<u>Voicing the Steel String Guitar:</u> *GAL Summer 2011*

<u>Talking points:</u>

Hierarchy of needs for guitar building;

The top material (species, grade)
Top bracing (species, style, mass)
Top thickness specs
Choice of body woods (solid, laminate, species, quality)
Body depth or size of air chamber
Neck woods (mass/strength)

Choice of scale length
Bridge mass and material
String gauge
Nut and saddle materials
Finish choices (FP, nitro, varnish, acrylics, cat lac, polyester, tung oil)

Basic maxims:

The top IS the voice, choose it with care and treat with the respect it deserves.

Keep top construction mass to a minimum sufficient to maintain stability, do not **overbuild** it.

Think of it as if you were building the guitar like a model airplane, make it to fly.

Everything about the guitar has some effect on both tone and responsiveness, to a greater of lesser degree. The single most important tone/power element is the top itself. Second is the brace mass and lastly the brace placement.

The back and side materials color the sound but they are not the voice itself. The back and sides effect bass response to some degree and sustain (dense woods increase sustain, soft reduce it). The also create reflective or absorptive effects depending on density and stiffness and can, in some cases add power back into the overall sound envelope via the "trampoline" effect.

The essence of the great guitar over the average guitar lies in its relative level of efficiency; its ability to take the energy of the string in motion and turn it into the maximum in singing tone quality and amplification of sound. Guitars work at about 5% optimum efficiency as a mechanical device. Even a small addition of overly massive elements in the build or other impediments to the motion of the plates will reduce the efficiency and thus the output. A 1% loss in the overall efficiency of the box is actually a 20% loss relative to the maximum possible.

The Vocabulary of Tone, how to talk about guitar sounds.

Power:

referred to as **Headroom**

the ability of a guitar to respond to heavy playing pressures with huge but musical voice

This has to do with its Dynamic Range (the ability of the guitar to be soft or loud while maintaining the full complexity of its voice).

Responsiveness:

The ability of the guitar to respond to any player pressure with immediacy and a full voice. (a matter of efficiency)

Projection;

How well the guitar throws its sound at a distance, also a matter of efficiency

Tone:

The vocal qualities of the instrument, how the elements come together to make the voice.

Articulation; how crisp and distinct the notes are

range: Mushy/dull........................crisp/normal.............................edgy/overly bright

Tone Color:: (how woody and complex or thin, metallic, and stringy the notes are

range: Very warm and woody..........balance wood and string..........minimally woody, bright

Depth of tone: whether the notes are full and complex or thin with little wood motion audible

range: thin, mostly string sound.......................piano-like solidity of tone with obvious woodiness

<u>Sustain:</u> how long the notes ring after striking them

range; Quick decay..........................Moderate..Long sustain

<u>Choosing the top</u>

The top is the most important element in the construction of the guitar, it IS the voice.

Raw tops

oversize and over thick plates changes ping tone and flex test results
skewing data to the positive side with cleaner ping tone and more sustain, also stiffer flex

(show before and after top halves, one sanded one raw)

Top Grading:

Best stops are not necessarily Master Grade and often not AAA
These tops are rare and nearly perfect cosmetically, thus expensive and pretty, however they are often softer with a less articulate voice due to overall fiber density:

Talk to your wood dealer in depth about grading and what you are looking for

The best sounding tops often feature wider grain, uneven growth rings and color changes,etc.

(Show Adi and Euro Adi samples and test)

The only way to tell true quality is to physically handle the tops to determine their worth
Best to buy at least 6 tops of a specific grade to test them, often you can return unused ones

Know your sources, they have the best information about the wood they sell

Know what you want in a top before ordering and tell the dealer your criteria in detail

**You absolutely <u>cannot tell the quality of a top</u> by looking at it,
appearance is no measure of worth**

Testing the Top

This is the single most important step in the guitar building process,
It will determine the degree of success of the build more so than any other component

First, know what your target sound envelope is, talk to your customer in depth.

Take back and side material and neck materials into account as they will color the sound

Match tops to back and side woods in a way that will get you closer to your target voice

Choose your species and physical properties to best approach the target voice:

Every species of top material has its own vocal characteristics. All samples of a given species will have similar tonal properties even when they differ in stiffness and grain count. The essential cellular structure and amount of **lignin*** in the winter and summer growth is a relative constant and determined by the genetics of the species. Only the microclimate growing conditions may vary somewhat.

Lignin:A complex polymer, the chief noncarbohydrate constituent of wood, that binds to cellulose fibers and hardens and strengthens the cell walls of plants.

If two samples of a species where one is less stiff than the other which is stiffer are made into guitars, the voices will have the same characteristics except for a slightly higher level of articulation and sustain in the stiffer of the two.

Engelmann will always sound like Engelmann, Sitka like Sitka, German like German etc.
It is a fundamental structural issue with each species.

There are groupings of species that exhibit very similar tonal properties because they are also similar in the structures within their wood makeup.

Hardness refers to the density and physical hardness of the wood.
Stiffness refers to the dynamic resistance to deflection of the wood.

Soft Woods (cont)

As a good rule of thumb, softer woods are less articulate (warmer, fuzzier) than harder woods. Same holds true for stiffness, stiffer means brighter and more articulate, less stiff softer sound.

Softer tops will have more bass response, stiff tops stronger treble response.

Soft tops work better on **small footprint boxes** where the tighter perimeter stiffens the top.
Stiff tops work better on **larger boxes** where the longer span acts to minimize additional stiffening.

Almost all modern Adi is softer than the old growth Adi Martin and Gibson used prior to 1939.
It has the headroom of the old stock, but the tone is more diffuse, often muddy and inarticulate..
Lutz is the only top wood that has the tone quality of the vintage Adi along with the headroom.

Ping Testing of Tops

Look for clarity, complexity, and sustain in initial test of ½ plates

(Illustrate with actual tops of various qualities) Demo guitars to correspond with tops.

Ping half tops holding by the middle of one side tapping middle of the plate.

Final test if for the power quotient.

Looking for the ability of the top to hold a clean ping tone and push large amounts of air.

The strong fundamental should be very sonorous and substantive.

Pinging should evoke lots of top motion and a clear sense of the air moving away from the top.

A top which lacks a musical quality to this fundamental note should be avoided.

<u>The Ping Test</u>:

(Demo holding the plates and tapping them to elicit ping tones.)

(Show and discuss range of tone qualities for various species and within a species).

It is not the frequency that matters. Frequency is a function of size and thickness of the plate. The important aspect to listen for is the character and quality of the ping and the sustain.

<u>A dull ping tone</u>: with short decay indicates a soft or very fibrous top/lots of internal damping
Leaving only the fundamental audible in the finished guitar, guitar will be muddy, no high end.

(Demo soft top with decent ping for contrast)(Demo foam models as well.)

<u>Decently crisp ping tone</u>: most tops fall into this range, a safe choice
Look for good sustain as well, balance from bass to treble, good partials mix

<u>Very crisp, ringing ping tone:</u> This top will make a very bright, articulate voice
It might benefit from softer bracing to even it out, could be percussive
Tonal spectrum sifted hard to the high mids and highs. Sparkly and intense.

<u>The three things to listen for with the ping test are: clarity, complexity, and sustain.</u>

<u>The second test of the raw plate is the power quotient test.</u>

When listening to the ping tone, look for a strong fundamental as well as overtones, clarity, and sustain. These elements will show up in the final voice of the guitar (assuming you do not overbuild the top structure).

The quality and amount of the above characteristics are inherent in the top material and are the building blocks of the voice to come.

These basic elements of the voice can be modified through choice of brace stock, bracing mass and location, choice of back and side materials (and their relative mass) and the materials of the neck. In addition, how the top is arched or not arched can alter the top's voice significantly.

Testing the glued plates as a unit:

It is at this stage that the true character of the top is revealed, when the plates are joined and sanded to rough thickness. I take my tops to .135" to start with a finish around .125-.130".

(Demo tops for ping tone and flex testing)

Talk about how the testing reveals the probable tonal outcomes for various tops.

Show how the different species are not the same ping tone and flex.

Show how stiffness or lack or is not necessarily a good or bad thing.

Top Arching

Illustrate and talk about how **arching the top** to a 30-36 ft. arc raises fundamental and shifts the tonal spectrum to the treble register losing depth of bass response.

Arching the top increases top tension and rigidity. Think eggshell effect.

Great for neck set, higher bridge and saddle, easier setups, prevents S curve in top

Reduces bridge torque and top motion as well as tonal depth and power.

It is impossible to achieve anything approaching the vintage tone with an arched top.

(Site examples of Blazer and Hanks and Martin Authentic models..)

Remember that EVERY top is different, even within a flitch from the same round of a tree. It must be treated as having its own unique tonal envelope and adjusted as to thickness and bracing accordingly.

It is equally true that every piece of wood involved with the guitar structure is unique and must be tested and evaluated for its effect on the final sound.

Top thickness:

Historically. guitar tops were generally thinner than today. The Adirondack materials were much harder and stiffer than their modern counterpart. Martin tops were .095-.110" with small bracing. Gibson tops were .095-.130, showing their materials varied more than Martin's.

I thin my tops to a starting thickness of .135 and the usual final thickness will be between .100 and .125. It all depends on how hard and stiff the top material is. Obviously stiff stock can go thinner than soft, but the tonal trade off is there as well. The thinner and stiffer the top, the brighter the tone, to the point of being shrill. Soft top materials work best at about .125". Too thick and the tone will be dull. Much thinner and there will be a loss of depth to the sound.

I let my tops do about 60% of the structural work and the bracing about 40%, but this will vary with top stiffness. I rarely use soft top material even if it has a good ping tone.

Bracing the top

The most problematic part of the build, how to brace the top.

Think VOICE first, then remember the ping tone of the selected top as well as its stiffness.

Choose a bracing material to compliment, enhance or alter the basic voice of the top wood.

(Show slides at this point)

Basic concepts:

A **softer brace** material and one that is less stiff will **fatten and sweeten the tone**, take off the edge.

It also increases bass response because it allows longer waves of the low frequencies to move the top more easily

A **harder brace** material will increase top stiffness also **increasing treble response** but reduce bass.

<u>Bracing: width/height/shape</u>

<u>Shape</u>:

The shape of the brace matters for both tone and structure. The old "knife" style Gibson bracing sounds totally different than the Martin parabolic shape on the same body size and top material. I have tested this repeatedly. The **knife brace imparts a percussive** and nasty quality to the tone along with lots of raw power. The more massive parabolic shape adds woodiness and warmth to the tone.

The narrower the brace footprint, the brighter the tone
The wider the brace footprint, the less bright the tone.

The more **parabolic shaped brace** like Martin uses has the same strength for its height, but adds mass to the sides of the brace, leading to a **woodier tone quality**. Both of these brace types had minimal footprints of .250 - .270"

<u>Footprint:</u>

A wide brace is not stronger than a narrow brace for the same height but greater width significantly reduces overall top motion and output. The width of the footprint impacts the overall motion or mobility of the top.
The **greater the percentage of bracing footprint** on the top the less the top can move and the converse is also true. The brace sitting on the top creates a **null zones** of minimal motion. Increase the null zones, reduce top motion, reduce null zones, increase top motion.

<u>Height:</u>

The shorter the brace, the more it can flex, the higher the amplitude of the top in motion
The taller the brace, the tighter the top, lower amplitude, reduced bass response.
It is a non-linear function, so small increments of height change make large changes in stiffness.

The height measured at the center of the brace is the primary strength factor. Mass added to the sides of the brace do not significantly increase strength vertically, but do alter the tone audibly.

<u>Important data point:</u>
Remember that increasing the height of a brace by 20% increases its rigidity by 50% and conversely, reducing a brace height by 20% REDUCES its rigidity by 50%.
Scalloping braces radically reduces its overall brace rigidity and allows greater top motion.

To X or not to X:

The X braced top has become the defacto standard in the American guitar industry and a majority of the hand builder arena.

It has a long tested history of success both structurally and tonally. There is no question that many of the very best acoustic guitars ever made use the X bracing system.

It is relatively easy to work with to alter to adjust the voice of the top wood. By changing size or location of the various components, the tonal spectrum and power can be shifted to suit the goal of the builder.

Since I build exclusively with the X brace system now and have for many decades (although not early on in my career), I will start there and explain my thinking process for working with it on a top.

I think of the top as having two primary regions: the area above the sound hole and the lower bout.

> The upper bout region is heavily braced and does not have much tonal impact.
> The lower bout is like a speaker cone and does 95% of the work of the guitar.

When I brace the upper bout, I am thinking neck rotational pressure and structure, structure....

I concentrate on the area from the sound hole to the end block or the lower bout for adjusting the voice of the guitar with bracing.

Structure is essential here also to prevent collapse of the top, but we underestimate the strength of the top plate combined with its bracing and tend to way overbuild this critical element of tone.

Remember, if the guitar is only 5% efficient and you add lots of unnecessary mass to the underside of the top, you have greatly reduced the top's ability to move and greatly reduced available string energy to drive the top. Excess mass increases loss of transfer or damping. It acts like a sonic heat sink, drawing available string energy into the mass rather than transferring it to the top and the air chamber where it can be converted to sound.

There is already internal damping going on in the top itself, the goal with the bracing is to speed and direct the movement of energy through the top without adding to that damping effect.

Bracing patterns:

I use the vintage X after having tried a number of more exotic forms and rejecting them. The sound they produced lacked character, they were even toned to the point of being boring.

I personally find variations of fan bracing, radial bracing (like Kasha) and hybrid radial bracing patterns all sound way too even and uninteresting. They also lack a wide enough dynamic range for my taste. Even with Adi tops, they lack headroom. The top moves in a more uniform fashion rather than with lots of asymmetry. The X bracing adds the asymmetric component to the top motion that also gives it the punch and power.

Tuning tops is an impossible task. All tops of all species exhibit a singular pitch for each body size (footprint) within a half step of f#. It has much more to do with size and mass of the top plate than anything else.

I will stay with what I know works and has worked for over 200 years of successful guitar making, the X brace system.

The ways I like to change the sound of the top are as follows, but not limited to these adjustments.

The splay of the X:

Actually, the splay of the X varies with the body size and shape to the degree necessary to cross the ends of the bridge feet with the tails of the X. This is both a structural and a tonal consideration. If you want a hard number, most D models are 102 degrees on the wide side. Smaller body guitars are closer to but never equal to a 90 degree angle.

Allowing greater or lesser motion of the bridge by increasing or decreasing the amount of the bridge sitting on top of the X tails changes the motion of the top and either allows for more motion or restricts it. The effect is dramatic. .

The so called "advanced" X that Martin employed for decades prior to 1940 kept the center of the X closer to the sound hole (about 1 1/4 inches on a 4 inch sound hole) and minimal crossing of the bridge feet. This loosens the top and increases its amplitude and power.

The downside of this configuration is that you must have a strong and relatively stiff top to minimize the S curve or partial top collapse that will inevitably take place under string tension. A soft top will distort too much and not bear the bridge torque.

Since the Adi top material used when these advanced X braced guitars were built was very stiff, hard and longitudinally strong, it was not so much of an issue. Modern Adi tops must be left thicker or arched more heavily to allow for light forward shifted bracing to be used. Both structural changes degrade tone quality.

(Tell story of re-topped OM for example)

One critical data point about my tops and all vintage Martins (as well as most other modern vintage guitar maker's tops) is that the arching is approximately a 50 foot arc which translates into a 1/8 gap at the ends of the 17 inch X brace when it is set down on a flat surface. Modern Martins have a 36 foot arc and follow the more modern building scheme. This is one reason the modern Martin does not sound like its historic counterparts.

(Demo brace curvature.)

Tone bars:

I always use 2 tone bars on all guitars larger than the 00 size; including all 000, D, J,and PS models.

I vary the angle they attach to the X tails and tuck them under the tails, but I honestly have not found their placement to have much impact on the tone of the guitar. I keep them light to allow this part of the top easy motion while helping to prevent excessive top pull behind the bridge.

Sometimes I use a different material for the tone bars, usually Adi, to sweeten the tone on a very stiff top. The softer and less stiff Adi works well to add woodiness to the sound.

Finger Braces:

I discovered by chance that smaller bodies like the 000 and 00 work well with just one finger brace rather than the traditional 2 on either side of the bridge plate. It is a work in progress.

The Bridge Plate:

I am a traditionalist in this aspect, I use a small, thin, hard maple bridge plate. My thinking is that it worked for Martin for 140 years and made many of the best sounding guitars I have ever played; if it ain't broke, don't fix it. (Tell the Somogyi bridge plate story.)

The primary purpose of this plate is to prevent premature wearing out of the top from the ball ends of the strings. It also prevents the possibility of the bridge ripping up the spruce if and when it comes partially or completely loose. It was a common sense structural element on Martin's part.

If you look back at Martin and Gibson guitars over the decades prior to 1940, each and every structural change that was made was in response to a problem having come along that brought guitars back for service. At both Martin and Gibson they were, as a small and highly skilled work force, simple woodworkers at heart and came up with simple, logical woodworking solutions to the many little structural issues arising over time.

Occasionally, it was the sudden availability of new and better materials (like the advent of pattern grade Honduran mahogany in 1916 allowing Martin to stop using Spanish cedar and the famous "bird's beak" complex neck joint} that led to production changes. Most of the small bracing changes were to correct for customers using too heavy a string-set on delicately built instruments causing top and bridge failures.

Scalloping:

In years past, I glued my braces to the top as rectangular pieces and then shaped them with chisels and sandpaper. Now and for the last fifteen years or so I pre-shape the bracing and glue to the top.

I like pre-shaping them. It allows me to test the brace for stiffness as I thin it or scallop it and I feel it affords me greater control over the final structure of the top.

I scallop or not depending on both the target sound and the specific physical properties of the top itself, adjusting the stiffness and sizing of the braces to suit the structural needs of the top and to make changes to the overall sound of the finished guitar. Since I do both Martin and Gibson style builds, I use very different brace shapes and patterns to achieve the vintage tone of each type.

Testing the finished top:

It may seem odd, but I rarely tap a finished braced top other than to make sure there are no loose braces. By the time I have made and glued the braces down, I already know what to expect from the finished guitar. It is a matter of having built so many guitars and played with hundreds and hundreds of tops over the years.

Because my total build time averages 22 hours over a two week span, I can still hear in my mind's ear the tap tone of the unbraced top and feel its flex, so my build data points are still fresh. My memory for sound is very acute and it serves me well in this voicing process. It has become totally intuitive after nearly 50 years of day in and day out guitar making.

I find that tapping a finished top yields little information. Some builders are now using the Chladni frequency generator sand test for their tops (see pics) with good results. Allen Caruth uses this method and has an excellent four hour video of the process if you are interested.

I do tap and flex the top when the box is ready for binding. While I can still see the top thickness around the edges, I tap the top to hear its response and tone, and I flex the top in the sweet spot for stiffness (the sweet spot lies on the lower right bout between the tail of the X and the lower tone bar. I adjust the thickness by sanding the perimeter to alter both the tap tone and the flex.

NOTE:
There are all kinds of scientific tests on guitars on-line to look at. I have read most of them and find them utterly useless. It is important to remember that every top is different, there is no absolute uniformity. Data from one guitar will only hint at how to treat the next guitar. One experiment I saw used a 1968 Gibson Dove as their test bed. I'm surprised the plates moved at all! That data is highly suspect.

Making the Box: How the back and sides impact sound and tone.

The back and sides form the air chamber of a guitar and impart their physical properties into the tonal mix of the finished instrument. Thus choice of body woods is important to tone.

To keep it simple, I think of all woods in terms of their density, hardness, and elasticity.

These qualities along with how the woods are thinned and braced add or take away tonal qualities from the whole, but in relatively subtle ways.

The top is still the voice and it is the dominant tone generator.

Here is a rough graph of various common guitar woods grouped by the three characteristic I list.

Low Density **Medium Density** **Very Dense**

palo escrito Indian rw Pau faro Light braz. Madagacar Dark braz. Hond. Coco Af.Blackw
Madagascar Madagascar Braz.

Khaya Walnut Hond, mahog Cuban mahog BL maple Suger maple
lacewood Hond. mahog
Spanish cedar Koa Koa

Density and hardness are similar for these species with the following differences:

Very soft	**Medium soft/hard**	**Hard**	**Very hard**
Spanish cedar	Red % silver maple	Bigleaf maple	Sugar maple
black walnut	Claro walnut	English walnut	
	Cuban mahogany	Honduran mahog	Khaya
	Pao Fero Indian RW	Braz.RW Mad RW	Honduran RW
		Lacewood	Af. blackwood
			Ebony

The elasticity graph.

Very elastic		**Moderately elastic**		**Inelastic (rigid)**
Spanish cedar		Hond. mahog		Madag RW
	Indian RW	Braz RW	Braz RW	Hond. RW
soft maple	BL maple	Sugar maple		African blackwood
		Lacewood		Cocobolo
	Walnut		Aust, blackwood	Ebony
myrtlewood				

These three qualities of back and side woods do the following to the sound of the guitar:

<u>Density:</u>

Less dense materials make for greater liveliness in the response and an increase in the power quotient. They also reduce the strength of the high partials, softening the tone.

The higher density materials add to the sparkle and sustain by increasing the available mass. They also tend to be rigid, which has an even greater impact on thinning the tone quality, less depth.

Hardness:

The physical hardness of a back and side material effects the wood's ability to either absorb or reflect sound waves moving about the box (actually a combination of absorption and reflection).

The more absorption the wood provides, the fatter and sweeter the tone quality, possibly too much so. Using soft woods are can make it difficult to achieve a good balance between warmth and clarity as the high frequency range is damped significantly.

Highly reflective woods are also dense and tend to be inelastic. They reflect the majority of the sound waves and cause the tone to take on a brittle, metallic, thin quality. There is a noticeable loss of tonal depth with very dense, hard woods so it is important to choose a top that will add warmth back into the mix rather than choosing a screamingly bright and stiff top.

Elasticity:

I think this is one of the most important and interesting of the three characteristics and one I have discovered late in my career.

The ease or difficulty of setting a plate in motion determines, in part, how much depth and power the guitar will have and how much sting energy will be lost in the process. The air chamber and back act to reinforce the motion of the top, or not, and the elasticity of the back, in particular, can greatly effect the efficiency of the guitar as a whole.

For this reason, I prefer to use woods that move easily, even the rosewoods that are quite dense, either by choosing a mobile species or by thinning out the more rigid material to where it can flex a bit. This may entail cutting a back down to as little as .070" as in the case of African blackwood and cocobolo. Scary process but worth the risk for the better tone and power produced.

For many years I thought that really nice Madagascar rosewood was not particularly different from Brazilian rosewood in how it behaved structurally and thus, tonally. After building dozens of guitars of similar sizes using both materials as well as the same top species, it became painfully obvious that this was simply not true. I had been seduced by the similarity in ping tones and appearances of the two rosewoods to think they sounded alike also.

Even when thinned heavily, Madagascar rosewood remains very stiff, stiffer than a Brazilian back at the same thickness. Brazilian and Pauo Escrito, for example, are far more similar in their elasticity than Madagascar and Brazilian, which only look similar. Brazilian has what I call a trampoline effect on the sound, pushing it out of the box with greater force, thus projecting well.

Body design:

Size Matters

The footprint of a guitar body and the depth of the air chamber all impact the tone of the finished instrument.

I know from experience that my rounded 16 inch J model (like a J-185 Gibson) never sounds or behaves like my 000 or D or the J-35 or any other guitar I make. It defies any changes in woods or tops and will not move away from the basic tone of that box shape. It has an almost annoyingly even tone quality and lacks the headroom of any other box I build, again, regardless of the top material. There is something about the shape of the body that effects the way sound moves through the system and it seems immutable.

Here is my take on body shapes and depths.

The most efficient guitars are small guitars, like the 00-12 fret and the 15 inch 000. Larger than that, the sound becomes more airy and the bass starts to take over the vocal register. Making the air chamber shallower on a larger box helps to balance out the bass, mids and highs as well as making the pumping of the air chamber air less audible, the blowing over the coke bottle effect. The wider top has its own effect on the balance of the voice and the sound often seems to wallow inside the box rather than projecting from it efficiently.

Small boxes throw the sound much better than larger boxes. It is a mechanical advantage they have, not a function of specific design elements.

Sound holes and Ports:

In the Martin history book there is a picture of a piece of paper from C.F.'s office circa 1885 that shows a complete listing of every model they were making at the time and the different sound hole size for each. So even early on, Martin had figured out the effect of hole size to air chamber frequency. This is the Helmholz frequency we all talk about. Smaller boxes us smaller sound holes to increase the bass response of an otherwise treble strong instrument.

I am a traditionalist and use only two sizes of standard sound holes, a 3 3/4 for the small boxes and a 4 inch for the D and larger boxes. I don't do Ports, that's for you modern guys.

I would not have thought large side ports or small top ports was a good idea, but I have played enough really fine modern guitars with these features to know that they can work well.

(Tell the story of the Beardsall)

The Neck:

There are a zillion theories about the neck, its effect on sound and feel, how it behaves with the motion of the body, etc, etc. Here is my very unscientific take on it based on my 50 years of experience and well over 1000 guitars under my belt. I could be wrong...

I approach the neck from two points of view: structure and tonal effect.

Structure

I want the neck to be strong and stable. I prefer an adjustable truss rod for service. I would build with a non-adjustable rigid system, but I don't trust it over time. My next iteration is to go back to the very sensitive, but light weight Gibson style single rod. I currently use a single action double rod.

Ebony fingerboards are harder, more rigid, and wear better than rosewood. I suspect they also add a little to the sustain of the box, but subtly.

Rosewood is lighter and less rigid and wears relatively quickly, but seems to add a bit of liveliness to the response of the instrument.

I use mostly ebony.

I only do the old fashioned wood to wood dovetail neck joint. It works, it is relatively simple to make and fit, it adds no extra mass to the guitar beyond what was already there. If the goal is to build lightly, the handy dandy bolt-on neck assembly needs to go bye, bye.

So much for structure...

Tonal effects:

The mass of the neck material seems to do two things to the sound of the guitar.

Light neck (Spanish cedar, light mahogany):
increases responsiveness of the guitar, adds warmth to the tone, draws less energy from the box

Medium neck (Honduran mahogany or similar);
The standard, works well, hard to tell what effect it has on tone

Dense neck: (hard maple, heavy mahogany, rosewood, etc.)
Definitely adds noticeably to the sustain of the instrument
Adds sparkle with accent on higher partials audible
Reduces the headroom of the instrument by drawing string energy from the box

The Scale Length

Basic rules of physics to keep in mind here:

The longer the scale, the higher the string tension for a given pitch.
It is a non-linear, exponential relationship.
A small change in scale length has a relatively large change in tension.

The longer the scale, the plainer and less complex the string motion and thus the less interesting the tone quality. Fewer small harmonic nodes form on the tighter string. The shorter the scale the greater the complexity of the string motion creating a more interesting tone.

I prefer the **24.9 " Martin/Gibson** short scale as is found on the 000 and many of the early Gibson flat tops of all sizes. I also use the slightly longer 25.4 " D scale for my larger guitars.

I have done scales as long as 26.25 but do not like the tone I get from them regardless of box size and wood choices. I find guitars with these longer scale to be dull and boring as well as underpowered..

The Baritone thing:

It is my belief that the current Baritone and Semi-baritone building frenzy is misguided.

Rather than doing the wholly logical thing and make everything bigger and scales longer to increase bass response, why not take the MOST EFFICIENT guitar box and turn it into a low tuned instrument? Remember, the bigger the box, the more mass and the less efficient it is. The longer the scale, the plainer the sound, why not go with something more complex as well.

(Demo 00-12 semi-baritone)

Basic rule of thumb:

If you need a longer scale to make the guitar have a bigger sound, it is probably overbuilt. A smaller box with a short scale can easily sound every bit as powerful and have a more complex voice than the bigger box with the longer scale.

The Bridge:

Again, mass is important as is how the bridge feet interact with the supporting bracing. Other than that, it is pretty much up to you to decide on design. The top is doing 90% of the work of the guitar, anything you add to it, either under it or on top of it can impact both tone and power. Less is more.

I use both the belly bridge and the slimmer, longer pyramid bridge because it fits my style of build. I have little data on other bridge types and their effects on the resulting sound. I do know for certain that the Tune-o-matic is not a good idea! Keep it simple.

The height of the bridge and corresponding saddle height is important because the height above the top determines the angle of the fulcrum for the string/top motion and thus the ability of the bridge to "load" the top.

Top "loading" is a mechanical term meaning how much torque is applied to the top by the bridge rotating with the string pull. The higher the point of rotation, the greater the force applied, the more top torque or loading.

Industry standards are a bridge height in the middle of 5/16 " and an additional saddle height of at least 3/16 ", although depending on the geometry of the top itself, an 1/8 to 5/32" saddle will work as well.

Bridge materials:

The bridge should be tough and hard. Ebony is a good and standard choice. I prefer African blackwood for its greater toughness and resistance to cracking. It also polishes really nicely and has some grain character to it.

Using a rosewood bridge will brighten the sound but has the trade off of being prone to cracking and it is not as tough or durable a material..

The Nut and Saddle:

You can alter the tone quality of a guitar by using different nut and saddle materials. More so with the saddle than the nut.

How hard of soft these two components are effects the level of brightness of the tone.

A muddy toned guitar will benefit from a really hard nut and saddle material (like fossil ivory), whereas an already bright or overly bright guitar can be tamed by using Micarta or similar soft materials. Corian actually works well in this case. I use bone or ivory exclusively as I choose tops that will already have the crispness I seek.

Strings:

Like it or not, not all strings are created equal. Every brand seems to have its own voice. I look for clarity and durability as well as easy left hand feel even with mediums. I string mostly with light gauge J-16 D'Addario. They do the job and are cost effective. I use their mediums for the flat picking crowd, the J-17's. I also use Nanowebs sometimes for their longevity. They don't sound as good, but the don't sound as good for a lot longer.

My feeling is, if you have to use mediums along with a long scale on your guitar in order for it to sound good, the guitar is overbuilt. Any guitar should sound almost as powerful and full voiced with lights as it does with mediums.

One test of a really good guitar is how it sounds with old, worn out strings. If it still have power and clarity and tonal depth with year old strings, it is either a vintage guitar or a very good modern one. Few guitars meet the challenge

Finish:

Every guitar maker's nightmare is applying the finish, regardless of the materials used.

It takes as much time to finish a guitar as it does to build it (rule of thumb).

Finish Matters

The best finish is a thin finish, on the order of 3-5 mils, regardless of material used.
Thin means it will protect the raw wood but still be flexible and allow full motion of the parts.

Each finish has its own degree of elasticity (here we go again with elasticity...it is important).

The old work horse material like French polish (shellac and variants) and nitrocellulose are more similar than different in their physical properties. Both for quite hard, rigid, brittle thin films.

Any finish overbuilt is going to case harden the guitar and impede the motion of the wood.

Modern catalyzed finishes have flexibility by virtue of their molecular structures, long interlocking chains of complex acryls and esters along with some very nasty solvents and catalys agents..

The only finish I would avoid at all cost is the non-UV cured polyesters. They do not stick well to any substrate, so they chip and delaminate easily. They also retain an odd softness which deadens the tone of the guitar like wrapping it in a thin rubber blanket.

I can't speak to the UV cured polyester, but I suspect it can be applied so thin that it minimizes the tonal downside. Poly is the only truly bullet-proof finish I know of, but I would never use it or advocate others use it.

Varnish of various flavors is being reinstated as a guitar finish after almost a century after it was last used on production instruments (primarily Gibson). It is a challenge to work with but in capable hands produces a lovely, warm, slightly soft but very tough finish.

I actually use a waterborne, self catalyzing acrylic lacquer from Target Coatings,; *EM 6000.* It has the burn in, high solids, quick build, fast cure-to-buff, easy touch up and most of the physical properties of the old nitro. It takes several weeks to fully de-solvate and harden, but it is a very forgiving finish to work with and safe enough to shoot without venting to the outside air. It can be sanded after 30 minutes and buffed after 24 hours, cutting down finish time significantly.

Final thought to leave with:

The top IS the voice, choose it wisely and work it with care.

Do not overbuild; lighter is much better than heavier. You would be surprised at how lightly you can build the structure of a guitar and still have it work without imploding.

.**Arching the top increases top tension and rigidity. It is an exponential function, not linear, whereby a small amount of arch significantly increases both top tension and rigidity. The top at rest or without arching will have a fundamental as much as 2 whole tones lower than a top with a 36 foot arc. Arching shifts the overall responsiveness of that top from bass-mids-highs to mids- highs and highest partials. The resulting tone becomes less deep and woody and brighter, stringy sound and greater playing noise.**

Fit and finish is important, but keeping the structure light and responsive is paramount for success. A flawlessly executed bit of fancy woodworking is not the same as a great guitar. It can be, but one aspect does not automatically follow the other. Just because you can do, does not mean you should.

Don't be seduced by fancy modern tooling into thinking you are a great guitar maker all of a sudden. Tools designed for production remove the direct human to wood contact so necessary for understanding the various materials intimately. Tooling can take away the sheer tactile joy from the build process. A sharp chisel in the hand is far more satisfying than turning on a CNC machine. Besides, how many guitars are you trying to make in a year? Hone your hand skills first.

Experience really does count. Build and play lots of guitars and pay attention. Educate your ears. Get your hands on as many vintage and modern guitars as you can, play them, listen closely to them and learn.

Use the internet as an information resource with great caution. There is much nonsense and misinformation contained therein. Be skeptical of all information unless you know the source well and trust it.Remember when reading on-line scientific research abstracts about guitars that a late 60's Gibson Dove was the data source for one such study. Keep a sense of humor about all of this and take it with a grain of salt. A Gibson Dove? Really?

Hide glue does not sound any different than LMI white guitar glue, sorry about that. **However, it is much more fun to use**.

Relax, none of us really know what we are doing. We are all flying blind with only occasional glimpses of the ground through the fog of unknowing. Enjoy the process. It does get easier over time.

John Greven, luthier