

Phenomenological Study of Passive Image-Based Observables Used to Determine Standard from Overladen Vehicles

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INTRODUCTION

When transporting nuclear materials via roadways in a concealed fashion, it is believed that the vehicles would be heavier than a standard vehicle due to the additional weight of a lead container. The objective of this study was to use a combination of thermal infrared and conventional color digital imagery in order to examine the physical phenomenology that may indicate an overweight vehicle.

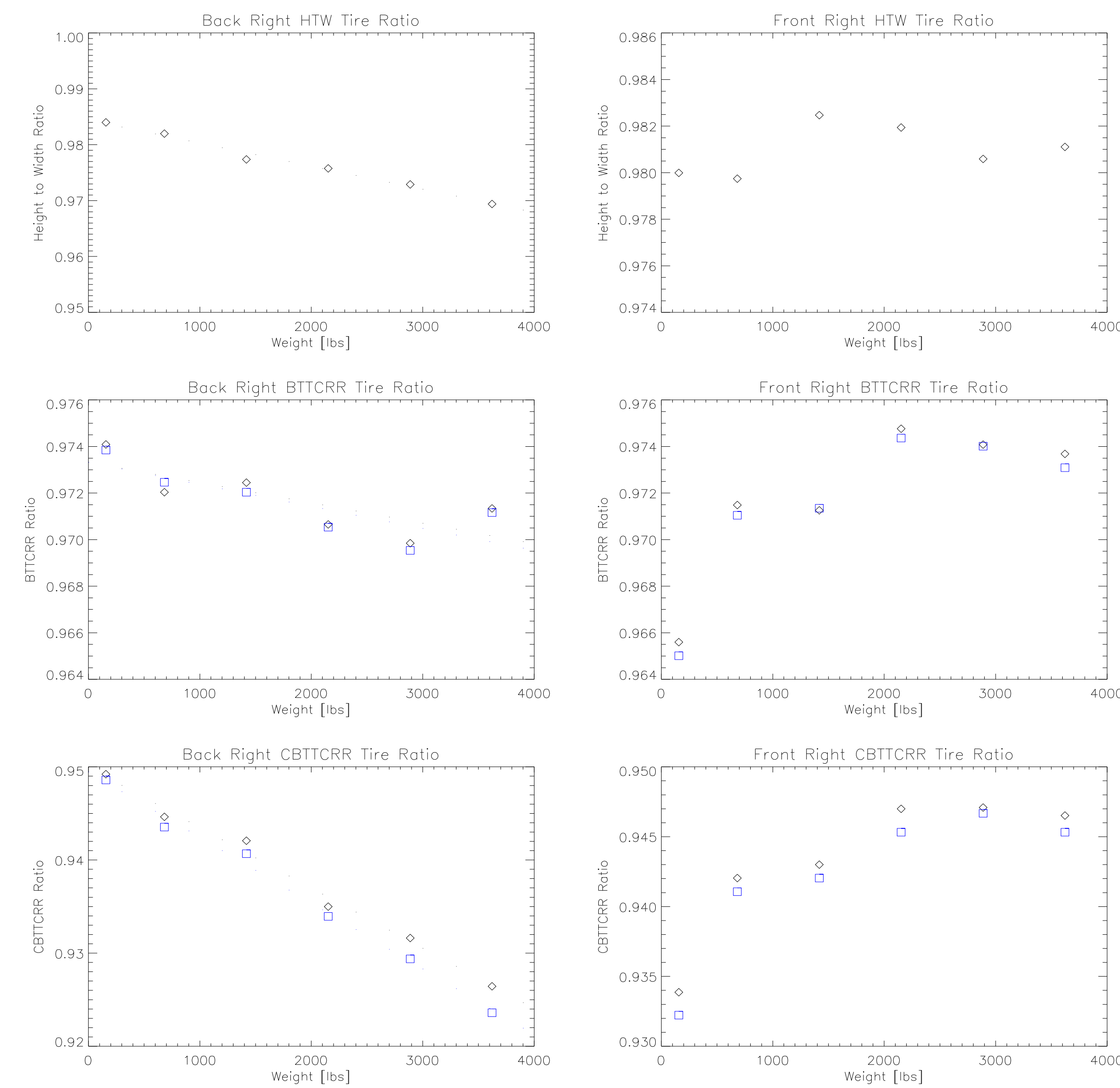


FIGURE 2. HTW ratios (top), BTTCR ratios (middle), and CBTTCCR ratios (bottom) plotted against vehicle weight for the back (left) and front (right) tires. Note that the BTTCR and CBTTCCR ratios were computed with 5 (blue) and 1 (black) degree ray separation. All three tire ratios for the back right tire indicate that an increase in vehicle weight leads to a decrease in the computed tire ratios. The front tire does not show the same trends, however they were not expected as the majority of the weight in the vehicle was supported by the back tires.

METHODOLOGY

A cargo van rated for 3200lbs was used with copy paper as the vehicle load, incremented by 735lbs to 3675lbs fully loaded. A controlled path was set in order to isolate the brake temperature from effects other than the vehicle weight. When the brakes reached 40C, the vehicle was driven a distance of 300ft at 30mph, the brakes were then applied for a distance of 60ft to bring the vehicle to a stop at which point imagery of the tires, various surface temperature measurements, and other calibration data were collected.

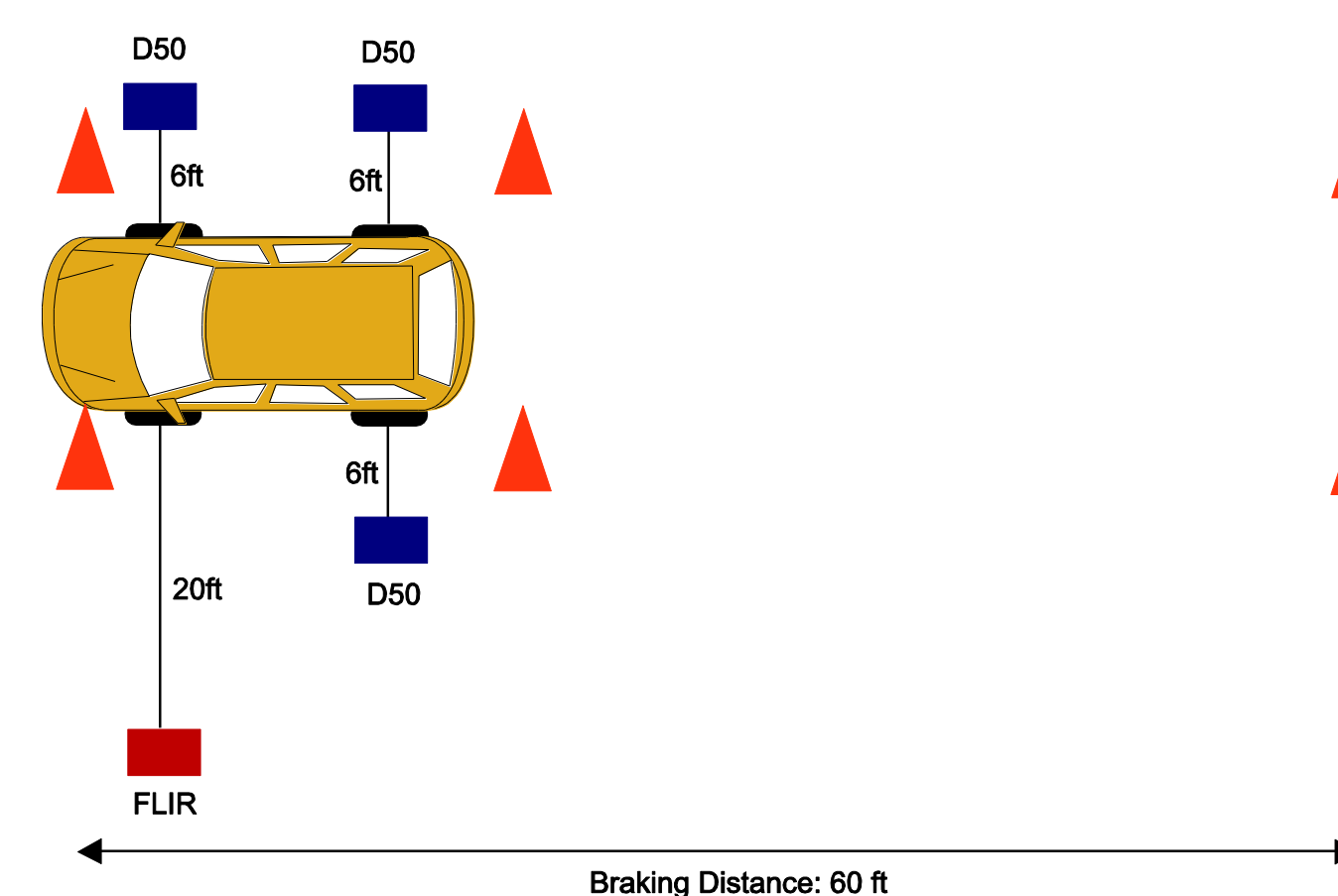


FIGURE 1. Diagram of the experimental set up.

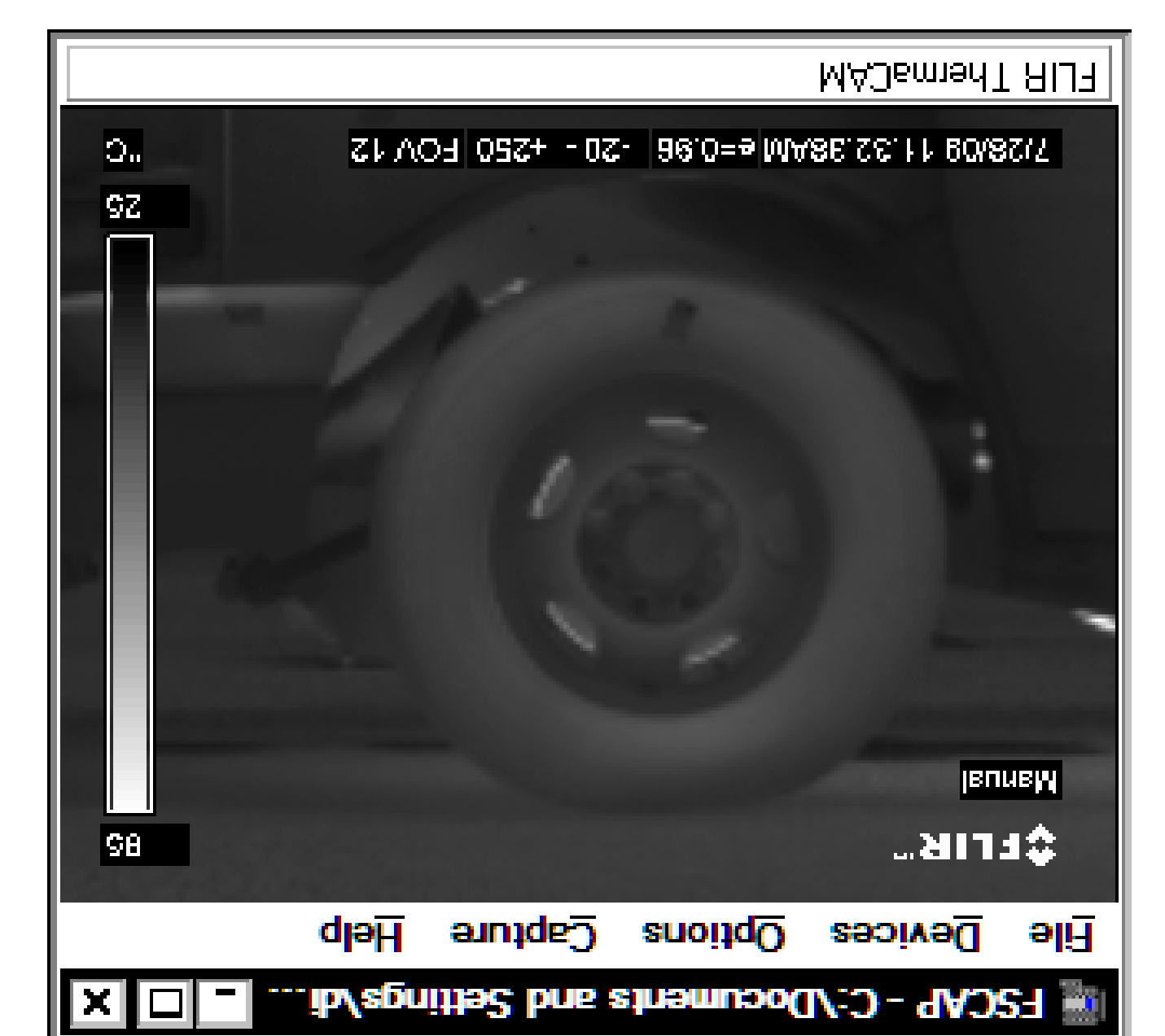


FIGURE 3. Experimental thermal (IR) image from the FLIR A20 camera, flipped to account for camera mounting. Two portions of the brake are visible, the inner part the brake pad has created a smooth surface, and the outer rim which has rusted. The rusted metal surface has a high emissivity and therefore acts more like a blackbody, explaining the difference in appearance.



CONCLUSIONS

Visible imagery was used to segment the tire from the image to obtain a tire metric used to define the circularity of the tire. Each of the three tire ratios (HTW, BTTCR, and CBTTCCR) showed that as the weight in the vehicle increased, the tire ratio decreased for the back right tire. The front tire did not exhibit these trends, but for the BTTCR and CBTTCCR ratios the tire ratio increased as the vehicle weight increased. It is believed that this is due to the center of mass shifting from the front to the rear as vehicle weight increases, alleviating pressure on the front axle and tires and increasing the tire ratios.

Thermal imagery was used to classify the apparent temperature of the brake rotor and the relative temperature differences between it and other vehicle parts. By assuming the camera is linear over a temperature range, the apparent temperature of a target can be derived from digital counts. Apparent temperature differences extracted from the imagery corroborated the results obtained with the physical surface temperature measurements, indicating that relative temperature differences increase as the vehicle weight increases.

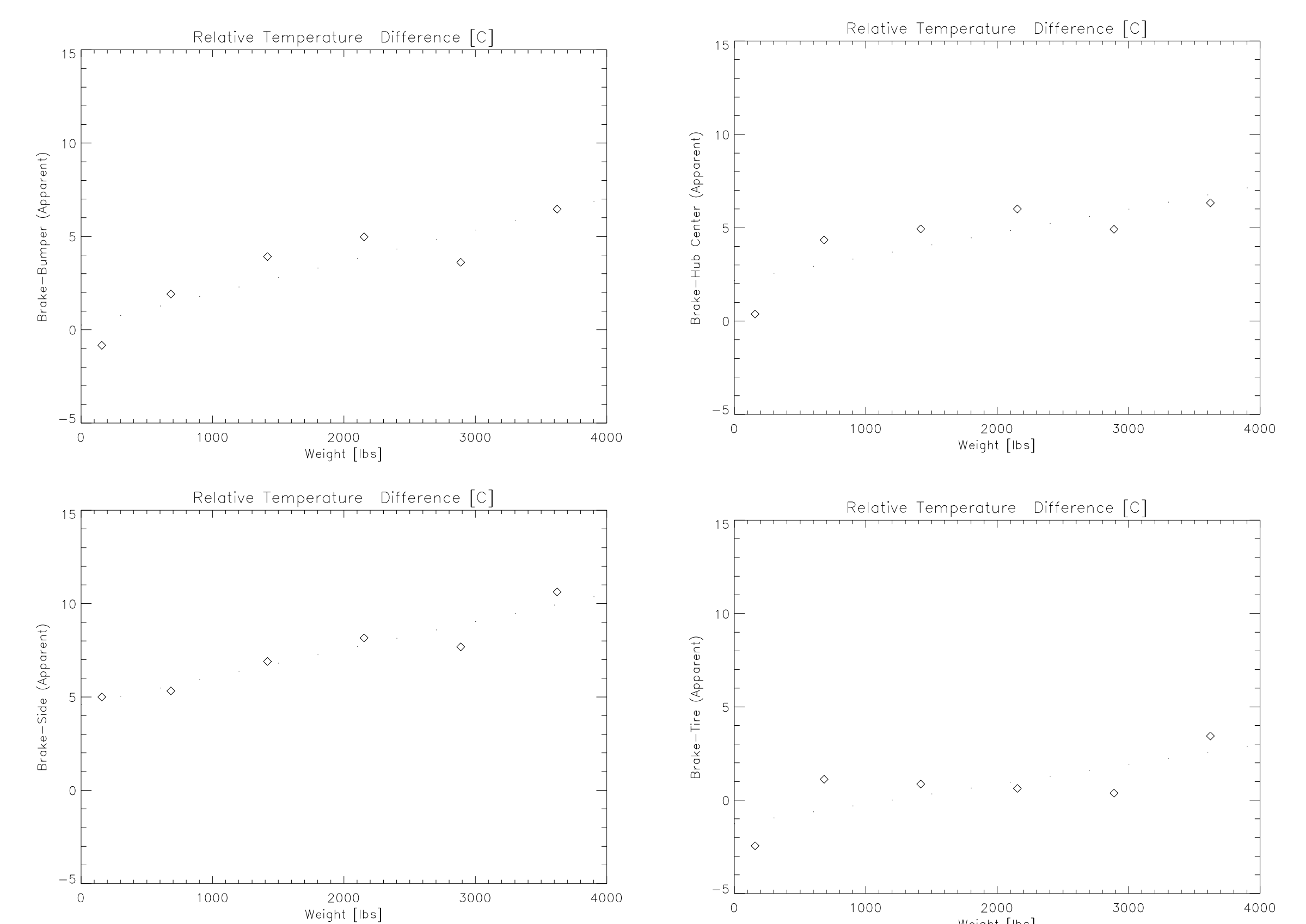


FIGURE 4. Relative apparent temperature differences as derived from the sensor. Relative temperature differences were computed as differences between the brake and the bumper (top left), the brake and the hub (top right), the brake and the side (bottom left), and the brake and the tire (bottom right). The differences were plotted against vehicle cargo weight and fit with a linear regression. In each instance, the relative temperature differences indicate that an increase in the weight in the vehicle leads to an increase in the relative temperature difference.

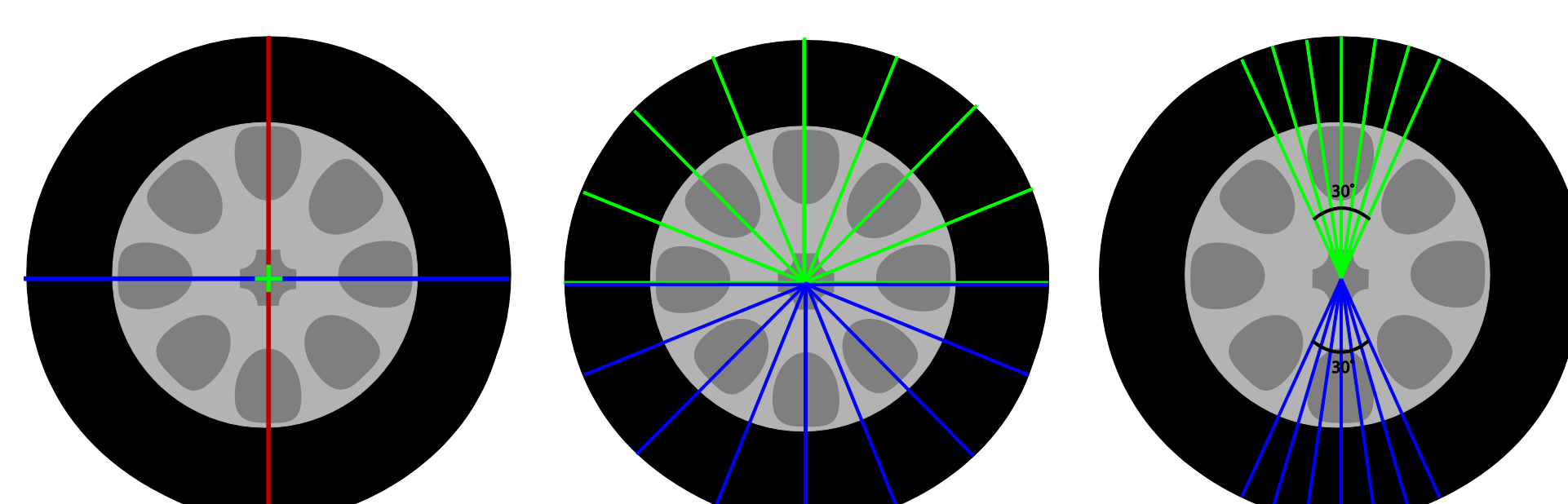


FIGURE 5. Left: Height to Width (HTW) ratio, simple ratio of vertical height to horizontal width. Middle: Bottom to Top Cumulative Radius (BTTCR) ratio, the sum of the lengths of rays cast on the bottom half of the circle divided by the sum of the lengths of the rays on the top half of the circle. Right: Constrained Bottom to Top Cumulative Radius (CBTTCCR) ratio, BTTCR ratio constrained to 15 degrees on either side of vertical on the top and bottom.

