How to Build Better Scale Model Vehicles

Construction Considerations for Building Championship-Caliber Models

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The machined parts shown in this booklet were made by Cody Grayland from drawings and specifications prepared by Mark S. Gustavson. Photoetch artwork was created by Robert Wick and rendered by Fred Hultberg of Fotocut. Chrome plating was done by Steve Jansen.
Introduction

Most modelers, at least occasionally, contemplate the construction of a sophisticated, accurate, and convincing model for display or competition—not just another “typical” model built at their current level of skills and abilities, but one that has that “winning edge” or that pushes concept, detail, and execution up to new levels. When faced with the objective of constructing such a model, the builder experiences the challenge of satisfying two very important aspects of the project: The overall scope and concept of what the model will look like and how complex and detailed it will be when completed; and how to design and assemble the many components and integrate them with other parts to create a convincing and accurate scale vehicle.

Good scale automotive modeling is much more than just gluing the right handful of parts together and then assuming that a realistic and satisfying model will result. Rather, successful building is a mixture of the proper conceptualization of the project, systematic planning, and superb craftsmanship in integrating a series of subassemblies and components into one model.

GSL International Model Car Championship (“GSL”) judging criteria focuses on the basic craftsmanship and realism of each model, including elements of authentic hydraulic/electrical/mechanical detailing, scale thickness of panels, realistic and skilled use of color, paint, and other finishes, and a convincing overall appearance. Too often, models displaying sophisticated detailing and operational features do not win because they lack in areas of basic craftsmanship. GSL judges evaluate the sophisticated elements of any entry only after basic craftsmanship criteria have been evaluated.

While primarily aimed at assisting interested builders in preparing for successful competition in the GSL International Model Car Championship, this modeling booklet will also be useful for all scale vehicle miniaturists who wish to construct thoughtful and accurate, intelligently-built scale automotive miniatures that create the illusion of reality. By carefully reading the following text and checking out the photographs, and then applying that information and approach to building models, you can improve the models you build and find greater success as a contestant.
Theme

*Is the model well-defined in theme and execution?* The first, and crucial, step in successful scale vehicle construction is to clarify what you want your model to be. Whether you are constructing a scale vintage hot rod, a custom, a competition vehicle, a factory dream car, a commercial vehicle, a diorama or other subject, you need to fully consider and define the outlines of your project so that all of the elements of the model are integrated with other. Visualize how your subject matter must look to represent the intended style or category of vehicle, and what elements must be present to convince and involve viewers (and even tell a story, if appropriate).

Think about what the viewer/judge will need to see to be convinced of the realism of your model. If it is a “period piece,” do all the components accurately reflect what was done or was available at the time? For instance, an accurate replica of the Dick Flint roadster or the scale reproduction of a factory stock 1950 Ford Club Coupe wouldn’t have radial tires. In the case of a “weathered” vehicle, it may help to create a “story” or “history” of the model to clarify how and why it appears as it does. What about your replica of that factory concept car—why not do research into the manufacturer’s design and marketing decisions, and then present a brief narrative of those facts that would aid viewers understand your project? Make sure that all elements of the models are part of a cohesive whole, and are supported by your research.

Make The Model Realistic

*Is the model realistic in general appearance and detail?* A convincing and competitive model must be a realistic miniature of the subject. For GSL competition, all models must be designed and built with the “practicality of use” in mind. For example, there must be space in fender wells to allow wheels to turn without interference, there must be reasonable space between a steering wheel and seat, and so forth. Similarly, entries in all classes must be functional and practical for their intended use. Modeling realism also means that operational and safety equipment should be present and physically connected to one another. For example, GSL Factory Stock class entries must be complete with all road-use legal equipment for the time of their manufacture. Competition class models must have all applicable safety equipment (roll bars, scattershields, fire extinguishers and so forth) required by the sanctioning organizations for the time frame that existed for the vehicle modeled. Custom/Street Rod/Street Machine and models in either Commercial Vehicle class must display common equipment required by the vehicle code (for the subject’s era) for the vintage vehicle constructed.

Research

*Is the subject well-researched and presented?* Focus on your subject—get familiar with it by doing thorough research. For example, if you have in
mind to replicate in scale a particular customized automobile, allow the
time necessary to do all possible research about that vehicle. In another
case, if you are modeling Spencer Murray’s Dream Truck, for instance, be
sure to research and select one of the several versions that were constructed.

There are many sources for your research. Check the catalogs from
major book retailers. From amazon.com to Classic Motorbooks, each com-
pany has hundreds of titles covering virtually every aspect of the 1:1 hobby.
You could also check out Hemmings Motor News, or one of the many dealers of vintage factory literature, for other more esoteric interests. Visit new
car showrooms or car shows to take photos of your vehicles and details.
Visit self-service auto dismantlers to learn how 1:1 cars are assembled, and
how automotive structures are designed and fit together. Don’t forget to
document that research for the judges!

Presentation of Research Materials, Documentation,
and Construction Details

*Are required documentation, research materials, and explanations of con-
stuction procedures, techniques, and details provided for the judges or the
audience?* The GSL Championship encourages the entrant to provide re-
search materials and details of construction of the model: several classes also
require research and documentation for a model to be eligible to compete
in that class. Research materials might include the history of the subject
you have replicated, and documentation can include technical informa-
Factory photos are also useful to determine shapes and aesthetic details. These photos and related materials can still be found.

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How to Build Better Scale Model Vehicles
Craftsmanship

Is basic craftsmanship present? Remember that basic craftsmanship and exquisite cleanliness are the most important elements in the construction of any convincing scale automotive miniature. Successful entrants must remove and leave no evidence of: ejection pin marks, parting lines, copyright notices and other signs of the manufacturing process. Make a point of using adhesives sparingly. Basic craftsmanship and a “clean” build are primary considerations in judging.

Here are some important techniques to master:

Removal of seams. Remove all seams where parts are joined, by filling with putty or other material, followed by careful sanding, priming, and painting. GSL judges carefully examine all parts for seams, especially in hard-to-reach spots.

Removal of parting lines. Parting lines (slightly raised ridges), created when multi-piece dies are used in the production of model kits, are present on parts in all models. Carefully examine all parts you are using and remove parting lines by using fine sandpaper (400 or finer grit) or a fine-grit sanding stick. When removing parting lines from round parts, care must be taken to avoid creating “flat” spots on the part. GSL judges carefully examine all parts of each model to determine if the modeler has removed all parting lines. It may also make more sense, if the rules allow, to replace an item: for instance, replacing a kit driveshaft with a piece of aluminum or brass tubing may better represent the 1:1 part.

Figure 3

It is important to erase all evidence of seams when joining parts. Use an instant glue, aided by an accelerator, to join parts. Then, use a medium-grit sanding stick to smooth the interface between the two parts and then use a little putty to fill in surface imperfections. Quality craftsmanship requires patience and careful work—but the results are worth it!
Figure 4  Highlighted with a little graphite, here is a typical seam along the edge of a part. It is essential that all such seams are eliminated but be careful that “real” seams (that would be present on 1:1 parts) are not removed.

Figure 5  Use a medium grit sanding stick, followed by a fine sanding stick, to remove the seam. Be careful not to introduce unrealistic surface irregularities by not sanding evenly along the entire length of the seam. Constantly check your work.

Figure 6  When finished, apply a thin coat of primer to check your work. If surface problems remain, use a small bit of putty to fill in the problems as shown on the left hand side of the view.
Figure 7  Note the careful work on these mufflers. Even if the intersection between parts can’t be seen or seen well, still finish every surface to achieve great craftsmanship. Be sure to drill out the exhaust tips, then apply a dark grey wash inside the pipes after the assembly is painted a steel color.

Figure 8  Seams on the bottom of transmissions and engine blocks, too, can be filed.

**Removal of ejection pin marks and copyright notices.** Ejection pins leave marks (round raised areas or round debossed areas) when the freshly-injected plastic parts are ejected from the dies. Take care to grind out and fill embossed ejection pin marks, or fill debossed ejection pin marks, to present a more realistic appearance. Often, these ejection pins appear under hoods, under roofs, on flat areas of undercarriages or chassis, and are sometimes difficult to remove. GSL judges thoroughly examine all areas of the model to determine if all ejection pin marks have been removed. Copyright notices also often appear on the chassis, or on other visible surfaces, and need to be removed.

**Careful use of adhesives.** A common problem is the use of incorrect adhesive and/or excessive use of adhesives resulting in excess glue “squishing” out between parts or marring the exterior finish or other parts of a model. Consider these guidelines:

- Don’t use instant glues to attach clear parts—these adhesives “fog” the clear plastic. It is better to use Kristal Kleer or similar products to affix
Figure 9  Even though this example of a copyright notice wouldn’t be obvious on the finished model (and is used here for the sake of clarity), it is important to remove all evidence of manufacturing.

Figure 10  Where possible, use a Dremel tool with a round cutter to lightly remove the inscription and abrade the surface. Remove just a little bit of the surface.

Figure 11  Apply a thin coat of putty to the area, then sanded to perfection, then prime and paint.
Either of these products will do a good job in attaching clear “glass” or in making clear lenses for headlights/tailights/instruments.

Though its uses are limited, a good two-part epoxy can be useful in strengthening panels. Following mixing instructions carefully.

- windshields, headlights/tailights, gauge fascias, and similar parts. Instant glues are used when permanent, hidden joints are desired; depending upon application, gap-filling or the thinner variety may be used.
- Five-minute, two-part epoxies are best when hidden recesses need to be filled when attaching parts.
Depending on the intended use, select between the thin “instant” adhesives and the much thicker instant adhesives (which should be used to attach large parts to each other or to fill in cavities inside parts). Where you are filling a cavity, or need a very strong joint, use an accelerator (middle container).

If you make a mistake, you can use a debonder. Use it carefully.

- Design your model so that attachment points between parts are hidden by the final assembly. For instance, create “ledges” on which parts like seats, dashboards, unified/one-piece chassis/underbodies can rest, and then attach them by locating pins that leave no obvious adhesive joints.
- It is also important to use the right kinds of adhesives. Solvent glues should be discarded in favor of the new generation of so-called instant adhesives that come in three viscosities. Where you can, use an accelerator, which will produce a stronger joint.

**Employ Realistic Assembly Techniques**

*Build models like “real” automobiles.* Auto manufacturers build their cars as they do for ease of assembly and to address quality control issues. As
Though the work is meticulous, the best way to build a realistic model is to build it in almost the same way that the full-scale vehicle is assembled. In this view, from left to right: (a) a spindle was scratchbuilt, cast in brass, and then machined to interface with... (b) the machined Bendix brake backing plate. Note the four holes around the central hole integrate with four corresponding holes drilled in the fascia of the spindle. The brake backing plate... (c) fits inside the reverse side of this vintage Buick finned brake drum. This drum has been machined in aluminum and will not be painted or plated. Note the five central holes index to outside of the rim of the wheel... (d) the rim is two parts for easier installation in contemporary tires.

The rim was machined from brass to fit a specific tire (this one available from The Modelhaus). Threaded shafts (0000-160 in diameter, available from the Morris Company) will be fitted to the five holes in the brake drum so that the rim can be mounted with scale hex nuts and removed for display. These parts will be used on Mark S. Gustavson’s Dream Truck².

a scale vehicle miniaturist, your objectives are almost identical—you want to be able to assemble your model in the best possible way consistent with a superb final product (your model). Therefore, if your goals are realism and a relatively trouble-free assembly, think about ways to build your model as if it was in 1:1 scale. Think about the model as a series of major assemblies composed of subassemblies which are, in turn, integrated with other assemblies to create a complete model.

Determine the body structure of your model. Is the subject vehicle a body-on-frame construction? Or is it a unibody model?
From the backside, note the carefully-considered tolerances between the brake backing plates, the Buick brake drum, and the inside half of the rim. There is a sleeve on the fasica of the spindle that indexes into the back of the brake drum.

**If the subject employs body-on-frame construction.** Construct a floorboard and a separate frame (if the kit isn’t already configured in this way). Cut the kit’s flooring away from the frame—if they are molded together—and scratch build a new underbody from raw materials (plastic or brass), using the kit part as a rough guide. The plastic frame can then be used (after clean up), or you can take it to a jeweler and have it cast in brass. Either way, you have simplified your final construction tasks, and created a fresh canvas for your detailing tricks. The frame should have small pins affixed to the top side (in hidden areas) that will fit into correctly-located holes on the underside of the body so that you can test fit that frame to the same place on your body repeatedly as you check out the fit and integration of the many part of your model as you develop them. Also, cut open your doors, trunk, and hood and fit the hinges before you attach the floorboard to the body shell. You’ll have to assemble the model through the openings in the body, but if all the major components have been previously and positively located, this is not the difficult task that it seems.

**If it’s a unibody car.** Construct the underbody platform (either by modifying the kit piece or by scratch-building one), but do not attach it to the body until you have finished all of the work that requires full access to the “inside” of the body. For instance, if you are going to open the doors, hood, and trunk, modify the body, or smooth out the inside of the roof (to remove ejection pin marks, etc.), complete these tasks first. Build your door/hood/trunk hinges and make sure they fit. Make whatever changes are necessary to the underbody platform, including suspension pick-up points, and only then mate the platform to the body shell. This body/platform assembling procedure allows you to stabilize a body that has been weakened by opening the doors, hood, and trunk. Of course, you will assemble your model through the openings, but that isn’t much of a problem if you work on the subassembly approach, and install these subassemblies in their proper sequence. You may also want to write an assembly manual to remind yourself of the correct assembly sequence.
Here is the brass frame for Mark S. Gustavson’s reconstructed Dream Truck. It attaches to the underbody of the model with small pins set on the upward part of the frame which match up to holes in the floor board—when finished, the pin-to-hole assembly technique can’t be seen. The rear axle assembly is a conglomeration of 12 separate parts, all silver-soldered together. The gear set attaches to the axle housing with 0000-160 bolts. At the front of the frame, the brackets to pick up the upper and lower A frames have been fashioned and soldered to the frame and cross member. The leading brackets on the rear axle trailing arm attach—with small bolts—to the brackets on the frame cross member.

Components

Is the entry comprised of a series of convincing subassemblies? Once you have defined your goal(s) and determined the nature and range of your basic mechanical and styling details, the next step is to visualize the completed, “whole” model by conceiving of the sets of subassemblies that will comprise your project. In doing so, the entire scope of the model becomes more manageable and less daunting, especially when complex models are being built. This procedure will also help to create an accurate miniature that will help convince the judges and viewers of the realism of your entry. Make each part, and each subassembly, a masterpiece model in itself: It is important to fashion each element of the model as if it could be entered in a contest without being combined with other parts. By treating each part, then each subassembly, and then larger assemblies of subassemblies, as if they alone would determine the character and quality of the entire scale vehicle, you are more likely to make sure that the fit, finish, and realistic appearance are consistent and convincing throughout.

Building Subassemblies and Components

Use a “locating pin” approach to install most components. Since the subassemblies on your model must be test-fit repeatedly before completion to be certain that the parts fit together in the same place EACH TIME, you need to develop a way to positively locate on part to another assembly.
Note the structural detail underneath the cab—this comes from a photoetch sheet created by artist Bob Wick and Fotocut (Fred Hultberg). The cutout in the rear rolled pan will be filled with a body-colored brass panel—necessary to permit the model to be assembled. These kinds of decisions must be made before any painting, finishing or assembly are attempted.

The frame fits into the body of the Dream Truck the same way every time it is fitted. This way, the interface between the parts can be repeatedly checked against the background of major components—whose interface with each other is stable—so that problems of fit can be solved before painting and final assembly occurs. This is a way to achieve realism and avoid difficulties.

One excellent way of doing this is to install small brass pins in pieces to locate the various major and minor components in relation to one another.

**Think about interfacing the parts.** When your project requires many parts to fit together, the combined physical intervals between those parts compound to the point that a seemingly insignificant misfit in each area can multiply and thereby result in a significant misfit of parts or entire subassemblies with an adjacent area. It is virtually impossible to think completely about the shape and size of every part, and how those parts fit with all other parts, early in the planning stages. You should think seriously about the dimensions of major subassemblies and their components, and how
Figure 22  A unibody model presents some special issues for the builder. Create the underbody and bond it to the body once the doors have been removed, the inside of the body has been finished, and the hinges have been fashioned and installed. The brass panels with the structural detail are photoetched. All suspension and drivetrain components will attach to the underbody structure. This model will be a replica of the lost Lincoln-Mercury dream car, the *Lynx*.

Figure 23  This hood has been constructed from brass and fitted with photoetched panels (vents) soldered to the hood. Note the formed hinges at the front of the hood that will bolt to a “receiver” up under the forward panel, just above the grille. Any fit and interface issues—for instance, to make sure that the hood will close down over the engine—can be solved before the model is painted or soldered.

those parts will influence the use and placement of other subassemblies. By establishing the “outer parameters” of each subassembly and how that subassembly integrates with other subassemblies in the early stages, you can work within the confines of those parameters and ensure the correct fit of every subassembly into the overall model. In this way, dimensional errors (or “tolerance drift”) can be contained within each subassembly and not compounded throughout the entire model. Think about ways to reduce these tolerances so they are contained within each subassembly. That is, the compounding of panel thickness, the fit between parts, and structural

*Building Subassemblies and Components* 15
The dashboard of the Lynx is a composite of styrene and brass. This entire subassembly has been fit to the unibody, and will be fully detailed (machined instruments, photoetch instrument faces, operating dash/radio/glove box lights) before placement in the painted model. Note the receiver for the steering column (half-brass sleeve on the underside of the dash, and tubing on the brass firewall): the machined steering column will also be fitted before any final finishing or assembly.

The dashboard is located on the body (remember, all subassemblies must have positive mounting points to assure stability and predictability) in the Lynx model in two ways: a brass sleeve for the heater motor, and a matching sleeve on the driver’s side for the steering column. The console also fits up under the central part of the dash (helping to locate the dash) which console, in turn, pins to the transmission tunnel.

requirements can be compensated for by designing techniques to permit some parts to overlap the mating surfaces between the various subassemblies; for example, the mounting flange for a dash board (as it meets the cowl of a model) could cover up the natural “gap” between the leading edge of the dashboard and the inside of the cowl. In that way, you don’t need to spend many hours absolutely mating up the dash to the cowl which you would have to do if they were to “butt join” together surface to surface.
With the dashboard temporarily in place, the through-the-firewall heater core (on the left, here) and the steering column (here, on the right) assure accurate and predictable placement. The two holes by the heater motor hole are for the heater hoses, and the detail adjacent to the steering column hole are for wiring harnesses and the master cylinder. Note the brass “receiver” channel for the windshield—a multi-part separate photoetch “chrome” surround will fit just inside the inner radius of this opening, thereby sandwiching the “glass” between this panel and the photoetch parts.

The machined intake manifold will attach to a machined bracket on the engine block. The small shafts are inserted into the intake manifold—the outside diameter of the pin is the inside diameter of the “receivers” in the engine block and the intake manifold. When finished, the exhaust manifold flanges will attach—in an alternative pattern to the intake ports show here—so that the dimensions of each part and their relationship to other engine and adjacent parts.

Try to “cheat” parts so that they appear to be the correct size, or that the entire part appears to be present even if one end of it is cut short to fit into the available space.

**Assemble major subassemblies: Each part a modeling masterpiece.** If you construct your scale model as the factory does, you’ll be able to control all size and detailing issues for each component as a subassembly in itself, thereby controlling and limiting its impact upon other elements of the model by integrating that subassembly with other subassemblies, then integrating
Mounted into a machined “receiver” on the engine block (with the intake ports alternating with the exhaust ports), the intake manifold fits in the same place every time. With the engine mounted in the frame (it will bolt to frame-located engine mounts), parts fit and related construction issues can be resolved. Two resin-cast carburetors from Model Car Garage will be installed.

Those subassemblies into the “whole” model. For example, assemble the rear axle as a unit, then fit it to the springs, add the wheels and tires, and then test-install that assembly on the frame or unibody. If you doubt an assembly will survive much handling, glue together a “mule” (of exact exterior dimension and mounting points) and use it as a fitting guide.

**Test fit every part repeatedly during the design and construction process.**
Think about how that part interfaces with other components. Test-fit everything repeatedly. As you continue to create levels of detail, you will always be amazed at how many glitches will show up as you check, and recheck, the fit of the pieces that you have crafted. The process can be frustrating, but it is much easier to deal with the potential problems in the early stages of construction and design, rather than during final assembly. The goal is to reduce the chances of parts not fitting together when final assembly occurs. Also remember to test-fit body parts to check for paint interference.

**Painting the body.** It’s a good practice to concentrate on the body cleanup and body modifications at the beginning of the assembly process. That gives you time to paint the exterior of the body early. This will permit you the time to find and fix any flaws. Leave enough time—at least three weeks—for the paint to shrink or “settle” before polishing. Before you apply your final coats of paint, test fit the major exterior body pieces (doors, trunk, and hood and allow for paint thickness which can foul up the best plans at final assembly). If necessary, lightly sand the facing surface of interfacing panels (e.g., opening door-to-fender interface) on the edge to reduce the thickness of the paint before applying the final coat of paint. While the body paint
Use a variety of “mechanical” colors, and washes and powders, to give the illusion of reality. Consult real engines and note the subtly different colors and textures that are common. (*Mercari* engine bay by Mark S. Gustavson)

Before finishing can occur, you need to have good parts to work with. Remember, present technologies and finishing supplies can produce excellent results. In this view, we see parts for a Ford 4100-series 4-barrel carburetor.

is drying, you can concentrate on building and detailing the subassemblies that fit into the body and chassis so that everything is ready to go together within a relatively short time frame. This reduces the risks of damage to your model: the longer it is left out waiting for the next parts to be finished and installed, the greater the risks of something being broken or lost.

**Detailing**

*Is the detailing authentic and realistic?* Make your detailing accurate. Don’t make the mistake of “burying” the model in irrelevant and inaccurate details by randomly attaching wires, brackets and clamps everywhere: route mechanical, electrical, and hydraulic elements in the way they appear in the “real world.” Check out research materials, brochures and ads, review
It is essential to organize your tools and supplies to avoid the delay and frustration of hunting for items that should be readily available. Purchase quality items once, keep everything clean, and replace dull blades and other consumables when necessary.

mechanics’ manuals (factory or aftermarket), visit car showrooms and old car shows, and go to junkyards, all of which can provide an incredible array of examples and information on how “real” cars are wired, plumbed, and assembled. Once basic craftsmanship is addressed, authentic detailing is evaluated.

Clean Assembly Area

Make your final assembly area surgically clean. Wear cotton gloves, and lay an old white T-shirt or soft cotton cloth over your work area. Alternatively, consider placing a piece of glass over a white or light gray background on your work surface, so you can easily see paint, glue or other contaminants. Keep the adhesives “off site” and import small amounts of adhesive to the model as needed. Never work above your model with any tool, adhesive, sandpaper, or any heavy or threatening object that will damage the model if it falls, is dropped, or is dripped on the model or any component.

Seek the Advice of Others

Get advice from other builders. Scale vehicle modelers are generous in sharing their solutions to various building problems, including which materials and techniques work best. If you see something you like, ask how it was done. If someone asks you how you accomplished a particular task, explain it. The exchange of information is a big help in better building, and is one of the most fun and enjoyable aspects of the hobby of scale vehicle construction.
Take Your Time

A great enemy to quality building is impatience and its companion—the belief that spending a lot of time on a single model is inconsistent with enjoying the hobby. Excellence in building has a price and, if you pay it, you will be richly rewarded with a work of miniature automotive art. On the other hand, not every model you build needs to be at the highest level . . . Keep it fun and vary your project goals.
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