Measuring Free-mo Modules
for Accurate CAD-based Layout Design and Planning

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July 2003

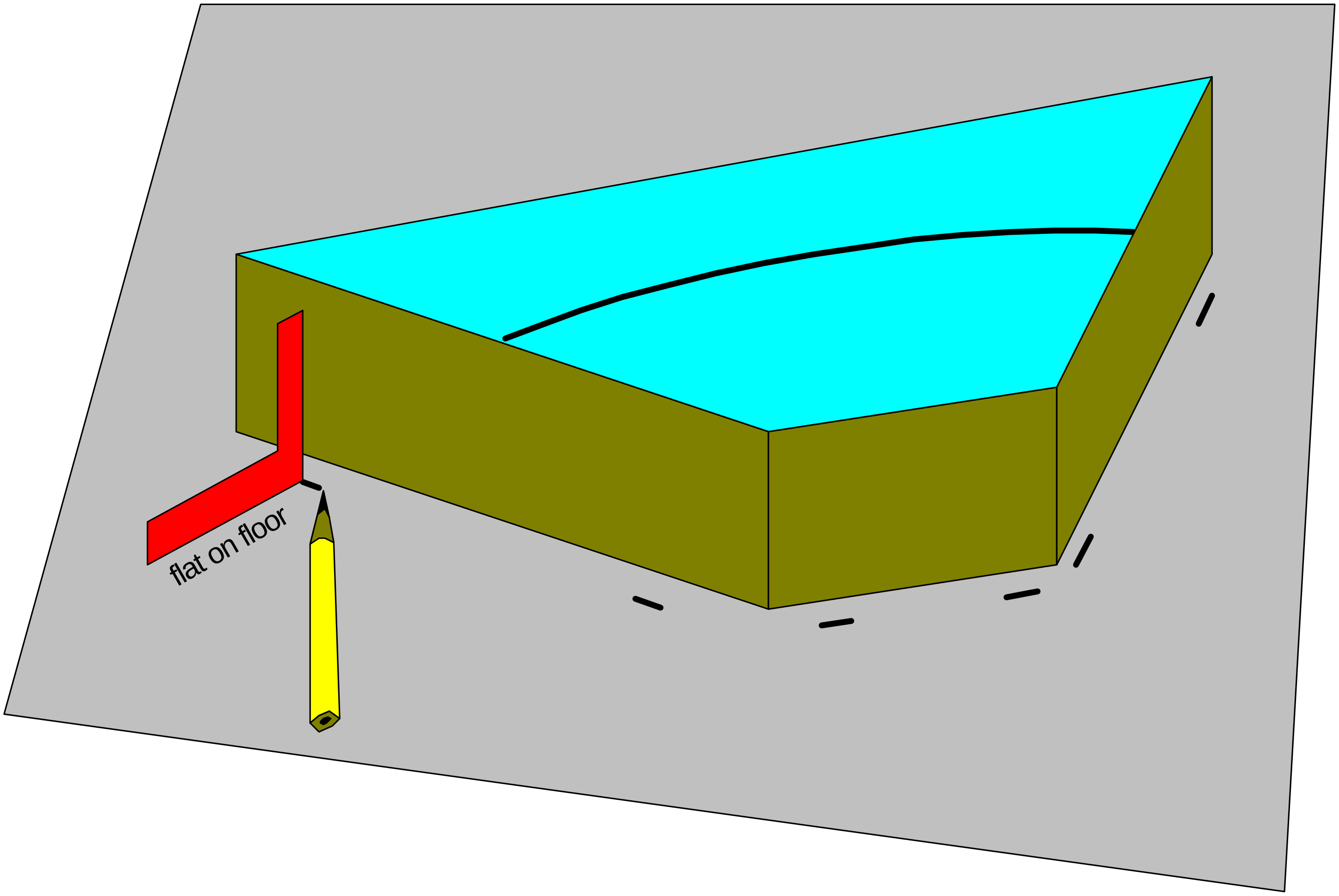
Designing Free-mo layouts is an essential activity for any Free-mo group. Because every Free-mo setup has a unique mix of modules and therefore a unique shape, and can occur in a wide variety of venues, accurately planning the layout arrangement and its orientation within the given setup space must happen well in advance of the actual setup event.

Using a computer and CAD software makes this task straight-forward, and even enjoyable. In some ways CAD-based layout design is an art form - it can become a hobby unto itself. It makes "what-iffing" a breeze, and it allows quick, electronic sharing of design ideas among members of the group, allowing each modeler's ideas and creativity to influence their next Free-mo event.

However, as NorCalF has learned the hard way, solid layout planning is based on accurate module CAD templates that reflect the actual size, shape, and angles of a constructed module. The first few NorCalF setups were arranged using templates based on module design drawings - and every setup came out "wrong", usually requiring some on-the-fly rearrangements of the layout to make it fit into the venue space. This frustrating process resulted in very long setup times and some frazzled "run chiefs".

The root cause of the problem is that many little errors can creep in during the construction of a module, resulting in a size and shape that is not the same as the original design. So using design drawings to plan physical layouts is a bad idea. Instead, templates based on the actual, physical modules are needed. It does not matter that a module is not exactly the size or shape its builder had intended ... what matters is that its true dimensions are used to plan it into a Free-mo setup. So, chances are that "45-degree" module is really a "40-something" module ... as the proud owner of a 48.35 degree "45" module, I have yet to meet a module that is exactly the size and shape it was designed to be.

Hence the purpose of this article - a method to measure a physical module for creating an accurate CAD template to be used in layout design. Once NorCalF had gone through the process outlined in this article, our setups have been very accurate and we've not had to make on-the-fly changes due to unexpected module sizes, shapes, or angles.



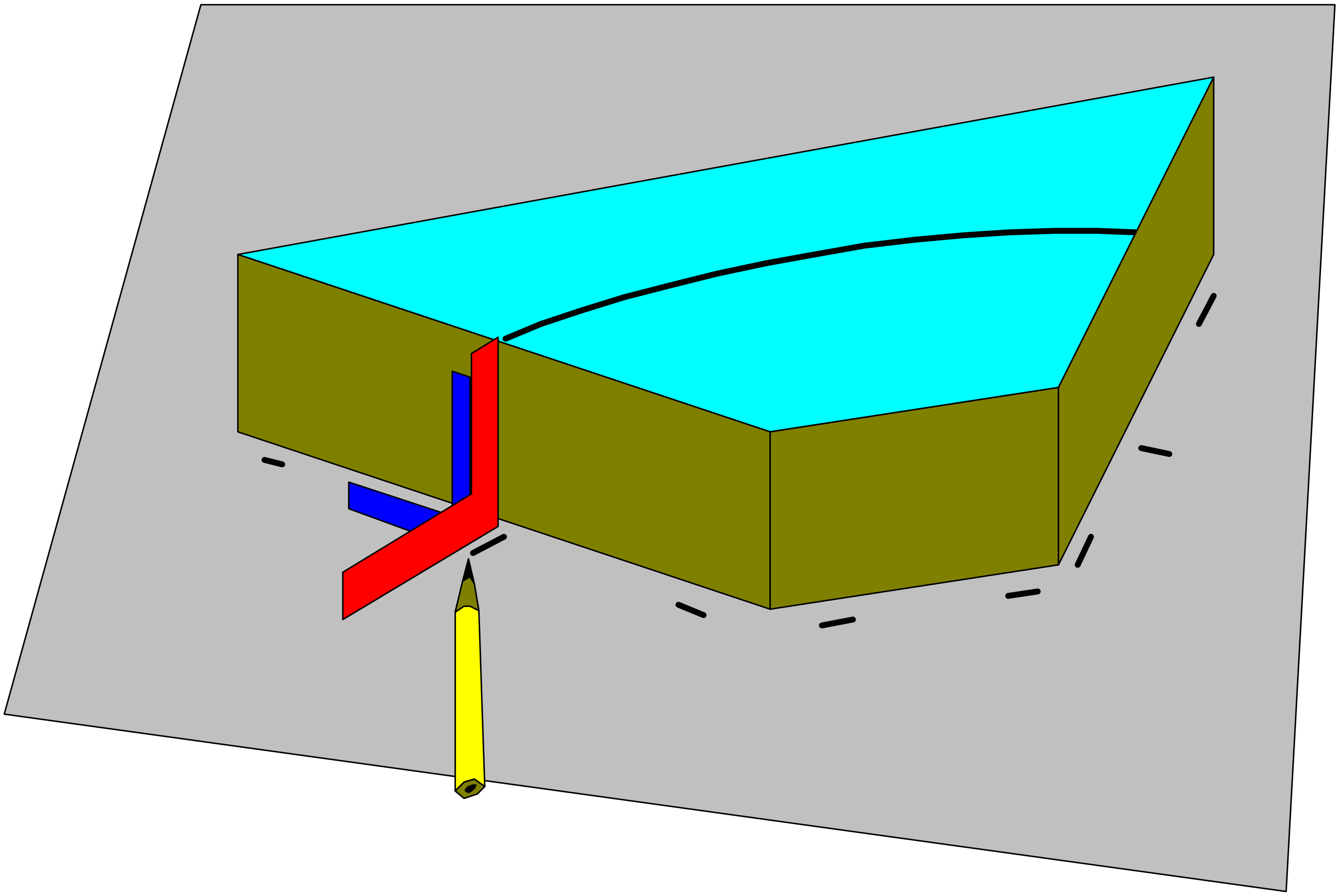
Step 1: Trace the module's perimeter

Find a large, flat and smooth surface to work on - a garage floor, driveway, patio, large kitchen or other hard-floored room are some possible locations. If you don't want to mark on the floor, lay out paper to mark on - tape together multiple sheets to adequately cover the footprint of the module to be measured. For a curved module allow space to extend the endplate planes out where they'll meet (for determining the module's curve angle). Make sure the paper is taped together as smoothly and flatly as possible - bubbles and humps in the paper will cause errors in the tracing.

Set the module flat on the floor WITHOUT its legs installed or extended. If items protrude from beneath and make the module sit cockeyed, use blocks of wood, etc. to support the module as level with the floor as possible.

Place a carpenter's L-square perpendicular to the module side and the floor - the module's sides may not be exactly perpendicular to the floor. That's OK - but set the square to make firm and flat contact with the floor. This ensures the tracing represents the module's outermost perimeter.

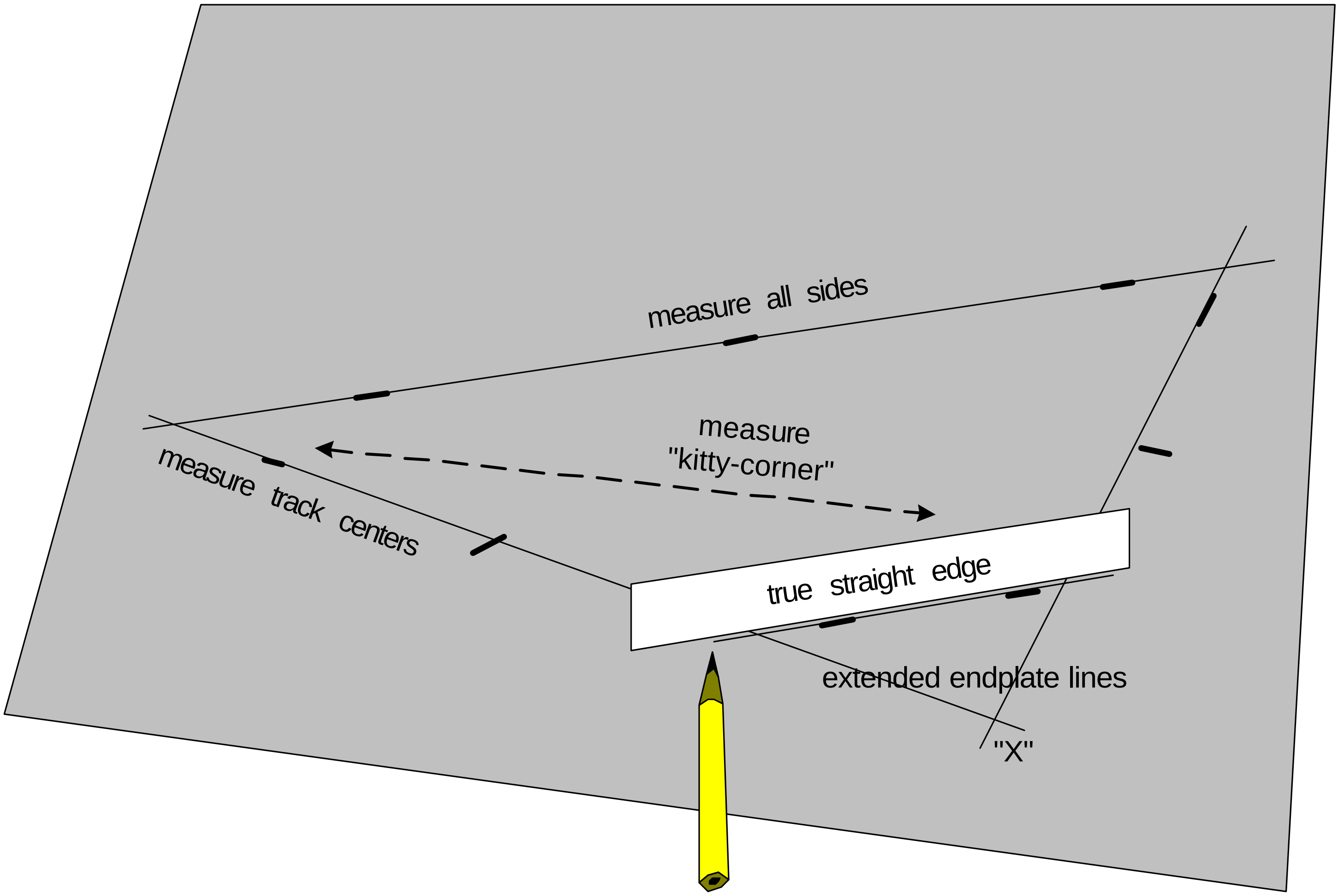
Mark the floor at the corner of the L-square - this indicates the module's outer perimeter. Make at least two marks per module side (near the corners is best); repeat for all the sides of the module to make a complete perimeter tracing.



Step 2: Mark the track centerlines

Place an L-square on an endplate at the center of the track, similar to what was done in step 1 (shown as the red square in the sketch above). Now place a second L-square, shown in blue, perpendicular to the first, and use it to ensure the first (red) L-square is perpendicular with the floor. Check that the first L-square is still aligned at the track center, and mark the floor along the square's floor leg. Repeat on the other endplate. This translates the track centers onto our tracing. Surprisingly, most module's tracks are not exactly centered on their endplates, and their precise location must be captured for the final CAD template.

That's all we need from the module - it can be removed and stored away at this point.



Step 3: Connect the dots & measure

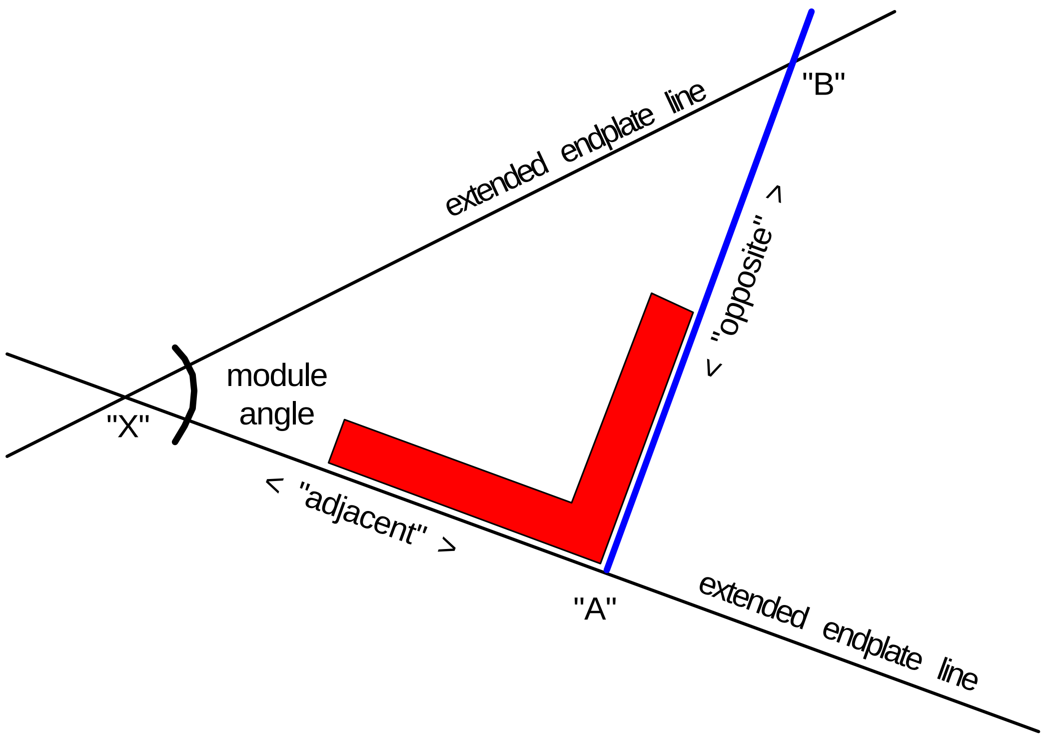
Using a long straight-edge, complete the module's perimeter tracing by connecting the marks for each side. Always use something that is truly straight - don't use a wooden board as they are usually not straight. A large aluminum level works well, as long as the marks are no further apart than the length of the level !

On curved modules, extend the endplate lines until they cross - shown in the sketch as point "X".

Carefully and accurately measure each side of the module tracing, from one intersection to another. Record your measurements on a separate notepad for use at your computer while drawing the module template in CAD.

Carefully and accurately measure the track centerline positions relative to the module corners.

Also measure between opposite corners (i.e. "kitty-corner") - this extra dimensioning will come in handy when trying to accurately capture the true relative angles of the module's sides in CAD.



Step 4: Determine a curve angle

Point "X" is where the extended endplate lines cross. From this point, carefully measure out some known distance, say 24", back along one of the extended endplate lines, and mark that point - labeled "A" in the above sketch.

Using the carpenter's L-square and the long straight edge, mark a line from point "A" perpendicular to the extended endplate line (shown in blue). Extend the line until it crosses the other endplate line - this point is labeled "B" in the sketch. You've just created a right triangle.

Measure the distances between points "X" and "A", and call that the "adjacent" to our desired angle. Now measure between points "A" and "B" and call that the "opposite" to our angle.

A tiny bit of trigonometry reveals the angle of the module:

module angle = arctan (opposite / adjacent)

"arctan" is the inverse function of "tangent" - most scientific calculators can do this.
And in fact the calculator tool included in Windows will do this:

-start the calculator tool (START-Programs-Accessories-Calculator)
-use the "view" menu to display the "scientific" version
-do the process of dividing the "opposite" length by the "adjacent" length
-check the "inv" box in the upper left of the calculator and click the "tan" button (lower left)

Record the resulting angle for your CAD template. Rounding to 2 decimal digits is fine.

Step 5: Make the CAD template

The final task is to draw the module's CAD template based on the measurements and angles from the tracing. The CAD template is then used to design Free-mo layouts in a CAD environment.

The process of making the template will vary depending on the CAD program used and the individual's preferences. The important aspects to capture accurately are:

1. the endplate positions and angles relative to each other
2. overall size and shape of the module perimeter
3. track location at the endplates

One possible method is:

1. draw individual lines of the exact length for each endplate and side
2. draw "kitty-corner" dimension lines at their exact measured length
3. orient one endplate line "square" with the CAD grid
4. orient the other endplate line at its relative curve angle to the first endplate line
5. empirically move and rotate the side lines and "kitty-corner" lines until their positions and endpoints align to match the module's overall perimeter shape
6. add track centerlines, crossing the endplates at their measured locations
7. add text for the module's name, curve angle, siding lengths, and any other data that could help a layout designer orient and utilize the module
8. save the entire CAD template as a "group" or "unit" for handling as a single object in a layout design effort

Eventually a library of module templates will be available to plan layouts. However, the other half of successful layout planning is using accurate floorplan data for the space to be occupied! If at all possible, have someone in your group measure the setup space to within 1". Include all obstacles (posts, steps, pipes, stationary furniture, keep-out zones, etc.), any doors and their "swing" area, and anything else that may influence a layout setup. Capture the floorplan in CAD at the same scale the module templates are drawn.

When designing a Free-mo layout the module templates are moved around and rotated to piece together an interesting layout, keeping clear of obstacles, providing adequate walkway isles, etc. It is very important to make certain the module's endplates meet exactly flat - the mating endplates must be at the same angle! This may require manually editing module rotation angles to accommodate 2-decimal-digit angle accuracies. Also make sure the endplates are flush - no overlapping or open spaces at mating endplates. Then, ensure the modules are aligned side-to-side by lining up the track centerlines across mating endplates.