerning the separation minima using ATS surveillance systems where Very High Frequency (VHF) voice communication is not available. The new minima are applicable only for a navigation performance of RNP4 or RNP2 and the communication systems that satisfy RCP240. Now, RNP4 and RCP240 aircraft flying in the same direction on the same or crossing tracks can be separated by 17 nm longitudinally and 19 nm laterally. In addition, opposite direction aircraft on reciprocal tracks may be cleared to climb or descend to or through the levels occupied by another aircraft when the aircraft have passed each other by 5 nm.

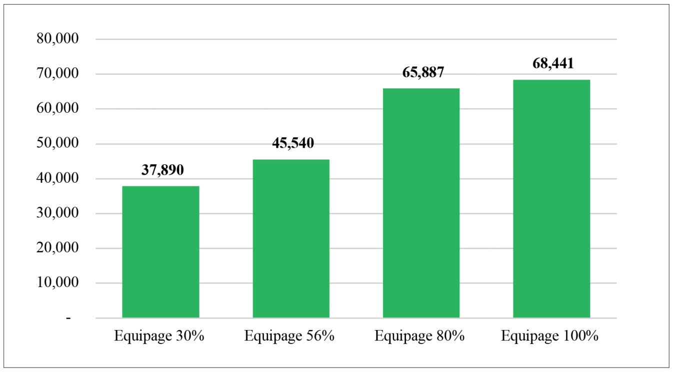
ATS surveillance in oceanic airspace with space-based ADS-B will improve the efficiency and safety of oceanic operations. Ideally, airlines would fly User Preferred Routes (UPRs) with step-climbs to the most efficient altitudes at optimum times. If UPRs are infeasible due to the airspace complexity or traffic equipage mix, ATS surveillance will allow for airspace optimization that may include additional routes to reduce traffic conflicts and improve traffic flow. CEP routes with its heavy US West Coast to Hawaii traffic would be a potential candidate for such an optimization.

CEP flight routes optimization

Seven CEP routes (two bi-directional and five one-directional) handle about 360 flights daily between the US West Coast and Hawaii (figure 1). CEP routes are not used evenly: route occupancy fluctuates depending on traffic mix and wind patterns on a particular day. Also, there are peak periods in both directions: 17-22 UTC for Westbound traffic and 2-6 and 9-12 UTC for Eastbound traffic.

One of the challenges with assessing operational improvements that have not yet been implemented is the lack of before and after operational statistics. In such cases, research is carried out using modeling and simulation to replicate actual and proposed air traffic operations. OpenSky-Avia chose AirTOP from Airtsopsoft, a Transoft Solutions company, to assess CEP routes operations with ATS surveillance. "While all





Above (figure 5): Monetized Benefits in CEP Airspace with Additional Routes
Left (figure 6): Emission Benefits in CEP Airspace with additional routes (tons of CO_2)
Below (figure 4): CEP Airspace with additional routes

simulation tools offer similar functionality, we found that AirTOP is more user-friendly in terms of user interface design and ease of navigation when performing tasks ranging from the import of raw data and constructing the model to data processing and final reporting" explains Frank Cheung, Lead Modeling and Simulation expert at Open-Sky Avia.

"We also found that AirTOP's capabilities are far superior to other similar products that are available on the market. For example, the Conflict Resolution feature, Base of Aircraft Data (BADA) aircraft performance-based fuel burn module, and fully automated reporting features, have allowed us to accomplish all our study objectives and saved our valuable resources on data processing. It is also worth noting that AirTOP's unparalleled technical support ensured any issues we encountered were resolved effectively."

For the purpose of this research, OpenSky-Avia constructed 3 simulation scenarios using AirTOP: (1) Baseline, (2) Alternative 1, and (3) Alternative 2. Under all three scenarios, a 24-hour period of CEP routes operation was modeled using the FAA Traffic Flow Management System (TFMS) schedule for July 26, 2019.

For the baseline, the TFMS schedule was calibrated with the actual flight trajectories using space-based ADS-B data provided by Aireon, the company behind the state-of-the-art oceanic surveillance system. The calibration ensured that OpenSky-Avia's baseline closely matched the actual CEP routes operations on July 26, 2019. In this scenario, current minimum oceanic separations were used: 80/50 nm for non-PBCS traffic and 30/30 for PBCS traffic. figure 2 presents the heatmap of traffic on July 26, 2019.

Alternative 1 assumed ICAO approved separations for oceanic airspace with ATS surveillance: 17/19 nm. Reduced separations allowed for step-climbs to efficient altitudes, due to fewer traffic conflicts, and also resulted in fuel savings. Flights were simulated from origin to destination but the operational statistics were collected and analyzed for the CEP route area only. An AirTOP simulation of this scenario is presented in figure 3.

For Alternative 2, the CEP route operations were modeled with three additional one-directional routes: two westbound routes (R464N and R578N) and one eastbound route (R465N). Route selection was based on the lowest traffic density and the shortest flight time through the CEP and transition areas. Figure 4 presents an AirTOP simulation of Alternative 2 with additional routes.

For all alternatives, four equipage levels were used: 30%, 56%, 80%, and 100% of PBCS traffic. 56% of PBCS traffic represents the FAA forecast for PBCS traffic in Oakland Oceanic airspace in 2021.

For the baseline and both alternatives, the following statistics were collected for CEP routes: fuel burn, time and distance flown, number of successful step climbs, distribution of traffic among CEP routes, and others. Of the many potential ATS surveillance benefits, specific focus was placed on fuel and emission savings. Alternative one produced fuel and emission benefits between $1 and $2.7 million. Study results suggest that the introduction of three additional routes would substantially improve operational efficiency with ATS surveillance in the CEP airspace. As presented in figure 5, monetised annual fuel and emission savings for alternative two are in the range of $10 and $17.6 million per annum for 30% and 100% PBCS equipage, respectively. A pre-pandemic fuel price of $1.60 per gallon and $85 social cost of carbon per metric ton of carbon dioxide were used to monetize the benefits. Also, as presented in figure 6, Alternative 2 produced a reduction in CO2 emissions between 38,000 and 68,000 tons per year depending on the equipage level. "In general, our working experience with AirTOP was excellent and we are planning to continue using the software to model the North Pacific (NOPAC) Route System and assess potential ATS surveillance benefits in that region," concludes Dr Guzhva. ❖