

APPENDIX H: ANALYSIS OF AIRCRAFT PROJECTED AREA

Appendix H provides an overview of the analysis performed by New Mexico State University (NMSU) of the projected aircraft for each of the three intruder aircraft used during the A46 Flight Testing. During the initial flight testing at NMSU, a CTLS Light Sport aircraft was utilized, and for the final flight testing at Kansas State University (KSU), a Cessna 172 Skyhawk and a Cirrus Design SR20 were operated. The following steps were taken to calculate the projected area of each aircraft.

- 1) Researchers procured a graphic of each aircraft with measurements in three orientations (front, side, and top);
- 2) A grid overlay with known dimensions was placed over each aircraft in three orientations (front, side, and top);
- 3) Blocks with at least 50% overlay of the aircraft were identified;
- 4) The number of each blocks were counted;
- 5) Calculate.

For example, Figure 1 depicts Step 1 of the process with a compilation of all three views of the NMSU CTLS along with measurements. Figure 2 is the side profile view of the CTLS with measurements for reference, and Figure 3 demonstrates Step 2, where a grid with known dimensions is placed over the aircraft. Step 3 is shown in Figure 4, where the green shaded boxes represent where a grid square is filled at least 50% with the aircraft overlay. The number of green shaded blocks in Figure 4, is 1,126 blocks with a known block size of 2.71 inches square or 7.34in²; thus, the CTLS has a projected area of 8,269.46in² or 57.43ft². A comparison of the projected areas of all three aircraft is shown in Table 1.



NMSU's CTLS Light Sport Aircraft

<http://flightdesignusa.com/wp-content/gallery/specifications/ctls-isa-inch-2.jpg>

Figure 1. NMSU's CTLS Light Sport Aircraft pictures used for Projected Area Assessment.

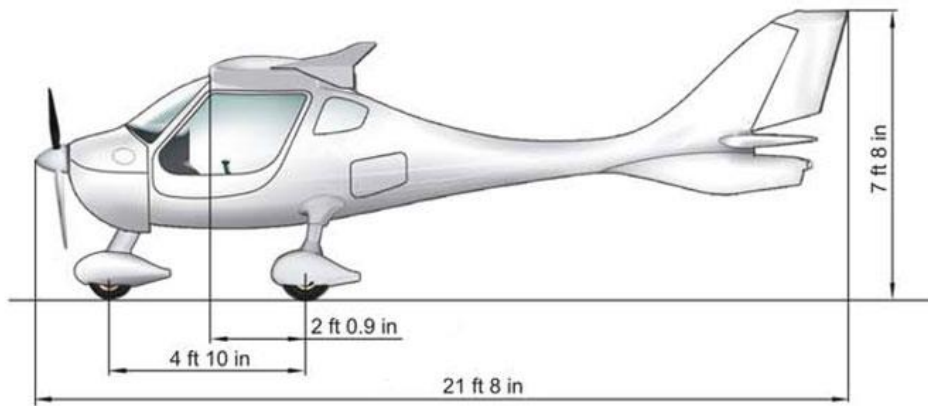


Figure 2. Side View of CTLS.

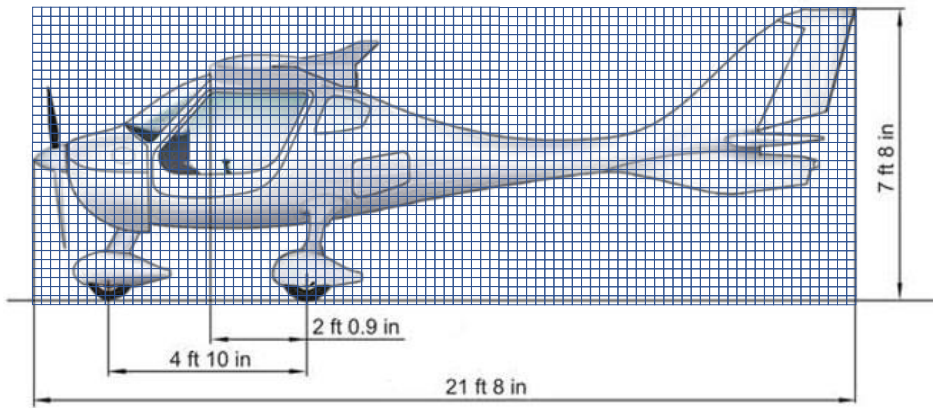


Figure 3. Grid Overlay of Side View of the CTLS.

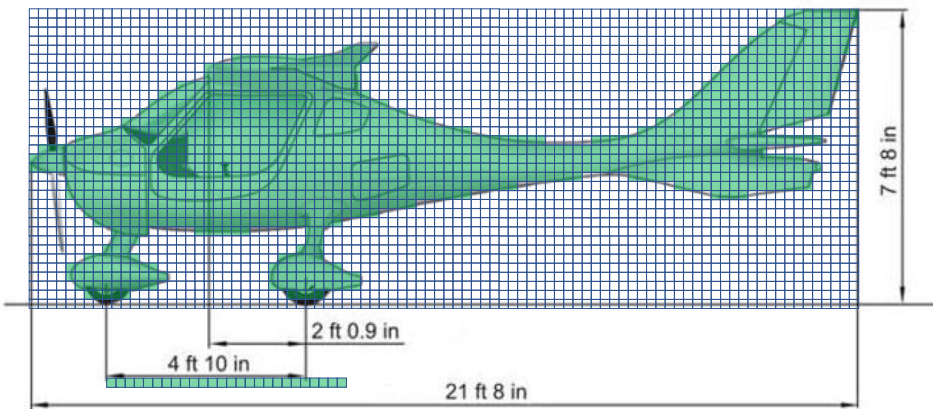


Figure 4. CTLS Side View Overlay with Estimated Area.



Figure 5. Front View of CTLS.

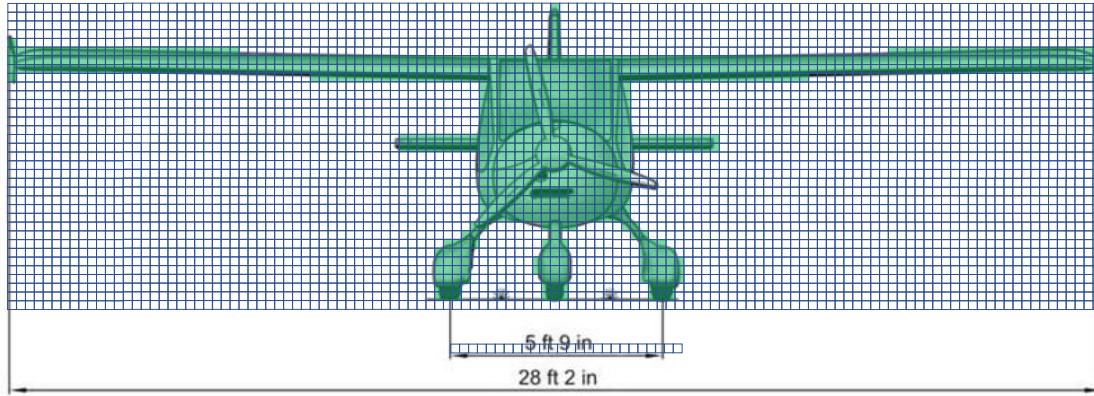


Figure 6. CTLS front view grid overlay with estimated areas.

The front view of the CTLS shown in Figure 6 has a total of 762 shaded blocks. Each block in this figure is 2.91 inches square or 8.47in^2 , resulting in a projected area of $6,452.69\text{in}^2$ or 44.81ft^2 . All blocks for the front view use a block dimension of 2.91 inches square or 8.47in^2 . From the front view of the aircraft, the wings have a total of 305 shaded blocks, with a projected area of $2,582.77\text{in}^2$ or 17.94ft^2 . The body of the aircraft is 327 blocks, with a projected area of $2,769.07\text{in}^2$ or 19.23ft^2 . The tail of the CTLS is 44 blocks, each totaling 8.47in^2 , resulting in a projected area of 372.60in^2 or 2.59ft^2 . The landing gear for the CTLS totals 86 blocks, with a projected area of 728.26in^2 or 5.06ft^2 .

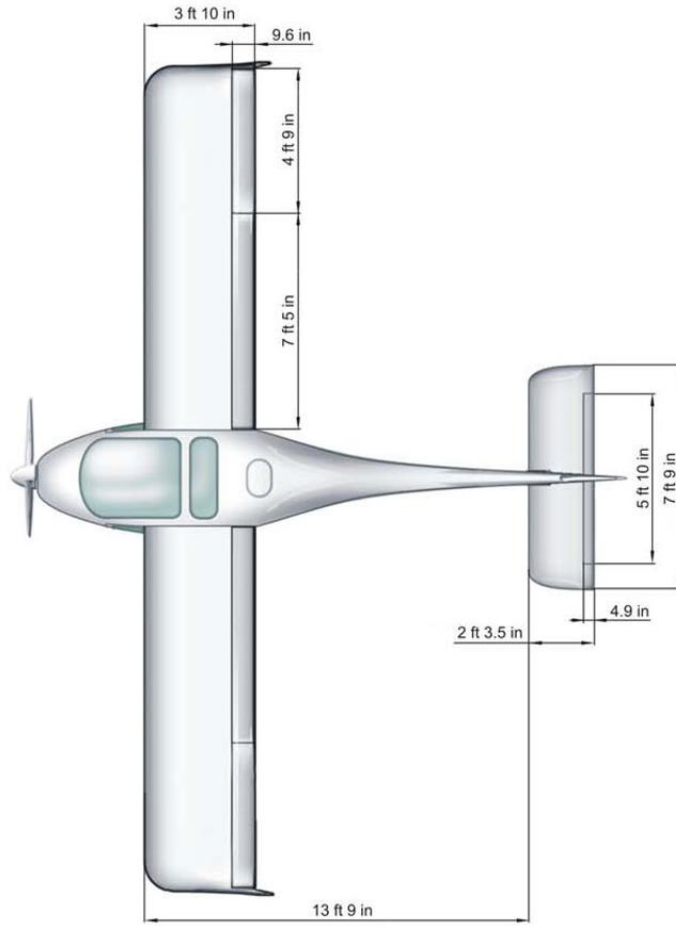


Figure 7. Top view of the CTLS used for projected area assessment.

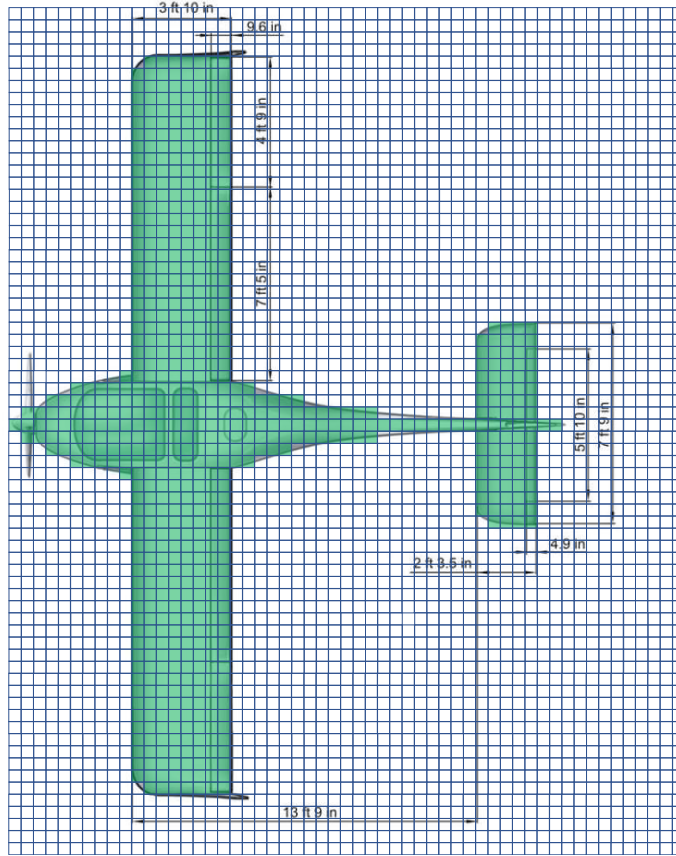


Figure 8. CTLS Top view grid overlay with estimated areas.

The top view of the CTLS shown in Figure 8 totals 684 shaded blocks. Each block in this figure is 5.64 inches square or 31.81in^2 , resulting in a projected area of $21,757.77\text{in}^2$ or 151.10ft^2 .

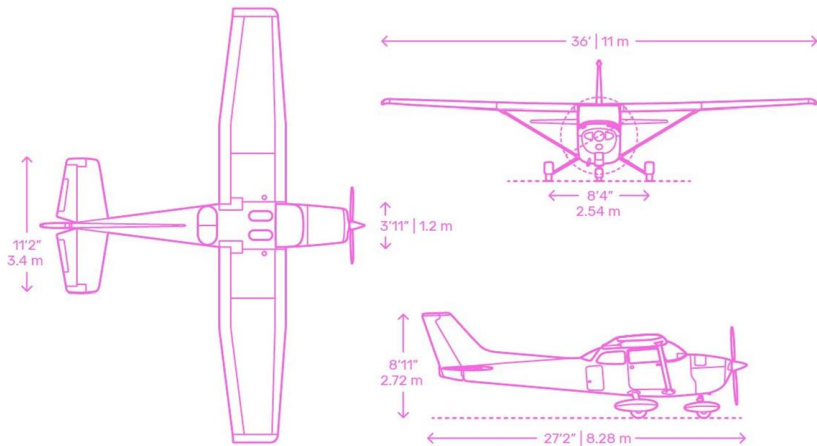


Figure 9. Cessna 172 Skyhawk pictures used for projected area assessment.

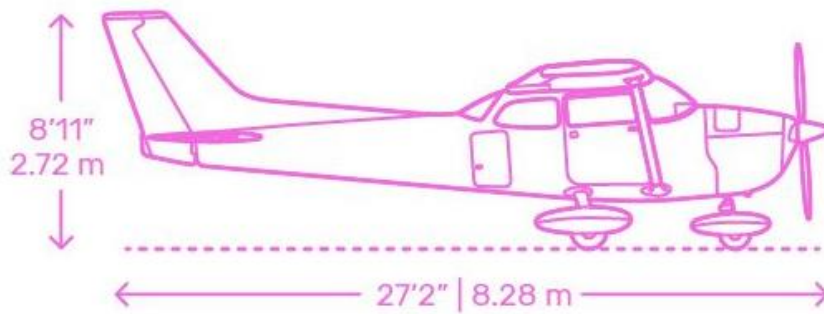


Figure 10. Side view of Cessna 172 Skyhawk.

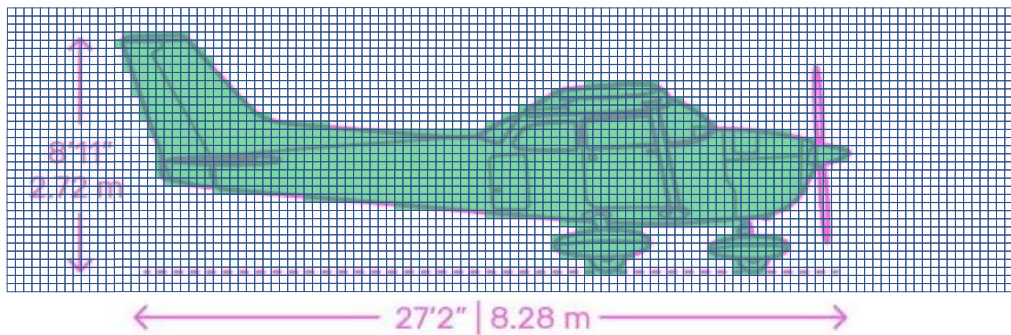


Figure 11. Cessna 172 Skyhawk grid overlay with estimated areas.

Figure 11 depicts the side view of the Cessna 172 Skyhawk with 1,157 shaded blocks. Each block is 3.684 inches square or 13.57in^2 resulting in a projected area of $15,702.64\text{in}^2$ or 109.05ft^2 .

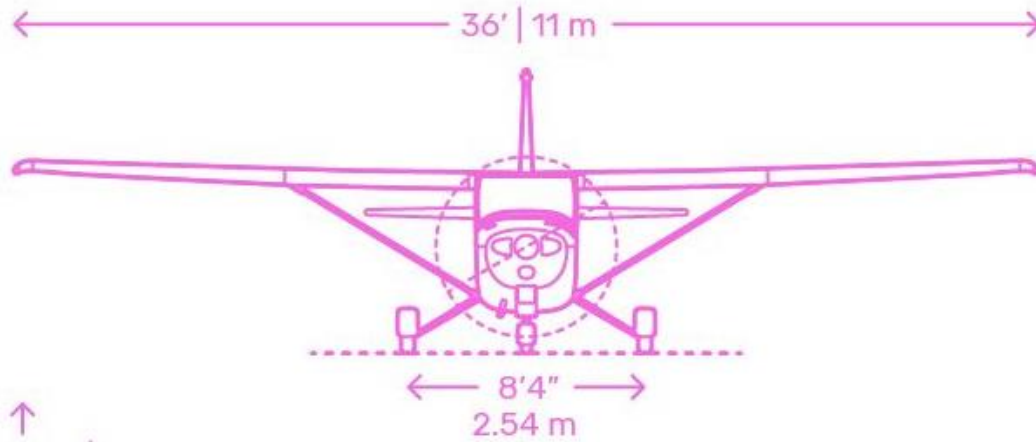


Figure 12. Front View of Cessna 172 Skyhawk.

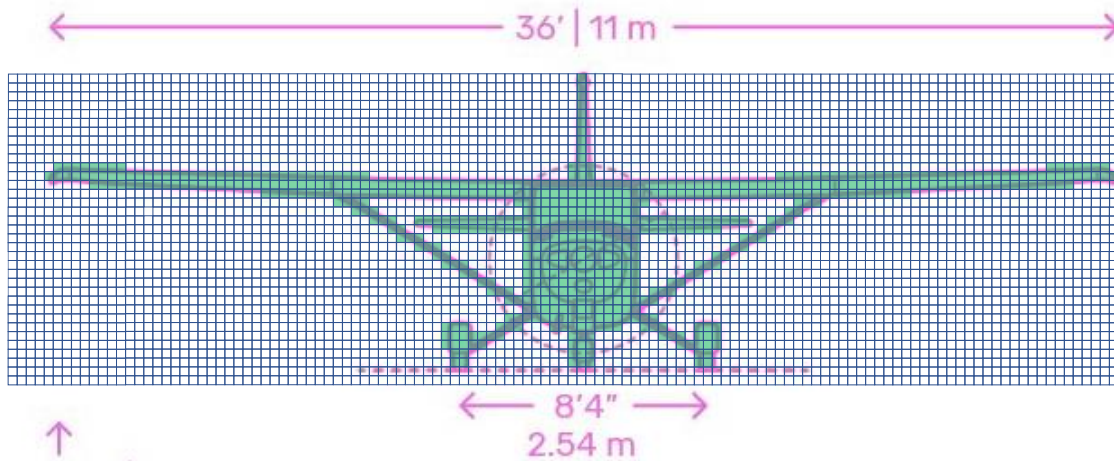


Figure 13. Cessna 172 Skyhawk front view grid overlay with estimated areas.

The front view of the Cessna 172 Skyhawk in Figure 13 has a total of 652 blocks. Each block in this figure is 3.646 inches square or 13.29in^2 , resulting in a projected area of $8,667.24\text{in}^2$ or 60.19ft^2 . All the calculations for the front view of the Cessna 172 Skyhawk were performed using the 3.646 inches square or 13.29in^2 dimensions. The wings and the struts totaled 318 blocks with a projected area of $4,227.27\text{in}^2$ or 29.36ft^2 . The body of the aircraft is 214 blocks with a projected view of $2,844.77\text{in}^2$ or 19.76ft^2 . The tail of the aircraft has a projected view of 784in^2 or 5.45ft^2 , based on 59 blocks. The landing gear of the Cessna 172 Skyhawk is 59 blocks, producing a projected area of 810.89in^2 or 5.63ft^2 .

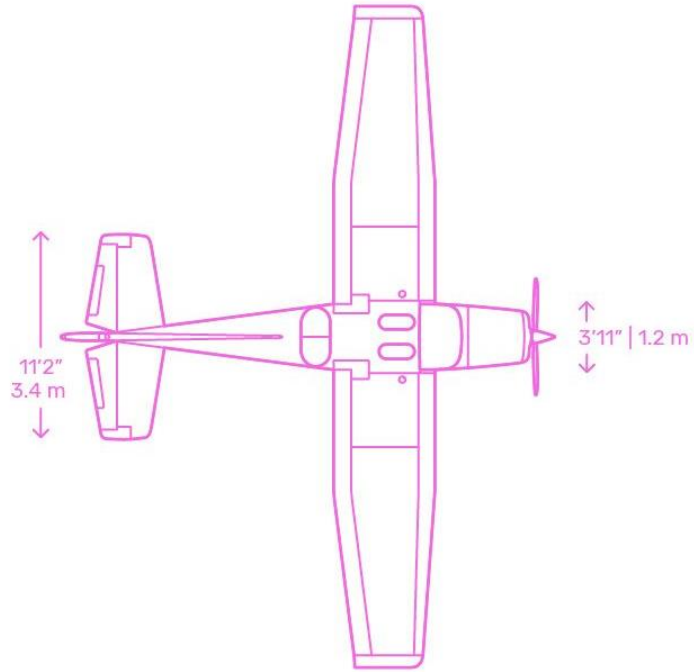


Figure 14. Top View of Cessna 172 Skyhawk.

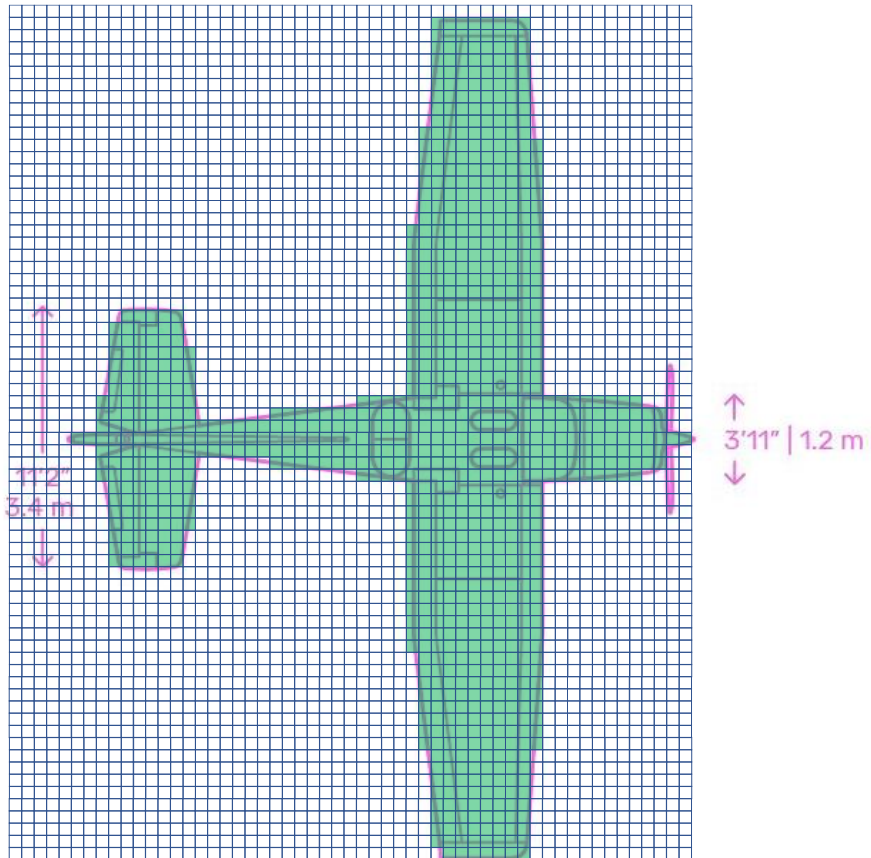


Figure 15. Cessna 172 Skyhawk top view grid overlay with estimated areas.

Figure 15 portrays the top view of the Cessna 172 Skyhawk with 984 shaded blocks. Each block is 6.261 inches square or 39.2in², resulting in a projected area of 38,572.92in² or 267.87ft².

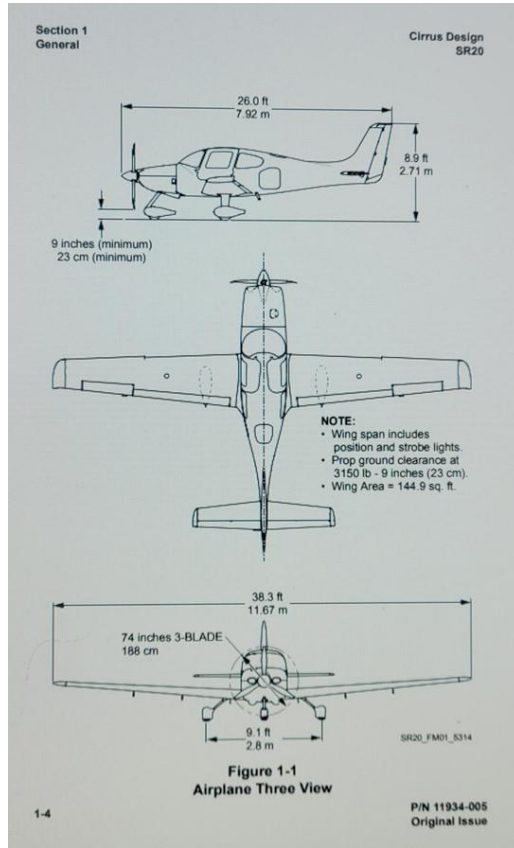


Figure 16. Cirrus Design SR20 used for projected area assessment.

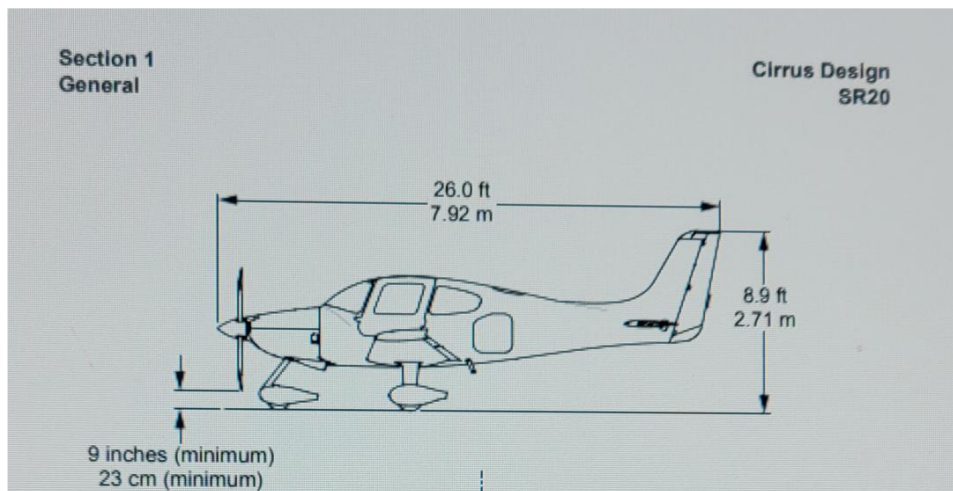


Figure 17. Side View of Cirrus Design SR20.

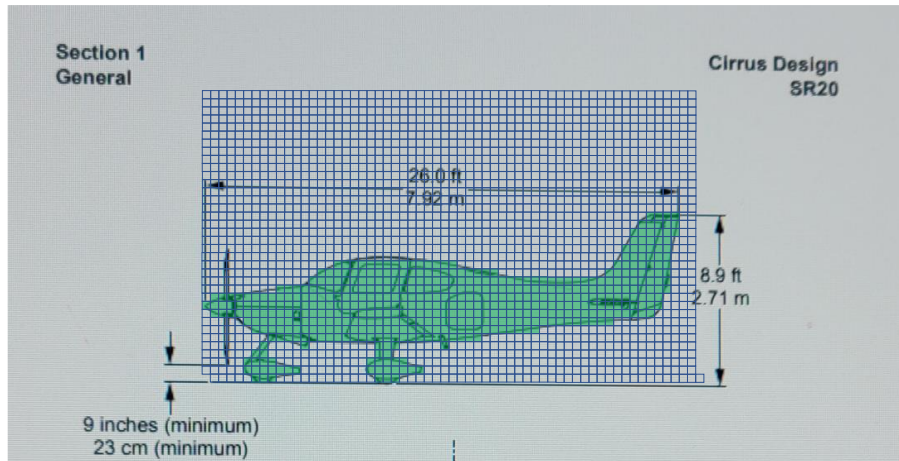


Figure 18. Cirrus Design SR20 side view grid overlay with estimated areas.

Figure 18 displays the Cirrus Design SR20 side view totaling 486 blocks. Each block is 5.47 inches square or 29.92in^2 for a projected view of $14,541.56\text{in}^2$ or 100.98ft^2 .

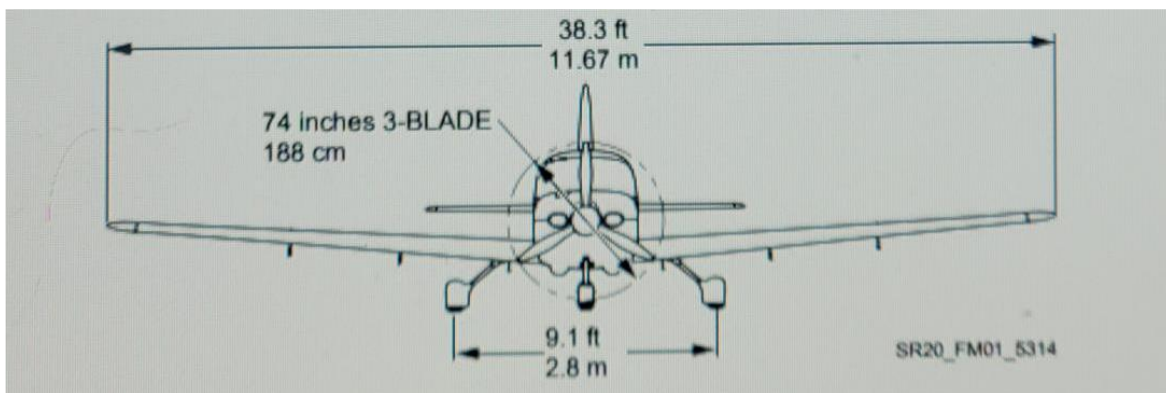


Figure 19. Front View of Cirrus Design SR20.

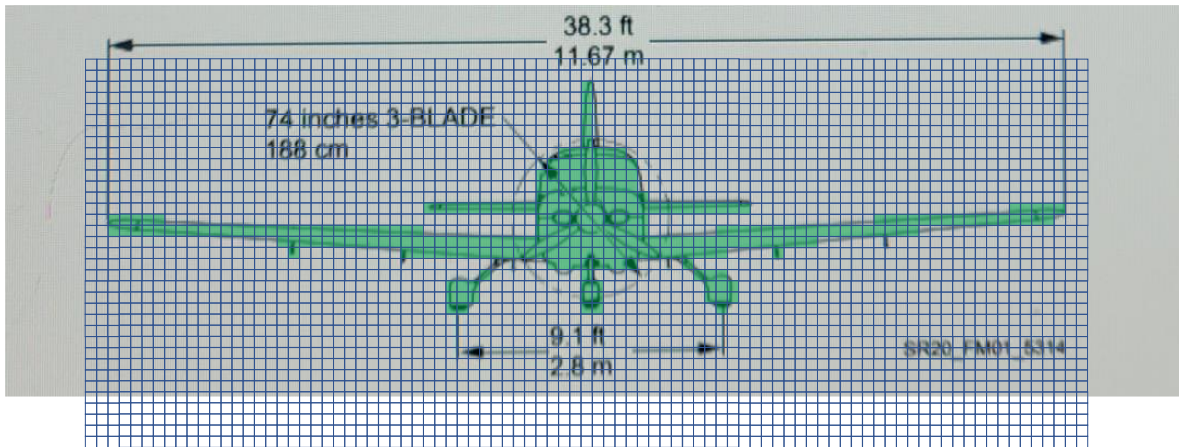


Figure 20. Cirrus Design SR20 front view grid overlay with estimated areas.

The front view of the Cirrus Design SR20, shown in Figure 20, totals 284 blocks. Each block represents 5.41 inches square or 13.29in^2 , resulting in a projected area of $8,312.14\text{in}^2$ or 57.72ft^2 . For all front view projected area calculations, the block dimensions used are 5.41 inches square or 29.27in^2 . The wings and struts total 129 blocks for a projected area of $3,775.58\text{in}^2$ or 26.22ft^2 . The body of the SR20 totals 102 blocks with a projected area of $2,985.35\text{in}^2$ or 20.73ft^2 . The SR20's tail is 25 blocks, making a projected area of 731.70in^2 or 5.08ft^2 . The landing gear is 28 blocks with a projected area of 819.51in^2 or 5.69ft^2 .

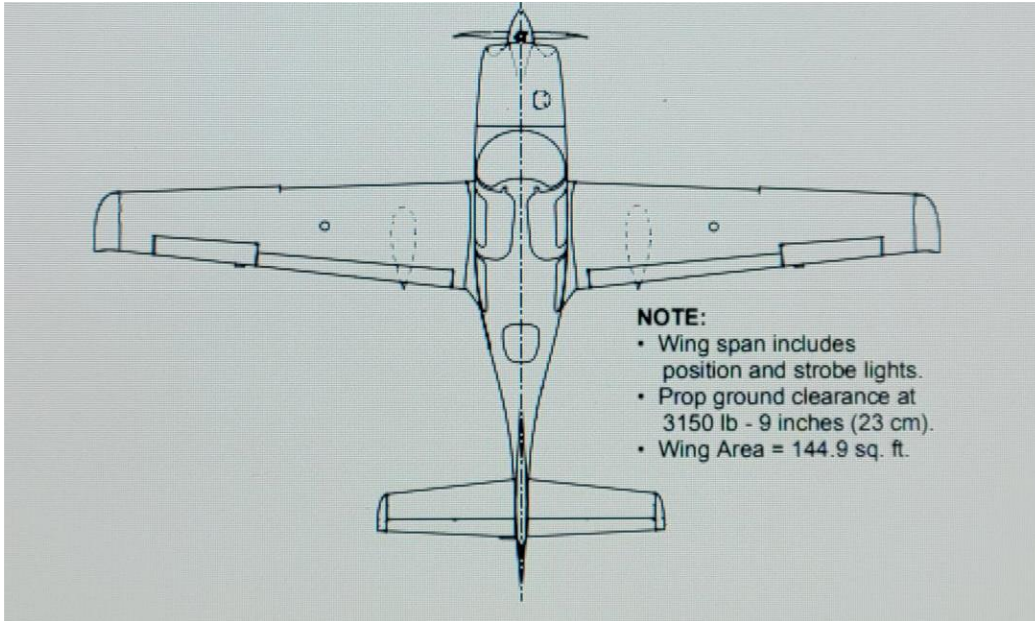


Figure 21. Front View of Cirrus Design SR20.

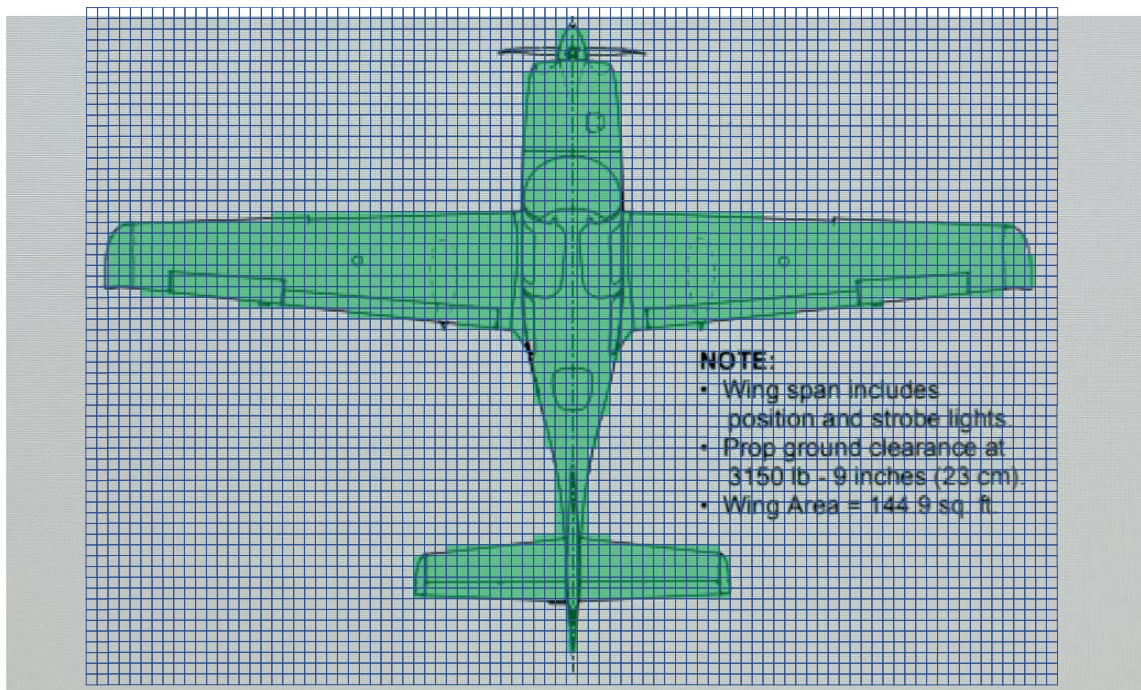


Figure 22. Cirrus Design SR20 top view grid overlay with estimated areas.

Figure 22 depicts the Cirrus Design SR20 top view totaling 1,150 blocks. Each block is 5.6 inches square or 31.36in^2 for a projected area of $36,064.00\text{in}^2$ or 250.44ft^2 .

Using the estimated block sizes for each of the views and the total number of blocks, the overall estimated projected areas in both inches squared and feet squared were made. Further breakdown estimates were made for the wings, body, tail, and landing gear for the front view estimations. This was done because often in viewing an aircraft head-on, the wings are long and thin and are not as easy to see. The aircraft body section presents the easiest element to see visually. Table 1 provides a summary of the estimated projected areas for all three aircraft.

Table 1. Estimated Projected Area for the CTLS, Cessna 172 Skyhawk, and the Cirrus Design SR20 Aircraft.

Aircraft	View	Section	Block side dimension (in)	Area of each Block (in ²)	Number of Blocks	Area (in ²)	Area (ft ²)
CTLS	Side	N/A	2.71	7.34	1126	8,269.46	57.43
	Front	All	2.91	8.47	762	6,452.69	44.81
	Front	Wings	2.91	8.47	305	2,582.77	17.94
		Body			327	2,769.07	19.23
		Tail			44	372.60	2.59
		Landing Gear			86	728.26	5.06
Top		5.64	31.81	684	21,757.77	151.10	
172S	Side		3.684	13.57	1157	15,702.64	109.05
	Front	All	3.646	13.29	652	8,667.24	60.19
	Front	Wings and struts	3.646	13.29	318	4,227.27	29.36
		Body			214	2,844.77	19.76
		Tail			59	784.31	5.45
		Landing Gear			61	810.89	5.63
Top		6.261	39.20	984	38,572.92	267.87	
Cirrus Design SR20	Side		5.47	29.92	486	14,541.56	100.98
	Front	All	5.41	29.27	284	8,312.14	57.72
	Front	Wings and struts	5.41	29.27	129	3,775.58	26.22
		Body			102	2,985.35	20.73
		Tail			25	731.70	5.08
		Landing Gear			28	819.51	5.69
Top		5.6	31.36	1150	36,064.00	250.44	

These estimated projected areas should be used only as general references. An aircraft is almost never seen exactly from the perspectives noted. The actual view by the observer will likely be a blend of these perspectives. Also, of note is the size difference between these aircraft. The CTLS is a smaller aircraft than the Cessna 172 Skyhawk and the Cirrus Design SR20. The Cessna 172 Skyhawk and the Cirrus Design SR20 are about the same size. For reference, the comparison of the aircraft sizes between the three perspectives, based on the projected areas above are as follows:

The side view projected area of the Cessna 172S is ~190% greater than the CTLS.
The front view projected area of the Cessna 172S is ~134% greater than the CTLS.
The top view projected area of the Cessna 172S is ~177% greater than the CTLS.

The side view projected area of the Cirrus SR20 is ~176% greater than the CTLS.
The front view projected area of the Cirrus SR20 is ~128% greater than the CTLS.
The top view projected area of the Cirrus SR20 is ~166% greater than the CTLS.

The side view projected area of the Cessna 172S is ~108% greater than the Cirrus SR20.
The front view projected area of the Cessna 172S is ~104% greater than Cirrus SR20.
The top view projected area of the Cessna 172S is ~107% greater than the Cirrus SR20.

The size difference may correlate to the resulting detection distances and may be used to extrapolate the detection distance of aircraft smaller or larger than these three.