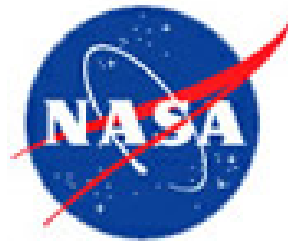


Plots of Speed Maneuvers for Arrival Delay



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The following plots show examples of speed-reduction maneuvers for arrival delay. The delays are used to fill an arrival time slot and to realize the required wake-vortex spacing behind the previous arrival to the same runway. This is the first kind of maneuver used for arrival delay, and when the limit is reached (because the aircraft is not allowed to reduce speed any further), other kinds of maneuvers are used, which will be shown in later sets of plots.

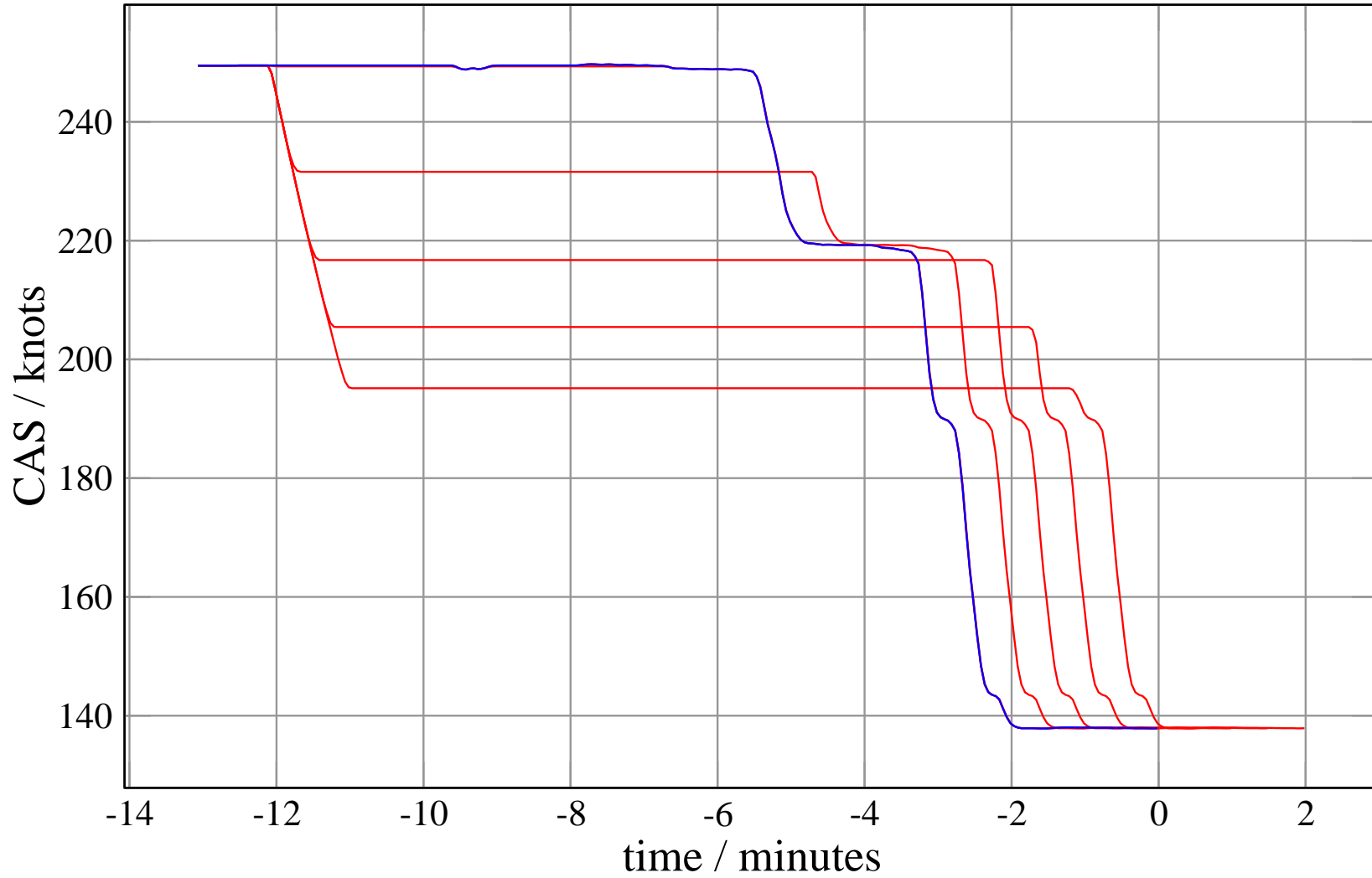
The original CAS (calibrated airspeed) profile in each plot is shown as a solid line, and the reduced CAS profiles are shown as dashed lines. The subtitle of each plot shows the aircraft type and the test results. The required delay for each route was incremented in steps of 30 seconds, and the speed reduction necessary to realize each required delay was computed using a bisection algorithm (while maintaining the original altitude profiles and accounting for winds). The minimum allowed CAS was 1.3 times the stall speed for the aircraft type. The resulting maximum delay (by speed reduction alone) is shown in the subtitle.

The error in the resulting delay is also shown in each subtitle. This error applies to the reference trajectory computation only and should not be confused with flight control accuracy. These errors can be made arbitrarily small at the expense of more computation by simply adding more iterations in the bisection algorithm. The maximum error for all runs was ?? seconds, and the computational time was approximately 8 milliseconds per delay solution. That is more than sufficient accuracy and more than fast enough for real time.

[generated using test/SpeedReductionTest.scala]

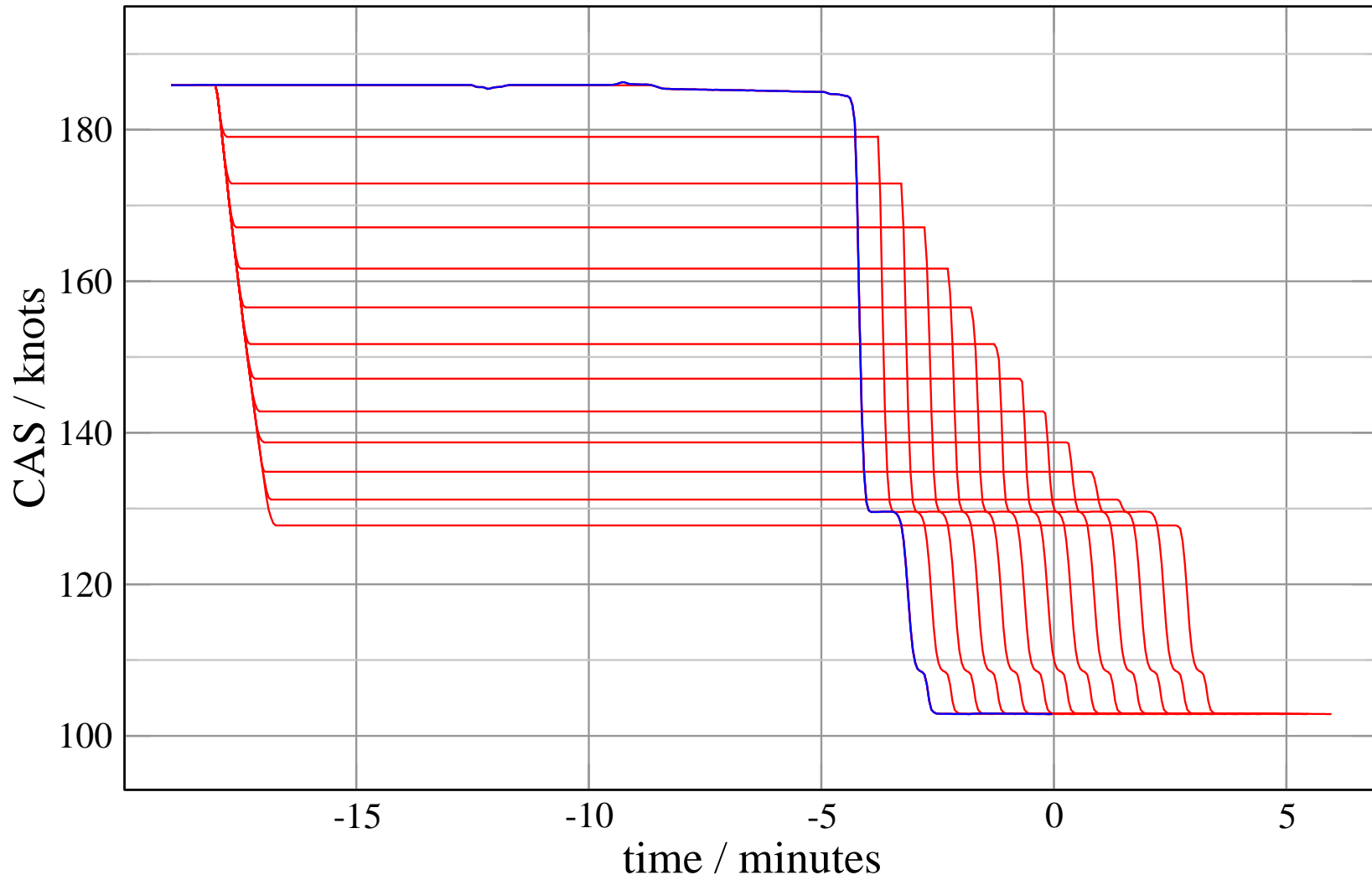
CAS Airspeed Reduction Profiles

110 (B737 D DAL/13L Arr) step: 30 sec, max delay: 2.0 min, max err: 0.09 sec



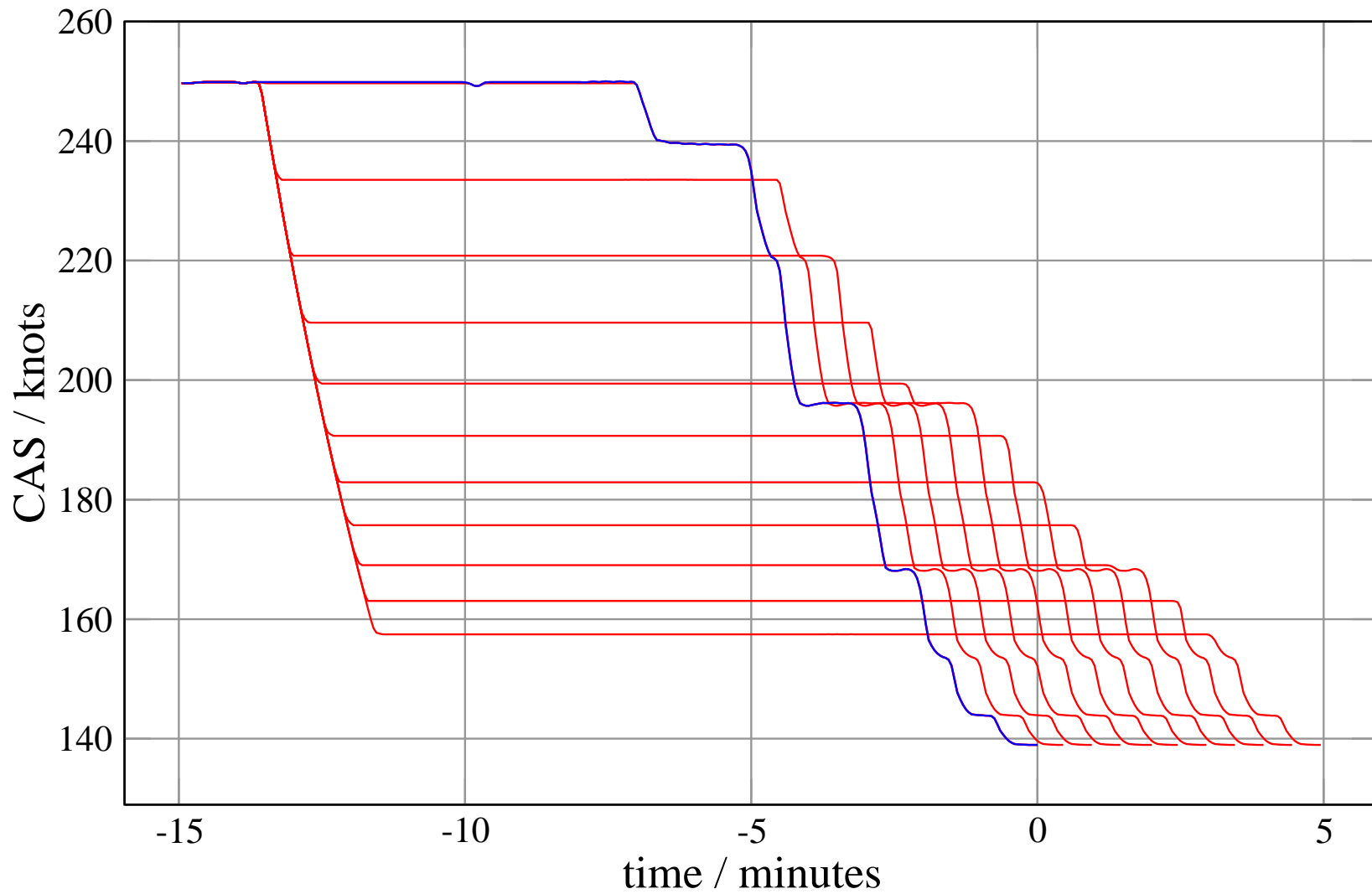
CAS Airspeed Reduction Profiles

1322 (BE20 F DAL/13L Arr) step: 30 sec, max delay: 6.0 min, max err: 0.12 sec



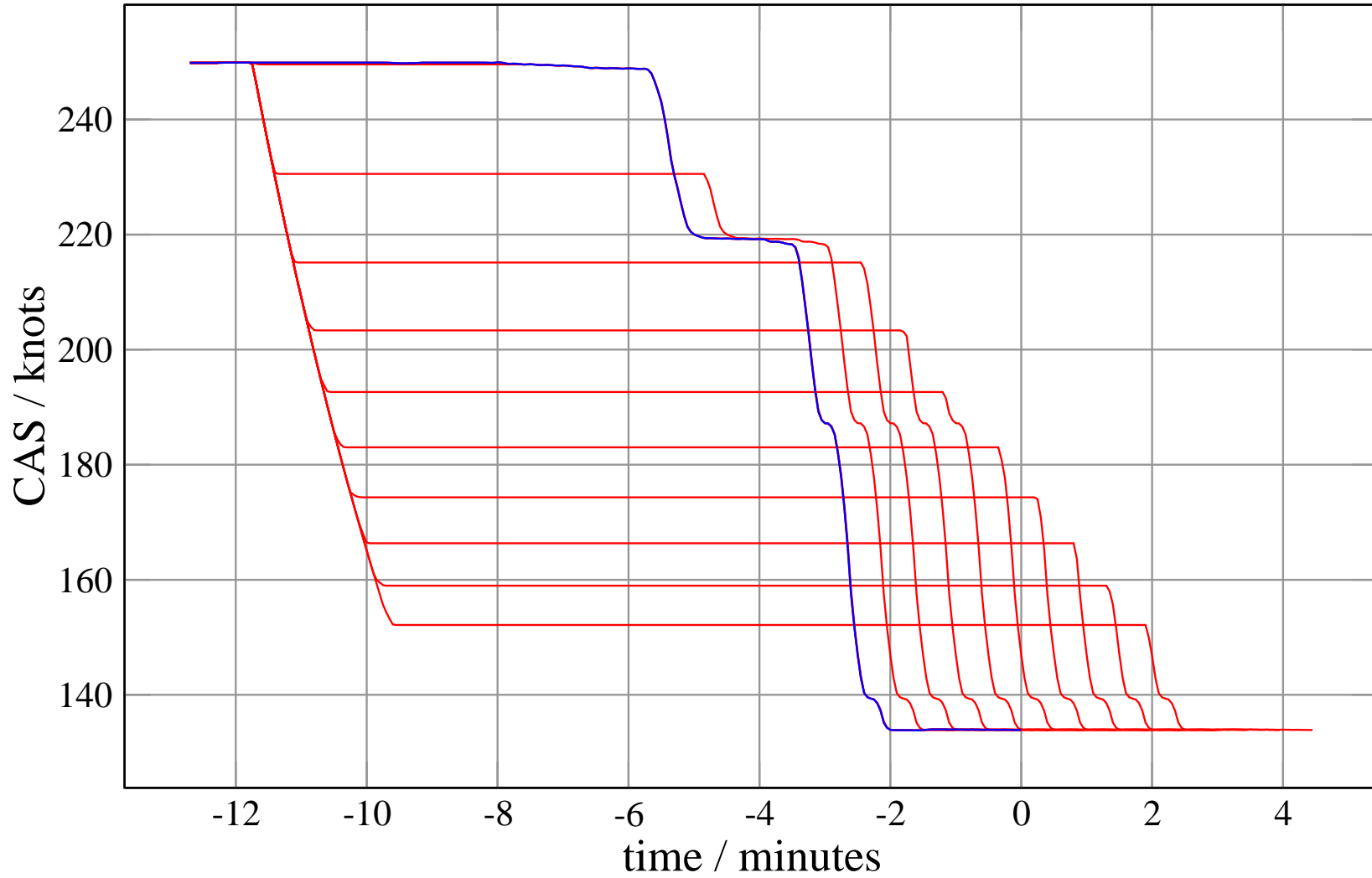
CAS Airspeed Reduction Profiles

1334 (E145 E DFW/18R Arr) step: 30 sec, max delay: 5.0 min, max err: 0.00 sec



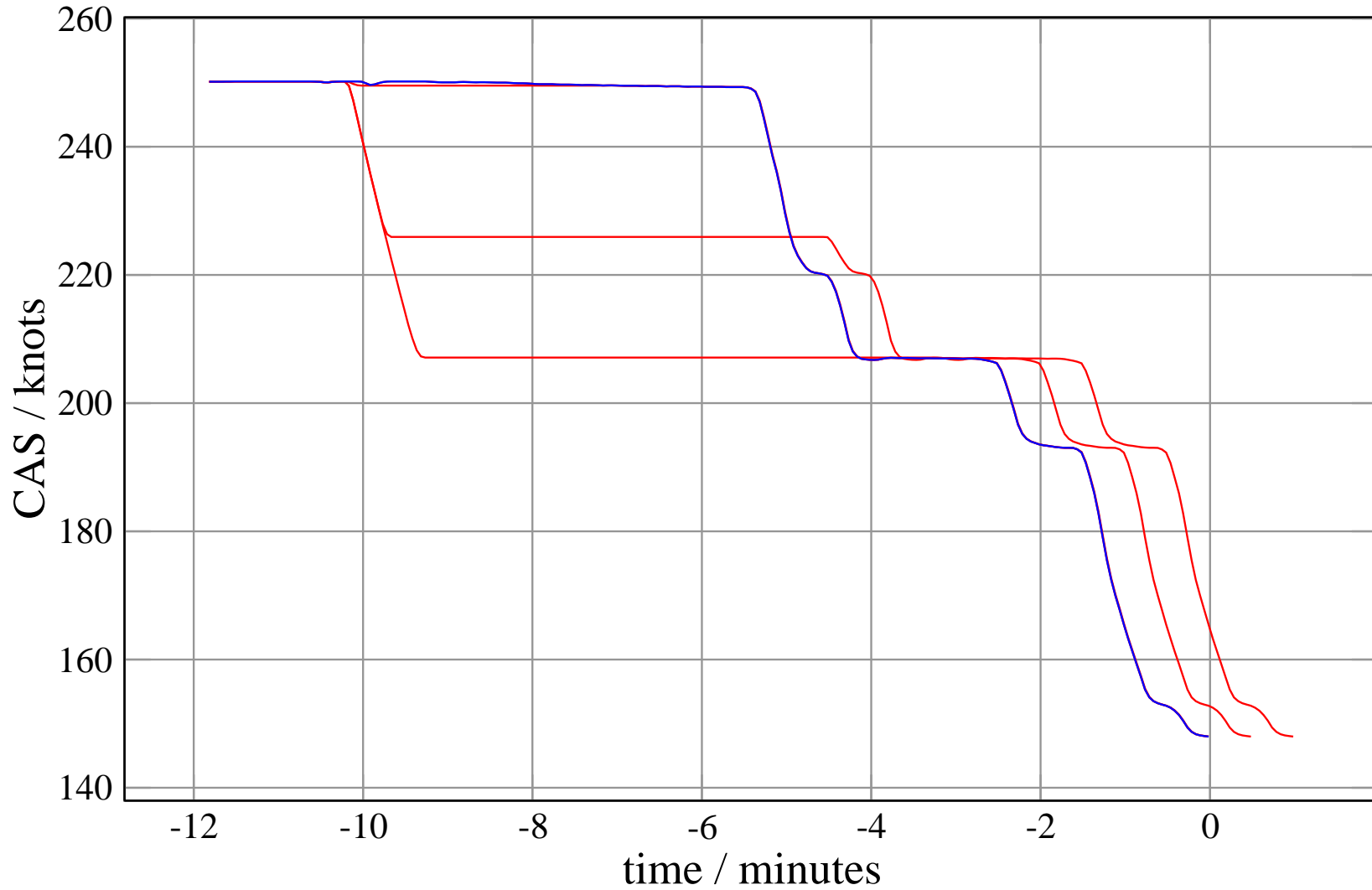
CAS Airspeed Reduction Profiles

1419 (CRJ2 E DAL/13L Arr) step: 30 sec, max delay: 4.5 min, max err: 0.01 sec



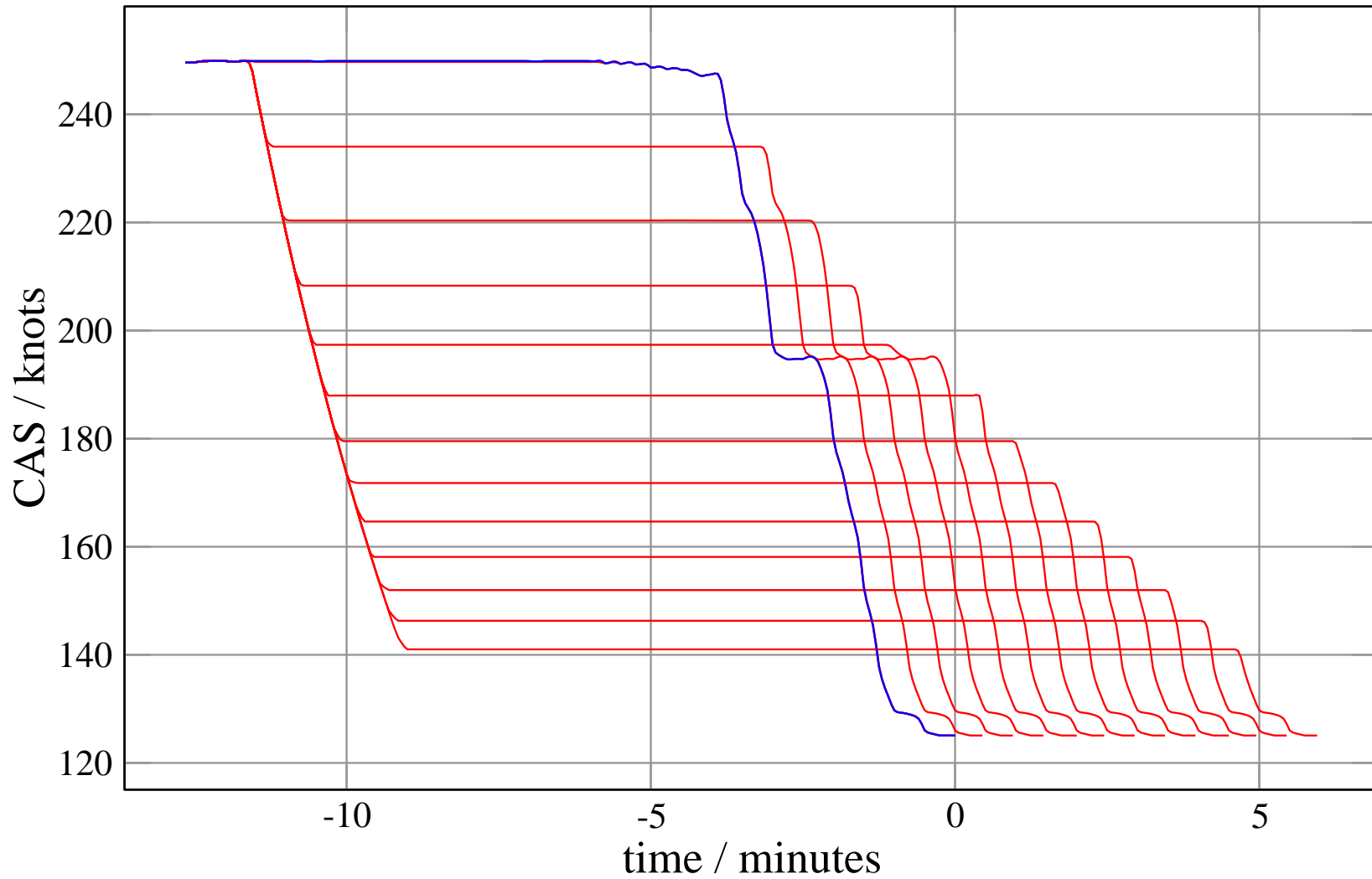
CAS Airspeed Reduction Profiles

1439 (DC10 C DFW/17C Arr) step: 30 sec, max delay: 1.0 min, max err: 0.02 sec



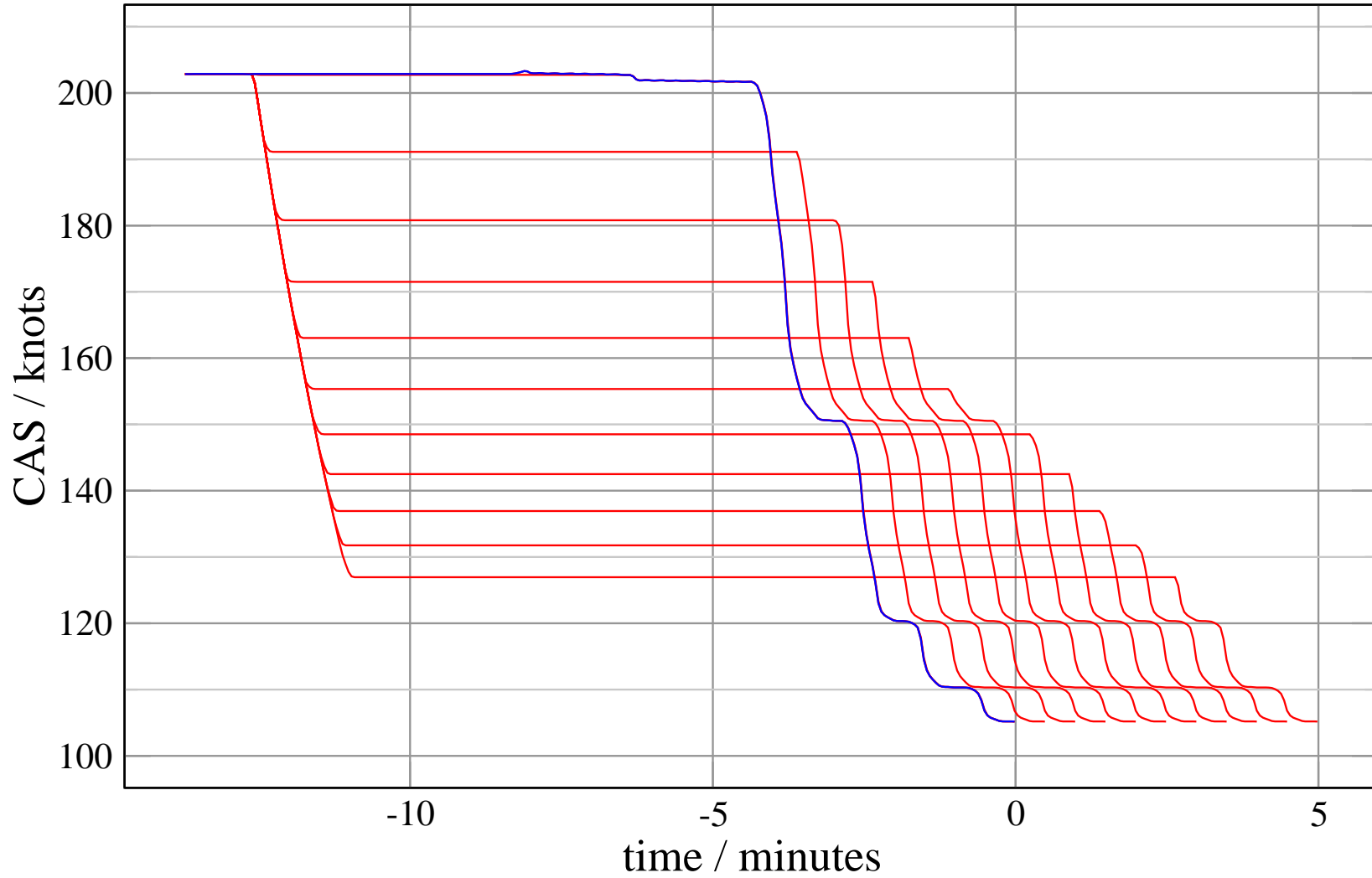
CAS Airspeed Reduction Profiles

1448 (LJ45 F DFW/17C Arr) step: 30 sec, max delay: 6.0 min, max err: 0.07 sec



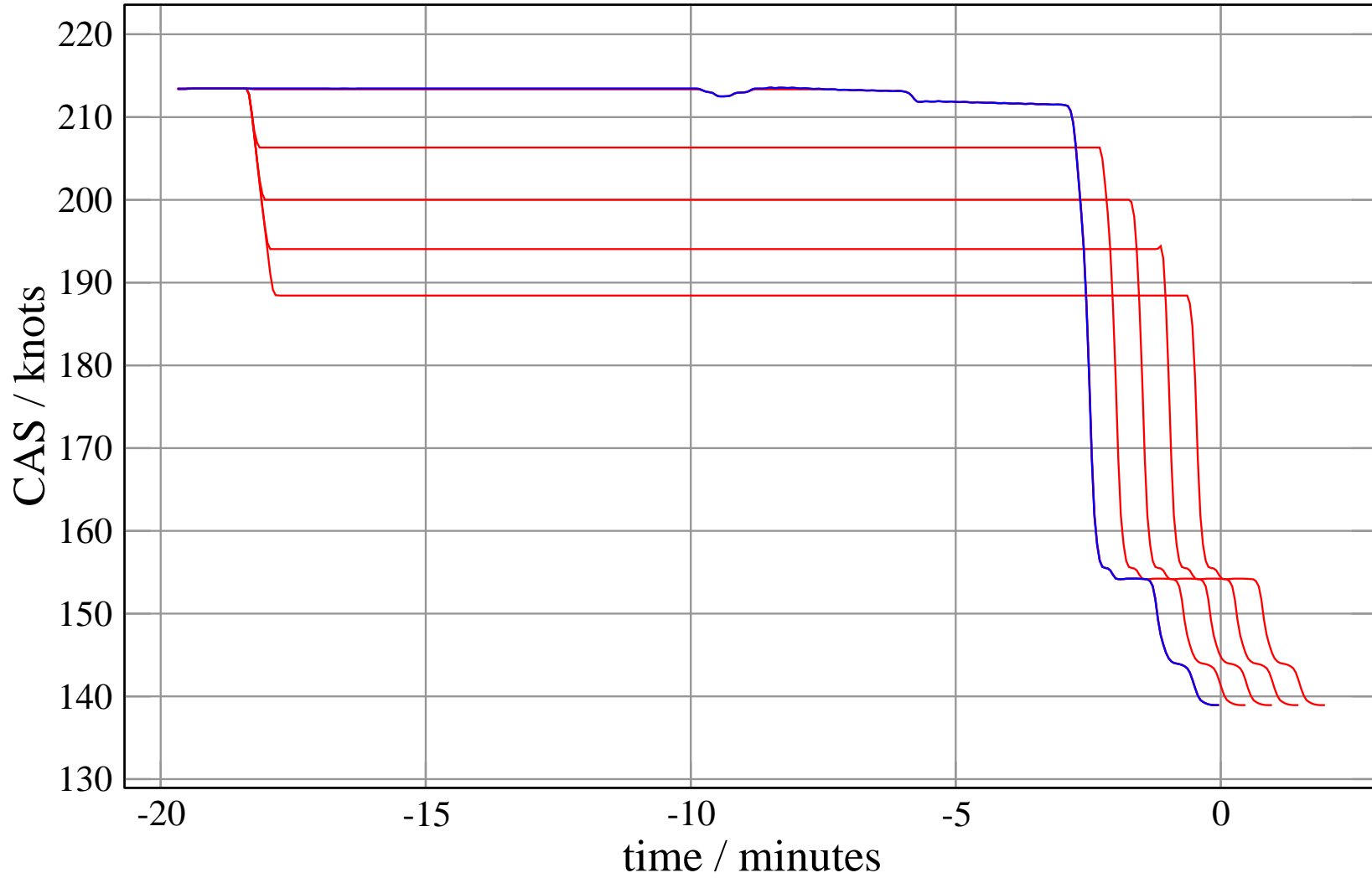
CAS Airspeed Reduction Profiles

1512 (BE20 F DFW/18R Arr) step: 30 sec, max delay: 5.0 min, max err: 0.00 sec



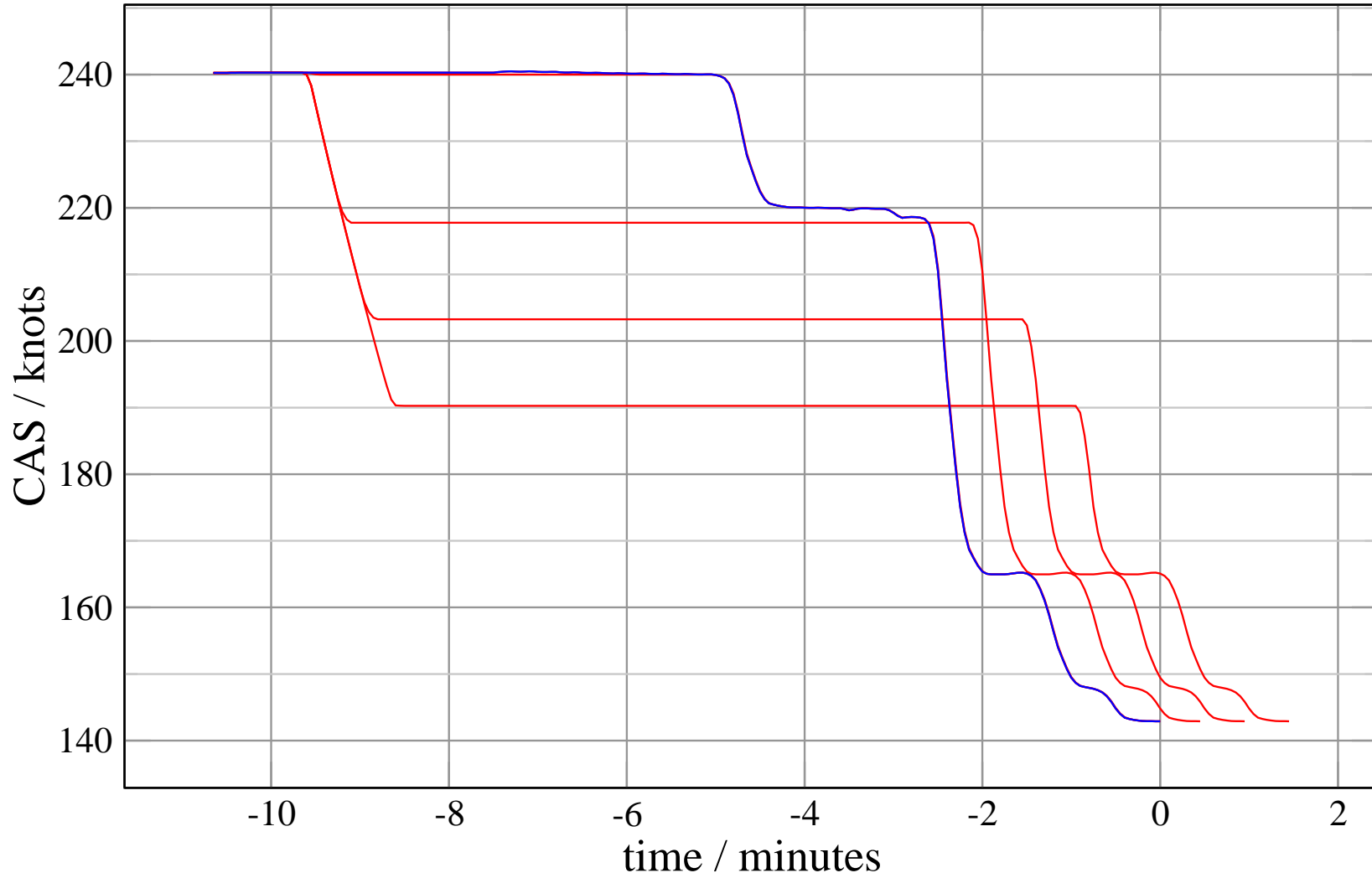
CAS Airspeed Reduction Profiles

1514 (B737 D DAL/13L Arr) step: 30 sec, max delay: 2.0 min, max err: 0.02 sec



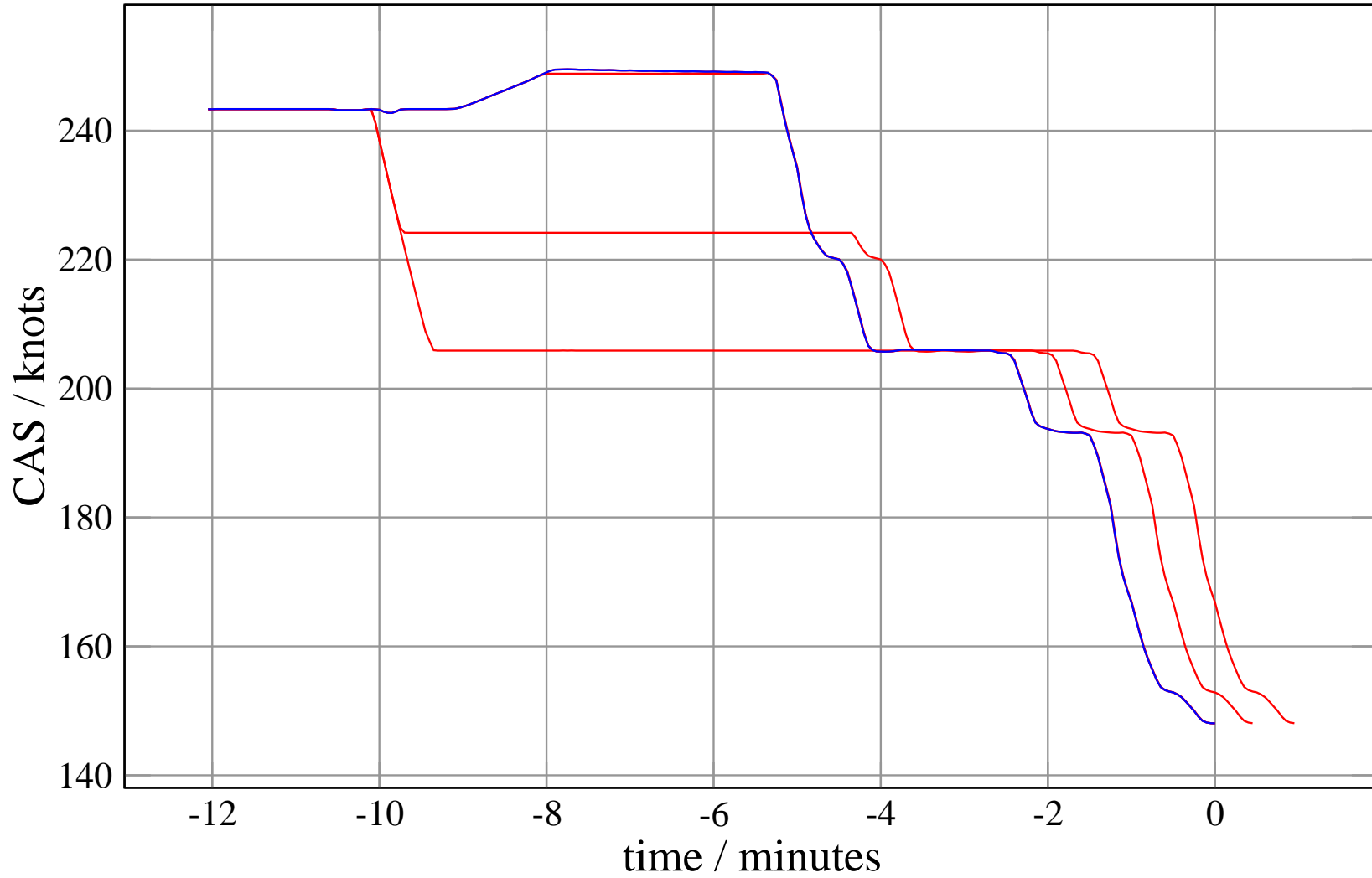
CAS Airspeed Reduction Profiles

1558 (B733 D DAL/13L Arr) step: 30 sec, max delay: 1.5 min, max err: 0.01 sec



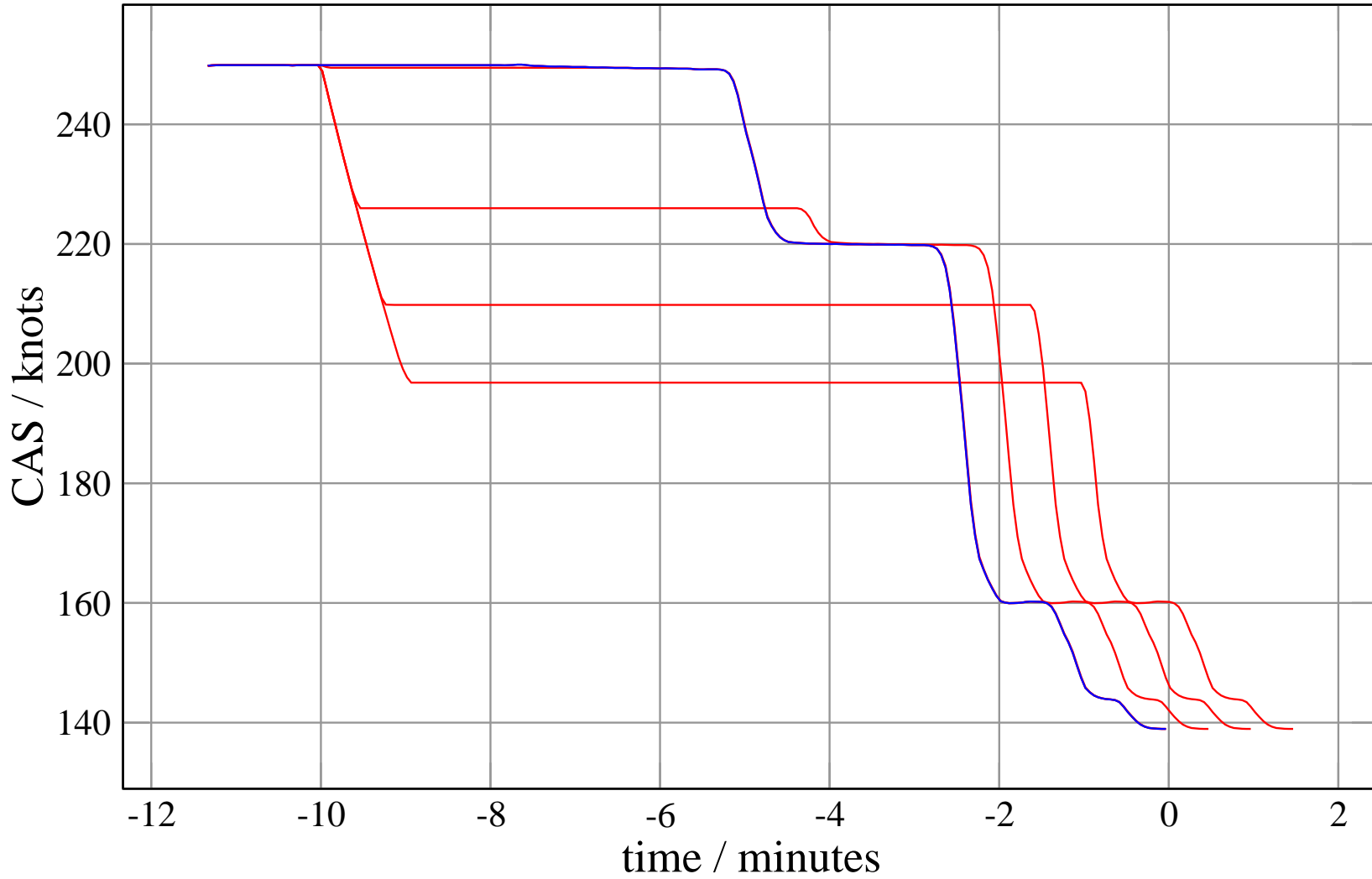
CAS Airspeed Reduction Profiles

1620 (DC10 C DFW/17C Arr) step: 30 sec, max delay: 1.0 min, max err: 0.03 sec



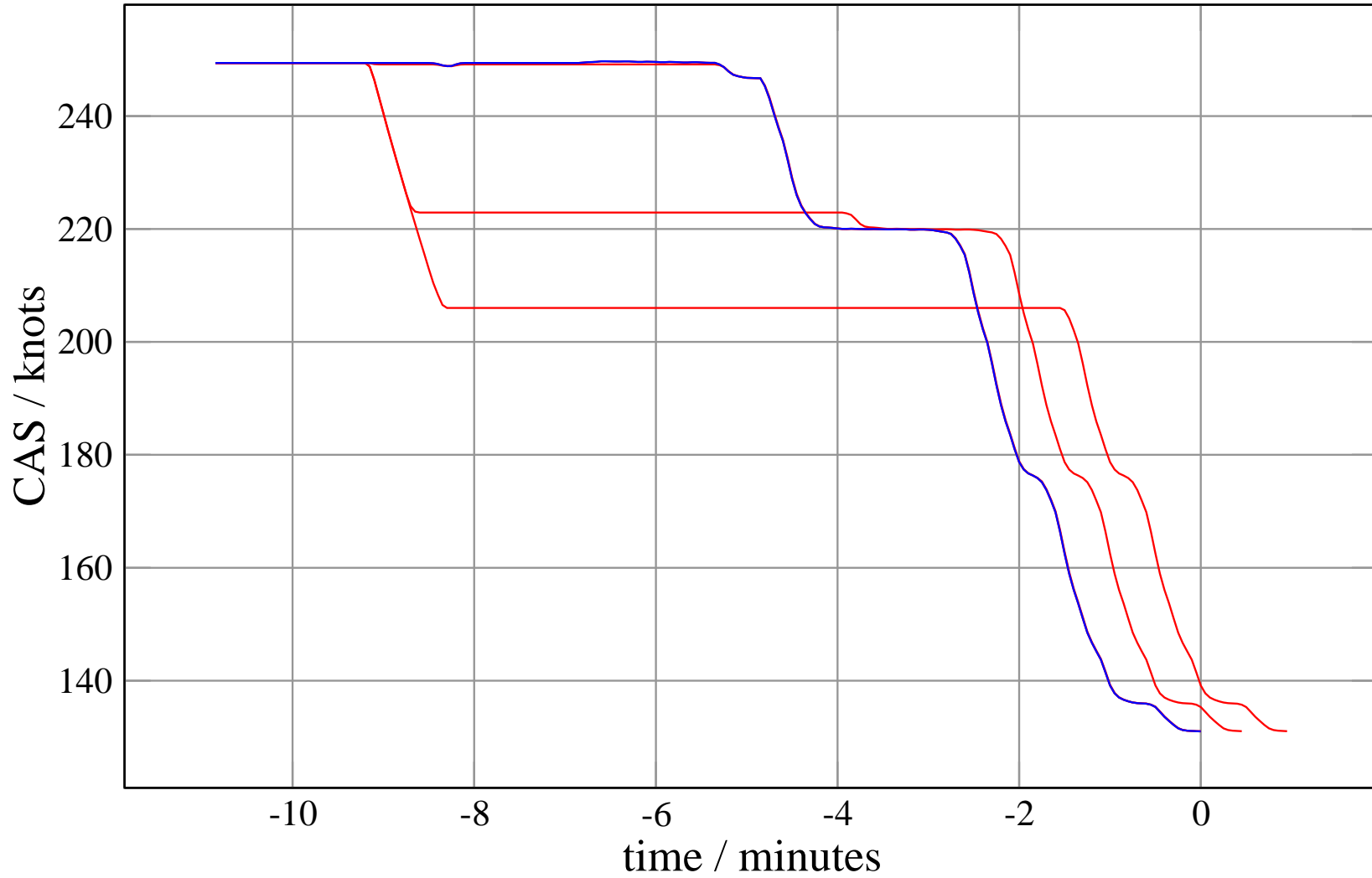
CAS Airspeed Reduction Profiles

1704 (B737 D DAL/13L Arr) step: 30 sec, max delay: 1.5 min, max err: 0.00 sec



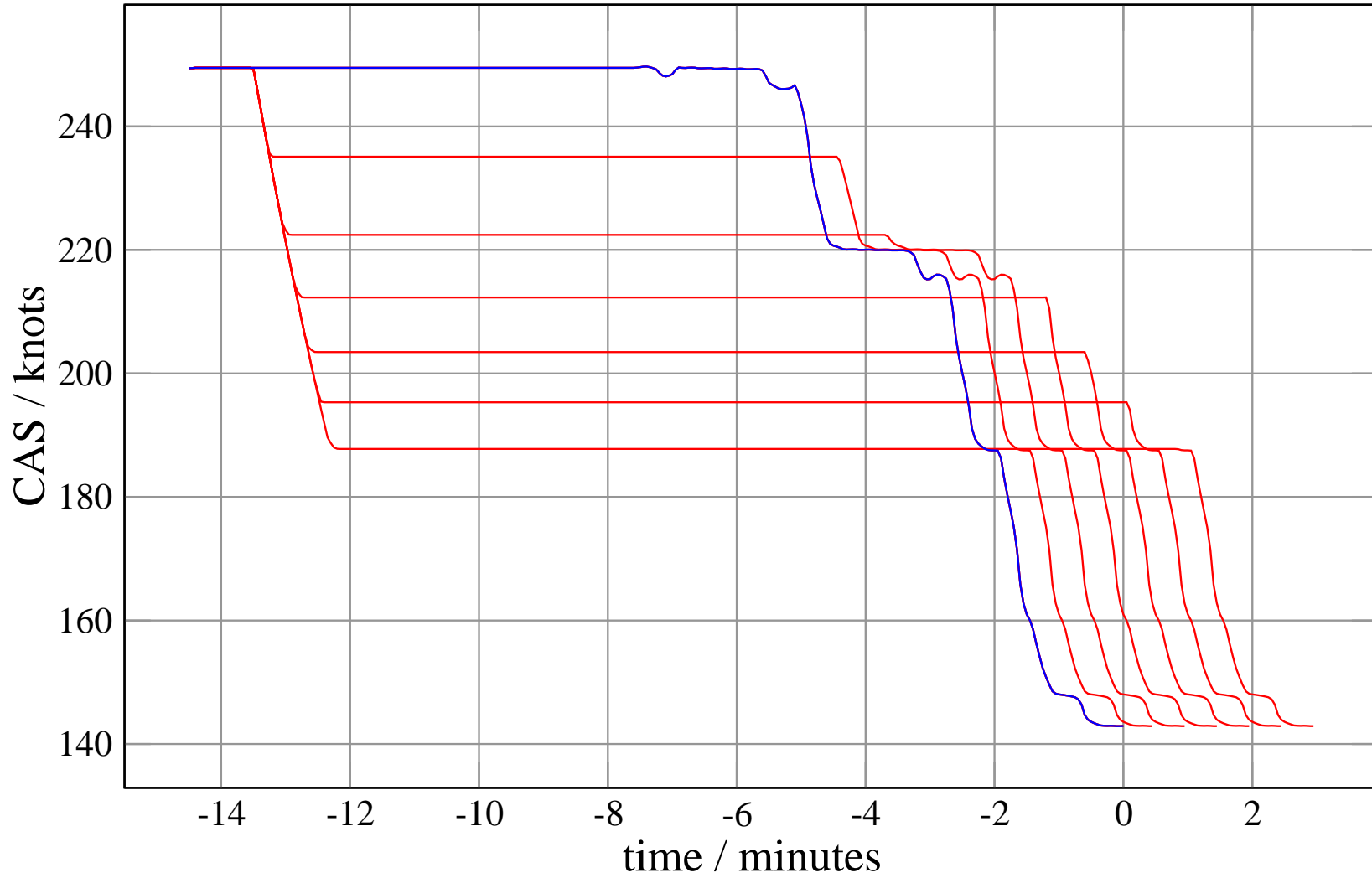
CAS Airspeed Reduction Profiles

1809 (A306 C DFW/17C Arr) step: 30 sec, max delay: 1.0 min, max err: 0.02 sec



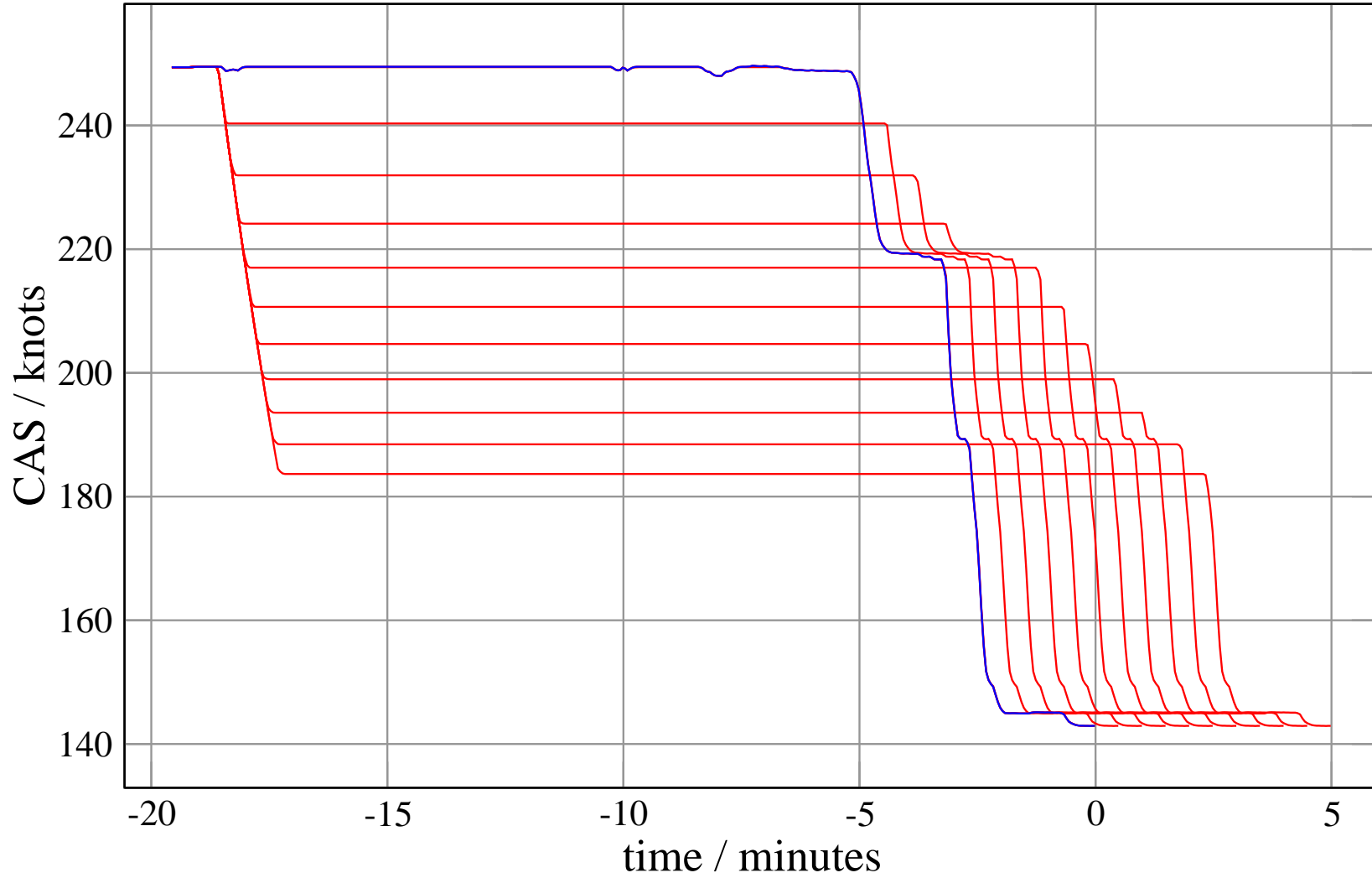
CAS Airspeed Reduction Profiles

1841 (B733 D DAL/13L Arr) step: 30 sec, max delay: 3.0 min, max err: 0.30 sec



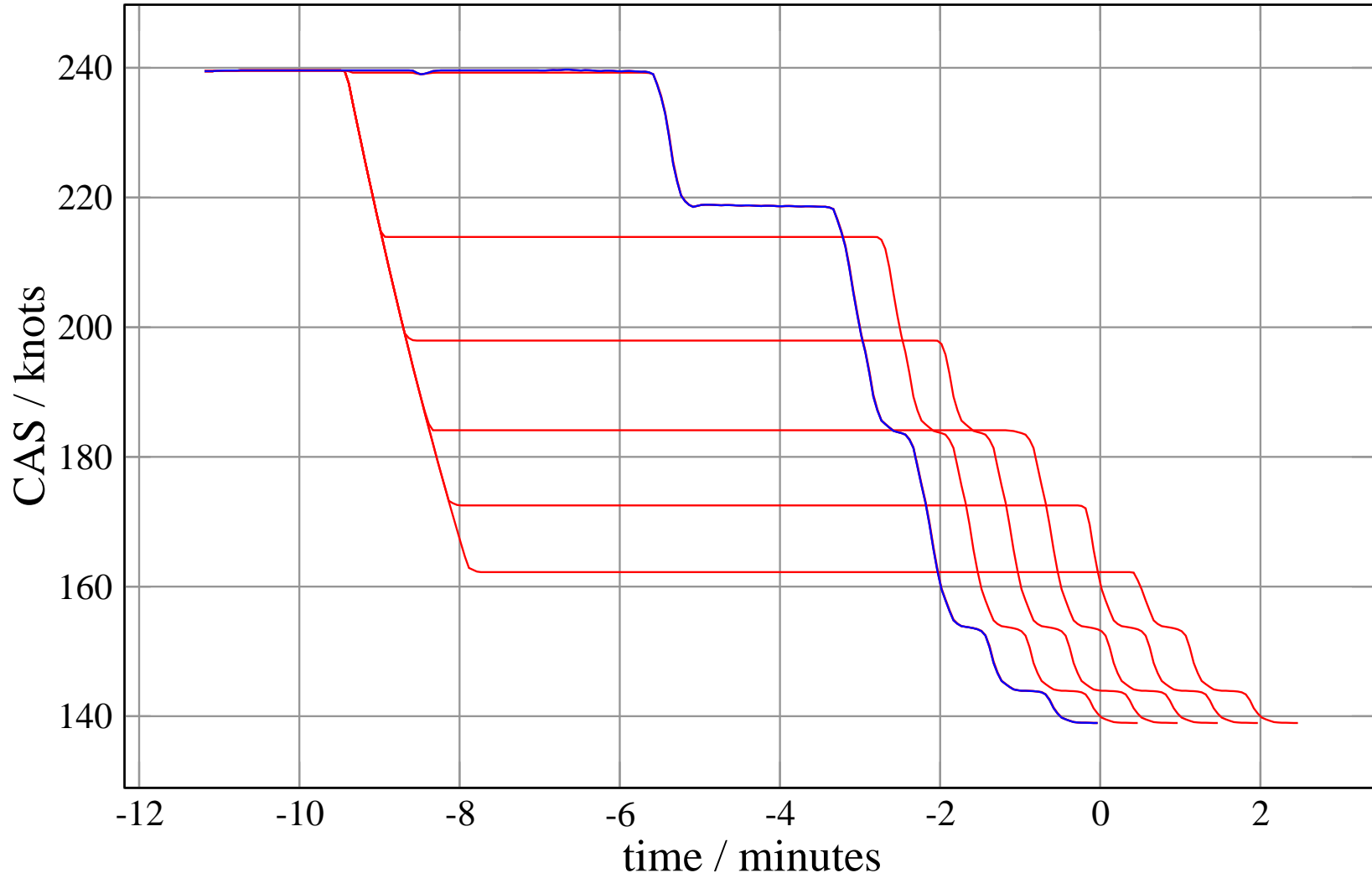
CAS Airspeed Reduction Profiles

1842 (B733 D DAL/13L Arr) step: 30 sec, max delay: 5.0 min, max err: 0.10 sec



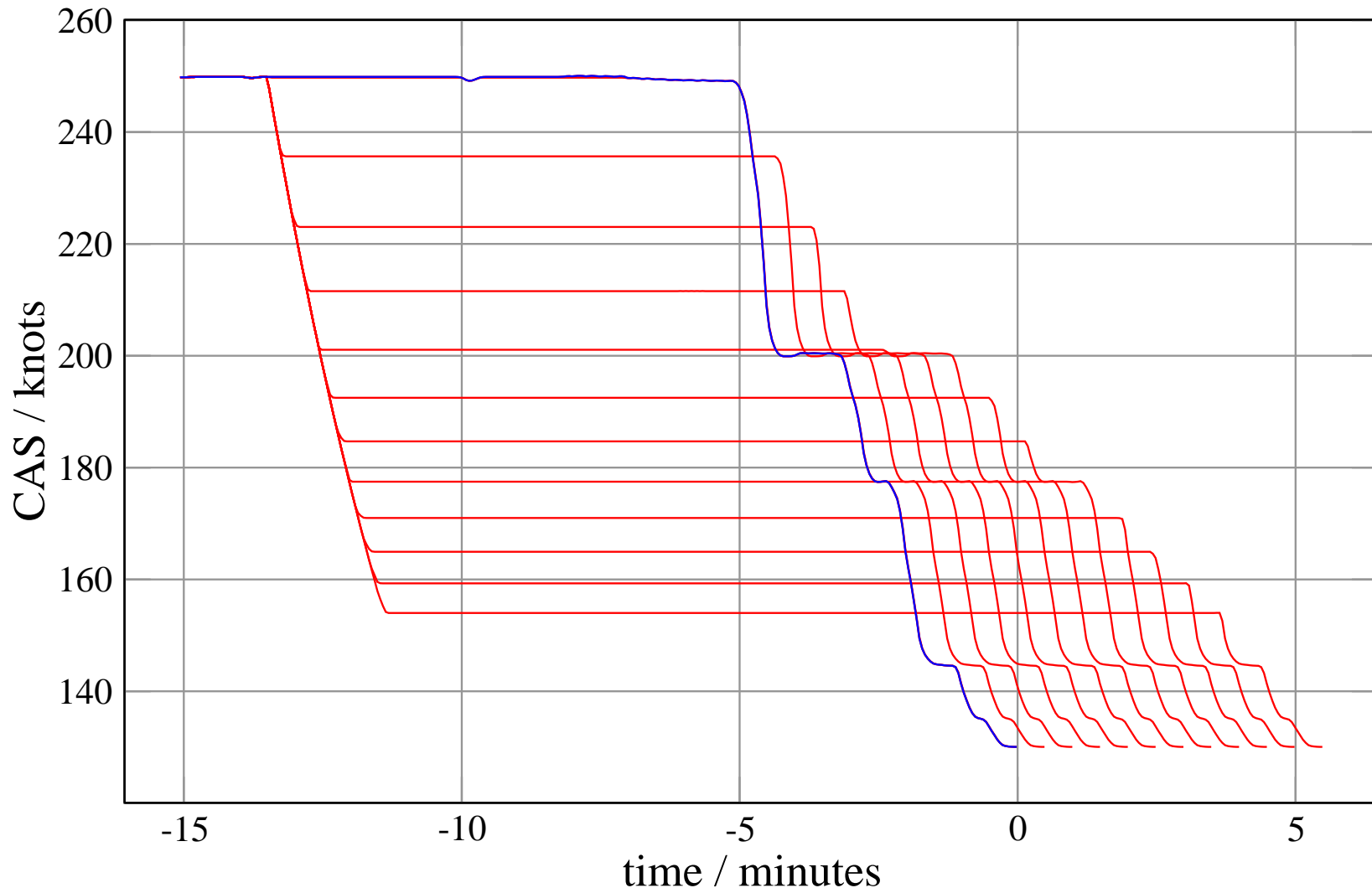
CAS Airspeed Reduction Profiles

1911 (E145 E DFW/18R Arr) step: 30 sec, max delay: 2.5 min, max err: 0.01 sec



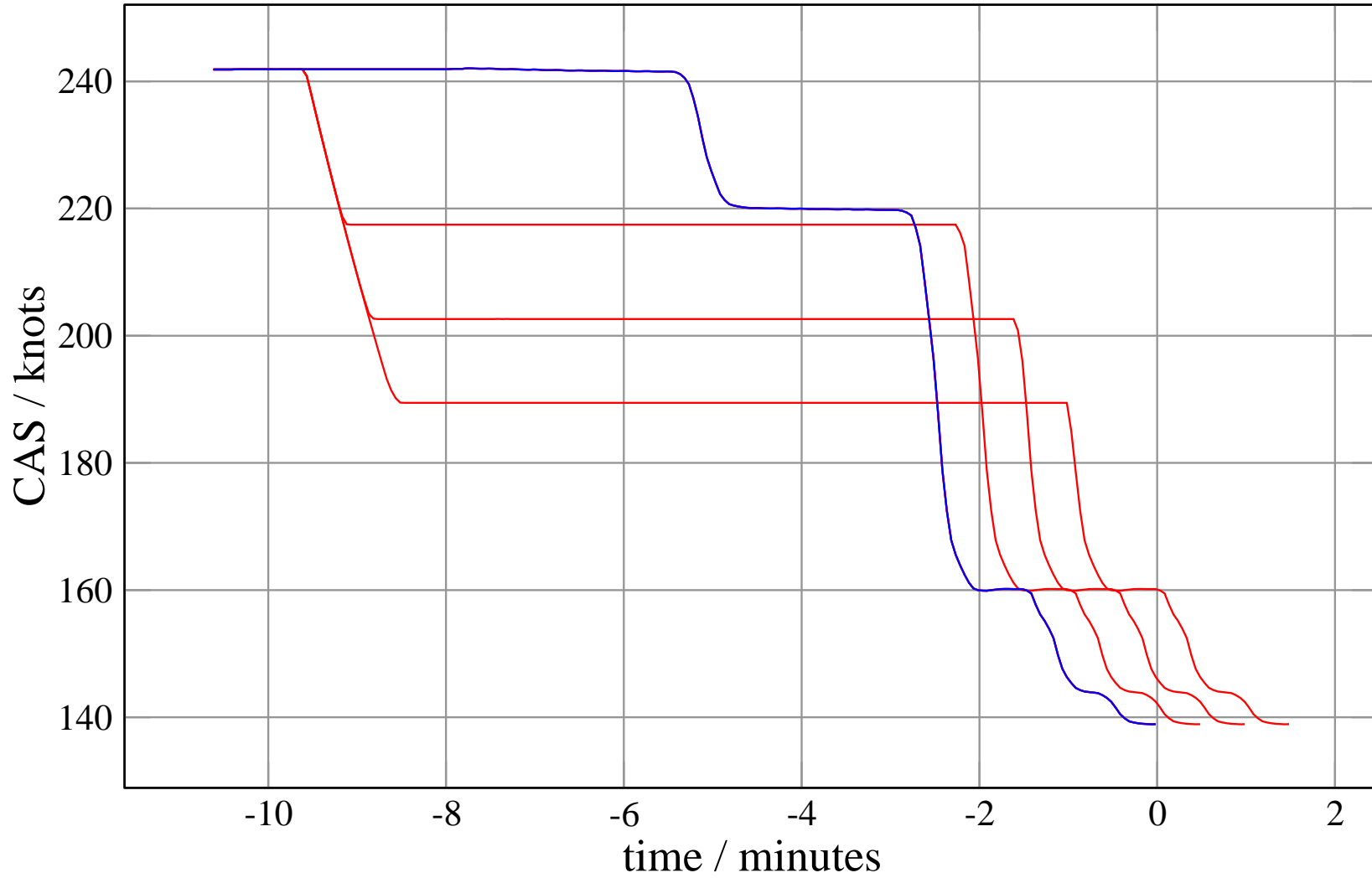
CAS Airspeed Reduction Profiles

1922 (E135 E DFW/17C Arr) step: 30 sec, max delay: 5.5 min, max err: 0.06 sec



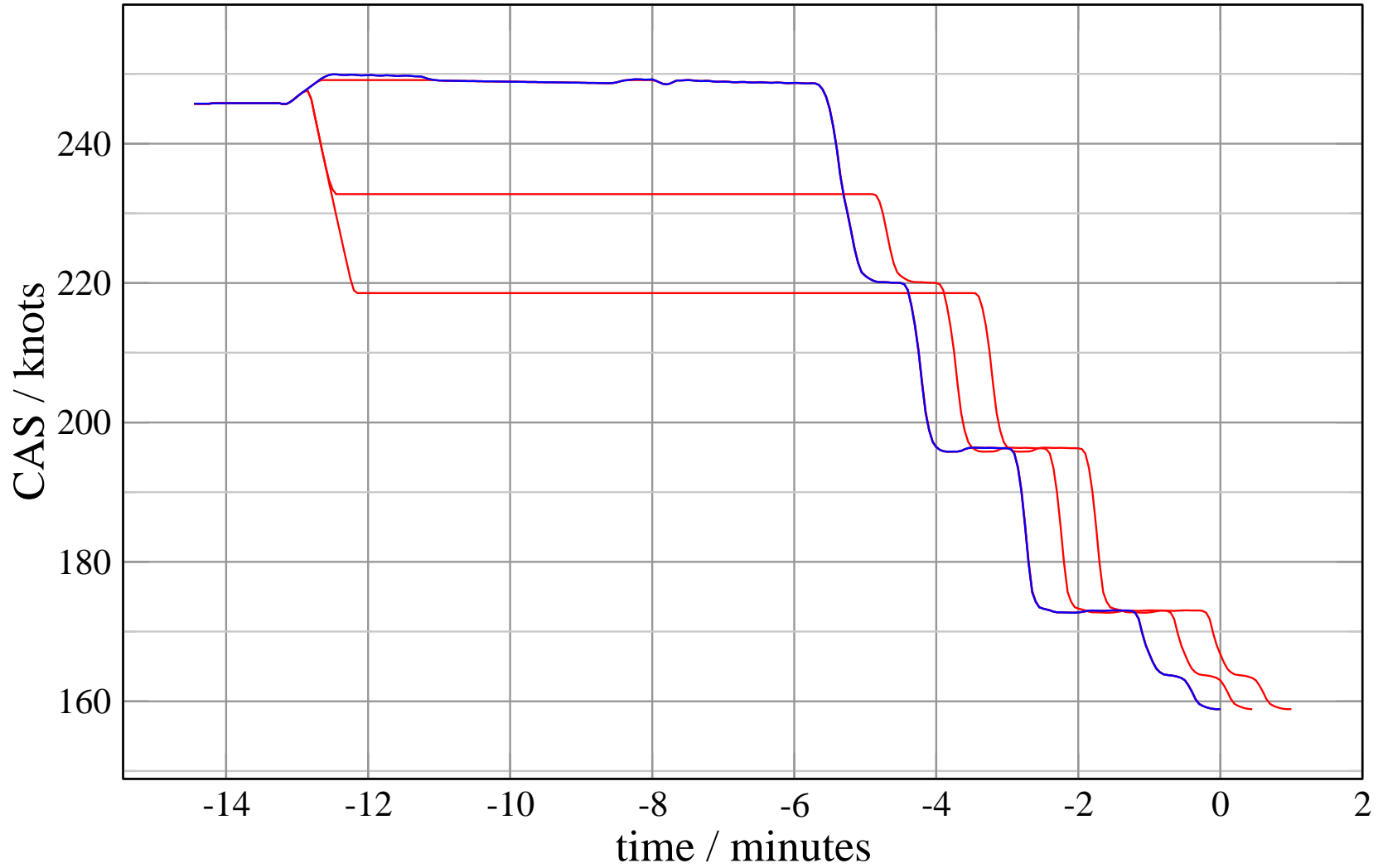
CAS Airspeed Reduction Profiles

2002 (B737 D DAL/13L Arr) step: 30 sec, max delay: 1.5 min, max err: 0.30 sec



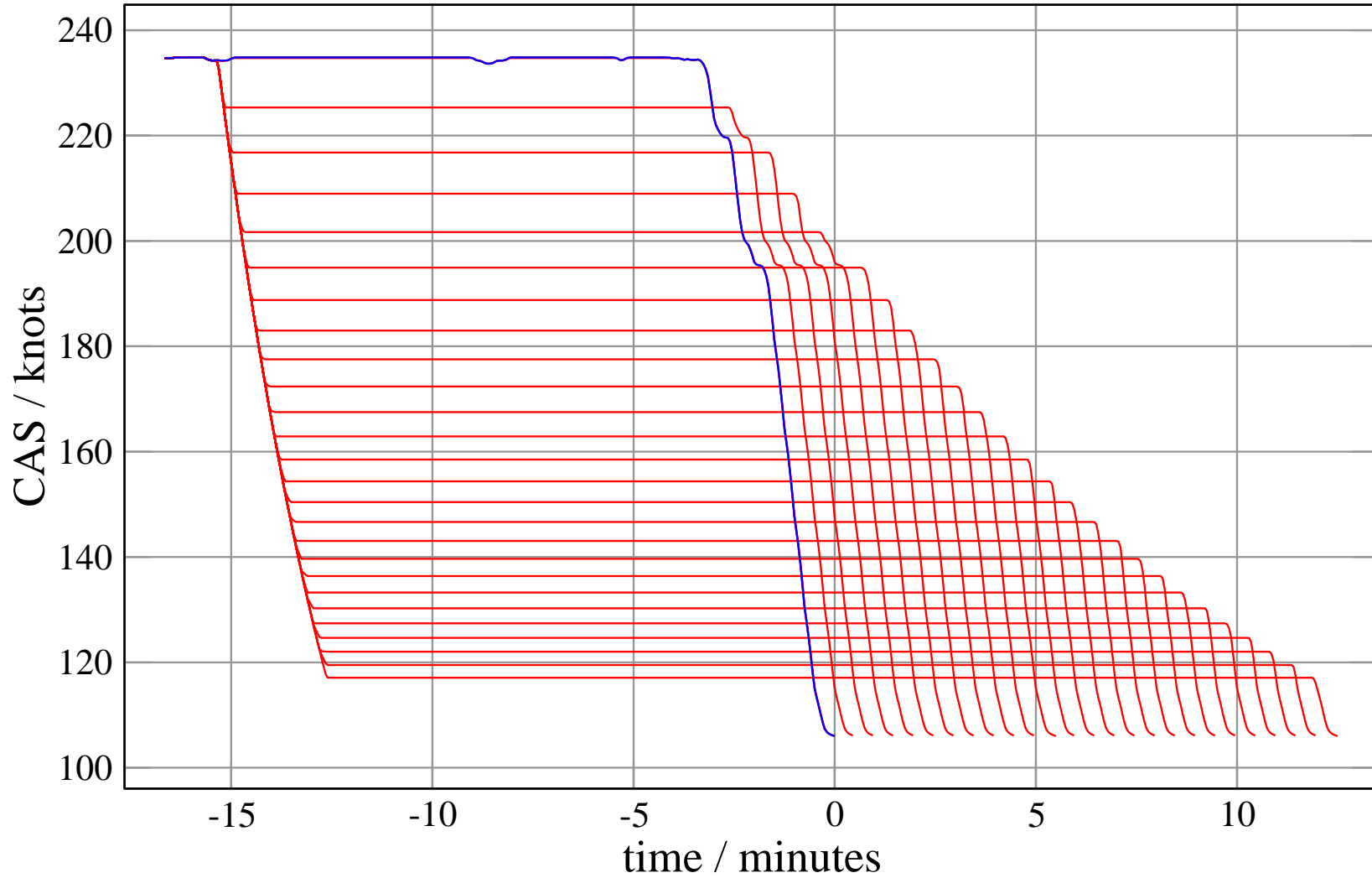
CAS Airspeed Reduction Profiles

2118 (B763 C DFW/17C Arr) step: 30 sec, max delay: 1.0 min, max err: 0.06 sec



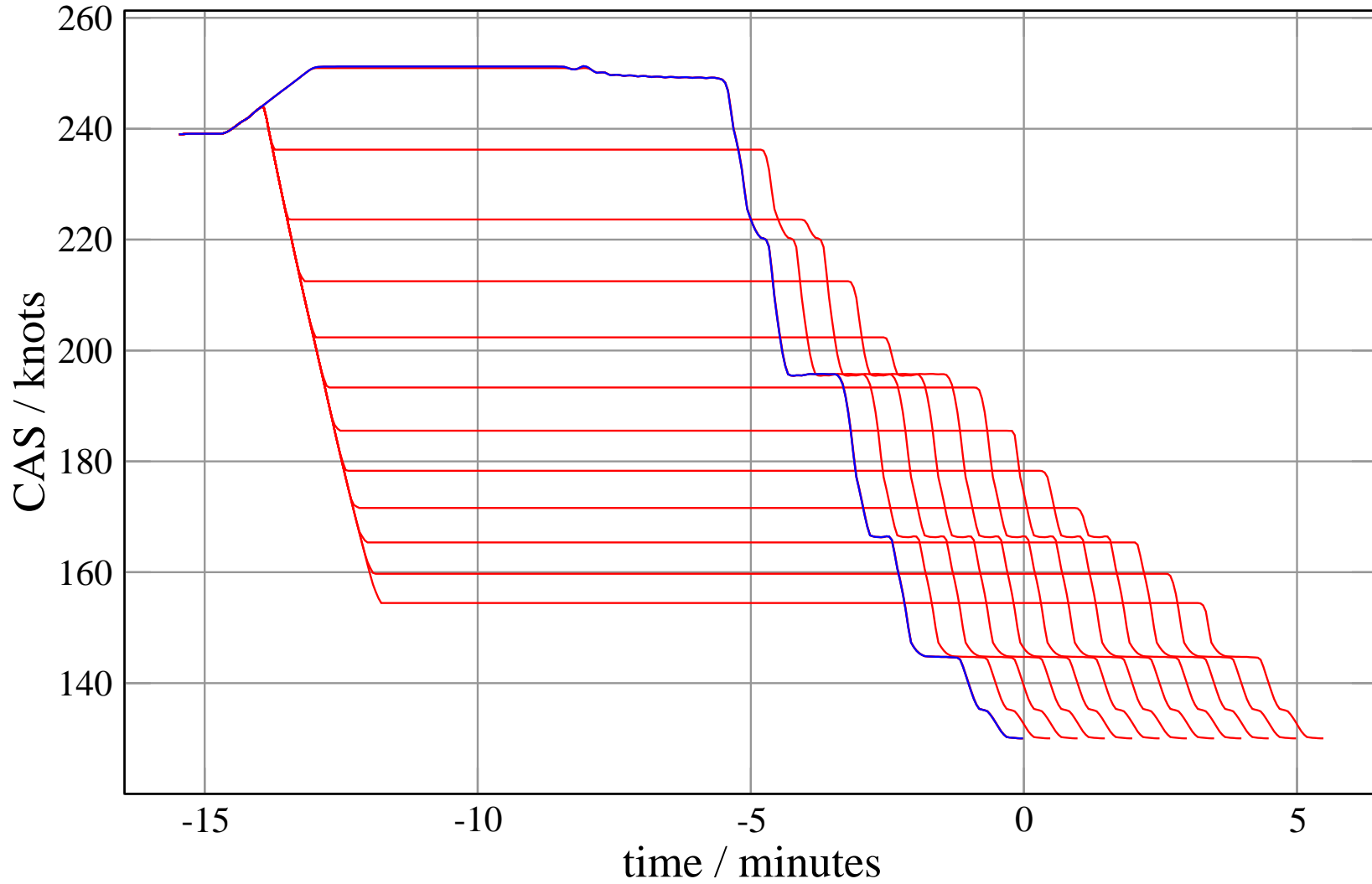
CAS Airspeed Reduction Profiles

23 (C441 F DAL/13L Arr) step: 30 sec, max delay: 12.5 min, max err: 0.03 sec



CAS Airspeed Reduction Profiles

25 (E135 E DFW/18R Arr) step: 30 sec, max delay: 5.5 min, max err: 0.00 sec



CAS Airspeed Reduction Profiles

54 (E135 E DFW/17C Arr) step: 30 sec, max delay: 5.0 min, max err: 0.05 sec

