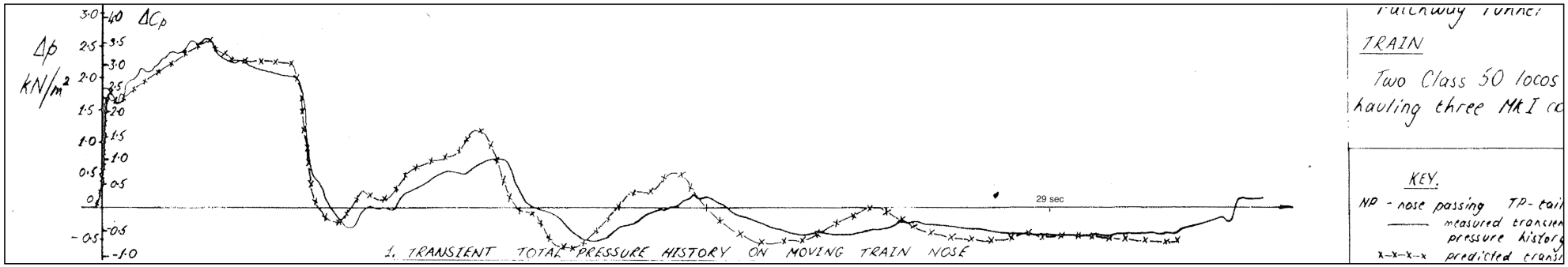
Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

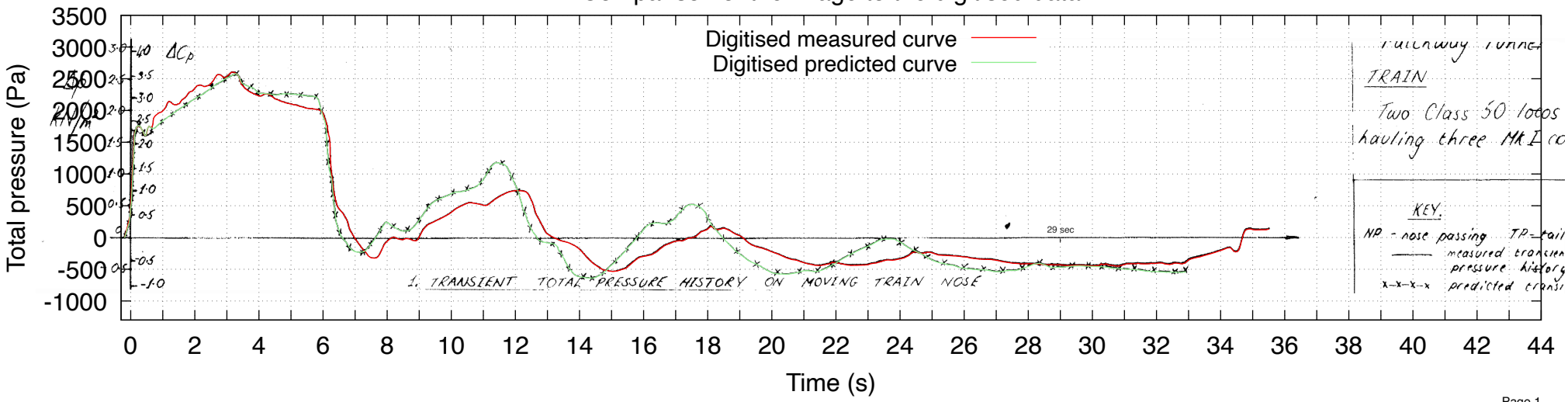
Image source: Top graph on page C3-48
Test place & time: Patchway Old tunnel (single track, no shafts), early 1970s
Consist: two BR class 50 locos hauling three Mk1 (slam door) coaches
Tunnel length: 1140 m, tunnel area: 22.61 m^2, tunnel perimeter: 18.19 m
Train length: 100.3 m, train area: 8.2 m^2, train perimeter: 9.83 m, train speed: 34.7 m/s (124.9 km/h)
Data in the image: measured and calculated total pressure in front of the train nose, with the dynamic pressure of the train speed subtracted.
Empirical data used in the paper's calculation: train nose contraction coefficient: 0.568, tunnel roughness: 0.005 m, train roughness: 0.2 m

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=29 s, P=0 Pa), (t=0, P=-500 Pa) and (t=0, P=3000 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-3a.tar' into WebPlotDigitizer for more details.

Original image, G&P 1st graph in Figure 3



Comparison of the image to the digitised data



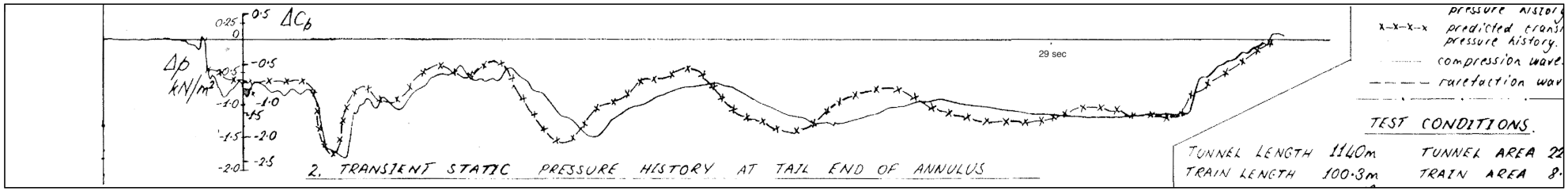
Source files: 1976-GP-Fig-3a-nose-ptot.txt and 1976-GP-Fig-3a-rotated.png.

Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

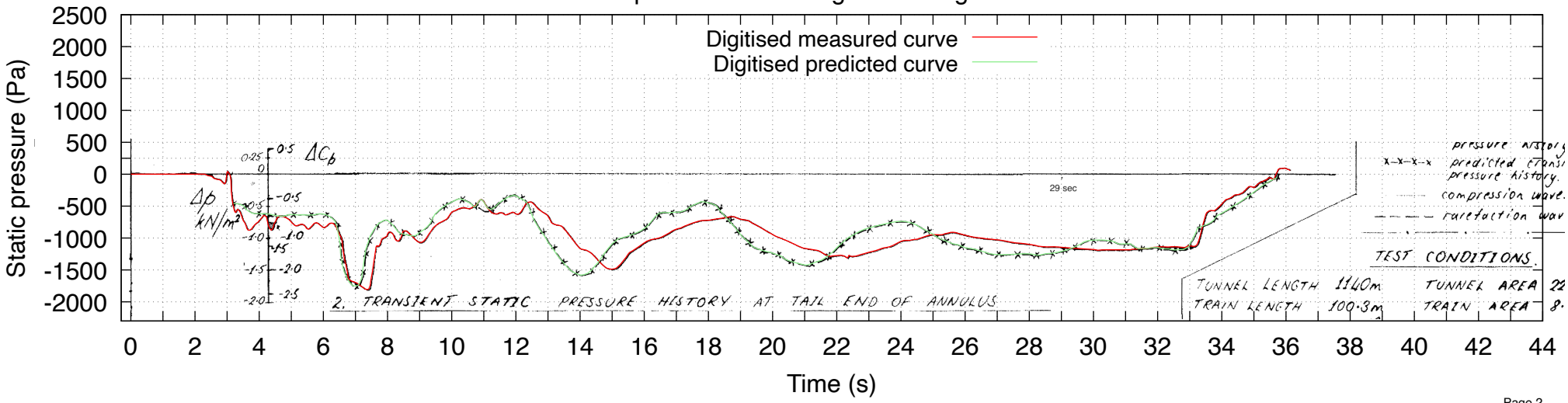
Image source: Second graph on page C3-48
Test place & time: Patchway Old tunnel (single track, no shafts), early 1970s
Consist: two BR class 50 locos hauling three Mk1 (slam door) coaches
Tunnel length: 1140 m, tunnel area: 22.61 m^2, tunnel perimeter: 18.19 m
Train length: 100.3 m, train area: 8.2 m^2, train perimeter: 9.83 m, train speed: 34.7 m/s (124.9 km/h)
Data in the image: measured and calculated static pressure near the train tail.
Empirical data used in the paper's calculation: train nose contraction coefficient: 0.568, tunnel roughness: 0.005 m, train roughness: 0.2 m

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=29 s, P=0 Pa), (t=4.3 s, P=-2000 Pa) and (t=4.3 s, P=250 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-3b.tar' into WebPlotDigitizer for more details.

Original image, G&P 2nd graph in Figure 3



Comparison of the image to the digitised data



Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

Image source: Middle graph on page C3-48

Test place & time: Patchway Old tunnel (single track, no shafts), early 1970s

Consist: two BR class 50 locos hauling three Mk1 (slam door) coaches

Tunnel length: 1140 m, tunnel area: 22.61 m^2, tunnel perimeter: 18.19 m

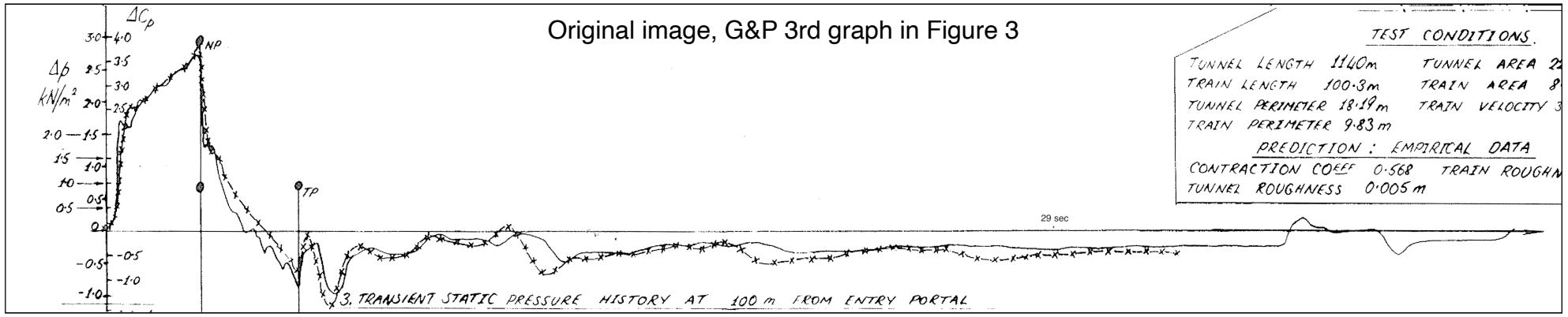
Train length: 100.3 m, train area: 8.2 m^2, train perimeter: 9.83 m, train speed: 34.7 m/s (124.9 km/h)

Data in the image: measured and calculated static pressure at the tunnel wall, 100 m from the entry portal.

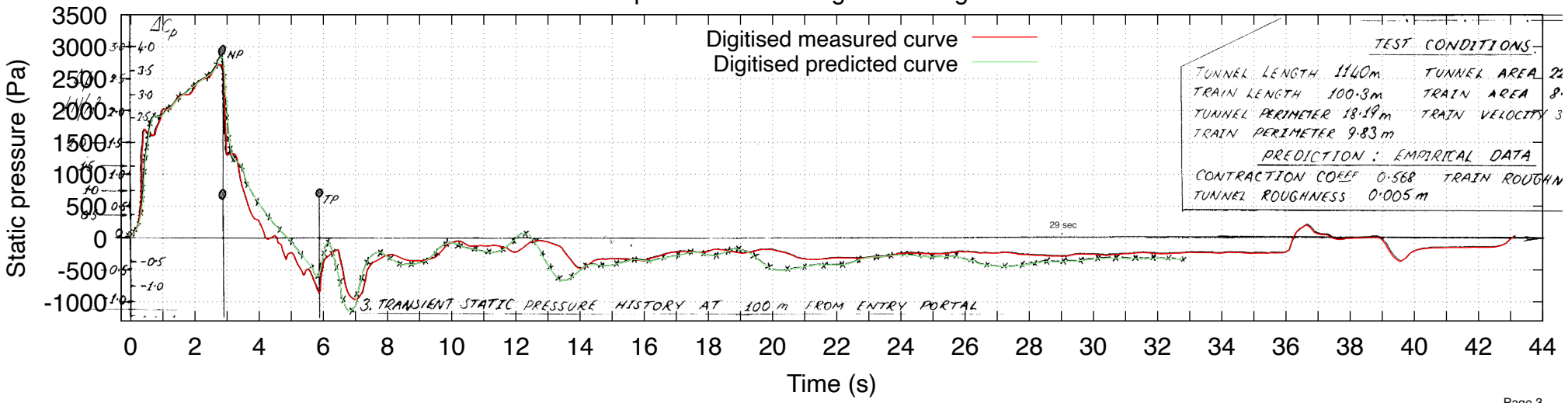
Empirical data used in the paper's calculation: train nose contraction coefficient: 0.568, tunnel roughness: 0.005 m, train roughness: 0.2 m

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=29 s, P=0 Pa), (t=0, P=-1000 Pa) and (t=0, P=3000 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-3c.tar' into WebPlotDigitizer for more details.

Original image, G&P 3rd graph in Figure 3



Comparison of the image to the digitised data



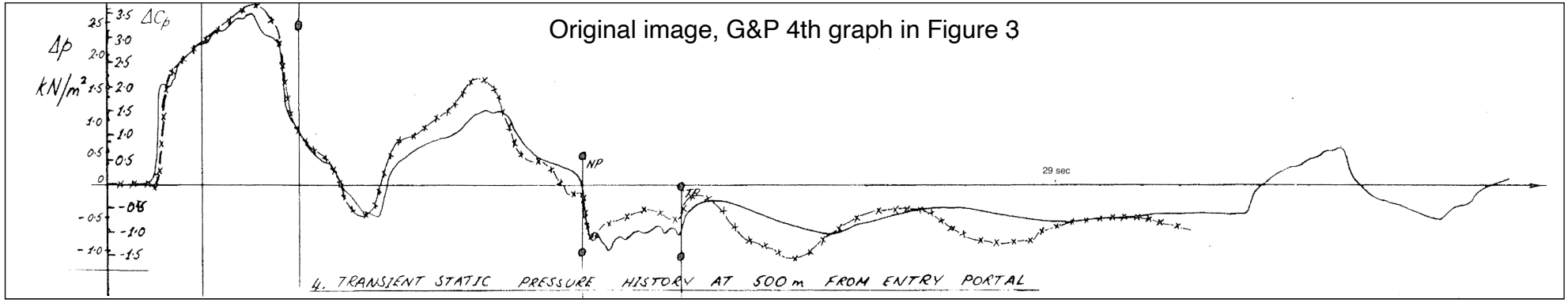
Source files: 1976-GP-Fig-3c-100m-pstat.txt and 1976-GP-Fig-3c-rotated.png.

Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

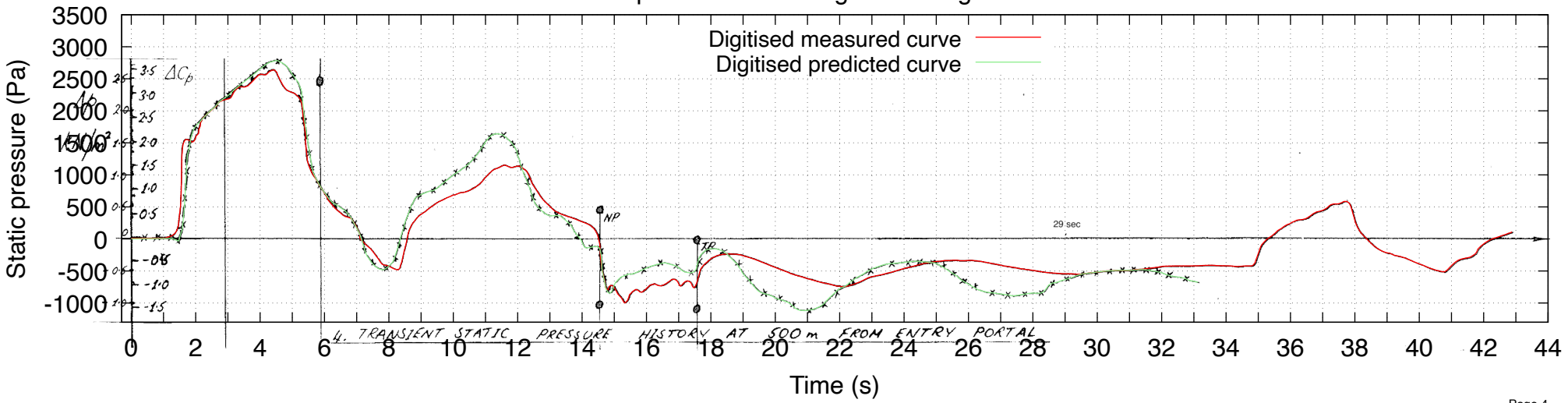
Image source: Fourth graph on page C3-48
Test place & time: Patchway Old tunnel (single track, no shafts), early 1970s
Consist: two BR class 50 locos hauling three Mk1 (slam door) coaches
Tunnel length: 1140 m, tunnel area: 22.61 m^2, tunnel perimeter: 18.19 m
Train length: 100.3 m, train area: 8.2 m^2, train perimeter: 9.83 m, train speed: 34.7 m/s (124.9 km/h)
Data in the image: measured and calculated static pressure at the tunnel wall, 500 m from the entry portal.
Empirical data used in the paper's calculation: train nose contraction coefficient: 0.568, tunnel roughness: 0.005 m, train roughness: 0.2 m

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=29 s, P=0 Pa), (t=0, P=-1000 Pa) and (t=0, P=2500 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-3d.tar' into WebPlotDigitizer for more details.

Original image, G&P 4th graph in Figure 3



Comparison of the image to the digitised data



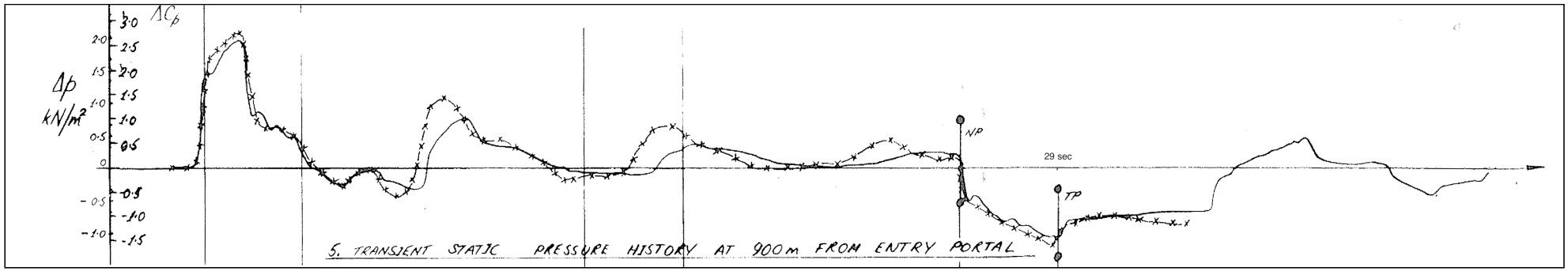
Source files: 1976-GP-Fig-3d-500m-pstat.txt and 1976-GP-Fig-3d-rotated.png.

Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

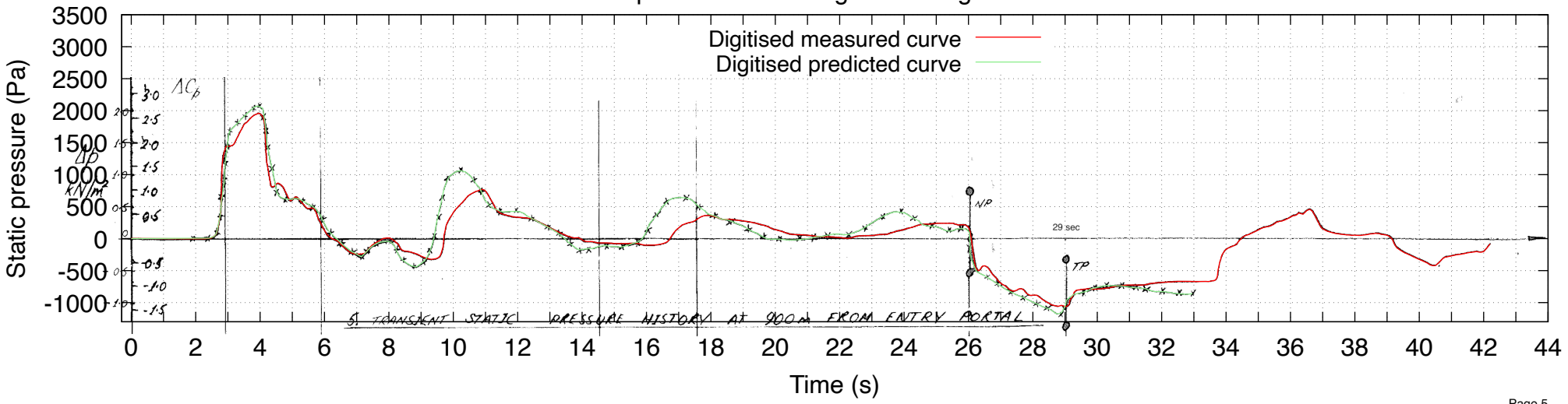
Image source: Bottom graph on page C3-48
Test place & time: Patchway Old tunnel (single track, no shafts), early 1970s
Consist: two BR class 50 locos hauling three Mk1 (slam door) coaches
Tunnel length: 1140 m, tunnel area: 22.61 m^2, tunnel perimeter: 18.19 m
Train length: 100.3 m, train area: 8.2 m^2, train perimeter: 9.83 m, train speed: 34.7 m/s (124.9 km/h)
Data in the image: measured and calculated static pressure at the tunnel wall, 900 m from the entry portal.
Empirical data used in the paper's calculation: train nose contraction coefficient: 0.568, tunnel roughness: 0.005 m, train roughness: 0.2 m

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=29 s, P=0 Pa), (t=0, P=-1000 Pa) and (t=0, P=2000 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-3e.tar' into WebPlotDigitizer for more details.

Original image, G&P 5th graph in Figure 3



Comparison of the image to the digitised data



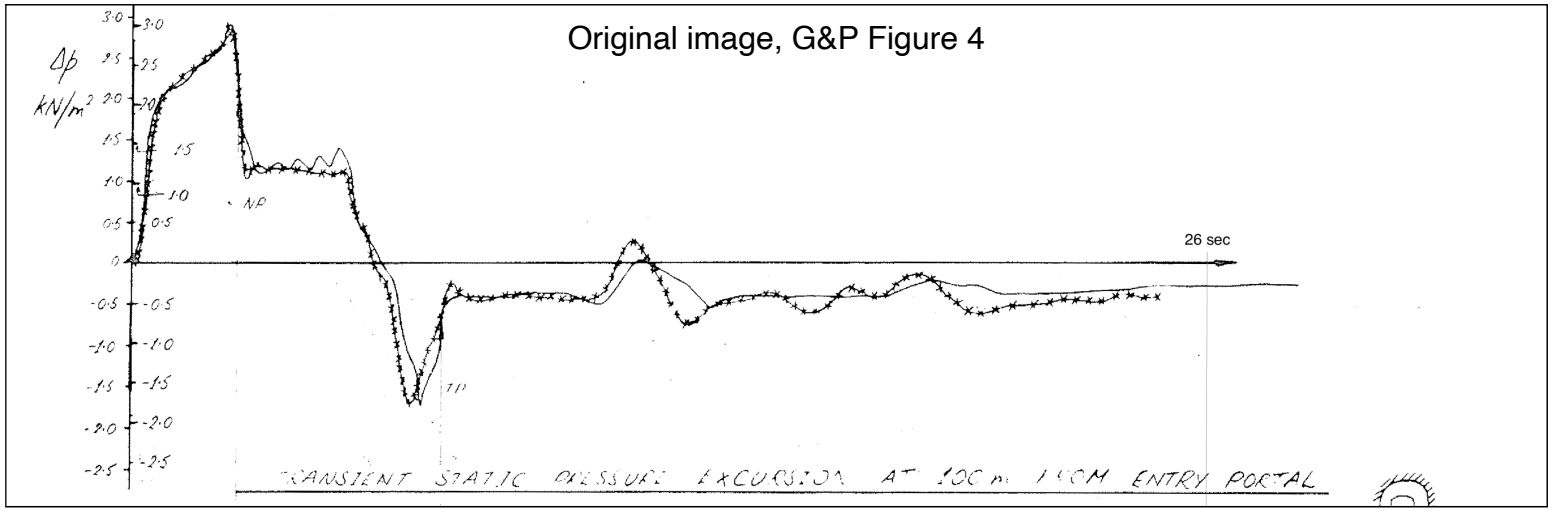
Source files: 1976-GP-Fig-3e-900m-pstat.txt and 1976-GP-Fig-3e-rotated.png.

Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

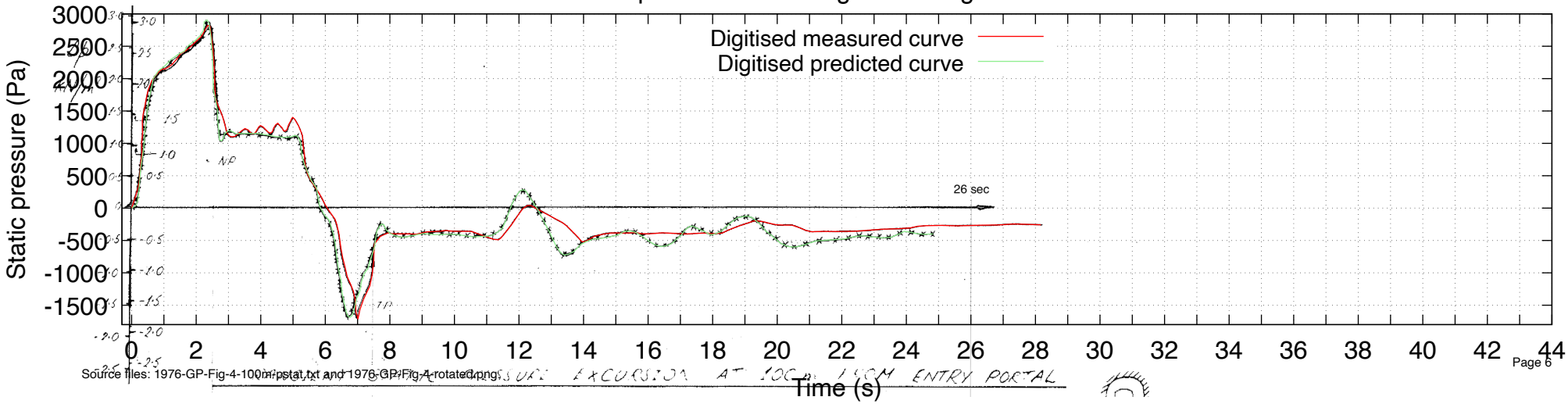
Image source: Graph on page C3-50
Test place & time: Patchway Old tunnel (single track, no shafts), early 1970s
Consist: British Rail HST prototype, 2 class 41 power cars plus 7 MkIII coaches
Tunnel length: 1140 m, tunnel area: 22.61 m^2, tunnel perimeter: 18.19 m
Train length: 196.6 m, train area: 9.11 m^2, train perimeter: 11.0 m, train speed: 39.42 m/s (141.9 km/h)
Data in the image: measured and calculated static pressure at the tunnel wall, 100 m from the entry portal.
Empirical data used in the paper's calculation: train nose contraction coefficient: 0.664, tunnel roughness: 0.005 m, train roughness: 0.0092 m

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=26 s, P=0 Pa), (t=0, P=-2500 Pa) and (t=0, P=3000 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-4.tar' into WebPlotDigitizer for more details.

Original image, G&P Figure 4



Comparison of the image to the digitised data



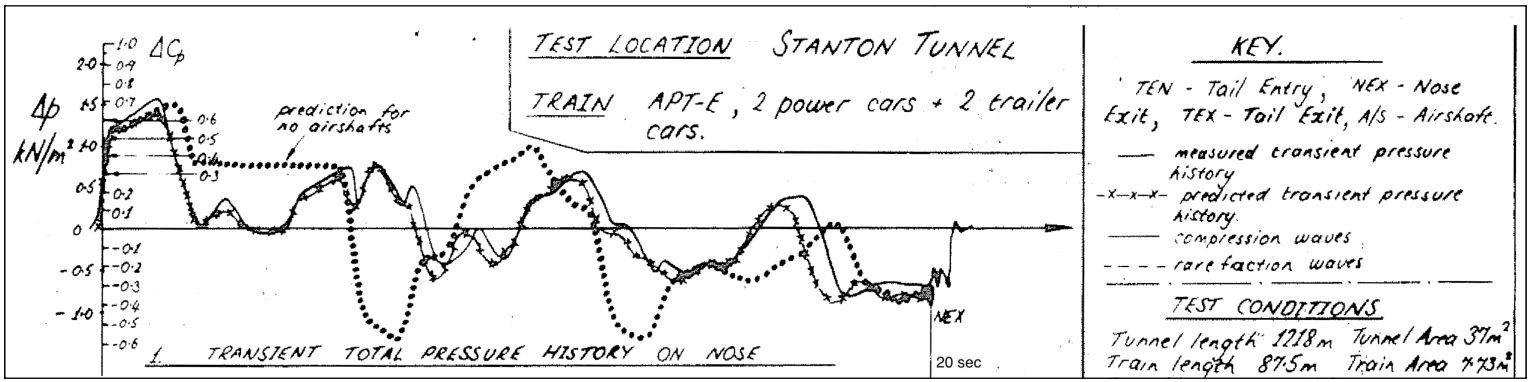
Source files: 1976-GP-Fig-4-100m-pstat.txt and 1976-GP-Fig-4-rotated.png

Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

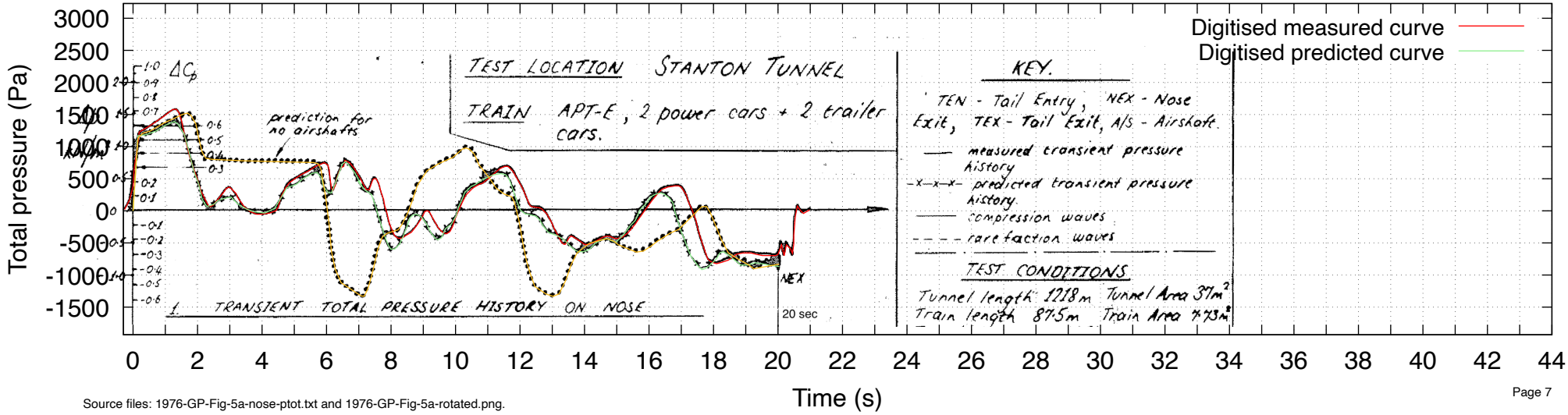
Image source: First graph on page C3-51
Test place & time: Stanton Tunnel (twin-track, 3 shafts), early 1970s
Consist: British Rail Experimental Advanced Passenger Train (APT-E), 2 power cars plus 2 trailer cars
Tunnel length: 1218 m, tunnel area: 37 m^2, tunnel perimeter: 21.56 m
Train length: 87.5 m, train area: 7.73 m^2, train perimeter: 9.64 m, train speed: 60.5 m/s (217.8 km/h)
Data in the image: measured and calculated total pressure in front of the train nose, with the dynamic pressure of the train speed subtracted.
Empirical data used in the paper's calculation: train nose contraction coefficient: 0.827, tunnel roughness: 0.005 m, train roughness: 0.009 m
Airshaft locations 283.9 m from entry portal, 607.7 m and 929.5 m
Airshaft areas 5.94 m^2, perimeters 8.64 m (brick-lined construction shafts 9 feet in diameter)
Airshaft lengths 30.0 m, 31.0 m and 31.0 m

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=20 s, P=0 Pa), (t=0, P=-1000 Pa) and (t=0, P=2000 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-5a.tar' into WebPlotDigitizer for more details.

Original image, G&P Figure 5a



Comparison of the image to the digitised data



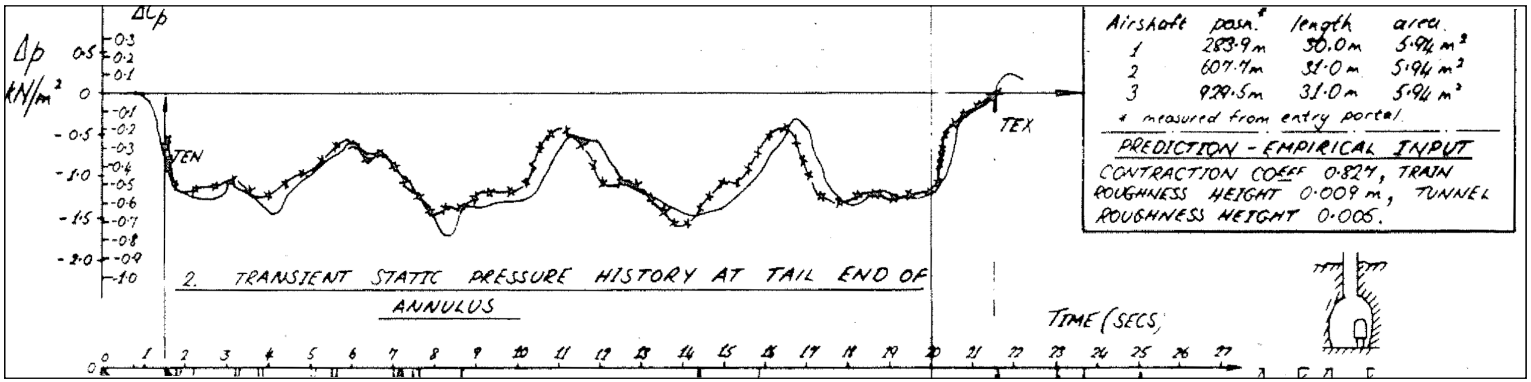
Source files: 1976-GP-Fig-5a-nose-ptot.txt and 1976-GP-Fig-5a-rotated.png.

Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

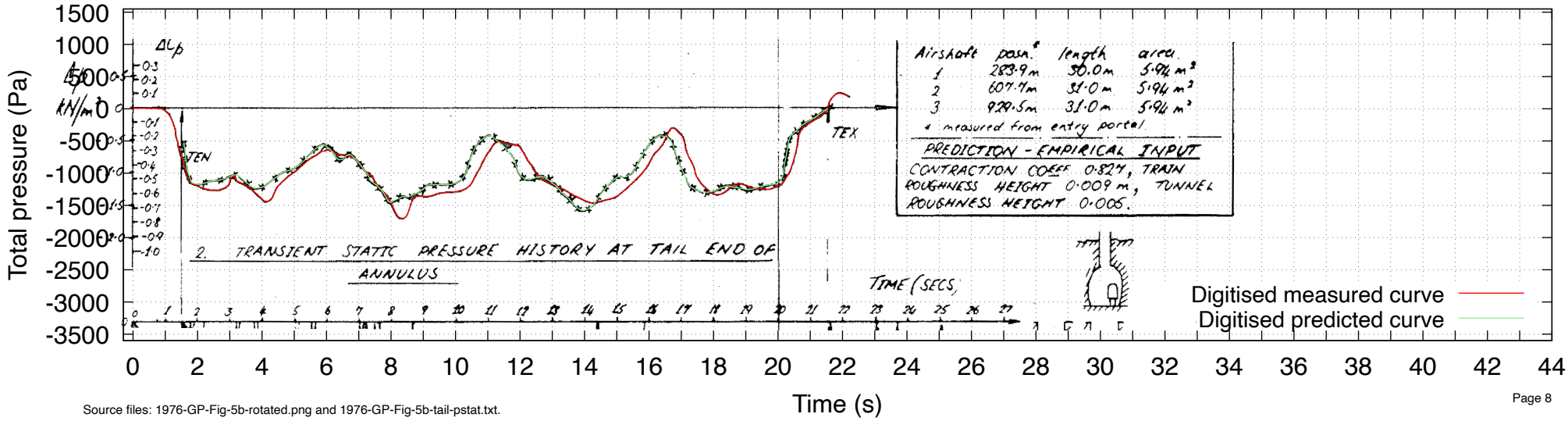
Image source: Second graph on page C3-51
Test place & time: Stanton Tunnel (twin-track, 3 shafts), early 1970s
Consist: British Rail Experimental Advanced Passenger Train (APT-E), 2 power cars plus 2 trailer cars
Tunnel length: 1218 m, tunnel area: 37 m^2, tunnel perimeter: 21.56 m
Train length: 87.5 m, train area: 7.73 m^2, train perimeter: 9.64 m, train speed: 60.5 m/s (217.8 km/h)
Data in the image: measured and calculated static pressure in near the train tail.
Empirical data used in the paper's calculation: train nose contraction coefficient: 0.827, tunnel roughness: 0.005 m, train roughness: 0.009 m
Airshaft locations 283.9 m from entry portal, 607.7 m and 929.5 m
Airshaft areas 5.94 m^2, perimeters 8.64 m (brick-lined construction shafts 9 feet in diameter)
Airshaft lengths 30.0 m, 31.0 m and 31.0 m

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=20 s, P=0 Pa), (t=0, P=-2000 Pa) and (t=0, P=500 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-5b.tar' into WebPlotDigitizer for more details.

Original image, G&P Figure 5b



Comparison of the image to the digitised data



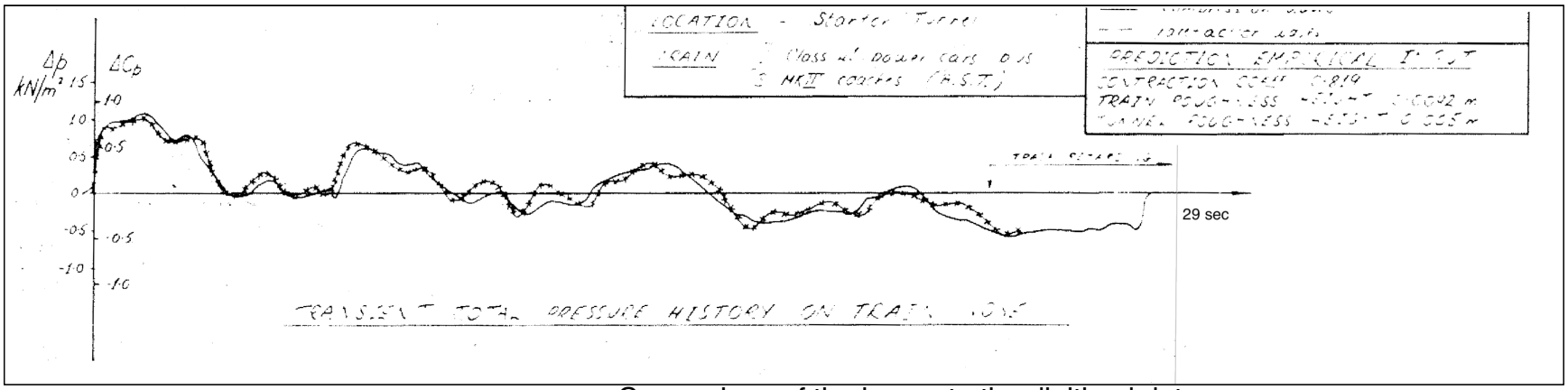
Source files: 1976-GP-Fig-5b-rotated.png and 1976-GP-Fig-5b-tail-pstat.txt.

Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

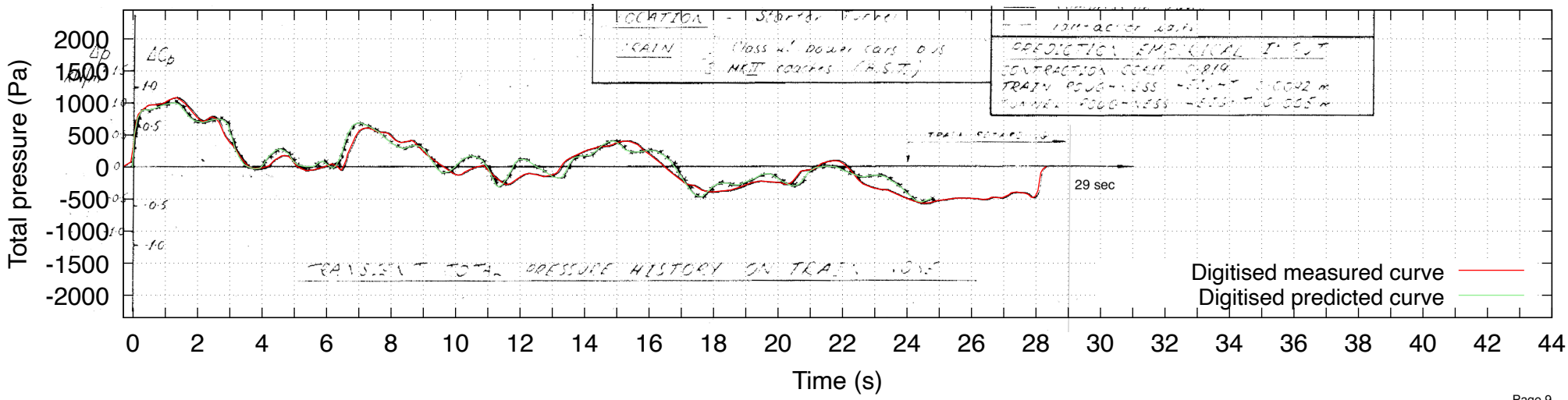
Image source: Graph on page C3-52
Test place & time: Stanton Tunnel (twin-track, 3 shafts), early 1970s
Consist: British Rail HST prototype, 2 class 41 power cars plus 3 MkIII coaches
Tunnel length: 1218 m, tunnel area: 37 m^2, tunnel perimeter: 21.56 m
Train length: 104.6 m, train area: 9.11 m^2, train perimeter: 11.0 m, train speed: 44.5 m/s (160.2 km/h)
Data in the image: measured and calculated total pressure in front of the train nose, with the dynamic pressure of the train speed subtracted.
Empirical data used in the paper's calculation: train nose contraction coefficient: 0.819, tunnel roughness: 0.005 m, train roughness: 0.0092 m
Airshaft locations 283.9 m from entry portal, 607.7 m and 929.5 m
Airshaft areas 5.94 m^2, perimeters 8.64 m
Airshaft lengths 30.0 m, 31.0 m and 31.0 m

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=29 s, P=0 Pa), (t=0, P=-1000 Pa) and (t=0, P=1500 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-6.tar' into WebPlotDigitizer for more details.

Original image, G&P Figure 6



Comparison of the image to the digitised data



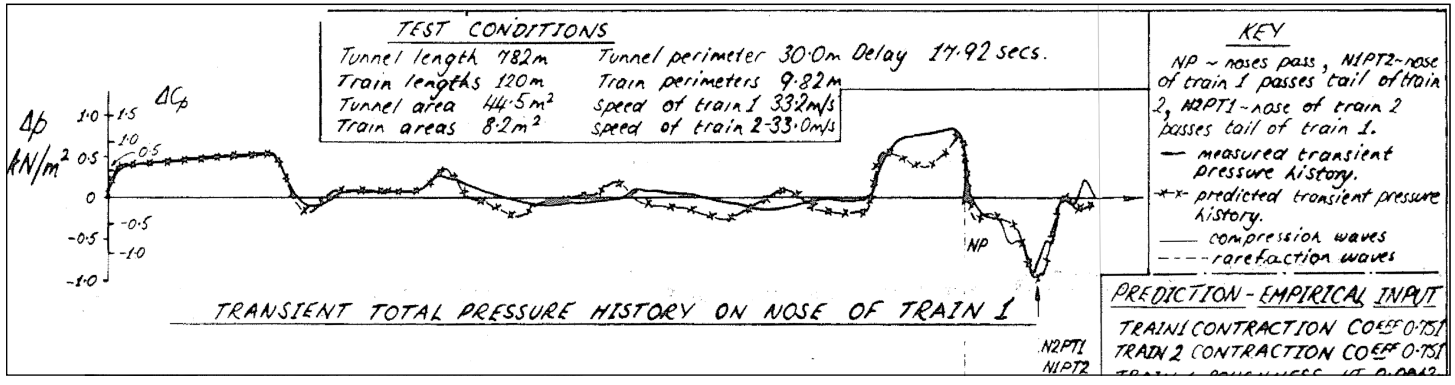
Source files: 1976-GP-Fig-6-nose-ptot.txt and 1976-GP-Fig-6-rotated.png.

Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

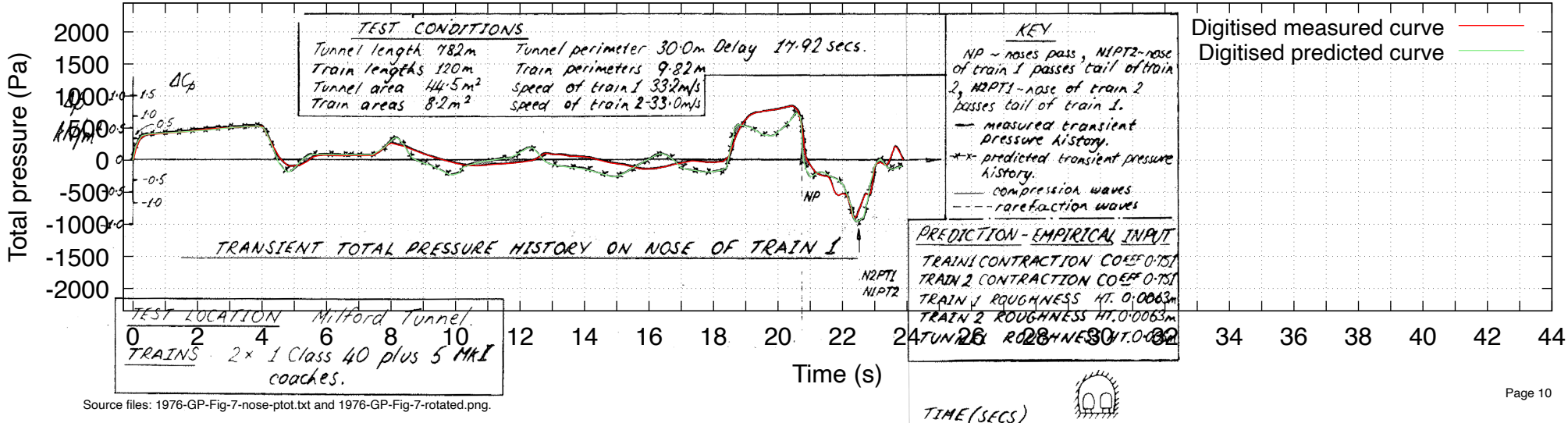
Image source: Graph on page C3-53
Test place & time: Milford Tunnel (twin-track, 4 shafts), early 1970s
Two trains, each consisting of one BR class 40 loco hauling five Mk1 (slam door) coaches
Tunnel length: 782 m, tunnel area: 44.5 m^2, tunnel perimeter: 30.0 m.
Train lengths: 120 m, train areas: 8.2 m^2, train perimeters: 9.82 m, train 1 speed: 33.2 m/s (119.5 km/h), train 2 speed: 33 m/s (118 km/h)
Data in the image: measured and calculated total pressure in front of train 1's nose, with the dynamic pressure of the train speed subtracted.
Empirical data used in the paper's calculation: train nose contraction coefficients: 0.751, tunnel roughness: 0.005 m, train roughnesses: 0.0063 m
All four air shafts blocked by air bags (so that this run can be compared to the one on the next page with the four shafts open)
Train 1 enters at 0 seconds, train 2 enters at 17.92 seconds, travelling in the opposite direction.

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=24 s, P=0 Pa), (t=0, P=-1000 Pa) and (t=0, P=1000 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-7.tar' into WebPlotDigitizer for more details.

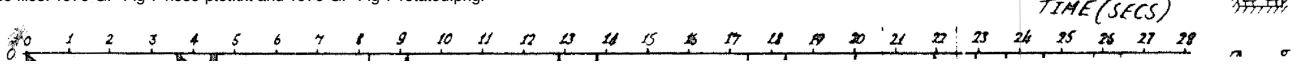
Original image, G&P Figure 7



Comparison of the image to the digitised data



Source files: 1976-GP-Fig-7-nose-ptot.txt and 1976-GP-Fig-7-rotated.png.



Source paper: "The measurement and interpretation of transient pressure generated by trains in tunnels", Gawthorpe, R G and Pope, C W, pages C35-C54 and Z28-Z30, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

Image source: Graph on page C3-54

Test place & time: Milford Tunnel (twin-track, 4 shafts), early 1970s

Two trains, each consisting of two BR class 40 locos hauling five Mk1 (slam door) coaches

Tunnel length: 782 m, tunnel area: 44.5 m^2, tunnel perimeter: 30.0 m.

Train lengths: 120 m, train areas: 8.2 m^2, train perimeters: 9.82 m, train 1 speed: 33.1 m/s (119.2 km/h), train 2 speed: 35.6 m/s (128.2 km/h)

Data in the image: measured and calculated total pressure in front of train 1's nose, with the dynamic pressure of the train speed subtracted.

Empirical data used in the paper's calculation: train nose contraction coefficients: 0.751, tunnel roughness: 0.005 m, train roughnesses: 0.0063 m

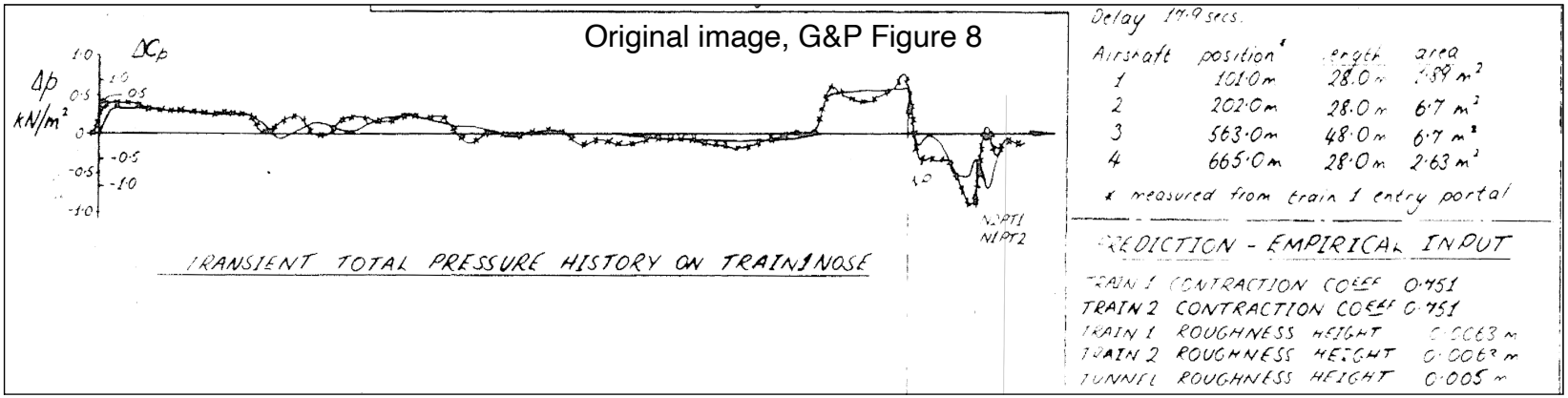
Airshaft locations 101 m, 202 m, 563 m and 665 m from the portal that train 1 enters

Airshaft areas 1.89 m^2, 6.7 m^2, 6.7 m^2 and 2.63 m^2. Airshaft lengths 28 m, 28 m , 48 m and 28 m

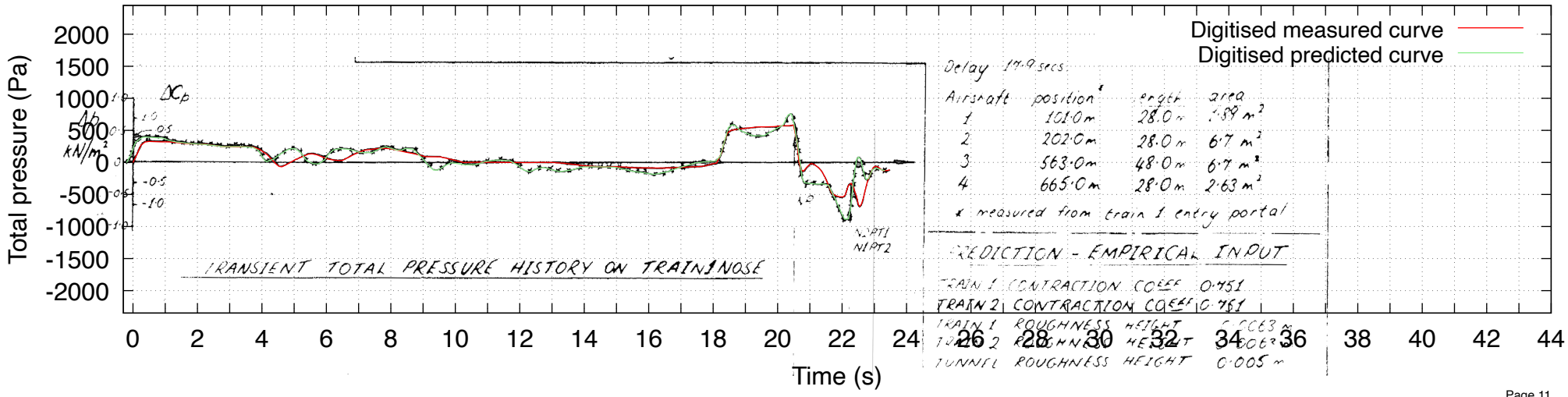
Train 1 enters at 0 seconds, train 2 enters at 17.9 seconds, travelling in the opposite direction.

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=23 s, P=0 Pa), (t=0, P=-1000 Pa) and (t=0, P=1000 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Gawthorpe-Fig-8.tar' into WebPlotDigitizer for more details.

Original image, G&P Figure 8



Comparison of the image to the digitised data



Source files: 1976-GP-Fig-8-nose-ptot.txt and 1976-GP-Fig-8-rotated.png.

Source paper: "The use of airshafts for the alleviation of pressure transients in railway tunnels", Vardy, A E, pages C55-C69 and Z30-Z32, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

Image source: First graph on page C3-54
Test place & time: Milford Tunnel (twin-track, 4 shafts), early 1970s
Two trains passing in the tunnel, in the same series of tests as Figures 7 and 8 of G&P
Empirical data used in the paper's calculation is not stated, but is likely to be the same as the data in Gawthorpe and Pope (G&P)
Data in the image: measured and calculated total pressure in front of train 1's nose

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=24 s, P=0 Pa), (t=0, P=0 Pa) and (t=0, P=1500 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Vardy-Fig-4.tar' into WebPlotDigitizer for more details.

Original source data is run 10 in Myring, D, "Measurements of transient pressures caused by two trains passing in a tunnel", British Rail R&D division, 1972
Train/tunnel length ratio 0.153 (train lengths 120 m). Train/tunnel area ratio 0.165 (train areas 7.34 m^2). 0.165 might be a printers error; 0.185 would give 8.2 m^2, the train area in G&P for their 120 m long HST.
Train 1 speed: Mach 0.098 (33.3-33.7 m/s, 120-121 km/h), train 2 speed: Mach 0.107 (36.4-36.8 m/s, 131-132 km/h)

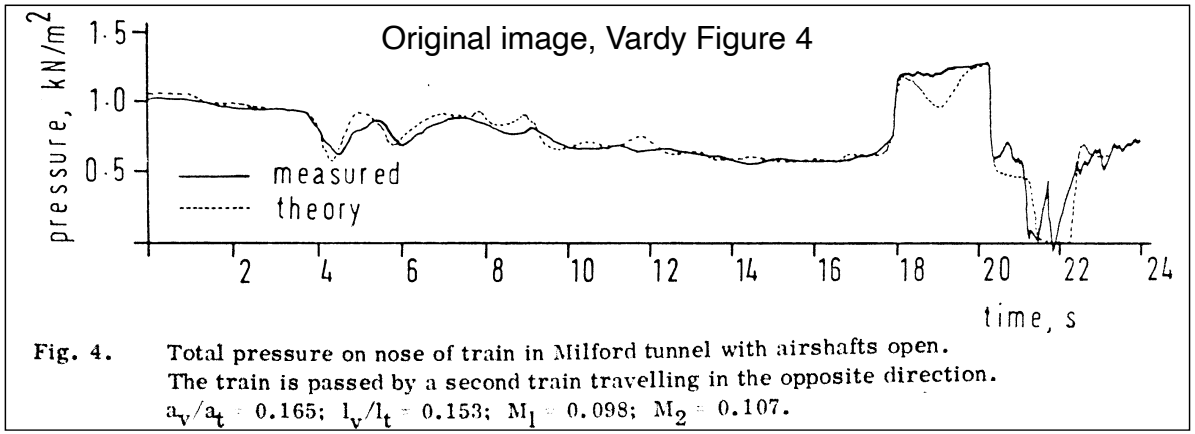
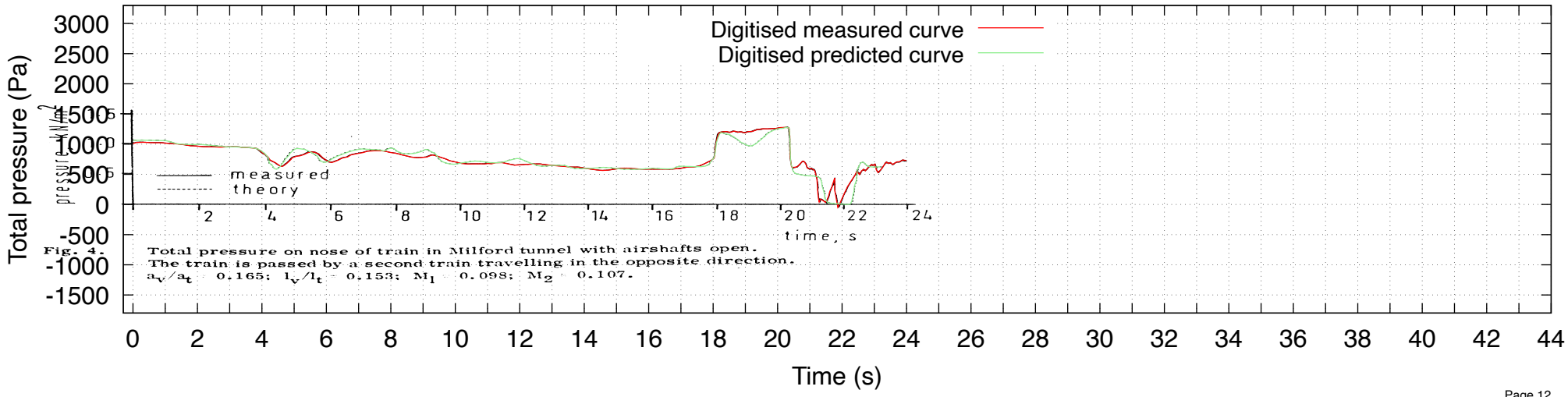


Fig. 4. Total pressure on nose of train in Milford tunnel with airshafts open.
The train is passed by a second train travelling in the opposite direction.
a_v/a_t = 0.165; l_v/l_t = 0.153; M_1 = 0.098; M_2 = 0.107.

Comparison of the image to the digitised data (at the same scale as G&P, because it's a useful comparison)



Source files: 1976-V-Fig-4-nose-ptot.txt and 1976-V-Fig-4-rotated.png.

Source paper: "The use of airshafts for the alleviation of pressure transients in railway tunnels", Vardy, A E, pages C55-C69 and Z30-Z32, Proceedings of the 2nd International Symposium on the Aerodynamics and Ventilation of Vehicle Tunnels (ISAVVT), 1976.

Image source: Second graph on page C3-54
Test place & time: Milford Tunnel (twin-track, 4 shafts), early 1970s
Two trains passing in the tunnel, in the same series of tests as Figures 7 and 8 of G&P
Empirical data used in the paper's calculation is not stated, but is likely to be the same as the data in Gawthorpe and Pope (G&P)
Data in the image: measured and calculated total pressure in front of train 1's nose

Digitisation method: WebPlotDigitizer was given the following setting out points: (t=0 s, P=0 Pa), (t=24 s, P=0 Pa), (t=0, P=0 Pa) and (t=0, P=1500 Pa). It adjusted the axes of the image to be orthogonal and digitised a set of manually selected points. Load '1976-Vardy-Fig-5.tar' into WebPlotDigitizer for more details.

Original source data is run 29 in Myring, D, "Measurements of transient pressures caused by two trains passing in a tunnel", British Rail R&D division, 1972
Train/tunnel length ratio 0.153 (train lengths 120 m). Train/tunnel area ratio 0.165 (train areas 7.34 m^2). 0.165 might be a printers error; 0.185 would give 8.2 m^2, the train area in G&P for their 120 m long HST.
Train 1 speed: Mach 0.099 (33.7-34 m/s, 121-123 km/h), train 2 speed: Mach 0.106 (36.1-36.4 m/s, 130-131 km/h)

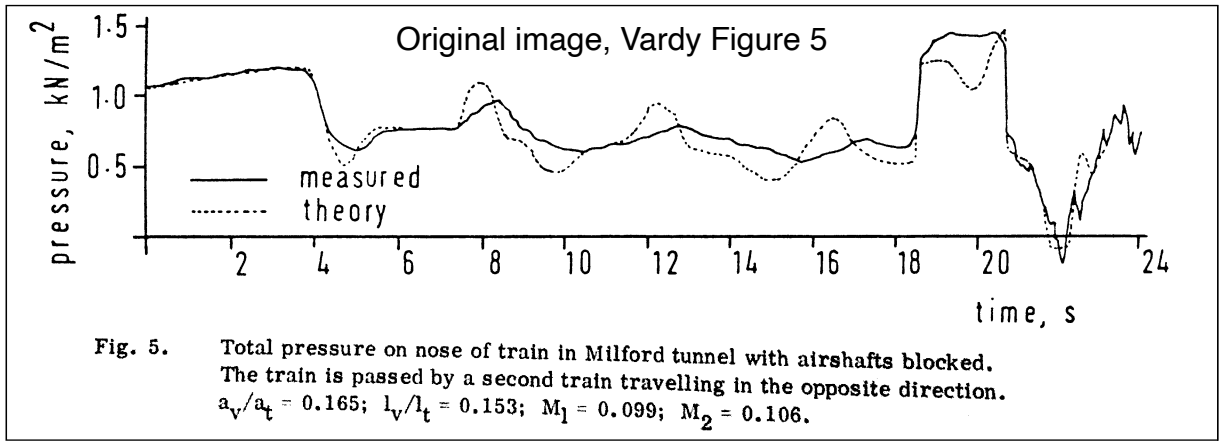


Fig. 5. Total pressure on nose of train in Milford tunnel with airshafts blocked.
The train is passed by a second train travelling in the opposite direction.
$a_v/a_t = 0.165$; $l_v/l_t = 0.153$; $M_1 = 0.099$; $M_2 = 0.106$.

Comparison of the image to the digitised data (at the same scale as G&P, because it's a useful comparison)