



## Flexdude in Space: Working on the Mars Science Laboratory

This past year I had the great privilege of working with the good folks down at Jet Propulsion Laboratory as part of a team working on the flex circuits going into the Mars Science Laboratory — the biggest, most complex Mars rover ever. It is scheduled to be launched in the fall of 2009.

It was fun to be part of such a big, high-profile project even though my part of the program was small — double-checking and reviewing flex circuit designs.

The Mars Science Laboratory (MSL) is about nine feet long and dwarfs the previous two rovers (see picture on page 2). It has much, much more scientific equipment that will enable it to sample more types of soil and rocks. It will also be able to travel

Throughout *The Flex Circuit News* there are links to the web pages of those companies or individuals mentioned in the articles, as well as links to advertisers web pages. Look for the pointing finger.



When size is everything

## Reeeeeeeally Big Flex Circuits

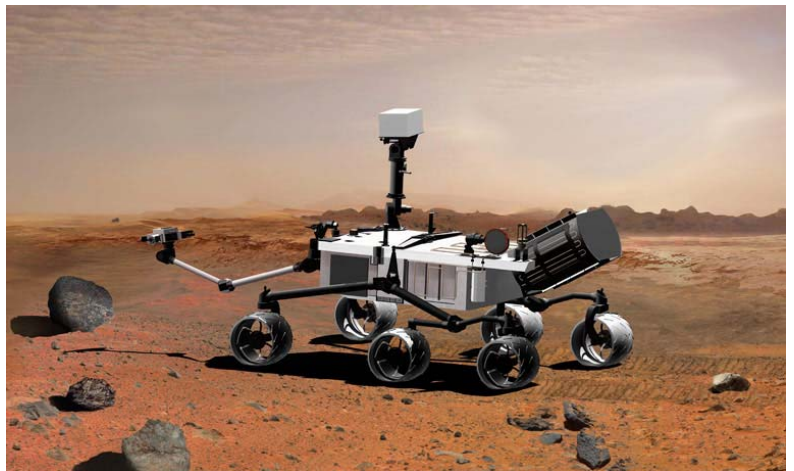
Tom  
Woznicki

Flex circuits are usually fairly small compared to rigid pcbs, and some of them can be really, really small. But what if you need a big flex circuit? I mean a really big flex circuit — five feet long or more?

While there are some design issues unique to large flex circuits, a bigger issue can be finding vendors — a flex manufacturer with equipment that can process large flex circuits and a materials supplier that can provide flex material in either rolls or very large sheets.

I have designed a handful of these oversized flex circuits for research projects in the past, and while working on the Mars Science Laboratory project I learned of new vendors that have the stuff necessary to make these reeeeeeeally big flex circuits.

Story continued on page 2



About the size of a small car, the Mars Science Laboratory rovers carries an impressive amount of scientific equipment to evaluate rocks and soil. Image courtesy of NASA.JPL-Caltech.

much further than the 2003 rover. The flex circuits for the MSL build on the success of the previous two rovers and play an important part in packaging all this functionality into a very compact, very mobile robot.

There is much more info on Mars Science Laboratory up on the JPL website — <http://marsprogram.jpl.nasa.gov/missions/future/msl.html>.



Large panel or step-and-repeat processing?

Large panel processing is exactly what it implies — being able to image, develop and laminate panels that are larger than 24X36 inches. Step-and-repeat uses standard equipment to process one section of the panel at a time.

If your vendor will use step-and-repeat processing it is good to keep the line widths and spaces as wide as possible — at least 10 mil lines and spaces. This increased width allows for slight misalignment as the flex material is moved and repositioned in the imager. Coverfilm lamination can also be done in a step process but there will be some oxidation at the boundary of the lamination press — be sure that your application can live with this oxidation. On the plus side, the step and repeat process has no length limit - you can make circuits 40 feet long or more with no splicing. On the minus side, you're usually limited to two copper layers.

Large panel processing involves oversized equipment that can generate large-format

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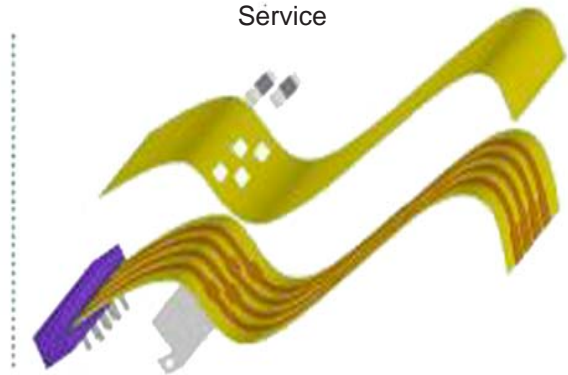


About the size of a small car, the Mars Science Laboratory rovers carries an impressive amount of scientific equipment to evaluate rocks and soil. Image courtesy of NASA.JPL-Caltech.

artwork, image, develop and laminate the large panels with no stepping. The flex vendors that have this large equipment in-house are few and they vary in size of panels that they can process.

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Fortunately, there are outside sources that can provide these services on some of the very largest panel sizes.

## Materials

Whether your vendor intends to use step-and-repeat or large panel processing, they first have to get material for these monster flex circuits. If you only need 0.5 or 1.0 ounce copper, many vendors, such as Rogers and Nippon Steel, can supply both adhesive-based and adhesiveless laminates in large rolls. DuPont laminates, however, are only available in sheets, regardless of the copper thickness. They can supply adhesiveless AP laminates in sheets up to 24X100 inches, and they can supply LF and FR adhesive-based laminate in sheets up to 24X50 inches. If the customer wants to use DuPont LF or FR materials in sizes larger than 50 inches the vendor must build the base material from coverfilm and copper foil — fortunately the coverfilms and freefilm adhesives come in rolls.

But what if the customer really needs an unusual laminate? Fralock, a specialty distributor in Southern California, can custom-make large sheet of adhesiveless or adhesive-based laminates. Because of their relationship with DuPont they can get Kapton® in unusual sizes and thicknesses and have a large autoclave to be able to create custom laminates.

Fralock  
28525 W. Industry Drive  
Valencia, CA 91355  
Phone: 661-702-6999  
Toll free: 800-372-5625  
Fax: 661-702.9899  
www.fralock.com



## Prototype Vendors

There are two prototype vendors I found that will tackle these extra large flex circuits. Q Flex in Southern California and All Flex in Northfield Minnesota.

All Flex is both a quick-turn prototype and medium volume flex vendor. They markets their



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extra long flex circuits under the trade name Maxi-Flex®. All Flex has upgraded their imaging and development equipment so that they can image a 24X96 inch panel. They use the step-and-repeat method for lamination.

All Flex is the only proto shop in the USA I know that builds copper-on-polyester flex circuits and they have made some Maxi-Flex® circuits using polyester materials. All Flex also recently invested in automated SMT assembly equipment to provide complete flex assemblies.

Q Flex, located in Santa Ana, California, makes these large flex circuits in large panel format. They have a custom-made autoclave that can laminate panels up to 14 feet long and 14 inches wide. For several years they have produced a 107 inch long flex for an aircraft wing application. Being able to laminate these extra long panels in an autoclave also gives Q Flex the ability to make long, multilayer impedance-controlled flex circuits with no splices.

All Flex, Inc.  
 1705 Cannon Lane  
 Northfield, MN 55057  
 Phone: 507-663-7162  
 Fax: 507-663-1070  
 www.allflexinc.com



This custom autoclave can be extended to laminate panels even larger than 14 feet. For panels that are wider than 14 inches, they have

access to another autoclave that can handle panels up to 36X96 inches.

Q Flex doesn't have in-house capability to image and develop large-format artwork but they have vendors in Southern California who can.

Q Flex, Inc.  
 1301 E. Hunter Avenue  
 Santa Ana, CA 92705  
 Phone: 714-664-0101  
 Fax: 714-415-5529  
 www.qflexinc.com



Q Flex is a very fine proto shop — I have done business with them for almost ten years and recommend them often.

### Production Vendors

Production vendors have more capabilities, but are more careful about what opportunities they take on. These jumbo-sized flex circuits are often low production volume that consume many hours of engineering, so this careful scrutiny of the flex opportunities is understandable. These vendors also tend to be suppliers to the military-aerospace industry, and their costs tend to be higher than those that cater to high-volume consumer products. That said, if you're looking for a two-foot-by-six-foot flex circuit you knew they're not going to be \$10 a piece — right?

First, let's look at Pioneer Circuits in Santa Ana, CA. Pioneer builds almost exclusively military and aerospace flex circuits, and they are famous in the flex world for creating very complex flex circuits for the first Mars Rover — Sojourner.




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The flex circuits that went up in the Sojourner rover were 26 and 30 layer rigid-flex circuits needed to solve space and weight problems. Pioneer also built the flex circuits for the Mars rovers that went up in 2003 — they're still working!

Pioneer has a large autoclave that is capable of laminating panels as big as 24X90 inches and have the ability to image and develop panels up to 30X144 inches. More importantly, Pioneer has loads of engineering talent with lots of experience building these very long flex circuits. They have also developed techniques to splice these long flex circuits together, creating controlled-impedance flex circuits upwards of 30 feet long.

Pioneer Circuits  
3000 S. Shannon St.  
Santa Ana, CA 92704  
Phone: 714-641-3132  
Fax: 714-641-3120  
www.pioneercircuits.com



There is loads of information about the Mars space program flex circuits and other aerospace programs on the Pioneer Circuits' web page.

Minco also produces flex circuits for the mil/aerospace industry, but they also have a presence in the commercial and industrial markets. I visited their facility back in 2005 (see May 2005 back issue). Minco has a large autoclave for laminating large flex panels up to 72 inches long, and can image and develop panels that large in-house. In addition to the flex circuit division, Minco also has divisions that makes heater flex circuits temperature sensors and instrumentation. Like Pioneer, Minco has bunches of engineering talent to draw from.

Minco  
7300 Commerce Lane  
Minneapolis, MN 55432  
Phone: 763-571-3121  
Fax: 763-571-0927  
www.minco.com



I was already familiar with both Pioneer Circuits and Minco, but while working on the MSL I learned about three more companies that have large panel capabilities: Speedy Circuits, Dynaco and Amphenol Printed Circuits.

Speedy Circuits in Huntington Beach, CA is a company very similar to Minco — they produce complex flex circuits for both the mil/aerospace and the commercial/industrial markets. They have a very large autoclave — 40X100 inches, so they can laminate a panel as large as 36X96 inches. Their etching capability is limited to panels 24 inches wide and their in-house imaging capability is limited to 20X30 inches, but they have access to outside services that can image and etch larger panels.

Speedy Circuits  
5331 McFadden Avenue  
Huntington Beach, CA 92649  
Phone: 714-898-4901  
Fax: 714-891-0607  
www.speedycircuits.com



Speedy also has a laser and gold, palladium and solder plating in-house. They plan to expand into the quick-turn prototype business, concentrating on turning simple rigid-flex prototypes within a week.

Amphenol Printed Circuits was formally known as Advanced Circuit Technology (ACT) in

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Hudson, New Hampshire. They were best known for their development of Sculptured® flex circuits — a technique with takes very thick copper and selectively makes both thick copper features for interconnection, such as pins or lugs, as well as thin copper traces in areas where the circuit will flex. Amphenol also manufactures standard flex circuits and rigid-flex circuits for the mil/aerospace and commercial/industrial markets.

Amphenol doesn't have an autoclave, but has an oversized lamination press that can fit a 24X54 inch panel — certainly large enough for many applications. They have the capability to image and develop panels that size in-house.

Finally, Dynaco in Arizona builds complex flex and rigid-flex for both mil/aerospace and commercial/industrial customers. Dynaco's in-house lamination presses are about 34X38 inches, but they do have access to a lamination press that is 36X78 inches right across the street at Neltec, a very large PCB laminate manufacturer. All other processes and assembly can be handled in-house. Dynaco also has a unique capability to produce microwave rigid-flex circuits and bookbinder flex circuits.

### So What About Your Industry?

I suspect many folks are saying to themselves "That's nice, but I don't work in aerospace - what good are these oversized flex circuits to me?"

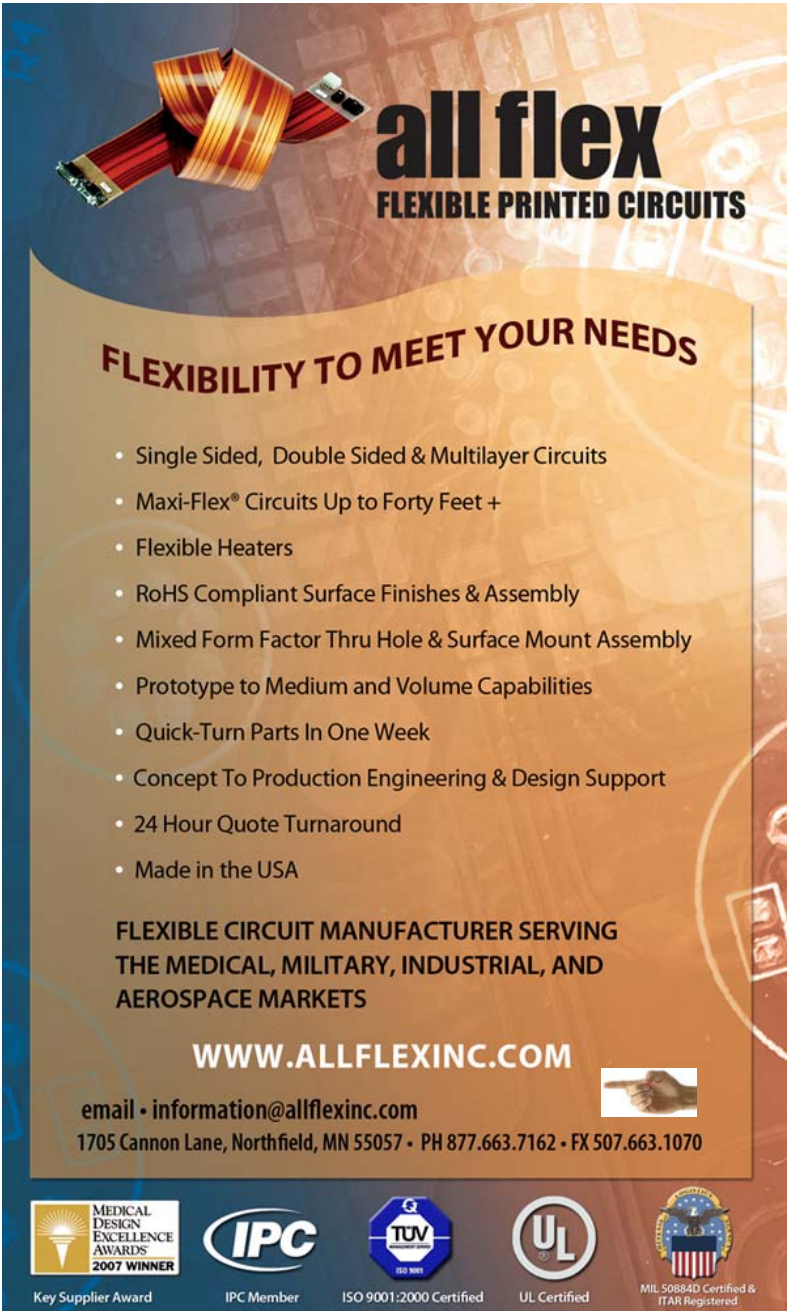
Well, gasoline is moving towards \$5.00 a gallon. Diesel fuel is worse — I'm looking at converting my diesel pickup to burn used french-fry oil. As the cost of

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energy soars the economics of many industries are changing. Car and truck makers are going to have to make vehicles smaller and lighter — exactly the same reasons that mil/aerospace folks use flex circuits! The solar power and medical industries are also changing — maybe your industry is too. So much so that an extra-large flex circuit can make sense? We'll see!



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On a personal note...

## Lots of Stuff to Tell

A thousand apologies for taking so long since the last newsletter. So much stuff going on outside the CAD cave — this might look like a cheesy Christmas newsletter (apologies to those of you who write those ~~cheesy~~ charming newsletters).

### AARP Wants You!

I'm now over 50 years old, so I guess I'm officially an old coot. My lovely and charming wife Julie threw a very nice party - Hawaiian theme complete with a four-piece band called the Faux Hawaiians. Lots of adult beverage was consumed and a good time was had by all.

### Old Yeller Is Gone

I've been blessed with a good wife, four kids, two Jeeps and a beer-drinking cat. Well, I can't say that any more - my old yellow Jeep is gone.

It was a lovable old rustbucket, a 73 CJ5 with a V8 engine and gears so low it could climb a tree. Perfect for keeping miles off our shiny cars and the occasional off-road adventure, especially since my son Mike was always driving the black Jeep. But Mike went off to college in Ohio and Julie started dropping subtle hints like "do we really need *two* Jeeps?" I resisted for the first year, but then I reluctantly took some pictures and put it on Craig's List for what I felt was a reasonable price. It sold in a day - guess it was meant to be.

With a pocket full of Benjamins but a heavy heart I watched it being towed away by the new owner. What did my supportive wife say to me? "It's a good thing you sold it now — if you'd waited and put more work into it you'd have never parted with it." Wives sometimes just don't understand...

### We Learn 'em Good At Cathedral High School

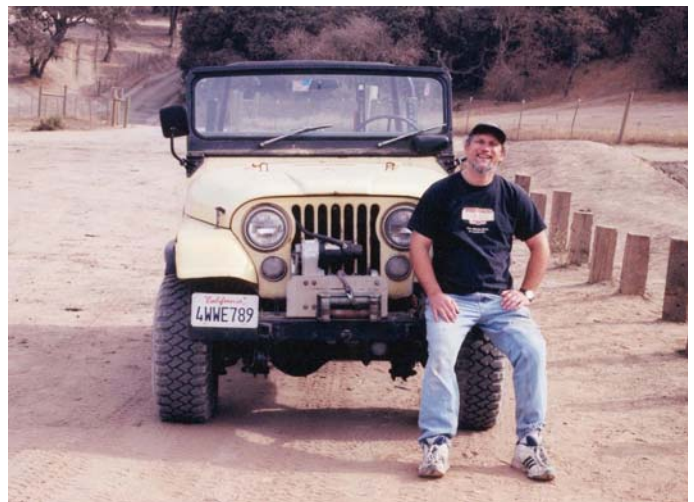
Mike graduated college and just finished his first year as a teacher at Cathedral High School in El Paso, Texas. He really wanted to teach in an all-boys Catholic high school. Cathedral is a really great school — it's just in El Paso. We were a



Blow 'em all out old fella!



The Faux Hawaiians



My lovable rustbucket — gone off to a new home.

little sad — we'd hoped he'd find a position close to home in California, but fortunately Southwest Airlines has direct flights to there from San Jose.



Later this month Mike will be getting married to the fetching Marie Broussard. Mike is a lucky man — she's as lovely on the inside as she is on the outside. Definitely a keeper. She must love him very much 'cause she's going to change her last name to Woznicki — a name no one can spell or pronounce.

### More Wood Butchery

Long time readers of The Flex Circuit News might remember the second story my brother Mark and I added to our house back in 2001 — see back issue for Jan 2002. I guess once you get some sawdust in your blood you can't get rid of it because I decided to try it again — this time adding a wrap-around porch to the front and side of the house. Of course it took much longer and cost much more money than I'd thought (can you say hidden termite damage?) but I think it turned out pretty good. Julie likes it. I have all my fingers and my electrical work didn't burn the house down — I'd say it was a success.

### Dune running

For something different we went down to Oceano Dunes near San Luis Obispo, CA. This is the only place I know where you can drive your vehicle right on the beach. It was just as if we were dropped into the movie Lawrence of Arabia, but without the camels — the dunes are huge! It's not nearly as much fun as mud running, but it was a good time and no mud to clean out!

In August Julie and I will be searching for flexible circuits in Hawaii — at the Keck Observatory on the big island. Can't take the Jeep but it should still be fun —we'll have a full report on our return!



A man is incomplete until he's married — and then he's finished.



Latest wood butchery project — a wrap-around porch.



Out in an ocean of sand.

Back issues of  
The Flex Circuit News  
are available on our web page  
[www.flexdude.com](http://www.flexdude.com)

