

Industri perkeretaapian Indonesia berkembang pesat melalui perluasan jaringan rel dan adopsi teknologi *modern*. Otomatisasi kereta, dari manual hingga otomatis penuh, ditunjukkan melalui *Grade of Automation* (GoA). GoA 3 merupakan salah satu tingkat otomatisasi beroperasi tanpa masinis, dengan peran manusia terbatas pada pemantauan dan penanganan darurat. Sistem ini telah diterapkan pada LRT Jabodebek yang menjadi objek penelitian terkait efisiensi, keandalan, dan rekomendasi pengembangan lebih lanjut.

Penelitian ini menggunakan pendekatan kuantitatif dengan metode *Data Envelopment Analysis* (DEA), melalui dua model yaitu *Variable Return to Scale* (VRS) dan *Constant Return to Scale* (CRS). variabel *Input* yang dianalisis meliputi jumlah *trainset*, frekuensi perjalanan LRT, *dwell time*, kecepatan operasional, jumlah stasiun, dan jarak antar stasiun. *Output* yang digunakan adalah volume penumpang dan waktu tempuh. Evaluasi keandalan dilakukan melalui *on time performance* (OTP) dan kesesuaian *headway* perencanaan dengan realisasi. Hasil analisis efisiensi dan keandalan menjadi dasar rekomendasi peningkatan layanan LRT Jabodebek.

Hasil penelitian menunjukkan bahwa seluruh jalur operasional Bekasi *Line* dan Cibubur *Line* telah mencapai efisiensi teknis sempurna dengan nilai efisiensi 1 pada model CRS dan VRS. Pada analisis *benchmarking* pada model CRS dan VRS adanya potensi peningkatan volume penumpang sebesar 26,48% tanpa penambahan *input*. Selain itu, analisis proyeksi pada model CRS dan VRS menunjukkan ada potensi penyesuaian *input* dengan penyesuaian frekuensi perjalanan tertinggi terbesar -17,75% (CRS) dan -12,73% (VRS). Penyesuaian jumlah *trainset* tertinggi sebesar -12,98% (CRS) dan -10% (VRS) serta penyesuaian peningkatan volume penumpang tertinggi sebesar 10,47%. Temuan ini menunjukkan bahwa optimalisasi operasional masih dapat dilakukan untuk meningkatkan kinerja layanan LRT Jabodebek. Hasil dari evaluasi keandalan layanan menunjukkan tidak ada perbedaan signifikan antara *headway* perencanaan dan realisasi. Hasil ini diperkuat dengan analisis *On Time Performance* (OTP) yang menunjukkan rata-rata ketepatan waktu keberangkatan sebesar 99,18% dan rata-rata ketepatan waktu kedatangan sebesar 99,08%. Angka ini menunjukkan bahwa operasional LRT Jabodebek telah berjalan sesuai jadwal dan keandalan layanan operasional dapat dikategorikan sangat baik. Temuan ini menjadi dasar dalam merumuskan strategi pengembangan sistem transportasi yang lebih efisien dan andal dalam jangka panjang.

Kata Kunci: GoA 3, LRT Jabodebek, Efisiensi, DEA, Keandalan.

ABSTRACT

Indonesia's railway industry is growing rapidly through the expansion of rail networks and the adoption of modern technology. Train automation, from manual to fully automated, is indicated through Grade of Automation (GoA). GoA 3 is one level of automation operating without a driver, with the role of humans limited to monitoring and emergency handling. This system has been applied to LRT Jabodebek which is the object of research related to efficiency, reliability, and further development recommendations.

This research uses a quantitative approach with the Data Envelopment Analysis (DEA) method, through two models namely Variable Return to Scale (VRS) and Constant Return to Scale (CRS). Input variables analyzed include the number of trainsets, LRT travel frequency, dwell time, operational speed, number of stations, and distance between stations. The outputs used are passenger volume and travel time. Reliability evaluation is done through on time performance and headway conformity planning with realization. The results of the efficiency and reliability analysis are the basis for recommendations for improvement of LRT Jabodebek services.

The results showed that all Bekasi Line and Cibubur Line operational lines have achieved perfect technical efficiency with an efficiency value of 1 in the CRS and VRS models. In the benchmarking analysis in the CRS and VRS models, there is a potential increase in passenger volume of 26.48% without additional inputs. In addition, the projection analysis in the CRS and VRS models shows that there is potential for input adjustments with the highest trip frequency adjustment of -17.75% (CRS) and -12.73% (VRS). The highest trainset number adjustment was -12.98% (CRS) and -10% (VRS) and the highest passenger volume increase adjustment was 10.47%. These findings indicate that operational optimization can still be done to improve LRT Jabodebek service performance. The results of the service reliability evaluation show that there is no significant difference between the planning and realization headways. This result is reinforced by the On Time Performance (OTP) analysis which shows an average departure punctuality of 99.18% and an average arrival punctuality of 99.08%. This figure shows that LRT Jabodebek operations have run according to schedule and the reliability of operational services can be categorized as very good. These findings form the basis for formulating strategies for developing a more efficient and reliable transportation system in the long term.

Keywords: GoA 3, LRT Jabodebek, Efficiency, DEA, Reliability.