APPENDIX A: CALCULATING THE DYNAMIC BELT POSITION

The belt pressure impression from the pressure sensor is combined with the pretest data from a coordinate measurement machine (CMM) to locate the dynamic belt position on the rear-passenger dummy's thorax.

The dynamic belt position is defined as the vertical distance from the chest potentiometer to the center of the dynamic belt path. The dynamic belt path is obtained by a regression equation identifying the center of the belt impression.

Dynamic belt position is calculated at two instances, at maximum chest deflection and at the maximum dynamic belt position. The belt position at maximum chest deflection reflects the dynamic belt position approximately at the time of the maximum compression recorded by the chest potentiometer. The maximum dynamic belt position refers to the highest belt position on the dummy's thorax during the loading phase. In some cases, these two positions can be identical. All the measurements are recorded in the dummy-thorax coordinate system (IIHS, 2022; Appendix).

The procedure for calculating belt positions is similar for both instances and is as follows:

1. The output file from the pressure sensor is checked for any loss of data, errors, etc. The appropriate frame into consideration is identified in the XSensor HSI software (Figure A1).

2. For each sensel (individual 5×5 mm pressure sensor element) that registers pressure, the corresponding Z-axis location (Figure A2) is obtained from the pretest CMM data.

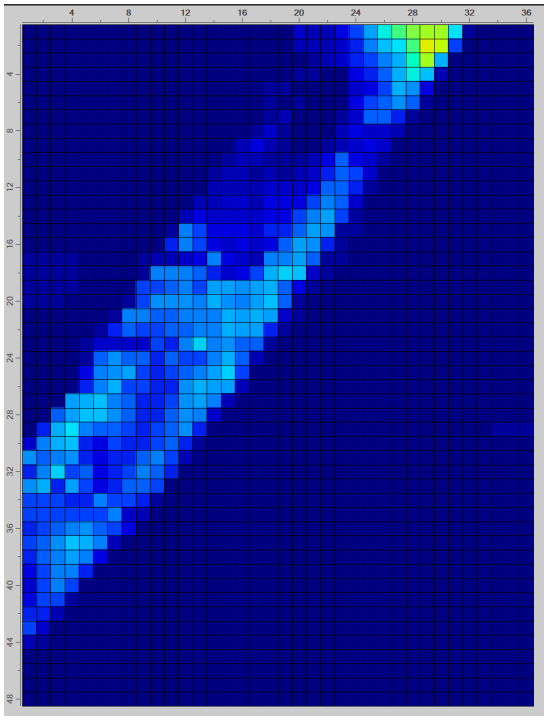

Figure A1. Belt pressure impression output from pressure mat at the frame in consideration

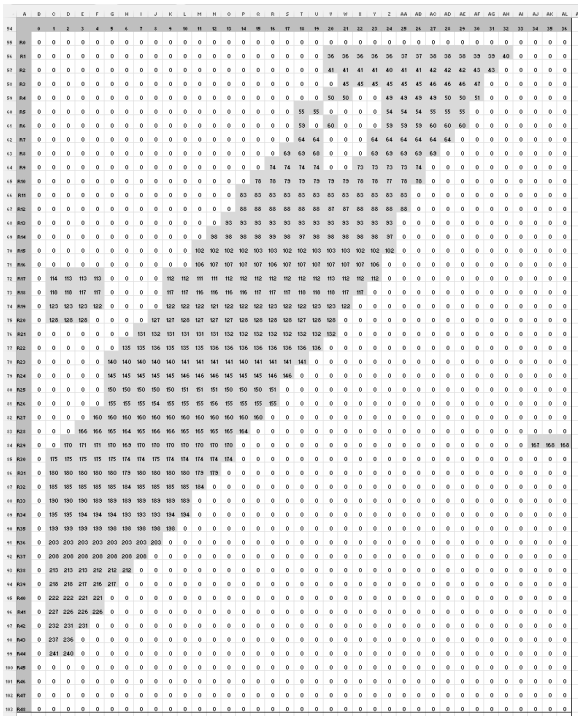

Figure A2. Corresponding Z-axis location of each sensel registering pressure (highlighted in grey)

3. The belt path is calculated by identifying the center of the belt impression for each column at this frame. The following guidelines are used to accurately calculate belt path:

   3.1 To avoid errors in calculation, the belt path center is calculated only in the columns where the complete width of the belt is visible (Figure A3).

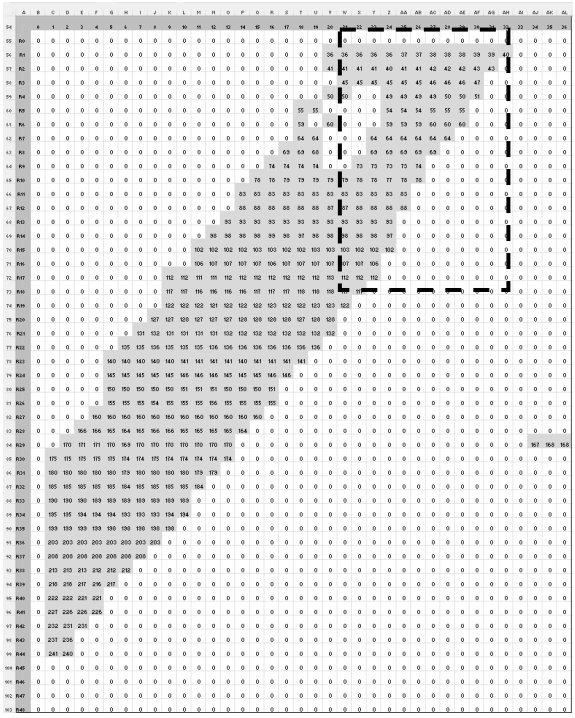

Figure A3. Belt path center is not calculated in highlighted columns because of missing top edge of belt

3.2 In columns where the midpoint of the belt is being calculated, pressure registered by contacts other than belt loading (Figures A4, A6) is removed by either increasing the pressure threshold (in the HSI software, Figure A5) or by manually editing the respective sensel values to zero (Figure A7). If the external contacts cannot be distinguished from the belt path in the identified frame, the nearest time frame where the external contacts can be distinguished is considered.

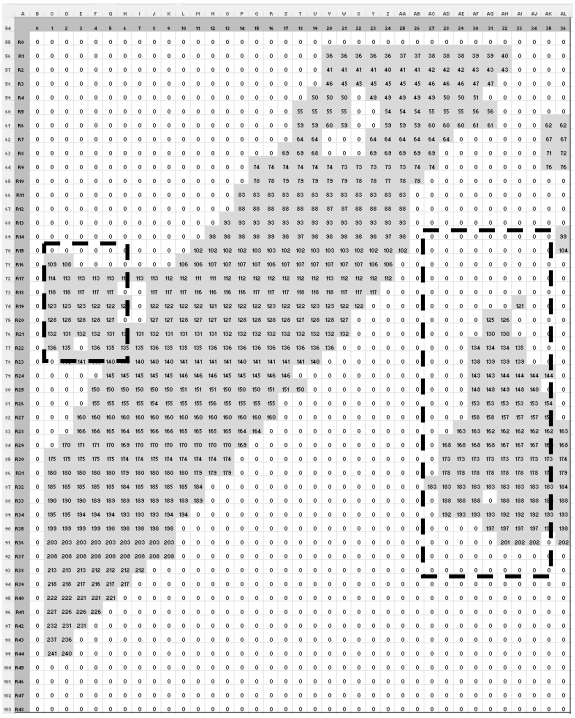

Figure A4. Pressure registered by contacts other than belt loading

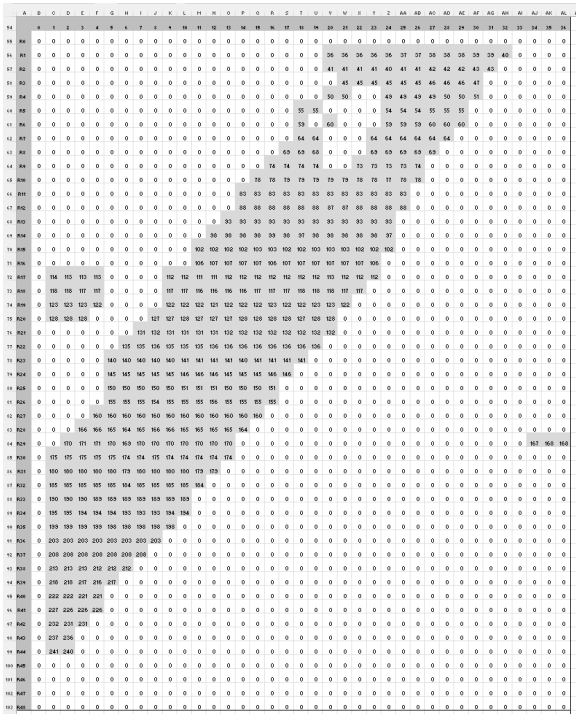

Figure A5. Increasing the pressure threshold to remove pressure registered by other contacts

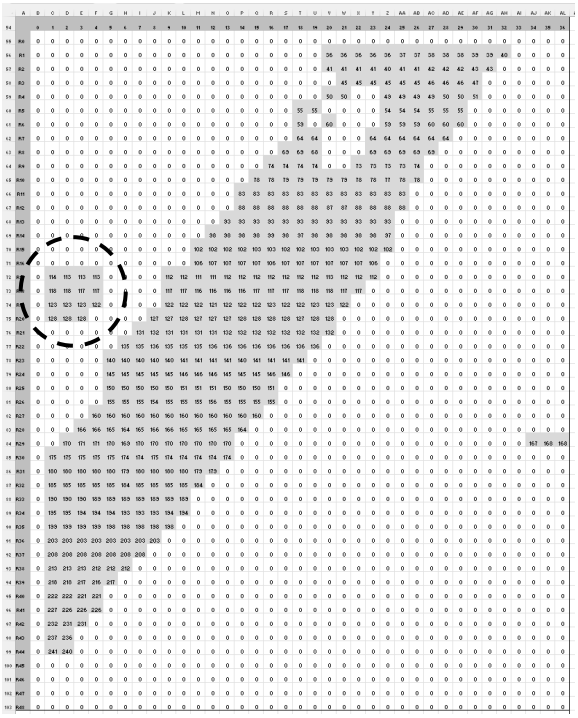

Figure A6. Pressure registered by sensels other than belt loading

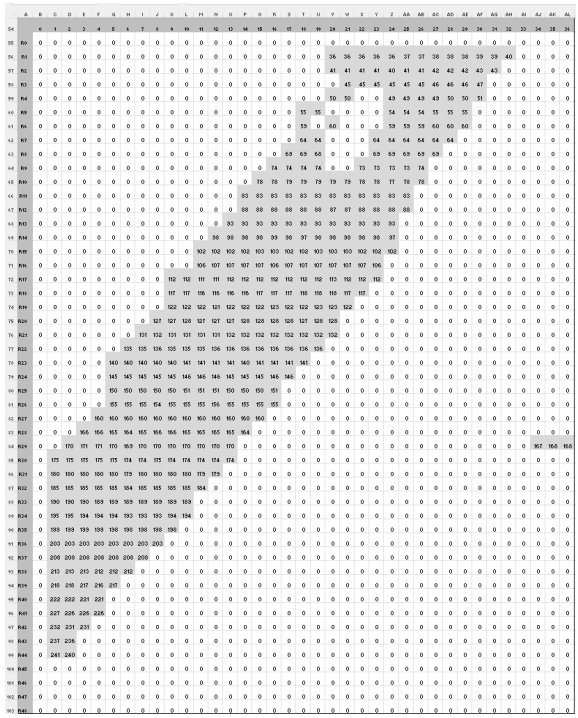

Figure A7. Manually removing the pressure registered by sensels

3.3 In some cases, there can be sensels along the belt path that register zero pressure (Figure A8). These sensels are manually edited to calculate the accurate belt path (Figure A9).

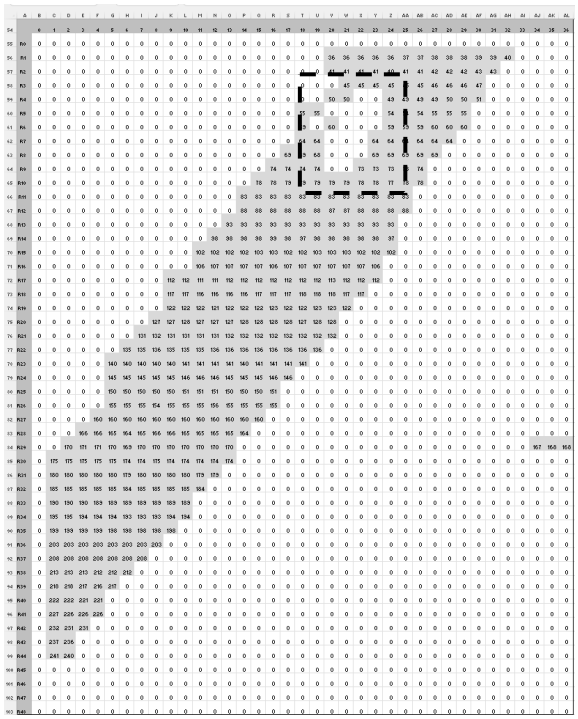

Figure A8. Sensels along the belt path that register zero pressure

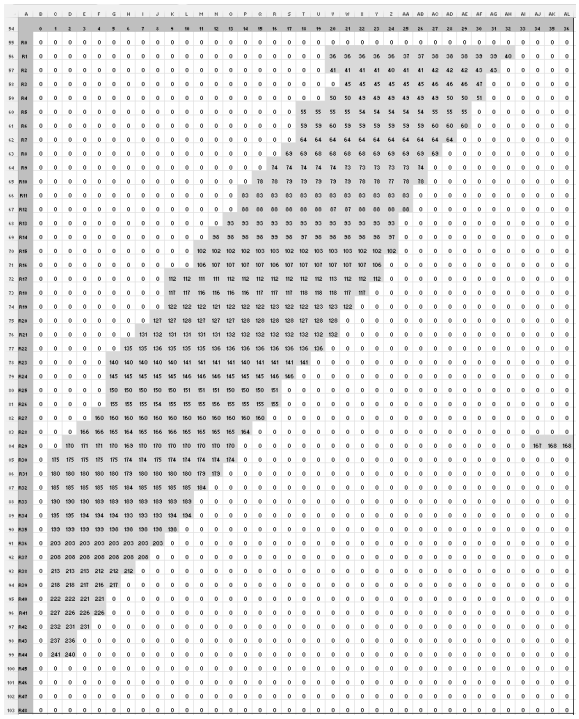

Figure A9. Manually editing sensels to calculate the accurate belt path

3.4 The center of each column is calculated to identify the centerline of the dynamic belt path (Figure A10).

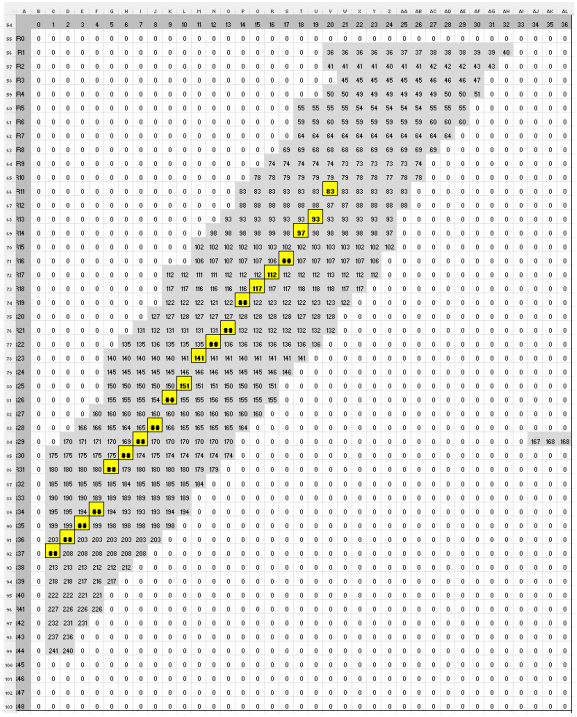

Figure A10. The centerline of the dynamic belt path (indicated by the highlighted (yellow) sensels)

4. A regression equation is created by using the belt path points identified in step 3. This regression equation is then used to calculate the dynamic belt position by interpolation.

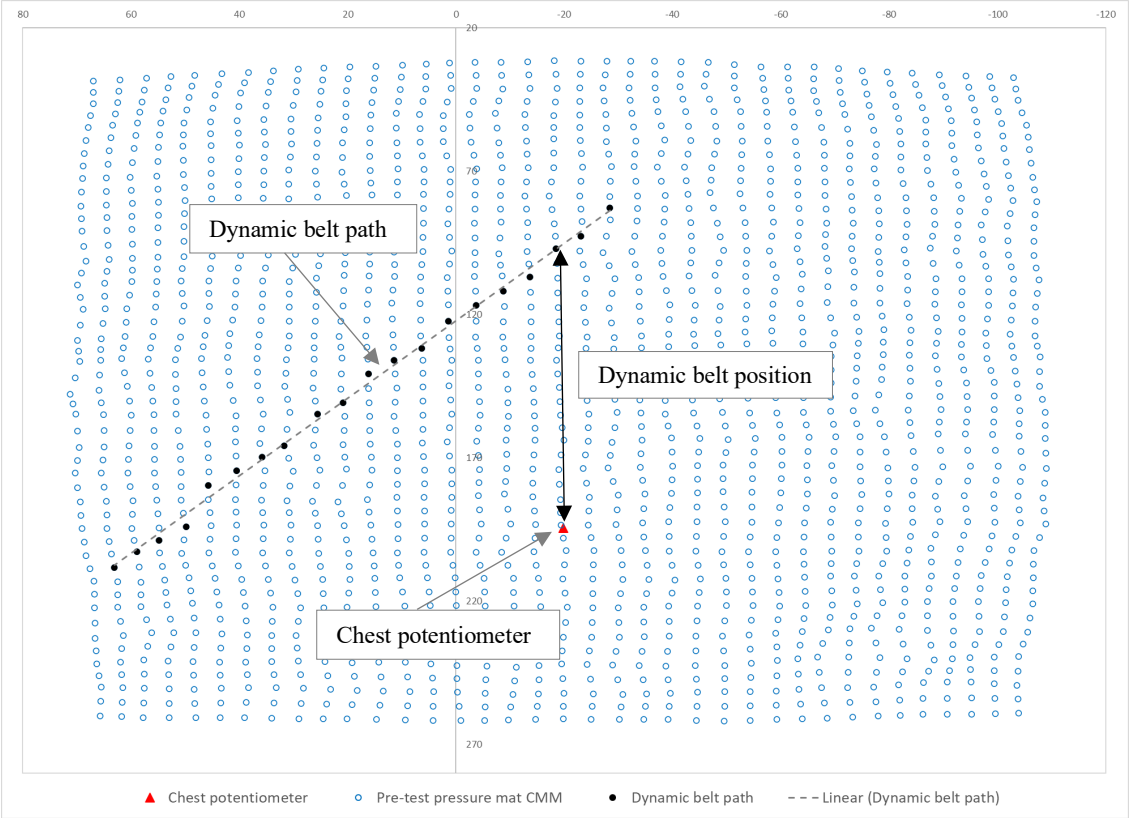

Figure A11. Calculating the dynamic belt position

References (Appendix A)

Insurance Institute for Highway Safety. (2022). *Moderate overlap frontal crashworthiness evaluation 2.0 crash test protocol (Version I*).