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The growth of global demand for air transportation has put increasing strain on the nations' air traffic management system. To relieve this strain, the International Civil Aviation Organization has urged all nations to adopt Performance-Based Navigation (PBN), which can help to reduce air traffic congestion, decrease aviation fuel consumption, and protect the environment. NASA has developed a Terminal Area Precision Scheduling and Spacing (TAPSS) system that can support increased use of PBN during periods of high traffic, while supporting fuel-efficient, continuous descent approaches. In the original development of this system, arrival aircraft are assigned fuel-efficient Area Navigation (RNAV) Standard Terminal Arrival Routes before their initial descent from cruise, with routing defined to a specific runway. The system also determines precise schedules for these aircraft that facilitate continuous descent through the assigned routes. To meet these schedules, controllers are given a set of advisory tools to precisely control aircraft. The TAPSS system has been evaluated in a series of human-in-the-loop (HITL) air traffic simulations during 2010 and 2011. Results indicated increased airport arrival throughput up to 10% over current operations, and maintained fuel-efficient aircraft decent profiles from the initial descent to landing with reduced controller workload. This paper focuses on results from a joint NASA and FAA HITL simulation conducted in 2012. Due to the FAA rollout of the advance terminal area PBN procedures at mid-sized airports first, the TAPSS system was modified to manage arrival aircraft as they entered Terminal Radar Approach Control (TRACON). Dallas-Love Field airport (DAL) was selected by the FAA as a representative mid-sized airport within a constrained TRACON airspace due to the close proximity of a major airport, in this case Dallas-Ft Worth International Airport, one of the busiest in the world. To address this constraint, RNAV routes and Required Navigation Performance with the particular capability known as Radius-to-Fix (RNP-RF) approaches to a short final were used. The purpose of this simulation was to get feedback on how current operations could benefit with the TAPSS system and also to evaluate the efficacy of the advisory tools to support the broader use of PBN in the US National Airspace System. For this NASA-FAA joint experiment, an Air Traffic Control laboratory at NASA Ames was arranged to simulate arrivals into DAL in Instrument Meteorological Conditions utilizing parallel dependent approaches, with two feeder positions that handed off traffic to one final position. Four FAA controllers participated, alternately covering these three positions. All participants were Full-Performance Level terminal controllers and members of the National Air Traffic Controllers Association. During the simulation, PBN arrival operations were compared and contrasted in three conditions. They were the Baseline, where none of the TAPSS system's TRACON controller decision support advisories were provided, the Limited Advisories, reflecting the existing but dormant capabilities of the current terminal automation equipment with providing a subset of the TAPSS system's advisories; numerical delay, landing sequence, and runway assignment information, and the Full Advisories, with providing the following in addition to the ones in the Limited condition; trajectory slot markers, timelines of estimated times of arrivals and scheduled times of arrivals (STAs), and speed advisories to meet STAs to meter points in the terminal area. The trajectory slot markers are advanced spatial and temporal delay visual cues that are generated for PBN flights. On the controllers' display, the slot markers are rendered to follow the associated flights' PBN routes, meet all published speed and altitude restrictions, and arrive on time at the flights' STAs to the meter points. Key findings from this simulation are the following. First, the TAPSS system has a potential to enable efficient PBN arrival operations within constrained TRACON airspace. Results indicate that with the Full Advisories available in the TAPSS system, the average extra track distance of RNAV arrivals decreased by 36% when compared to the Baseline, and 90% of RNP-RF arrivals stayed on-path as compared to 87% in the Baseline. Second, the TAPSS system has a potential to reduce controllers' communication task load. Results indicate that the average number of voice commands issued to PBN arrivals were reduced by 13% when using the Full Advisories, compared to the Baseline. Third, post-run questionnaires indicated that the study participants found the TAPSS system and its advisories useful. In particular, the participants found the trajectory slot marker most useful among the available advisories. Additional research is expected to further validate the utility of TAPSS system for supporting PBN operations, with different terminal areas and airports. Incorporation of wind conditions, true and forecast, in future simulations is anticipated.