INTISARI

Padatnya pergerakan lalu lintas penerbangan di suatu ruang udara berpotensi menimbulkan masalah pada efisiensi dan keselamatan penerbangan, sehingga ICAO telah mencanangkan penerapan *Performance Based Navigation* (PBN) dalam metode navigasi. Salah satu spesifikasi navigasi dalam penerapan PBN adalah *Area Navigation* (RNAV). Bandara Internasional I Gusti Ngurah Rai telah menerapkan RNAV-1 pada prosedur penerbangan kedatangan atau *Standard Instrument Arrival* (STAR) di wilayah ruang udara *Terminal Maneuvering Area* (TMA) sejak tahun 2013. Tujuan penerapan RNAV-1 yaitu untuk mengendalikan kompleksitas lalu lintas kedatangan, mencapai *Continuous Descent Operation* (CDO), serta mengurangi beban kerja *Air Traffic Controller* (ATC) dengan mengurangi jumlah komunikasi yang dilakukan kepada pilot. Namun dengan kompleksitas arus lalu lintas kedatangan yang semakin meningkat, menyebabkan tujuan tersebut belum tercapai secara optimal. Teknik pengaturan *radar vector* masih sering dilakukan petugas ATC *Approach* dalam mengendalikan lalu lintas kedatangan saat *peak hour*, sehingga meningkatkan jumlah komunikasi petugas ATC. Tujuan penelitian ini adalah untuk menganalisis tingkat beban kerja petugas ATC *Approach* pada penerapan prosedur STAR saat ini, dan apakah konsep *Point Merge System* dapat diterapkan di wilayah TMA Bandara Internasional I Gusti Ngurah Rai.

Metode analisis regresi linear berganda digunakan untuk menganalisis pengaruh beban kerja dimensi eksternal dan iklim kerja terhadap stres kerja petugas ATC, yang menggunakan data hasil survei wawancara dengan 46 petugas ATC. Analisis tingkat beban kerja dimensi internal juga dilakukan dengan metode NASA-TLX, dan selanjutnya dilakukan analisis regresi linear sederhana, untuk menganalisis hubungan jumlah instruksi yang dilakukan oleh petugas ATC terhadap beban kerja dimensi internal pada penerapan prosedur STAR saat ini. Setelah dilakukan analisis beban kerja petugas ATC, maka dilakukan perancangan konsep desain *Point Merge System* pada prosedur penerbangan kedatangan di wilayah TMA Bandara Internasional I Gusti Ngurah Rai, dengan menggunakan data sekunder, yaitu persentase pergerakan lalu lintas kedatangan, penggunaan *runway*, dan data aeronautika bandara. Selanjutnya dilakukan simulasi pada *Real Time Simulator* ATC, menggunakan data volume lalu lintas kedatangan tertinggi berdasarkan hasil survei pada jam sibuk di Bandara Internasional I Gusti Ngurah Rai.

Hasil analisis menunjukkan bahwa rata-rata beban kerja dimensi eksternal petugas ATC saat ini berat, dan berpengaruh sebesar 86,7% terhadap stres kerja petugas ATC. Selain itu, rata-rata beban kerja dimensi internal petugas ATC saat ini tinggi, dan jumlah komunikasi yang merupakan kebutuhan tugas dari aktivitas petugas ATC berpengaruh sebesar 65%. Pada hasil analisis simulasi, didapat bahwa konsep *Point Merge System* dapat diterapkan pada prosedur STAR di wilayah TMA Bandara Internasional I Gusti Ngurah Rai. Berdasarkan simulasi skenario 1 yang dilakukan berdasarkan volume lalu lintas kedatangan tertinggi dari hasil survei, yaitu pada tanggal 22 September 2019, dengan jumlah 27 pesawat, didapat penurunan rata-rata waktu tempuh penerbangan *(flying time)* sebesar 32%. Sedangkan simulasi skenario 2 dengan volume lalu lintas kedatangan pada tanggal 26 Desember 2019, yaitu 32 pesawat, didapat penurunan *flying time* sebesar 8%. Selain itu, jumlah komunikasi yang dilakukan petugas *Terminal West Controller* berkurang sebesar 27%, dan 46% pada *Terminal East Controller*.

Kata Kunci: *Point Merge System*, beban kerja, NASA-TLX, *Real Time Simulator*

ABSTRACT

The dense movement of air traffic in an airspace has potential problems in flight efficiency and safety, thus ICAO launched the implementation of Performance Based Navigation (PBN) in the navigation method. One of the navigation specification in implementing PBN is Area Navigation (RNAV). I Gusti Ngurah Rai International Airport has implemented RNAV-1 in flight procedure Standard Instrument Arrival (STAR) in the Terminal Maneuvering Area (TMA) airspace since 2013. The purpose of implementing RNAV-1 is to control the complexity of arrival air traffic, achieving Continuous Descent Operation (CDO), and ease the workload of Air Traffic Controller (ATC) by reducing the amount of communication between ATC and Pilot. with the increasing complexity of traffic flow arrivals, causing the purposes have not been attained optimally. The radar vector control technique is still often performed by ATC Approach in controlling arrival traffic during peak hours, thereby increasing the number of controller' communications. This study aims to analyze the workload level of ATC Approach on the current implementation of STAR procedures, and analyze if Point Merge System concept could be implemented in the TMA airspace of I Gusti Ngurah Rai International Airport.

The method of multiple linear regression analysis was used to analyze the strength of the effect of external dimension workload and work climate on work stress of ATC, using data based on the result of interview with 46 controllers. Internal dimension of workload analysis was also carried out by NASA-TLX method, and then a simple linear regression analysis was conducted, to analyze the relationship between the number of instructions of ATC and the internal dimension workload in implementation of current arrival flight procedure. After analyzing the workload of ATC, the concept of point merge system on arrival flight procedure at TMA airspace of I Gusti Ngurah Rai International Airport was designed. The design using secondary data, namely the percentage of arrival air traffic, runway in use, and the airport aeronautical data. Subsequently simulation of the concept design was conducted in ATC Real Time Simulator, using the highest arrival air traffic volume data based on the survey result during peak hour at I Gusti Ngurah Rai International Airport.

The result of the analysis showed that the average of external dimension workload of ATC is currently in ‘Heavy’ level, and has an influence of 86,7% on the work stress of ATC. The average of internal dimension workload of ATC also currently in ‘High’ level, and it has influential as much as 65% by the number of instructions as the task demand of controller’s activity. In the simulation analysis results, it obtained that the concept of Point Merge System can be applied to STAR procedure in the TMA airspace of I Gusti Ngurah Rai International Airport. Based on scenario 1 simulation which has 27 arrival flights on September 22nd 2019, a 32% decrease in average flying time was obtained. While the simulation scenario 2 which has 32 arrival flights on December 25th 2019, obtained a reduction in flying time by 8%. In addition, the number of communications of Air Traffic Controller is decreased, which is the number of instructions of Terminal West Controller was reduced by 27%, and 46% at Terminal East Controller.

Keywords: Standard Instrument Arrival, RNAV, Point Merge System, workload, Real Time Simulator