TBFM in the Cloud

Case Study

TBFM in the Cloud

Background

The Time Based Flow Management (TBFM) system is a complex, expensive, safety-critical computer system that runs in air traffic control facilities in the United States. It is used to help traffic management coordinators manage the flow of aircraft within about 200 miles of an airport as planes descend from their cruising altitudes into the busy terminal airspace near an airport. TBFM is an essential tool for managing traffic in the National Airspace with a primary function to maintain safety buffers between aircraft and secondary goals to efficiently use limited airspace capacity and enable flights to fly optimal trajectories into destination airports from a business and environmental standpoint.

Use of the Cloud has allowed commercial and Government systems to leverage the flexibility, scalability, reliability, and security of Cloud infrastructure to achieve significant efficiencies, and rapid innovation, in complex operational environments. The associated move to a micro-services Service Oriented Architecture (SOA) in the Cloud has further enhanced modularity, re-use of system capabilities, and simplification of verification and validation testing.

Through the separation of data management, the move to the Cloud has also expanded the application of advanced analytics to bring additional value to these operations. As the FAA progresses toward the full implementation of the Next Generation Air Transportation System (NextGen), efforts to modernize the technological systems of the National Airspace System (NAS) include research into the potential Cloud deployment of NAS services.

Analysis Approach Diagram
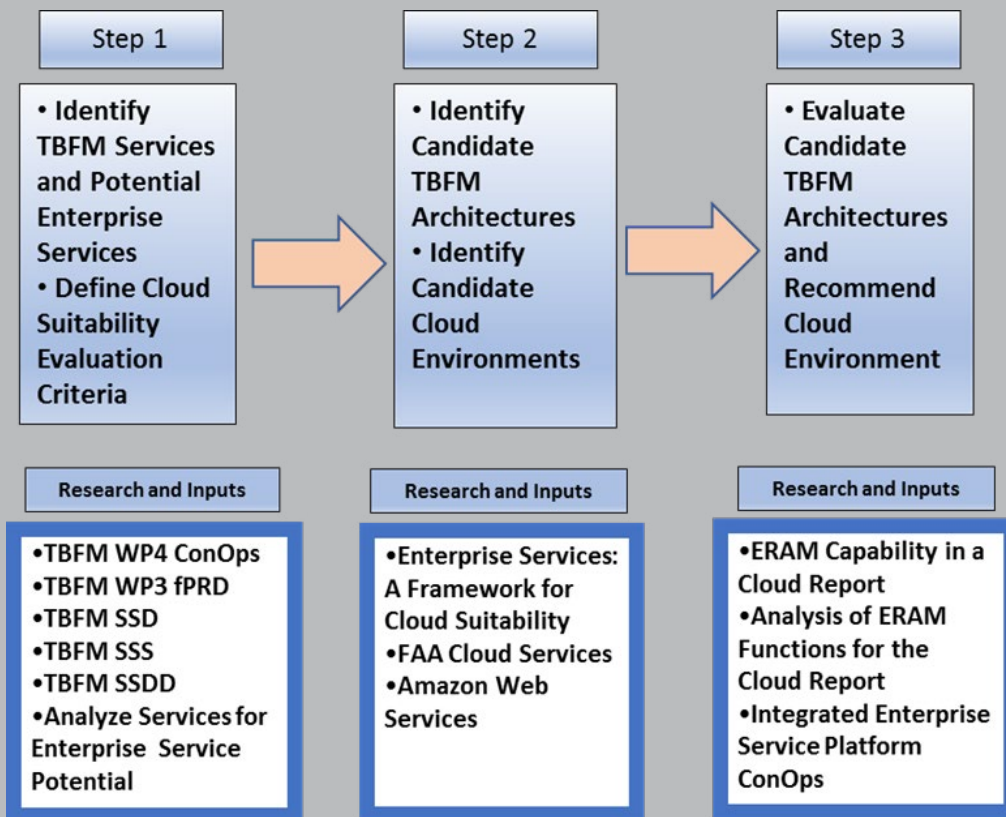
Mosaic's Technical Support

Recognizing the transformative potential of a shift to the Cloud for TBFM, the FAA awarded Mosaic a task order under the SE2025 R&MA contract to conduct a detailed analysis and assessment of potential TBFM functions and subsystems that could be migrated

to the FAA Cloud Services (FCS) environment and could provide reusable enterprise services. Through the application and enhancement of the FAA Enterprise Services Infrastructure Framework (ESIF), Mosaic developed multiple alternative candidate technical architectures for the future of TBFM, considering the decomposition of TBFM functions into individual enterprise services and micro-services, which takes advantage of evolving disciplines and our extensive experience with TBFM. Through Mosaic's service-oriented architecture approach, we designed a standard trajectory generator service usable by En Route Automation Modernization (ERAM), Traffic Flow Management System (TFMS), TBFM, Terminal Flight Data Manager (TFDM), and other systems.

This project included detailed analysis, design, engineering, and integration of component TBFM services into candidate alternative architectures that meet reliability, maintainability, and availability (RMA) requirements, security requirements and provide operational benefit. Also, this analysis addresses current shortfalls, gaps, and limitations of the TBFM system in meeting its intended Operational Improvements (OIs) related to the initial TBO.

Mosaic includes system-of-systems integration and system safety engineering as a core criterion for evaluating TBFM architectures and operational implications of re-hosting TBFM in the Cloud. Considering a move to the Cloud of NAS systems allows the FAA to take advantage of existing and evolving Commercial-off-the-Shelf (COTS) capabilities, such as Cloud infrastructure and Software-as-a-Service delivery models to enhance the supply of NAS capabilities. The enterprise service analysis conducted by Mosaic in this effort focuses on appropriateness and applicability of the Cloud for TBFM from the perspectives of operational impacts, policy, acquisition, safety, staffing and personnel, and industry trends and forecasting of all these considerations over the life of TBFM as an enterprise system.

In this effort, Mosaic conducted a detailed cost analysis of Cloud infrastructure costs associated with each TBFM candidate architecture evaluated in the study. We conducted modeling of TBFM communication/data throughput considering Cloud deployment, analyzed opportunities for cost-saving through elastic provisioning of Cloud infrastructure, and identified potential savings through adoption of COTS monitor and control software to replace 30% to 50% of proprietary software in the TBFM code base that creates excessive expense and dependence for the FAA on code that it does not own.

Hourly Average Arrival Count for Selected TBFM Service Groups
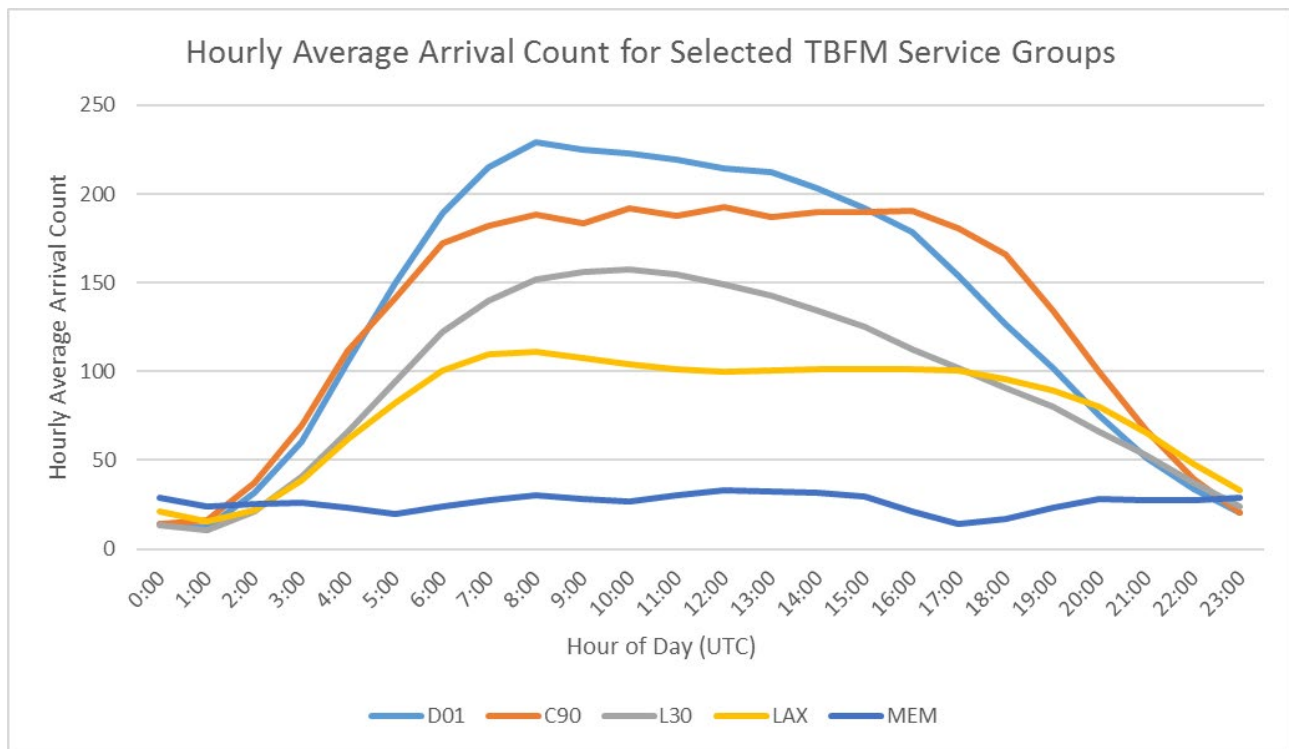
Using Cloud elasticity, virtual servers could be spun-up according to demand

Conclusion

Mosaic determined that cloud-based enterprise services enable increased usage of NAS data and emerging technologies such as, AI, machine learning, and digital twins. The cloud deployment of TBFM services is a viable option concerning security, latency, and RMA issues. The cloud provided elasticity, agility, and cost savings to TBFM and other NAS services.

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