Flight model updates for 4.12

Work example for P-36 and P-40

General

Just like the previous patches, 4.12 will see some updated and some new flight models, mostly planes that previously had been AI controlled only, or new planes. In the past we've often been asked what we do when we create or change flight models, and up to now we haven't given a detailed answer. This is simply because giving a sufficiently detailed answer is quite a bit of work on its own, and we didn't find the time - until now.

4.12 will have the P-36 flyable. Having been an AI controlled plane up until now, the flight model was very crude and needed an update. Since it shares the air frame with the P-40, an update for the P-40 was thought to be mandatory as well, for consistency. With this example, we'd like to share what the flight model making process typically involves.

Research

General

Extensive research is the first step with every flight model done or redone, and to give you an idea, we've compiled an incomplete list of sources which we checked for the update of the P-36 and P-40 flight models. Most valuable are of course the primary sources, but also secondary sources often contain good information, be it about operational use, field modifications or just the bibliography. A couple of websites proved very useful, some of which have uploaded copies of first hand sources. Many sources still remain unlisted, for instance hard to reference primary snippets, or applicable general information, with very few specifics.

Typically we go through thousands of pages of varying quality, more for some planes that are very well documented, less for others were sources are very hard to find. As you can imagine, research can be very time consuming, so we are grateful for the help we sometimes receive from the community, making hard to get sources available to us.

1st hand sources - test reports, manuals, technical specifications

- technical order No. 01-25C-1 - handbook of operation and flight instructions for the P-36A pursuit airplane, Nov 25th, 1938
- technical order No. 01-25CB-1 - handbook of operation and flight instructions for the P-36A and P-36C pursuit airplane, revised May 25th, 1940
- technical order No. 01-25CB-1 - pilot's flight operation instructions P-36A and P-36C airplanes, revised Feb 15th, 1943
- technical order No. 01-25CE-1 - pilot's handbook of flight operating instructions for model P-40B and P-40C, Jul 25th, 1942
- technical order No. 01-25CK-1 - handbook of operation and flight instructions for the models P-40K and P-40K-1 fighter airplanes, Aug 20th, 1942
- AN 01-25CN-1 - pilot's flight operation instructions for Army model P-40N series British model Kittyhawk IV airplanes, Sep 25th, 1944
- AN 01-25CN-2 - erection and maintenance instructions for Army model P-40N series British model Kittyhawk IV airplanes, Aug 30th, 1944
- air publication 2012A pilot's notes - Curtiss H-75A-4 (P36) aeroplane Cyclone GR1820 -G205A Engine, Oct 1940

- air publication 2014A volume 1 - Kittyhawk I aeroplane, Aug 1941
- air publication 2014A pilot's notes - the Kittyhawk I aeroplane, Jul 1941
- pilot training manual for the P-40, 1944
- operation and service manual - Wright Cyclone 9 aircraft engines, 1944
- technical order No. 02-35GC-1 - handbook of operation instructions for the model R-1820-65 engine and associated models, Oct 10th, 1942
- technical order No. 02-5AD-1 - handbook of operation instructions for the model V-1710-35 engine and associated models, Oct 25th, 1941
- maintenance manual - R-1830 S1C3G Twin Wasp, Feb 1960
- operators handbook - Twin Wasp C3 engines, Jul 1943
- instruction manual - Pratt & Whitney engines R-1830-43 & 65, Nov 1943
- handbook - operation and maintenance for Allison V-1710 "F" type engines, Apr 1st, 1943
- sales brochure - Curtiss Hawk 75 pursuit airplane, unknown date
- preliminary handbook - operation and service instructions for the model P-36A pursuit airplane, 1938
- sales brochure - Curtiss Hawk 75-A pursuit airplane, unknown date
- notice sommaire generale - l'avion de chasse Curtiss Hawk 75A-1, unknown date
- notice de manoeuvre - l'avion de chasse Curtiss Hawk 75A-1, 1939
- report A.&A.E.E. 749a, part 1, Mohawk I A.R.645, Cyclone GR1820 - G.205A, oil cooling and cylinder temperature tests, Dec 15th, 1940
- report A.&A.E.E. 749a, part 2, Mohawk I A.R-645 and A.R-678, Cyclone GR1820 - G.205A, performance trials, Apr 5th, 1941
- report A.&A.E.E. 749a, part 4, Mohawk I A.R.640, Cyclone GR1820 - G.205A, tests with air cleaners, Mar 13th, 1941
- report A.&A.E.E. 749a, part 5, Mohawk I A.R.645 and A.R.678, Cyclone GR1820 - G.205A, fuel consumption measurements and handling tests, Apr 5th, 1941
- report A.&A.E.E. 749b, part 1, Mohawk II A.R.631, Twin Wasp R-1830-SC3-G, oil cooling and cylinder temperature tests, Dec 18th, 1940
- report A.&A.E.E. 749b, part 2, Mohawk II A.R.631, Twin Wasp R-1830-SC3-G, brief performance trials, Mar 6th, 1941
- air corps technical report 4338 - performance test of Curtiss Y1P-36 airplanes, Aug 28th, 1937
- engineering section memorandum report - Curtiss P-36B airplane, Sep 25th, 1939
- engineering section memorandum report - P-36A , Oct 31st, 1940, Jan 7th, 1941, May 16th, 1941, Jun 19th, 1941
- official summary of characteristics for P-40, P-40B, P-40E
- official performance summary for P-40, P-40B, P-40E
- reports A&A.E.E. 783, parts 1 to 19, in particular
  - report A&A.E.E. 783, part 5, Kittyhawk A.K.572 - weights, loading data and leading particulars, May 23rd, 1942
  - report A&A.E.E. 783, part 6, Kittyhawk A.K.572 - fuel consumption trials, May 13th, 1942
  - report A&A.E.E. 783, part 8, Kittyhawk A.K.572 - rate of climb and position error measurements, May 27th, 1942
  - report A&A.E.E. 783, part 11, Kittyhawk I A.L.229 - take-off and landing trials, with and without overload fuel tank, Sep 2nd, 1942

- report A&A.E.E. 783, part 12, Kittyhawk I's A.K.572 and A.L.229 - engine cooling trials, Sep 3rd, 1942
- report A&A.E.E. 783, part 15, Kittyhawk I A.L.229 - weight and loading data, Sep 30th, 1942
- report A&A.E.E. 783, part 17, Kittyhawk I A.L.229 and A.K.572 - handling trials, Dec 3rd, 1942
- report A&A.E.E. 783, part 19, Kittyhawk Ia L.T.573 - level speed performance with normal cowling fitted, Jun 20th, 1943

- C.S.I.R. report F.8, Kittyhawk aircraft, 1942
- D.T.S. technical bulletin no. 31, P-40N performance, 1944
- William H. Phillips - comparison of aileron characteristics as determined in flight tests of P-36, P-40, Spitfire and Hurricane pursuit airplanes, Nov 16th, 1942

2nd hand sources - books on the subject

- Francis H. Dean - America's hundred thousand, 1997
- Lionel Pursyn - Curtiss Hawk H-75 in French service, 2010
- Lionel Pursyn, Kari Stenman, Andrew Thomas - P-36 Hawk Aces of World War 2, 2009
- Michal M. Mietelski - Samolet mysliwski Curtiss Hawk 75, 1987
- Marek Rys - Curtiss P-36 Hawk, part 1, 2000
- Marek Rys, Seweryn Fleischer - Curtiss P-36 Hawk, part 2, 2000
- Jiri Chodil, Seweryn Fleischer - Curtiss P-36 Hawk, part 3, 2000
- Kalevi Keskinen, Kari Stenman, Klaus Niska - Curtiss Hawk 75A, 1975
- Peter M. Bowers - The Curtiss Hawk 75, 1966
- Ernets R. McDowell - Curtiss P-40 in action, 1976
- Marek Rys - Curtiss P-40 Tomahawk, Kittyhawk, Warhawk, part 1, 2000
- Zbigniew Kolacha, Marek Rys - Curtiss P-40, XP-46, XP60, part 2, 2000
- Krysztof Janowicz - Curtiss P-40, part 3, 2000
- Terill Clements - American Volunteer Group Colours and Markings, 2001
- TsAGI - samoletostroenye v SSSR 1917- 1945, part 2, 1994

particularly useful websites

- http://www.gc2-4.com/histavions.htm
- http://www.wwiiaircraftperformance.org/P-36/P-36.html
- http://www.wwiiaircraftperformance.org/P-40/P-40.html
- http://www.raafwarbirds.org.au/targetvraaf/p40_archive/p40_data.htm
- http://www.enginehistory.org/reference.shtml

Sorting information

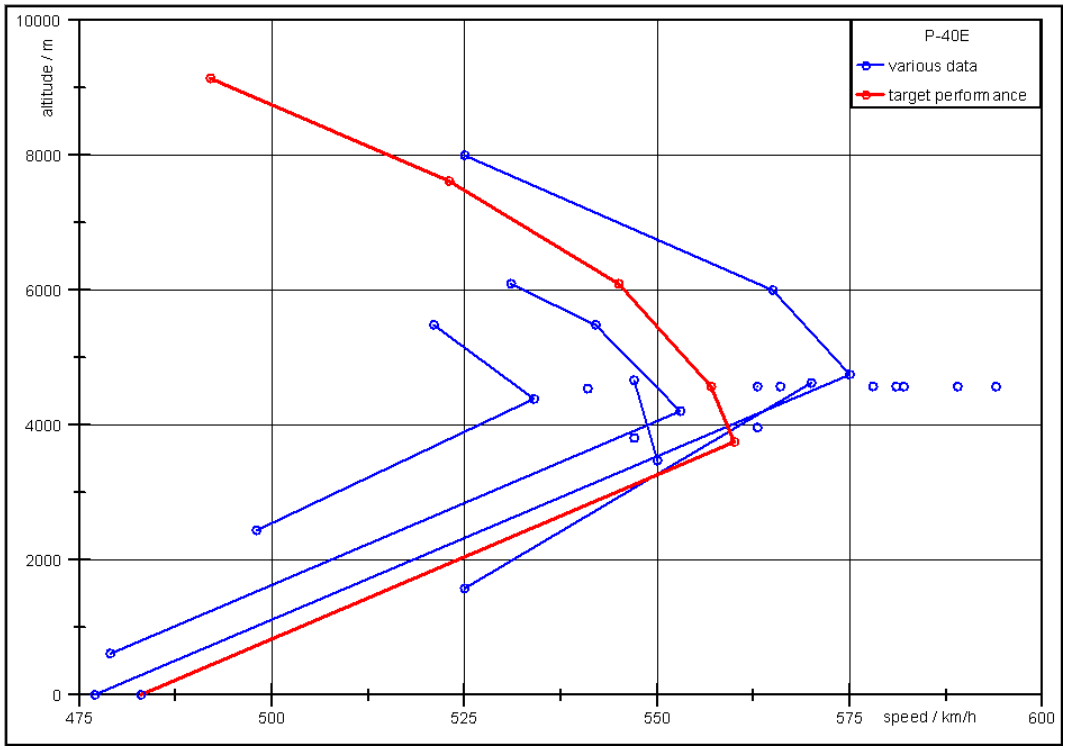
General

The above sources provide an abundance of data. However, all this data does not necessarily support each other. Part of the package always is contradicting and even wrong information, so the information has to be sorted, verified against each other, checked for plausibility, put in the proper context. Eventually target qualities have to be derived.

Below we've used speed data of Allison V-1710-39 powered P-40's for an illustration of typical variance of researched data. We've simply put various speed data into the chart, the data already filtered to showing supposedly clean airframes (no external stores) on maximum admissible power.

Similar compilations, though not graphically as interesting and often not as extensive, will be done for many more aspects, like climb performance, weights, stalling characteristics, take off and landing behaviour, and lots more.

Example: Speed data for P-40 with Allison V-1710-39 engine



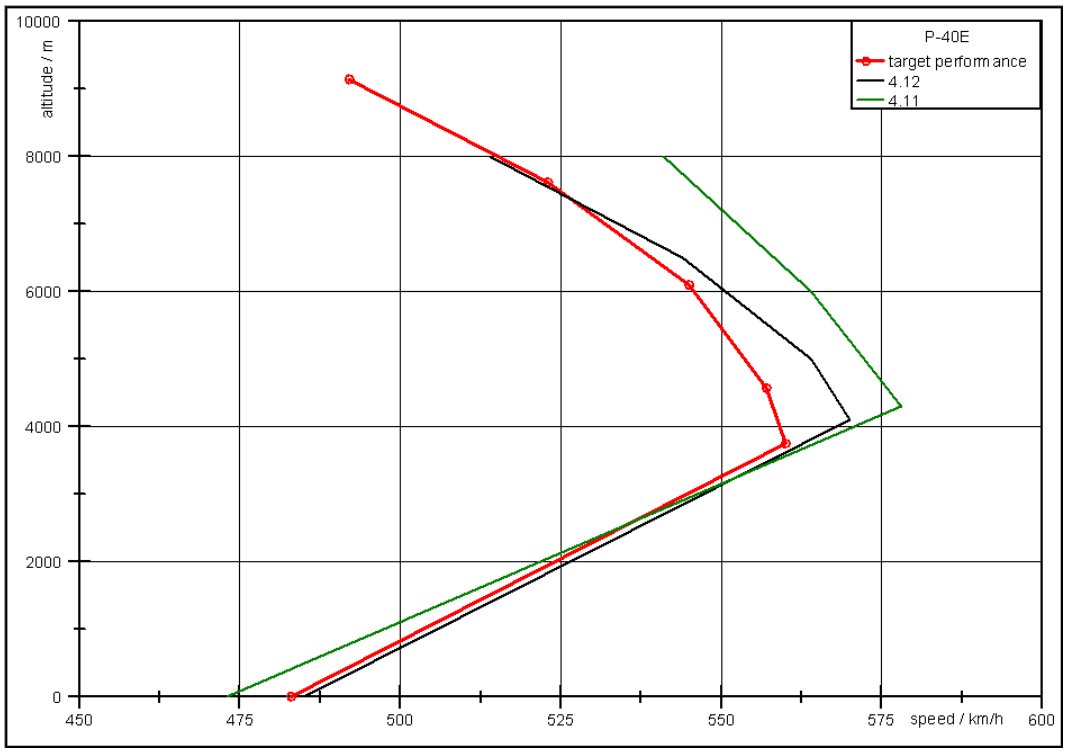
We've found no less than 22 data sets, mostly top speed at altitude figures, but also some detailed information, mostly British and Australian tests. Eventually we decided to go for the speed performance as tested by the Australians, which seems to show the best performance at low altitude, and planes are supposed to be modelled to best performance. Performance around the full throttle altitude achieved with that plane appears a bit low in comparison with the other data. The Australian test is coloured red in the above chart.

Actual flight model making

General

This is the easy part - the derived parameters can be entered into the engine and plane flight model files. If the research gave good results, and a few particularities of the game engine have been taken into account, historically correct input data will result in an fairly accurate flight model right away. Still, next phase is testing, and then there will usually be a couple of iterations until the desired results are reached. But even with all the iterations, the actual flight model making is about 1% of the total work.

Example: Speed performance of P-40E



We are trying to stay inside of 3% of determined target speed performance. This figure is based on typical variances and tolerances found in the actual aircraft. The above chart shows that for the most part we can get it much more accurate, however, at around full throttle altitude, there's a noticeable difference. That's not a problem, because for one we already considered the full throttle altitude to be lacking a bit and second, the difference is only about 10 km/h - well within our 3% margin. Also added is current performance with version 4.11.1.

Testing

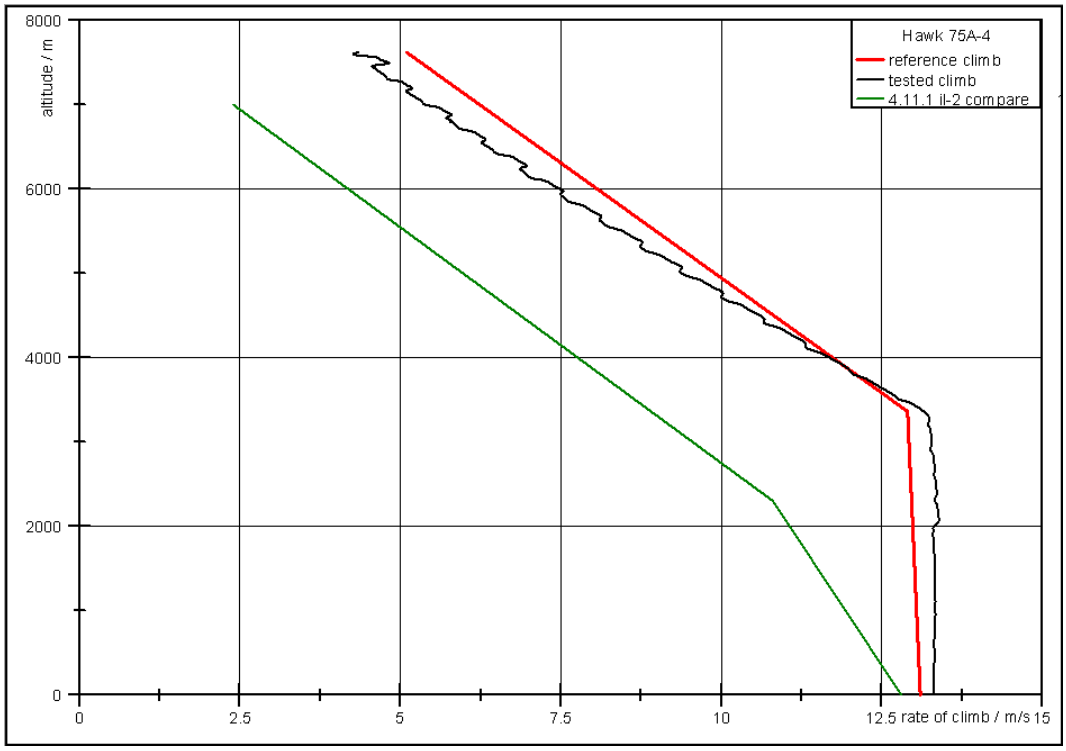
General

Testing might be the biggest task when it comes to flight modelling, right along with research. The changes have to be verified in game, for all planes effected, and all quantities involved. This is a time consuming and complex task, because a change in the flight model aimed to fix a detected problem, might cause a new problem where so far everything was OK. So even a small change might require a whole lot of new testing.

Usually, we conduct climb, speed, take off, landing, ground handling, stall, spin, overheat, dive, roll, turn, trim and other tests, and of course take the plane into virtual combat to see if it behaves as expected when it matters. All in all, a lot of effort, which is luckily helped with by our beta testers.

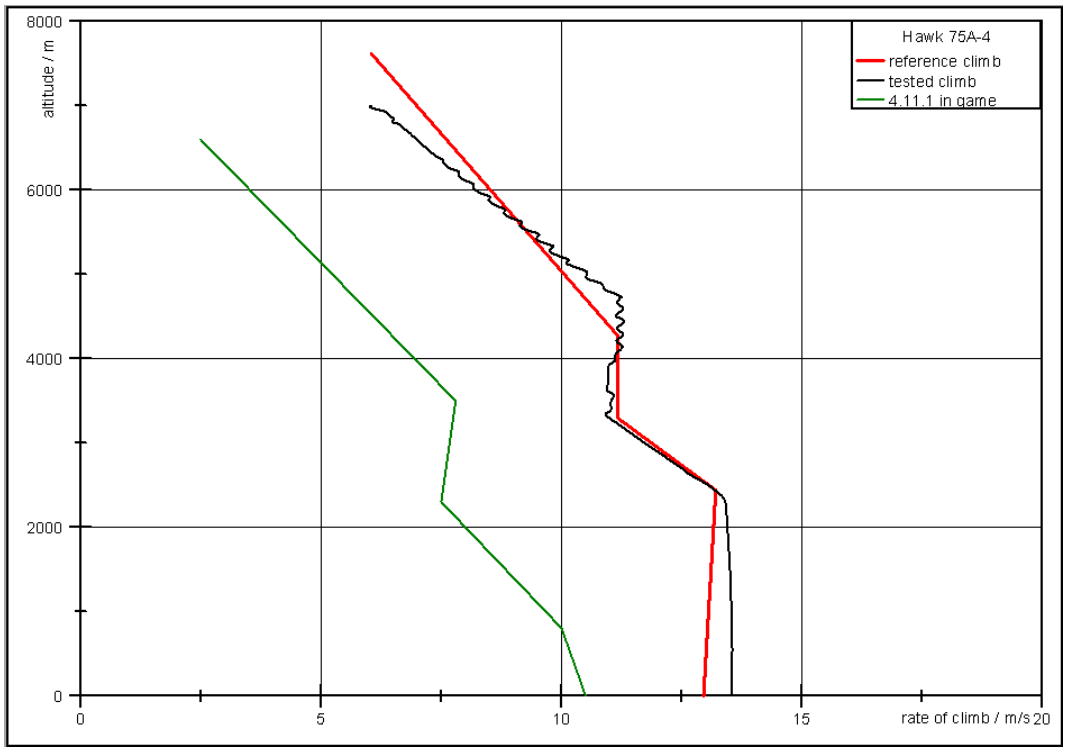
Below we've attached a couple of charts showing in game climb performances, compared to old in game performances and the historical reference. Even though it is a simple test, it is easy to spend a day on confirming projected performance for a plane family as large as the P-36 / P-40 family - a climb to high altitude may easily take 15 minutes. Do it at several speeds and several fuel loads, and you can imagine where the time goes.

Hawk 75A-3 climb



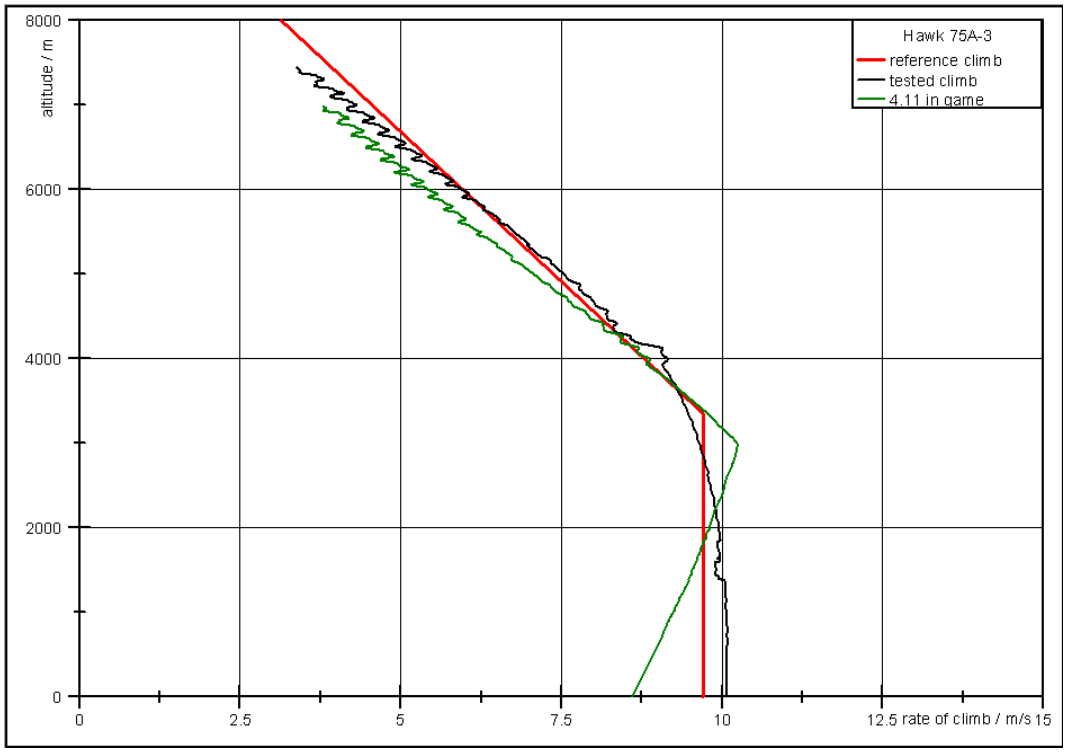
Reference is the median between a British and a US test, conducted at different weights but at the same power settings. Using the average weight of both tests, and same boost, rpm, speed profile and radiator setting (roughly 92% pitch, 100% power), we are now within 0.5 m/s for most of the altitude. It is also apparent that the new flight model is much closer to the real thing that the one it is replacing (il-2 compare data 100%).

Hawk 75A-4 climb



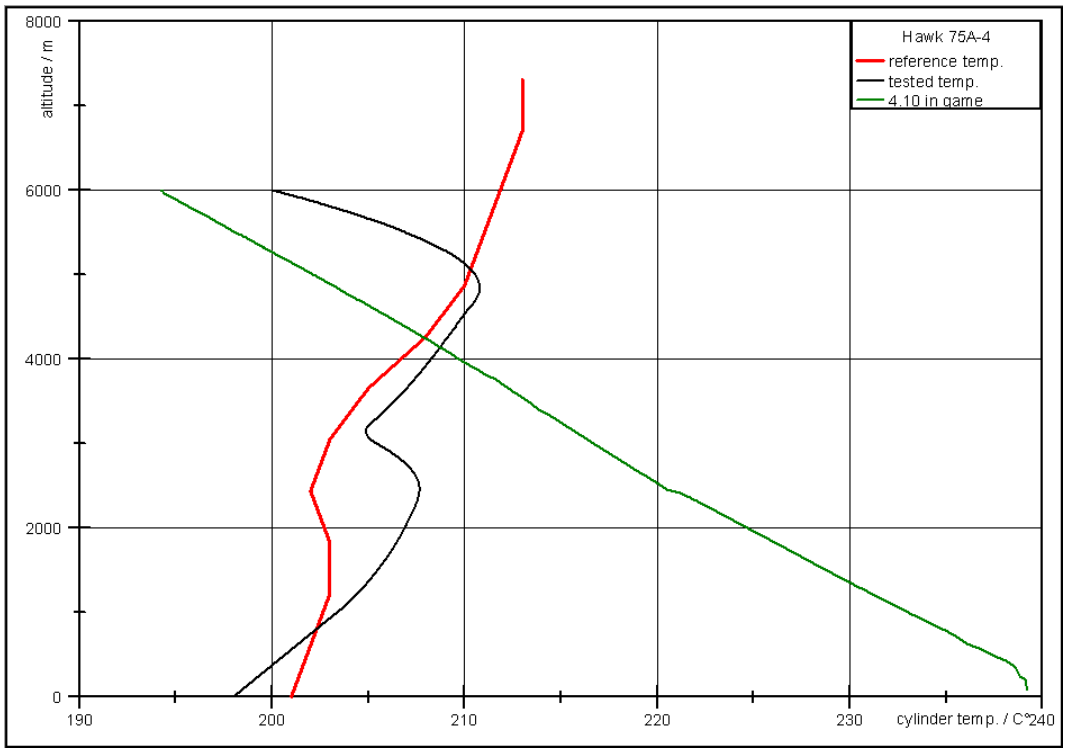
Reference is a British test. Recreating this test in game under the same conditions, we again are within 0.5 m/s for the most part. It compares favorably with the old flight model, which is nowhere near the recorded performance.

P-40E climb



Target for touching flyable models is to at least not make it worse. The P-40 climb chart might serve as an example. Both in game climbs have been done at the same settings, mirroring the reference climb, as closely as possible. As can be seen, there's little to chose between the two, the biggest advantage of the new flight model being an accurate boost gauge.

Hawk 75A-4 cylinder temperatures in a climb



Some people have been wondering about the overheating, in particular with the new model introduced with the version 4.11. If data is available, we try to match it as good as possible, as the above chart shows. For comparison we've added the 4.10 version, with both flight and overheat model from back then. Neither the new model nor the new engine parameters are perfect, but they are a lot more close than they used to be.