High angle smoothing plane comparison

By Lyn J. Mangiameli ***June 2002*** *(PDF conversion by Peter Williams)*

Well, this is finally it. What will follow in several parts is the high angle smoothing plane investigation I have been working on for over a year. I've done about all I can to make it thorough and objective, but no project of this nature can be entirely either. Because of that, I'm going to try to put forward as much information as possible, that way you will know why I did things, how I did things, and what are the specific findings obtained. If you want, you can use the techniques presented to conduct evaluations of your own, and I intend to suggest some investigations that may be worth doing in the future. By posting the background first, any questions as to how things were done, or why things were done can be understood before the plane rankings are presented.
Lyn

Introduction:

This review is different from my earlier plane reviews that have focused on the design, ergonomics and quality of manufacture in addition to the surface the plane could achieve. In this review, there were only two primary objectives: To determine if high bedding angle planes, as a group, tended to perform better than standard angle planes on difficult to plane woods (i.e., should you obtain a High Angle plane if you work with difficult hardwoods that are prone to tearout, fuzzing, etc.); and, more specifically, to find which planes and/or plane configurations yielded the best surface on particularly difficult to surface woods. Issues of comfort, edge longevity and ease of use were not a focus of comparison, although where a particular plane has been exceptional in some respect, I will comment on it. Basically, this was an attempt to find which planes and/or plane configurations could deal with those difficult wood surfaces that nothing else seems to work for. Under such circumstances, it is assumed that one is willing to give up comfort and/or edge retention, in the quest to achieve the best possible surface.

Planes:

The planes used were from seven different manufacturers, with a total of eleven planes used in the comparison. Often, the planes represented the best of their kind and style (i.e. Stephen Thomas for the English Infill; Clark & Williams for the traditional wood smoother, Lie-Nielsen & Lee Valley for the Bailey/Bedrock style, ECE/Primus for the Continental style wood smoother, Mujingfang for Taiwanese style, and Knight Japanese Infill as a Japanese/English hybrid). A pure Japanese style plane was about the only style omitted. Clifton planes were not included as they do not offer a high bedding angle plane, nor recommend back bevels. HNT Gordon was not included as their smoother is very similar to the Mujingfang HA. Other potentially desirable planes like a Holtey and other modern English style infills were not available for loan (at least based on requests posted to BP and rec.woodworking) or were beyond my desire or resources to purchase. The planes included were all used in a configuration recommended and /or supplied by the manufacturer. The specific planes, by manufacturer were:

1. Clark & Williams beech coffin smoother, fixed mouth, single iron/wood wedge, 55º $265
2. Knight Finish smoother, purple heart body, vera wood soles, ebony strike plate, adjustable mouth, single 1/4 inch Starret steel iron/wooden wedge, 47º, $137.00
3. Knight Japanese Bladed Bloodwood Brass and Steel Infill, fixed mouth, single blue steel iron/metal and wood wedge, 47.5º, $560+
4. Lee Valley #4.5 metal smoother, adjustable frog, A2 iron plus chip breaker, Norris style adjuster, lateral blade support screws, 45º $169
5. Lee Valley #4.5 metal smoother, adjustable frog, A2 iron plus chip breaker, Norris style adjuster, lateral blade support screws, 45º plus 15º blade back bevel for 60º overall effective angle. $169
6. Lee Valley Low Angle Smooth plane, adjustable mouth, single A2 iron, Norris style adjuster, lateral blade support screws, 12 bed plus 20 degree bevel for 32º overall effective angle, $139
7. Lie-Nielsen #4.5 Bedrock smoother, adjustable frog, A2 cryo'ed iron plus chip breaker, Bailey style adjuster, 50º frog $300 (or $75 for 50º frog alone to retrofit to their Standard Angle #4.5).
8. Mujingfang Ebony Taiwanese style fixed mouth smoother, iron plus elementary metal wedge/chip breaker, 40º Price not yet set.
9. Mujingfang Rosewood Taiwanese style body, push/pull transverse bar, fixed mouth smoother. Single iron, wood wedge. 62.5º Price not yet set.
10. ECE / Primus Improved Smoothing Plane, Pearwood body, Lignum Vitae soled, adjustable mouth smoother. Iron plus chip breaker, unique adjustment/blade retention system, 50º $199
11. Stephen Thomas custom Cocobolo Infill, adjustable mouth A2 blade with chip breaker, Norris style adjuster, 47.5º, approximately $2700

This and additional information is summarized in the table below:

PLANE	PRICE (US$)	ANGLE	CHIP BREAKER	BLADE THICK* (Inches)	BLADE TAPER	WEIGHT (Grams)	STYLE	SOLE
Clark & Williams	$265	55.0	No	.187	Yes	740	Wood	Wood
Knight Finish	$139	47.0	No	.250	No	760	Wood	Wood
Knight J.Infill	$560	47.5	No	.191	Yes	1980	Infill	Metal
Lee Valley #4.5	$169	45.0	Yes	.125	No	2250	Metal	Metal
LV#4.5 Back Bevel	$169	60.0	Yes	.125	No	2250	Metal	Metal
LV Low Angle	$139	32.0	No	.125	No	1700	Metal	Metal
L-N #4.5 HA Frog	$300	50.0	Yes	.150	No	2450	Metal	Metal
Mujingfang Ebony	N/A	40.0	Yes	.125	No	620	Wood	Wood
Mujingfang RW HA	N/A	62.5	No	.125	No	760	Wood	Wood
ECE/Primus, Imp.	$199	50.0	Yes	.114	Yes	1100	Wood	Wood
Stephen Thomas	$2,700	47.5	Yes	.156	Yes	2750	Infill	Metal

*Blade thickness measured at thickness where bevel meets face, if blade was tapered.

I own 9 of the eleven planes, having purchased four of them (both Knight smoothers, the Lie-Nielsen #4.5 and the ECE/Primus, Improved), having received four of them in exchange for feedback (Lee Valley #4.5 & Low Angle Smoother & both Mujingfang planes), and one plane (a cosmetic second Lee Valley #4.5) was donated for this comparison. Two planes were loaned to me for this comparison; the Clark &Williams was obtained from a private owner and Badger Pond regular, and the Stephen Thomas Infill came directly from Mr. Thomas. Interestingly, the two models of Mujingfang planes will not be available from the company I received them from

(one will be carried in a slightly different configuration, the other will not be carried), but both will be available through Woodcraft late this Summer or in the early Fall.
Blade width ranged from 1.875 to 2.375, blade thickness ranged from .114 to over .25, with over half the planes having a blade thickness of 1.25. Several of the planes had tapering blades, but the minimum thickness was .114 even on the tapered blades. Blade styles included laminated steel (e.g., Knight Japanese Blade Infill), carbon steel (e.g., Knight small finish/smoother), A2 steel (e.g., Lee Valley, Lie-Nielsen and Stephen Thomas), and alloys that were not and could not be identified (Primus, Mujingfang). As most know, the Lie-Nielsen planes have long been available with high quality carbon steel blades, but these have recently been replaced by A2 steel blades. In an earlier series of comparisons, the two blades have performed identically when freshly honed. However, since many of the planes in this comparison used A2 blades, and since the A2 blade is the current configuration, only the Lie-Nielsen A2 blade was used in this comparison.

Woods:

12 different species of wood were selected, with at least two samples obtained of each wood. A total of 26 samples were used in the comparisons, as White Oak was represented twice, once with straight grain, and once with curly figure. I tried but excluded woods like Snakewood that were too abusive to blades, but otherwise attempted to select woods that have proven difficult to plane to a good surface with a high quality, but standard angle plane. Woods were:

Blackwood Acacia
Bloodwood
Bubinga
Cocobolo
Ebony
IPE
Lacewood
Lignum Vitae
Fiddleback Maple
White Oak (straight grain & curly grain)
Padauk
Purple Heart

The woods were donated by Steve Knight (a very generous supply of exotics) or came from my private stock (most purchased from Southern Lumber in San Jose); Lee Valley helped me to obtain a couple of woods I had difficulty acquiring on my own.

Methodology:

All tasks and ratings involved with this comparison were performed by the investigator alone (i.e., me). All planes were allowed several weeks to acclimatize to the temperature and humidity of my shop. All plane soles were checked for flatness with a Bridge City Tools Straightedge, and then lapped flat if necessary using “scary sharp” techniques on a long piece of glass. All plane blades had both their faces and backs flattened (as needed) and backs were polished by hand using waterstones; bevels were made flat and sharpened to .5 micron on my Lee Valley Power Sharpening System. The consistency and quality of the edge was checked each time with a 5 x magnifier.

The wood samples were milled rectangularly, usually with a 1.5 to 1.75 inches wide face, so that all planes would see the same width of surface to be cut, the wood was then planed smooth with a freshly sharpened Lee Valley #4.5 with standard pitch and bevel angle. Sufficient cuts were made to insure that adjustment was such as to produce optimal performance from the plane. This became the benchmark condition with the Lee Valley #4.5 at 45º used to establish the surface condition of each wood sample.

Then one of the comparison planes followed to see if any difference could be discerned. Sufficient cuts were made to insure the best adjusted performance was achieved from the plane. If adjustment required more than six strokes, the blade was pulled and re-honed, then adjustment proceeded again. No evaluation cuts were made with a blade that had more than six prior adjustment cuts. Notes were taken on a separate rating sheet for each wood sample. Two photos of each surface were shot (one of the area of maximal "damage" and one represented the larger view of the sample) and coded so that the plane was not readily identifiable.

The Lee Valley #4.5 blade would then be re-honed at .5 and used to renew/return the wood surface to the Lee Valley #4.5 level, then another plane was tried with the same follow up steps. This was repeated over and over until all the planes had been tried on a given sample of wood. If planes were close in performance, back to back comparisons were made to refine awareness of their differences. Then the process was repeated for another species of wood. This continued until each plane had been compared on a sample of each wood species. Then the entire process was repeated using a second sample of each wood. Planes were selected in a quasi-random order for each wood species (that means I tried to use different orders of planes for each sample, but random selection was not guaranteed).

Ratings of the planes were based on several criteria, which for a given wood might include some combination of surface smoothness (both visual and tactile), depth of tear out, amount of tearout, clarity of the wood surface, etc. There were no fixed criteria, as different woods displayed different characteristics and were handled differently by the planes. For example, some woods displayed a lot of tearout, but the clarity of the remainder of the wood was consistently very good; while another wood may have shown no obvious tear out, but there were several differences in how smooth the wood felt to the hand.

A point was awarded for each discernible improvement in overall performance. For some woods, there were several discernible levels of performance (i.e., the surface left by plane B was better than the surface left by plane A, and the surface left by plane C was better than that provided by plane B.) Points were awarded to each plane according to how many discernible steps in performance it represented relative to the benchmark Lee Valley #4.5. Thus, for a very difficult wood, like cocobolo, the plane that performed the best was able to achieve a score of 5 on one sample, representing that five different levels of performance were discernible between the surface left by this plane and the benchmark plane while using the full range of planes on this wood. In contrast, on a few woods, no discernible differences were detectable between any of the blades, thus all planes were rated as "0" relative to the benchmark performance.

It is important to understand that these ratings represent, in the statistical sense, an interval scale. Though there was an arbitrary "0" point (the benchmark plane's performance), the "0" did not represent poor performance and the maximum score did not represent a "perfect" surface. There were some woods on which an essentially perfect surface was achieved by the benchmark plane (which isn't too surprising since it has been very favorably compared to some of the best of standard angle planes), and even the highest rated plane may not have achieved flawless

performance on other woods. The intervals were determined by the overall group of planes' variation in performance, relative to the benchmark plane, and did not represent any externally established structure. Thus, the intervals do not represent equal steps (the steps ultimately being determined by the performance of the planes), but rather represent rankings, in which ties can occur among two or more planes.

After all the samples had been planed, the scores for a given plane on both samples of a wood were entered into a statistical database (SPSS) and averaged. The developed photos for a given wood (both samples) were then all laid out on a table and again ordered according to overall discernible differences. Unfortunately, the photos did not allow for as fine a discrimination as did the direct evaluations which involved the ability to feel the surfaces and more easily consider a flawed area in the context of the overall surface. It was decided after starting the evaluations, but before analyzing the data, that if the rankings differed by more than one level of placement, between photos and direct observations, then one half the difference in ranking would be added (which might be a positive or negative score) to the rankings achieved through direct observation. Fortunately, these complications were avoided in that the final blind ranking of the photos was never in conflict with the direct observations, though sometimes fewer categories of difference were discernible through sole use of the photographs.

Results:

First, results will be listed by overall ratings for each plane (an obvious order by bedding angle and style becomes apparent). If you want just the overview, you can stop there. Then planes will be ranked according to the number of their first and second place finishes (including ties). Finally, each plane's rating will be given for each wood. This lets you see which planes did best on a given wood and also gives you a good idea of how much variation in plane performance was present for a specific wood. You can consider planes and bedding angles with reference to the woods you most often use, or you can gain an idea of what planes tend to always do a good job over your own personal group of woods.

Again keep in mind that the Lee Valley #4.5 standard angle smoother is the benchmark and thus always presents with a score of zero. Bedding angles are as close as I was able to measure on the planes used, and may or may not agree with the manufacturer's specifications.

Rankings based on total rating points accrued over all woods:

Lee Valley Low Angle	32º	-4.0
Mujingfang Ebony	40º	-0.5
Lee Valley #4.5	45º	-0.0
Knight Finish	47º	4.0
ECE/Primus Imp.	50º	5.5
Lie-Nielsen #4.5 HA frog	50º	6.0
Clark &Williams Coffin	55º	6.0
LV #4.5 back bev.	60º	8.5
Mujingfang Rosewood HA	62.5º	13.5
Knight Japanese Infill	47.5º	13.5
Stephen Thomas Infill	47.5º	19.5

Ranking based in order of number of 1st and/or 2nd place finishes:
(These rankings do not include the three woods on which all planes produced the same level of surface. Multiple ties may have occurred on a given wood)

Lee Valley #4.5	45º	0	0
Mujingfang Ebony	40º	0	1
Lee Valley Low Angle	32º	0	2
ECE/Primus	50º	0	2
Lee Valley #4.5 back bevel	60º	0	4
Lie-Nielsen #4.5 HA frog	50º	1	1
Knight Finish Smoother	47º	1	2
Clark & Williams Coffin	55º	1	3
Mujingfang Rosewood HA	62.5º	2	3
Knight Japanese Infill	47.5º	4	2
Stephen Thomas Infill	47.5º	7	2

The following are the plane ratings on each of the wood samples. The ratings are based on the average score from two samples of each wood. Again, each point represents one discernible level of difference between at least two planes.

Blackwood Acacia:
(One of the most difficult woods; no plane produced a perfect surface)

Lee Valley Low Angle	32º	-2.0
Clark & Williams Coffin	55º	-1.0
ECE/Primus	50º	-1.0
Knight Finish	47º	-1.0
Mujingfang Ebony	40º	-1.0
Lee Valley # 4.5	45º	0.0
Lie-Nielsen #4.5	50º	0.0
Knight J. Infill	47.5º	1.0
Stephen Thomas Infill	47.5º	1.0
Lee Valley #4.5 back bevel	60º	2.0
Mujingfang Rosewood HA	62.5º	3.0

Bloodwood:
(All planes produced an excellent and indistinguishable surface)

Bubinga:
(No plane provided a perfect surface, but little difference between planes)

Knight Finish	47º	-2.0
Clark & Williams Coffin	55º	-1.0
ECE/Primus	50º	-1.0
Lee Valley Low Angle	32º	-1.0
Lee Valley #4.5 back bevel	60º	-1.0
Lie-Nielsen #4.5	50º	-1.0
Mujingfang Ebony	40º	-1.0
Lee Valley # 4.5	45º	0.0
Knight J. Infill	47.5º	0.5
Mujingfang Rosewood HA	62.5º	1.0
Stephen Thomas Infill	47.5º	2.0

Cocobolo:
(Another of the most difficult woods; no plane produced a perfect surface)

Lee Valley Low Angle	32º	-1.0
Lee Valley # 4.5	45º	0.0
Mujingfang Ebony	40º	1.0
Knight Finish	47º	2.0
Knight J. Infill	47.5º	2.0
Lee Valley #4.5 back bevel	60º	2.0
Lie-Nielsen #4.5	50º	2.0
ECE/Primus	50º	3.0
Clark & Williams Coffin	55º	3.5
Mujingfang Rosewood HA	62.5º	4.5
Stephen Thomas Infill	47.5º	4.5

Ebony:
(Best planes provided a good surface)

Lee Valley # 4.5	45º	0.0
Mujingfang Ebony	40º	0.0
ECE/Primus	50º	0.5
Knight Finish	47º	0.5
Lee Valley Low Angle	32º	0.5
Lee Valley #4.5 back bevel	60º	0.5
Lie-Nielsen #4.5	50º	0.5
Clark & Williams Coffin	55º	1.0
Mujingfang Rosewood HA	62.5º	1.0
Knight J. Infill	47.5º	1.5
Stephen Thomas Infill	47.5º	1.5

Ipè:
(All planes produced an excellent and indistinguishable surface)

Lacewood:
(Best planes produced an adequate surface)

Clark & Williams Coffin	55º	0.0
Knight J. Infill	47.5º	0.0
Lee Valley # 4.5	45º	0.0
Mujingfang Ebony	40º	0.0
Mujingfang Rosewood HA	62.5º	0.0
ECE/Primus	50º	0.5
Lee Valley Low Angle	32º	0.5
Lee Valley #4.5 back bevel	60º	0.5
Knight Finish	47º	1.0
Lie-Nielsen #4.5	50º	1.0
Stephen Thomas Infill	47.5º	1.0

Lignum Vitae:
(Best planes produced an excellent surface)

Mujingfang Ebony	40º	-1.0
Lee Valley Low Angle	32º	-1.0
Clark & Williams Coffin	55º	0.0
Lee Valley # 4.5	45º	0.0
ECE/Primus	50º	1.0
Mujingfang Rosewood HA	62.5º	1.0
Lie-Nielsen #4.5	50º	1.5
Knight Finish	47º	2.0
Knight J. Infill	47.5º	2.0
Lee Valley #4.5 back bevel	60º	2.0
Stephen Thomas Infill	47.5º	4.0

Fiddleback Maple:
(All surfaces were good, but best were exquisite)

Clark & Williams Coffin	55º	0.0
Lee Valley # 4.5	45º	0.0
Lie-Nielsen #4.5	50º	0.5
ECE/Primus	50º	1.0
Knight Finish	47º	1.0
Lee Valley Low Angle	32º	1.0
Lee Valley #4.5 back bevel	60º	1.0
Mujingfang Ebony	40º	2.0
Mujingfang Rosewood HA	62.5º	2.0
Stephen Thomas Infill	47.5º	2.0
Knight J. Infill	47.5º	3.0

Curly Oak:
(All surfaces were good to very good)

Clark & Williams Coffin	55º	0.0
ECE/Primus	50º	0.0
Knight J. Infill	47.5º	0.0
Lee Valley Low Angle	32º	0.0
Lee Valley # 4.5	45º	0.0
Mujingfang Ebony	40º	0.0
Knight Finish	47º	0.5
Lee Valley #4.5 back bevel	60º	0.5
Lie-Nielsen #4.5	50º	0.5
Mujingfang Rosewood HA	62.5º	0.5
Stephen Thomas Infill	47.5º	1.0

Straight Grain Oak:
(All planes produced a very good surface)

Padauk:
(All surfaces were good to excellent)

ECE/Primus	50º	0.0
Knight Finish	47º	0.0
Lee Valley # 4.5	45º	0.0
Lee Valley #4.5 back bevel	60º	0.5
Lie-Nielsen #4.5	50º	0.5
Mujingfang Ebony	40º	0.5
Mujingfang Rosewood HA	62.5º	0.5
Stephen Thomas Infill	47.5º	0.5
Clark & Williams Coffin	55º	1.0
Lee Valley Low Angle	32º	1.0
Knight J. Infill	47.5º	1.5

Purpleheart:
(Poor to very good surfaces)

Lee Valley Low Angle	32º	-2.0
Mujingfang Ebony	40º	-1.0
Knight Finish	47º	0.0
Lee Valley # 4.5	45º	0.0
Mujingfang Rosewood HA	62.5º	0.0
Lee Valley #4.5 back bevel	60º	0.5
Lie-Nielsen #4.5	50º	0.5
Clark & Williams Coffin	55º	1.5
ECE/Primus	50º	1.5
Knight J. Infill	47.5º	2.0
Stephen Thomas Infill	47.5º	2.0

Discussion:

I wrote in the introduction, and I think it is good to reiterate it now:

> *In this review, there were only two primary objectives: To determine if high angle planes, as a group, tended to perform better than standard angle planes on difficult to plane woods (i.e., should you obtain a High Angle plane if you work with difficult hardwoods that are prone to tearout, fuzzing, etc.); and, more specifically, to find which planes and/or plane configurations yielded the best surface on a range of particularly difficult to surface woods.*

It is important to keep in mind that the results from this investigation do not necessarily, or even likely, represent the performance of planes on less dense and commonly used woods such as walnut, mahogany, cherry and poplar. It is also good to keep in mind that the findings do not so much represent a comparison of manufacturers, as they are a comparison of plane styles and configurations; the difference in performance between the Lee Valley #4.5 with an effective cutting angle of 45 degrees and the same plane with an effective cutting angle of 60 degrees is a good example.

Plane characteristics vs quality of surface achieved:

There were only two consistent findings associated with good performance across the range of woods: that infill style planes performed better than any other style; and for non infill planes, performance was consistently better as effective cutting angle (bedding angle plus back bevel angle-if any) increased. These findings are obvious upon casual comparison of effective cutting angle and total performance points, and, with respect to effective cutting angle, is confirmed by elementary nonparametric correlational analysis (Spearman Correlation Coefficients). Taken as a total group of all eleven planes, effective cutting angle correlates at the .697 level (a perfect correlation would be 1.0), a strong correlation, and is found to be significant at the .017 level (fewer than 2 times in a hundred could such a finding occur by chance). The finding is extremely strong if we remove the two infill planes from consideration. For the remaining nine planes effective cutting angle and total performance points is correlated at the .9874 performance level, with a significance of .000 (in words, less than one time in 1000 would this occur by chance). Other plane characteristics, such as total weight or blade thickness failed to achieve a significant correlation, with or without the inclusion of the infill planes. While the top performing plane was the heaviest (the Stephen Thomas infill), for those tied for second place in the category of total performance points, one ranked 5th from the top and the other was two places below that. Put another way, at 760 grams, the Mujingfang Rosewood HA plane that tied for second in total points is little more than one third the weight of the top ranged plane, and only a little more than half the weight of the plane it tied with for second place. So in general, on these dense difficult woods, weight doesn't correlate with improved performance, but angle does. This does not mean that weight does not matter, but likely that performance is related to some function of both angle and weight (as is suggested by the relatively low angle but high weight infill rankings).

Blade thickness was equally un-associated with plane performance. Though this goes against some conventional wisdom, it does not surprise me that much. All of these blades were bedded more fully than some typical Bailey style planes. With each plane, the blade support extended at least all the way down to the top of the bevel, and in the case of the Lee Valley Low Angle plane, to just short of the blade edge. The thinner the blade, the shorter the bevel width, thus the closer the bedding came to the blade edge. With a blade bedded near to its edge, I personally doubt that blade thickness is that much of a factor, once a certain basic thickness is achieved, which in this investigation would suggest anything around 1/8th inch is sufficient. More likely, thicker blades

are most important on Bailey style planes where when the frog is advanced and bedding ends well above the blade edge.

None of these planes had what has traditionally been considered a thin blade. The thinnest blade comes in at just slightly under 1/8th inch, most were at 1/8th inch, and only one blade was considerably thicker than the others (the Knight Finish/Smoothing plane at 1/4 inch). Four planes had blades that were tapered, so the thickness at the top of the bevel was used as the measuring point for thickness, this resulted in measuring the thickest blade section for three of the planes (i.e., those blades thinnest at their top) and one of the thinnest sections for one plane (the Japanese blade that tapered down from a thick top).

The presence or absence of a chip breaker, by itself, seemed to have no influence on plane performance with these woods. Half the planes used one, half the planes didn't. Of the high rated infills, one used a chip breaker, one didn't. Particularly telling, of course, is that the Lee Valley #4.5 ranked very differently depending upon the effective cutting angle used, but in both cases, the same chipbreaker was employed. Perhaps, but this is only unsupported speculation, at these higher angles a tightly coupled chip breaker (such as is employed on the ECE/Primus which is coupled to the blade with two screws) is more important for its ability to reinforce a thinner blade, than for it any chip breaking performance per se.

Half the planes had a wood sole, half the planes had a metal sole. No association was found between sole material and surface finish on the woods planed. While two of the three top ranking planes had metal soles, so did two of the three lowest ranking planes. Sole material did make a difference with regards to usage characteristics, but not to the quality of finish obtained. It is worth noting here, that all plane soles, whether wood or metal were waxed with Renaissance microcrystalline wax.

Blade width was basically eliminated as a characteristic of the planes' performance, as all wood samples were made no wider than the narrowest blade. However, this does not mean that blade width might not play some significant role on tasks that involve wider boards or panels.

Functional characteristics vs quality of surface achieved:

Shaving thickness itself was not in a 1:1 relationship with quality of surface, and not all planes were able to make equally fine continuous shavings. Some planes took very fine even shavings and provided an excellent surface (most commonly the Stephen Thomas, Knight Japanese Blade Infill and the Mujingfang High Angle), but some planes producing fine shavings left a rather mediocre surface while other planes produced much thicker shavings but left a better surface.

User variable plane characteristics, such as blade extension, mouth width (on those planes where this could be adjusted), and cap iron/wedge tension were not consistent between planes, woods, or even individual samples of the woods. Each were and needed to be adjusted to obtain the best performance for the planing task at hand, and no overall settings appeared to apply for any of the planes.

User qualities:

User qualities break down primarily into ease and refinement of adjustment, the ability to move the plane across the wood, and general matters of fit and comfort.

Adjustment:

This issue is surely biased by my limited experience with wood planes. I have eight wood planes that do not have mechanical adjusters (and four that do), and have used this style for many years, but I am clearly not a master of wood plane adjustment. With that caveat made clear up front, I'm going to discuss one of the most important distinctions between planes, as I experienced it, other than the surface finish they achieved.

The ability to achieve fine and consistent changes in planing performance as a result of changes in blade extension and alignment is what I call adjustment control (a stupid name, just the best I came up with). To me, this is more than just a reflection of the refinement and precision of adjustment mechanisms, but also includes the ability of the plane to translate these changes in blade position into a change in cutting performance. The Stephen Thomas plane was simply a delight to adjust and repeatedly demonstrated the highest levels of adjustment control. It simply allowed me to make very fine adjustments in meaningful blade extension that translated into distinguishable changes in differences in the characteristics of the shaving made and/or surface revealed. No other plane came even close. No other plane could I take to a new wood with a freshly installed blade and so quickly achieve the optimal setting for the shaving or surface I wished to achieve. Consistent with my definition of adjustment control, it allowed for easily achievable very fine settings that resulted in distinguishable and meaningful changes in plane performance. At risk of repeating myself, this plane was able not only to make fine changes in blade position, but respond to those changes. It has spoiled me for all other planes, on this characteristic alone.

Interestingly, the plane that ranked second in this respect was the Lie-Nielsen #4.5. It was notable superior to the other planes. Even though the Lee Valley #4.5, in my experience, has the better adjuster, and I find it slightly more precise when comparing the two planes in their standard angle configuration, it did not show as great a degree of functional control over the plane's cutting as did the Lie-Nielsen. Perhaps the angle and back bevel has something to do with this, but that is a consideration I have absolutely no foundation for. Regardless, the Lie-Nielsen #4.5 with its HA frog, was meaningfully (at least to me) superior to all planes but the Stephen Thomas.

Roughly tieing for third place was the ECE/Primus, the Lee Valley #4.5 in both its configurations, and the Mujingfang High Angle. These planes I could be happy with, had I not experienced the Stephen Thomas.

The remaining planes were acceptable except for one. The disappointment was the Knight Japanese Infill. I found it a huge hassle to adjust and it never provided the sense of control that was offered by the Stephen Thomas, the Lie-Nielsen or even the Mujingfang High Angle plane and the Primus. When finally set perfectly, the Knight Infill performed excellently, as the total points figures show, but I just hated having to remove the iron as I knew it was going to be a struggle to properly adjust it again. Part of my trouble adjusting this plane is likely explained by a certain lack of skill adjusting by hammer, but I suspect the combination of the tapered Japanese blade and the very tight fixed mouth also contributed to the frustrations I encountered with this blade. I'm sure in normal use, I'd use this plane sparingly, just so I didn't have to sharpen and readjust the blade again, but it sure works well when set correctly.

Movement across the wood:
Two factors are involved here, but I shall consider them concurrently. The first factor is the ability to plane right through a resistive surface, such as the densest woods or woods with notably varying density. The second factor relates to the ability to change the direction of the plane to accommodate shifting grain. In this case two planes stood out, one for each of the factors.

Again, the Stephen Thomas plane was just wonderful in its ability to seemingly effortlessly maintain the momentum of the planing stroke throughout its entire length. Surely this is largely related to it being the heaviest plane, but likely other factors, such as control over blade extension, ergonomic factors such as grip shape and placement, and effective cutting angle all contributed to its ease of movement through the wood. Stephen's plane is over six pounds. I loved the weight, but I'm not sure everyone would be very happy with it. I really do plane a lot, and have the associated task specific musculature. I'm not sure someone else would handle the Stephen Thomas or some of the other HA planes in the same way or with the same control as I do, but if the unsupported weight of a plane is not an issue, the Stephen Thomas makes use of its weight and other characteristics very successfully when making cuts through the denser woods.

Second in this regards were the two metal planes followed by the Knight Japanese Ironed Infill. Again weight seemed to be the primary underlying factor, though the former two planes also use a more "Western" style grip, as does the Stephen Thomas. Also quite acceptable was the Mujingfang HA, which is a plane that felt and performed like a plane much heavier than it really is. I should note that I used this plane without its optional crossbar that will allow pulling and a somewhat different sort of pushing grip.

The Primus plane, the C&W and the Knight Finish plane often seemed to lack the authority to continue with cuts along the length of a dense wood such as purpleheart or cocobolo. As a result, they required greater physical effort to move through the wood stroke, and became more difficult to control as the activity of the larger muscles predominated over the more precise smaller directional control muscles.

A point worth bringing up here, although it might well be considered with respect to several other topics, is blade width. Clearly as angle goes up, resistance increases for a given blade width. Obviously, the wider the plane blade, the higher the resistance. Ideally, a lighter plane with a higher angle, would use a narrower blade, while a heavier plane might more easily allow for a higher, more resistive, angle. I can't say that this idea is supported by either the data on quality of surface achieved, nor by my own subjective experience using the planes. Perhaps that is because manufacturers have intended that as blade width increases, so also does the overall plane weight. Still, one wonders about the trend of Lie-Nielsen to make its widest planes available with high angle frogs, and what might be the relative performance of a heavy plane but with a narrower blade used at high angle. A future study might involve back bevels applied to a Lie-Nielsen Bronze #4 compared to an iron Lie-Nielsen#4.5 with similar back bevels

The other factor is one of ability to manipulate the plane to change directions to account for changing grain and other wood variations. In this area, as was also revealed in last year's review of the Lee Valley #4.5, the ECE/Primus Improved Smoothing Plane stands alone. There is something about the slippery Lignum Vitae sole, the Continental handle arrangement, and perhaps some other unidentified characteristic that allows the Primus to stand unchallenged in this respect. Particularly on cocobolo, where some synergistic interaction takes place with this plane, the ECE/Primus just effortlessly skims across the surface, cutting a fine shaving and instantly responding to the lightest muscular input to change direction or force. On this particular wood, it is like going from a Stephen Thomas Porsche Turbo to a Primus Formula One car.

Ergonomics:
I've touched on this previously, but it is worthy to return to as a topic of its own. In this investigation, I placed all other considerations secondary to sheer surface finish for the specialized high angle "super smoother." Still, all other things being equal, it is nice to have a plane that is comfortable for extended use. This is of course a highly personalized consideration, and one that is totally subjective. For me, two planes stood out, though the two planes that ranked the highest for me couldn't be more different: the Stephen Thomas and the ECE/Primus. The Stephen Thomas took a while to get used to, with its smaller enclosed grip, but once I adjusted to the enclosed grip, it soon became one of my favorites.

The ECE/Primus, with its Continental front horn and rounded rear notch was always a pleasure to hold, and allowed rapid changes in direction without having to contort one's hands or wrists. I have always found the ECE/Primus, with its unusual (in North America) grip, to be a particularly refreshing break from long planing sessions with a Bailey style plane.

The Mujingfang High Angle plane also was comfortable. Its Taiwanese style "roofed" front body and cross bar allow for several comfortable gripping positions.

The Bailey style grips found on the Lie-Nielsen and Lee Valley planes have not become the Western standard without reason. I like the Lee Valley rear tote slightly better, it having a slightly different angle and length than the more traditional tote found on the Lie-Nielsen, but both are good for both brief and extended use.

The Clark &Williams was new to me, and I was impressed with how readily this small, coffin style of plane felt right in my hand. I wish it had more mass, but I suspect one could comfortably use this plane for extended periods of time.

The Knight planes fall at the bottom of my list. His Finish/Smoothing plane is too blocky for comfort and makes no accommodation for grip. It is acceptable for shorter periods of planing, but became less comfortable to use the longer a planing session went on.

The Knight Japanese Blade Infill, is one of the most beautiful planes to view, but one of the least practical to use for extended periods. The grips are very smooth and fairly comfortable when the plane is riding on the surface of the wood, but this plane is fairly heavy and there is no accommodation made for lifting the plane from the wood. The shape of the Bailey style grips are the best for lifting a heavy plane, allowing it to be easily gripped both forward and aft. The English infill style is second, with the enclosed tote offering at least a one handed grip. But the heavy Knight Japanese Blade Infill is a disaster, requiring a tight pincher grip to be used to pick up the plane after every stroke. The style that was generally acceptable for a light wooden plane, becomes a recipe for repetitive stress injuries when applied to such a heavy plane. The good news is that Steve is aware of this and is quite actively researching and modifying his planes to achieve better gripping shapes.

Limitations of this investigation:

Try as one might, an investigation such as this is fraught with error variance (factors unrelated to the focus of study). There is so much difference in wood, settings and tuning, tuning abilities between people, style of use, etc., it makes such a investigation almost futile.

For one, it would be simply overwhelming, both in expense and time, to consider all the many suitable planes and the various configurations available to the woodworker. For example, it would have been desirable to have included one or more true English style infills (Norris, Spiers, Preston, etc) as well as their more modern replicas. It would have also been useful to examine at least several planes able to support multiple back bevels, lets say an ECE/Primus, Lee Valley and Lie-Nielsen with back bevels at 50, 55, 60, and 65.

There are advantages in maintaining consistency by using one rater, but it would have been a stronger study if it had been possible to use three raters using all the planes on all the woods.

There is such difference between samples of a given wood, not to mention differences between woods, that all rankings must be considered only crude approximations to what will likely be one's own experience. I tried to minimize this problem somewhat by basing ratings always on at least two samples of a given wood, but this should not be considered sufficient. To be truly valid, something more like eight samples of each wood would need to be evaluated. A good example of why this is true can be found by comparing the performance of planes used in this investigation with those that were also used in my previous Lee Valley #4.5 review which included comparisons to the Lie-Nielsen #4, Lie-Nielsen #4.5, Lie-Nielsen Low Angle and ECE/Primus Improved Smoothing planes. Now granted, I didn't employ such elaborate methodology in that earlier review, but it is illustrative to compare the following words from the previous review to the present findings:

> *Purpleheart. L-N LA did best here, followed by L-N4.5 and V4.5. ECE/Primus prone to chatter on this wood. Not a hint of chatter from the V4.5 and virtually as good from the L-N4.5.*

In contrast, in this investigation, the Lee Valley Low Angle plane performed quite poorly on Purpleheart while the ECE/Primus achieved a fairly good surface. I suspect the differences between then and now is not the difference between the Lee Valley and Lie-Nielsen low angle planes, but likely is the result of different samples of wood.

Woods, and the individual sample of wood before one, is the primary arbiter of what plane will perform best at a given time!

Conclusions:

Again, I want to reiterate, there were no "bad" planes in this investigation. Every one of these planes is well made, and works very well indeed on some woods and for some purposes. However, not all of these planes were as suitable to application on the dense, difficult, sometimes heavily figured woods deliberately selected for this investigation.

So, was there a "best" plane? In my mind there certainly was. The Stephen Thomas infill planed at a superior level more consistently than any other plane. Its ability to do that at a relatively modest effective cutting angle implies that it will handle a wider variety of woods than the higher angle planes. It felt good, it was easy to adjust, it breezed through the densest woods, it made some of the finest and most even of shavings; simply, it was just wonderful to use and a true asset as a tool to quickly achieve the finest surface planing can accomplish. Alas, wonderful comes at a very high price, one that exceeds all the other planes in the investigation combined, and for more reasons than price alone, it will be a plane of very limited availability. If you have the money for it, though, it won't disappoint and will likely even save a professional hand tool user money in the long run.

Was there a best value? I think so. A Lee Valley #4.5 with an extra blade or two for back bevels is by far the best value in my opinion, and is also one of the most versatile of planes (along with a Lie-Nielsen with a 45 degree frog). For roughly $200 (including an extra blade), you can have a level of performance I suspect can be brought to only a little short of the best in performance. Using back bevels, I expect the Lie-Nielsen #4.5 will offer much the same performance, but at about twice the price (again, including an extra blade for back beveling). Still, not a bad price for such a versatile plane.

Another plane strongly in the running is the ECE/Primus Improved Smoothing Plane, with its adjustable mouth, it will likely respond equally well to back bevels, and at a price comparable to the Lee Valley.

For me, the lessons most safely drawn from this investigation (and for the reasons I express above, all speculation should be done very cautiously) is that higher blade angles are generally useful for denser woods, that back bevels work and are an inexpensive way to achieve a range of effective cutting angles, and that a plane with an adjustable mouth is almost essential to exploit the use of a back beveled blade. It appears also, that there is something about the infill design, that allows such planes to perform over a wide range of wood types, with but only a modest increase beyond Standard pitch.

There is a saying in medicine to "treat the patient, not the machine," (that is, pay attention to whether the patient is breathing, not just whether the machine is saying the patient is breathing, or not). I think a similar saying is a good way to end here, "Use the plane that you find works best for the wood before you, not the plane any review or investigation has suggested was the best plane for their woods."

I'm sure I've failed to address some important points, and simply don't have the knowledge or wisdom to respond to others. I'll try to answer the ones I can in response to questions appearing on BP, and will revise and update this complete report when there is something valuable to include. Now, on to some investigations of super high angle planes (over 60 degrees) and how all this relates to scraper planes. Just don't expect the results for a while. :-)