

INTISARI

Unmanned Aerial Vehicle (UAV) kini menjadi salah satu terobosan penting dalam dunia survei dan pemetaan karena mampu mengumpulkan data spasial dengan cepat, efisien, serta aman dibandingkan metode konvensional. Dalam industri pertambangan, UAV banyak dimanfaatkan untuk memantau kondisi tambang, menghitung volume galian, hingga mendukung perencanaan operasional. Di sisi lain, *Terrestrial Laser Scanner* (TLS) selama ini tetap menjadi standar acuan utama berkat akurasi yang tinggi, meskipun membutuhkan waktu lebih lama, biaya lebih besar, dan tenaga kerja yang lebih banyak. Namun demikian informasi mengenai ketelitian vertikal DTM dan volume hasil UAV masih terbatas, apalagi jika dibandingkan dengan metode TLS. Oleh karena itu penelitian ini bertujuan mengevaluasi ketelitian vertikal DTM dan volume hasil akuisisi UAV terhadap hasil akuisisi TLS.

Penelitian ini dilakukan di area disposal PT Bukit Makmur Mandiri Utama (BUMA) *site* Adaro Tutupan. Data UAV diperoleh melalui akuisisi foto udara menggunakan JOUAV CW-007 dengan tiga sesi penerbangan dalam satu hari, sedangkan data TLS, *Ground Control Point* (GCP) sebanyak 9 titik yang telah disediakan dari perusahaan. Tahapan penelitian meliputi pengolahan foto udara menggunakan perangkat lunak Agisoft yang meliputi georeferensi menggunakan sembilan GCP, pembentukan *dense cloud*, selanjutnya pembentukan *Digital Terrain Model* (DTM). Pengambilan sampel vertikal pada DTM dan perhitungan volume dengan metode triangulasi perhitungan prisma menggunakan perangkat lunak Surpac. Pengambilan sampel koordinat dan volume dibagi menjadi tiga area yang diklasifikasikan berdasarkan ketinggian. Analisis dilakukan dengan uji statistik t-tabel berpasangan pada sampel ketinggian disposal. Sementara itu, standar toleransi perbedaan volume disposal mengacu pada standar *American Society for Testing and Material*.

Hasil penelitian menunjukkan bahwa hasil perbandingan ketelitian vertikal DTM hasil akuisisi UAV terhadap TLS memperlihatkan adanya perbedaan pada setiap area ketinggian, dan uji statistik t-tabel menunjukkan bahwa perbedaan tersebut signifikan. Meski demikian, perhitungan volume UAV hanya memiliki selisih kurang dari 2,78% terhadap TLS, yang masih berada dalam batas toleransi standar ASTM. Dengan demikian UAV dapat dijadikan alternatif efektif dalam kegiatan monitoring tambang terutama dalam perhitungan volume.

Kata kunci: *Unmanned Aerial Vehicle*, *Terrestrial Laser Scanner*, *Digital Terrain Model*, Ketelitian Vertikal, Volume

ABSTRACT

The Unmanned Aerial Vehicle (UAV) has become one of the most significant breakthroughs in the field of surveying and mapping due to its ability to collect spatial data rapidly, efficiently, and safely compared to conventional methods. In the mining industry, UAVs are widely utilized to monitor mine conditions, calculate excavation volumes, and support operational planning. On the other hand, the Terrestrial Laser Scanner (TLS) has long remained the primary reference standard because of its high accuracy, although it requires longer acquisition time, higher costs, and greater manpower. However, information regarding the vertical accuracy of Digital Terrain Models (DTM) and volume results derived from UAV data is still limited, particularly when compared with the TLS method. Therefore, this study aims to evaluate the vertical accuracy of DTM and volume obtained from UAV acquisition against those derived from TLS acquisition.

This study was conducted in the disposal area of PT Bukit Makmur Mandiri Utama (BUMA) at the Adaro Tutupan site. UAV data were acquired through aerial image acquisition using a JOUAV CW-007 with three flight sessions conducted within a single day, while TLS data, nine Ground Control Points (GCPs) were provided by the company. The research stages included aerial image processing using Agisoft software, which involved georeferencing with nine GCPs, dense cloud generation, and subsequent Digital Terrain Model (DTM) construction. Vertical sampling on the DTM and volume calculation were carried out using the triangulated prism method in Surpac software. Coordinate and volume sampling were divided into three areas classified based on elevation. Statistical analysis was performed using a paired t-test on the disposal elevation samples. Meanwhile, the tolerance standard for disposal volume differences refers to the American Society for Testing and Materials standard.

The results indicate that the comparison of vertical accuracy between UAV and TLS reveals differences across each elevation area, and the paired t-test shows that these differences are statistically significant. Nevertheless, the UAV-derived volume differs by less than 2.78% compared to TLS, which remains within the ASTM tolerance limits. Therefore, UAVs can be considered an effective alternative for mining monitoring activities, particularly for volume calculation purposes.

Keywords: *Unmanned Aerial Vehicle, Terrestrial Laser Scanner, Digital Terrain Model, Vertical Accuracy, Volume*