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PM FEATURES ///

VOL. 187 NO. 10

60 Disaster-Proof Your Life

Only 12 percent of Americans have taken adequate steps to prepare for crises. Are you one of them? Whether you encounter a house fire or a hurricane, this guide can help protect your family and home *before* calamity strikes.

BY JOHN GALVIN

70 American Beauty

To restore a 1959 Ford firetruck, PM's senior home editor and his twin brother combine by-the-book techniques with creative engineering. The end result is a good-as-new machine, along with some strengthened bonds of brotherhood.

BY ROY BERENDSOHN

76 How the Blowout Happened

It wasn't a single bad decision or equipment failure that caused the worst offshore oil spill in U.S. history; the sinking of the Deepwater Horizon oil rig resulted from a long chain of errors. PM examines the lessons of the tragedy in the gulf.

BY CARL HOFFMAN

88 The Halo Effect

After a full year of fine-tuning, beta testing and 1.1 billion kills, the most anticipated video game of all time is here. We bring you the inside story on the gargantuan effort behind *Halo*'s last intergalactic battle—and how the aliens almost won.

BY ERIK SOFGE

Brother, can you spare a wrench? Carl Berendsohn (right) hands a combination spanner to his sibling Roy as they restore a classic truck to working order.



ON THE COVER

Dan Saelinger photographed model Joe Sutherland at Industria Superstudio in Manhattan on July 30, 2010. Set design by Megan Caponetto; styled by Inessah Selditz; grooming by Greg Clark.



Popular Mechanics

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From robot-sorted mail to flying cars, *The Wonderful Future That Never Was* (\$24.95) is a collection of bold PM predictions.

IN STORES THIS MONTH



Avoid engine overhauls: This dished-out lifter (right) and accompanying cam lobe were damaged soon after starting a rebuilt motor.

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X O C T O B E R

SPARKS, SWEAT AND SMOKE A few
years ago, PM's Mike Allen rolled and welded
10-gauge sheet steel into a backyard smoker.
We're now gathering materials to build this
project again, live at World Maker Faire, Sept. 25
and 26 at the N.Y. Hall of Science in Queens, N.Y.



FESTIVAL OF THE DIYERS What makes a
great DIY festival? Steam power, fire, woodwork-
ing and robots, for starters. By that measure,
Maker Faire's first appearance in New York
should make the grade. Come to the festival and
visit the POPULAR MECHANICS booth, where the edi-
tors will be welding, cutting and drilling, or check
out our step-by-step video of the build online.
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WHAT THEY'RE DOING



× THOMAS D. JONES

Tom Jones, space shuttle astronaut and author of *Sky Walking*, has spent much of 2010 developing a proposal for a robot mission to explore the composition and origin of asteroids. Scheduled for review and potential funding by NASA this fall, the project aims to increase knowledge about the formation of the solar system. The planetary scientist is also consulting for NASA on concepts to send astronauts to nearby asteroids in the future.





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Too little, too late: An armada of vessels attacks the gulf spill.

PM EDITOR'S NOTE

How BP Ignored History's Lessons

We should have seen this coming. Twenty-five years ago, a series of devastating technological failures rattled the global engineering community: the catastrophic meltdown at Chernobyl; the gas leak at a Union Carbide facility in Bhopal, India, which killed an estimated 20,000; the loss of the *Challenger* space shuttle. In each case, capable engineers had developed large, complex systems whose inherent risks they believed they had under control. And in each case, they were surprised when the unthinkable happened.

In the aftermath of those disasters, engineers focused anew on failure analysis, the study of how complex systems—and the people who run them—fall apart under pressure. At schools such as Stanford and Drexel, researchers study the roots of technological breakdowns. They've found that engineering disasters, like military defeats, are rarely the result of a single decision or stroke of bad luck. They are often months or years in the making. And, when the inevitable disaster finally strikes, the experts in charge are overwhelmed and have no backup plan.

In this issue, PM contributing editors Carl Hoffman and Davin Coburn analyze the events

that resulted in the devastating failure of BP's Deepwater Horizon oil rig. What they found is a disaster that never should have happened. On the long checklist of technological, cultural and managerial factors that lead an organization to catastrophe, BP inked every box. The late Soviet Union's hapless nuclear technicians and NASA's bureaucratized engineers were overmatched by complex systems whose risks they didn't fully appreciate. BP has no such excuse. The lessons of Chernobyl, *Challenger* and dozens of other engineering failures have been studied for years. Everyone in a company or agency engaged in dangerous, highly technological work should understand them.

Every general—in fact, every lieutenant and captain—worth his brass has studied why Rommel lost in Africa, Lee at Gettysburg and the U.S. in Vietnam. The study of failure teaches humility, caution and the need to question assumptions. In the aviation industry, pilots, managers, engineers and regulators study every major accident, hoping to learn from mistakes and pinpoint technological flaws that can be corrected. As a result, aviation has developed a culture of safety that has driven accident rates to once unimaginable lows.

We can accomplish the same thing in the oil business, and it's all the more important now that companies are drilling deeper and in more remote places than ever before. Dangers are greater and responding to problems is harder. We can't afford to turn off the oil spigot. But we must take a more systematic, clear-eyed approach to drilling safety. Our special report is one small step in that direction.

JIM MEIGS
Editor-in-Chief

We're Flattered ...

After months of design, development and functionality testing, we launched the showcase issue of POPULAR MECHANICS on the iPad in July. As soon as it went live on the App Store, comments from critics, peers and readers filled our inboxes and the tech media. Gadget leader Gizmodo.com announced: **"The latest big magazine iPad app is here: POPULAR MECHANICS. It's very possibly the best."**

But great response didn't stop there. **Nearly 40,000 people have downloaded the app** so far, and **75 percent of people who rated the app gave it four or five stars.** As one buyer put it: "This is exactly what the iPad was waiting for!"

While we're humbled by the success of our first foray onto the iPad, we're already hard at work developing a **fully interactive monthly edition of PM, which will launch with the November issue.** So now you'll have two great ways to read PM: paper or 'Pad.



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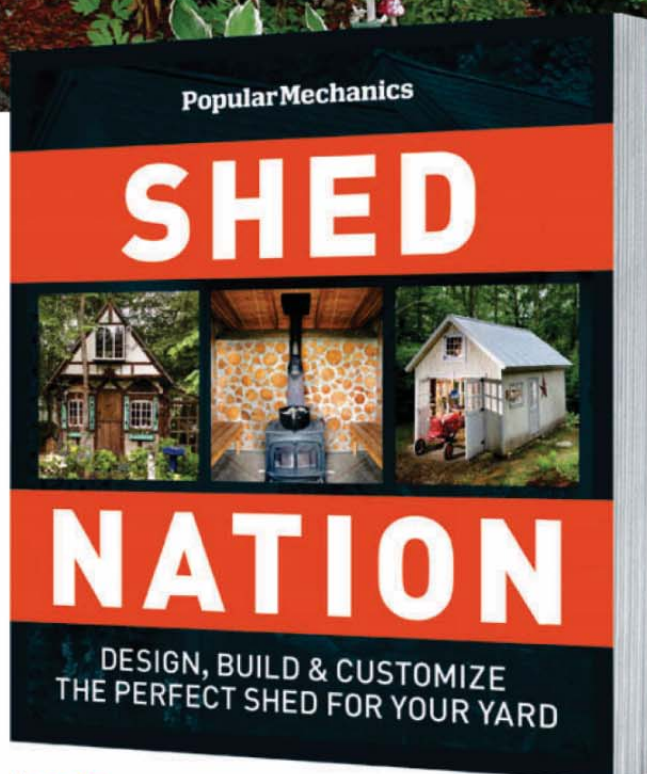
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Fence Tech

Your story on the Nogales border fence ("Mending Fences") suggests there's no effective technology for detecting tunnels. What about using ground-penetrating radar (GPR)? This technology has been used for years to detect the location and size of caves. Highway departments have used similar radar units to detect voids beneath existing roads. The radar transceivers are quite powerful and portable, and software can provide a good image of voids to a considerable depth. You may wish to investigate this technology in a followup story.

CHARLES NELSON
CLEARWATER, MN

I found your August story on the Nogales border fences interesting, and I offer another solution: over-the-horizon radar. Originally developed by MIT and Motorola, the radar was part of a distant-early-warning system that I helped upgrade in Canada and Greenland. Using this technology, you could count engines on a flying aircraft, polar bears and other game walking on the ice—all up to 50 miles away. I am sure it could be updated for use along our southern border.

WARNER SHELDON SKIFF
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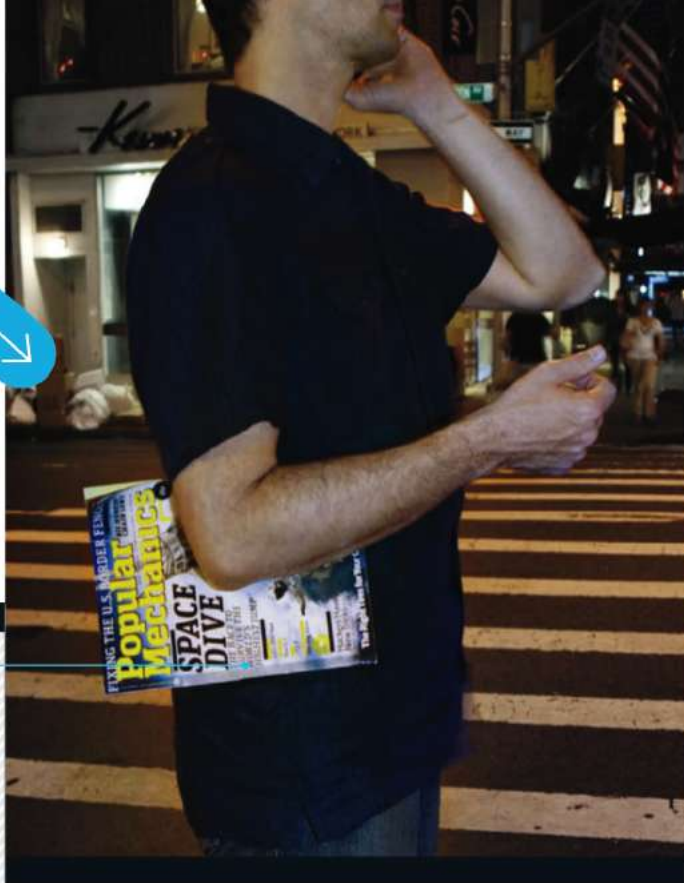
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ISSUE

08 / 10

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x
Readers responded to our stories on fences along the U.S.–Mexico border, chain saws, the PM iPad app and special effects.



Saws That Cut It

I live surrounded by the woods in the hurricane-prone area of the Mississippi Gulf Coast, where having a good chain saw is not a luxury—it's a necessity. Roy Berendsohn's test of chain saws ("Wood Chopper's Ball") was the deciding factor in my choice of which new saw I plan to purchase. I used to be able to research this information on my own, but a wife and four children later, time has become a precious commodity. I just wanted to thank y'all for continuing to provide the reliable research that I have come to expect from PM. Keep it up.

CHARLIE KING
OCEAN SPRINGS, MS

PM Goes Interactive

The special interactive iPad app version of PM is great—I was

starting to think there was never going to be quality media on my iPad. Plus, I've been a fan of PM since I was a kid. I left a five-star review—you've got a winner here and (hopefully) a model for other media.

TOTEMNOTE
VIA E-MAIL

Physical Effects

I found it interesting that "Spin Machine," about the technology behind the movie *Inception*, examined not digital effects but instead a physical room mounted on rigs that rotated as the actors jumped around the set. In 1951's *Royal Wedding*, dancer Fred Astaire appears to dance on the walls and ceiling, an effect that was achieved using nearly identical techniques and stages.

JOHN MIEHLE
CAPE CORAL, FL

what do you think?



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A proud history of savings and reliability, backed by the strength of Warren Buffett's Berkshire Hathaway Inc. (Note: the above portrait is not Mr. Buffett.)

Nearly 15 years ago, GEICO became a proud part of Warren Buffett's famed holding company. Back then, the Gecko was one of the hardworking people — sorry, reptiles — in our GEICO offices. Now he's helped GEICO become not only the third-largest car insurance company in the country, but also the fastest growing. Which is no surprise. For over 70 years, GEICO has worked hard to save people hundreds on car insurance. So why not give the Gecko a call to see how much you could save? You'll find he's easier to reach than Mr. Buffett.

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• QUICK HITS

**Infrared Breakthrough**

Researchers at Germany's Fraunhofer Institute have developed a camera optimized for "long wave" infrared radiation—the range that corresponds roughly to body temperature—that can operate with sharp resolution at room temperature. (Existing models generally require bulky and expensive cooling systems.) The new design uses "micro-bolometers," a type of sensor that changes electrical resistance when struck by incoming radiation and directly outputs a digital signal that is converted into an image. Among the uses the researchers propose for the camera: early detection of deer as they cross dark country roads.

**Cool Math**

Air conditioning in cars burns a lot of gas—up to 30 percent of the total in hot climates. But the real waste occurs in cooler regions, thanks to climate-control systems that keep the compressor running needlessly at temperatures as low as 41 F, according to a Swiss government study. In places like Europe and the northern U.S., switching off the a/c when it's below 64 F can save two-thirds of the extra gas.

Tech Watch

• SCI-FI MEDICINE

Synthetic Antibodies

Chemists at the University of California, Irvine, have created "plastic antibodies" that attack and neutralize dangerous toxins in the bloodstream. The researchers formed tiny polymer casts of bee-venom peptides and then injected the new nanoparticles into mice already exposed to the venom. The plastic antibodies encased the toxic molecules, slowing the venom's spread and reducing deaths among the mice. The chemists hope to expand the molecular-imprinting technique to attack a wide variety of pathogens.

—ALEX HUTCHINSON



• INNATE ABILITIES

A True Internal Compass

Mammals are born with a sense of direction—or at least rats are, according to a pair of experiments by researchers in Britain and Norway. The scientists implanted electrodes in the brains of two-week-old rats that hadn't yet opened their eyes. Surprisingly, the neurons that govern direction were active almost immediately. The results support philosopher Immanuel Kant, who 200 years ago said that humans' conception of space must be innate rather than learned from experience.



• AERIAL HIGHWAYS

Your Flying Car Is (Almost) Ready

The Terrafugia Transition features **foldable wings** as well as rear-wheel drive, which makes it viable for both road and runway. Although the FAA granted a 110-pound weight exemption to allow the 1430-pound Transition to be classified as a Light Sport Aircraft, a consumer model has yet to be approved by the agency. Terrafugia has collected more than 80 down payments for the \$194,000 vehicle, which it expects to release in 2011.

—BRIAN RESNICK



A man in a workshop, wearing a light blue t-shirt and jeans, is looking at the engine of a red car. The car's headlight and grille are visible in the foreground. The background is slightly blurred, showing workshop equipment.

MEN DON'T LOO THEY GE DOO

WITH EVERY AGE COMES RESPONSIBILITY. IMPORTANT SAFETY INFORMATION BELOW.

We know that no medicine is for everyone. Don't take VIAGRA if you take nitrates, often prescribed for chest pain, as this may cause a sudden unsafe drop in blood pressure.

Talk with your doctor first. Make sure your heart is healthy enough to have sex. If you have chest pain, nausea, or other discomforts during sex, seek medical help right away.

In the rare event of an erection lasting more than four hours, seek immediate medical help to avoid long-term injury.

In rare instances, men who take PDE5 inhibitors (oral erectile dysfunction medicines, including VIAGRA) reported a sudden decrease or loss of vision, or sudden decrease or loss of hearing. It is not possible to determine whether these events are related directly to these medicines or to other factors. If you experience any of these symptoms, stop taking PDE5 inhibitors, including VIAGRA, and call a doctor right away.

The most common side effects of VIAGRA are headache, facial flushing, and upset stomach. Less common are bluish or blurred vision, or being sensitive to light. These may occur for a brief time.



NO MORE EXCUSES. DO THE THINGS YOU'VE NEVER

YOU'VE NEVER SAT IDLY BY BEFORE. THERE'S NO REASON YOU'D START NOW.

So if you're like millions of men who have some degree of erectile dysfunction (ED), talk to your doctor about VIAGRA. It's America's most prescribed ED treatment. VIAGRA can work in 30 to 60 minutes and, for some men, in as little as 14 minutes.*

For more information go to viagra.com or call 1-888-484-2472 (1-888-4VIAGRA).

THIS IS THE AGE OF TAKING ACTION.

VIAGRA[®]
(sildenafil citrate) tablets

VIAGRA does not protect against sexually transmitted diseases including HIV.

Take VIAGRA about one hour before you want to have sex. VIAGRA works for 4 hours. VIAGRA only works with stimulation.

Please see Important Facts for VIAGRA on the following page or visit viagra.com for full prescribing information.

*Data taken from a study of 228 men with ED who previously had success with VIAGRA. Of the 115 men who took VIAGRA 100mg, 35% had erections hard enough for successful intercourse at 14 minutes, and 51% of men at 20 minutes.

Individual results may vary.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.FDA.gov/medwatch or call 1-800-FDA-1088.

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IMPORTANT FACTS

VIAGRA[®]
(sildenafil citrate) tablets

(vi-AG-rah)

IMPORTANT SAFETY INFORMATION ABOUT VIAGRA

Never take VIAGRA if you take any medicines with nitrates. This includes nitroglycerin. Your blood pressure could drop quickly. It could fall to an unsafe or life-threatening level.

ABOUT ERECTILE DYSFUNCTION (ED)

Erectile dysfunction means a man cannot get or keep an erection. Health problems, injury, or side effects of drugs may cause ED. The cause may not be known.

ABOUT VIAGRA

VIAGRA is used to treat ED in men. When you want to have sex, VIAGRA can help you get and keep an erection when you are sexually excited. You cannot get an erection just by taking the pill. Only your doctor can prescribe VIAGRA.

VIAGRA does not cure ED.

VIAGRA does not protect you or your partner from STDs (sexually transmitted diseases) or HIV. You will need to use a condom.

VIAGRA is not a hormone or an aphrodisiac.

WHO IS VIAGRA FOR?

Who should take VIAGRA?

Men who have ED and whose heart is healthy enough for sex.

Who should NOT take VIAGRA?

- If you ever take medicines with nitrates:
 - Medicines that treat chest pain (angina), such as nitroglycerin or isosorbide mononitrate or dinitrate
- If you use some street drugs, such as "poppers" (amyl nitrate or nitrite)
- If you are allergic to anything in the VIAGRA tablet

BEFORE YOU START VIAGRA

Tell your doctor if you have or ever had:

- Heart attack, abnormal heartbeats, or stroke
- Heart problems, such as heart failure, chest pain, or aortic valve narrowing
- Low or high blood pressure
- Severe vision loss
- An eye condition called retinitis pigmentosa
- Kidney or liver problems
- Blood problems, such as sickle cell anemia or leukemia
- A deformed penis, Peyronie's disease, or an erection that lasted more than 4 hours
- Stomach ulcers or any kind of bleeding problems

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal products. Tell your doctor if you take or use:

- Medicines called alpha-blockers to treat high blood pressure or prostate problems. Your blood pressure could suddenly get too low. You could get dizzy or faint. Your doctor may start you on a lower dose of VIAGRA.
- Medicines called protease inhibitors for HIV. Your doctor may prescribe a 25 mg dose. Your doctor may limit VIAGRA to 25 mg in a 48-hour period.
- Other methods to cause erections. These include pills, injections, implants, or pumps.
- A medicine called REVATIO. VIAGRA should not be used with REVATIO as REVATIO contains sildenafil, the same medicine found in VIAGRA.

POSSIBLE SIDE EFFECTS OF VIAGRA

Side effects are mostly mild to moderate. They usually go away after a few hours. Some of these are more likely to happen with higher doses.

The most common side effects are:

- Headache
- Feeling flushed
- Upset stomach

Less common side effects are:

- Trouble telling blue and green apart or seeing a blue tinge on things
- Eyes being more sensitive to light
- Blurred vision

Rarely, a small number of men taking VIAGRA have reported these serious events:

- Having an erection that lasts more than 4 hours. If the erection is not treated right away, long-term loss of potency could occur.
- Sudden decrease or loss of sight in one or both eyes. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. They may be caused by conditions like high blood pressure or diabetes. If you have sudden vision changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Sudden decrease or loss of hearing. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. If you have sudden hearing changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Heart attack, stroke, irregular heartbeats, and death. We do not know whether these events are caused by VIAGRA or caused by other factors. Most of these happened in men who already had heart problems.

If you have any of these problems, stop VIAGRA. Call your doctor right away.

HOW TO TAKE VIAGRA

Do:

- Take VIAGRA only the way your doctor tells you. VIAGRA comes in 25 mg, 50 mg, and 100 mg tablets. Your doctor will tell you how much to take.
- If you are over 65 or have serious liver or kidney problems, your doctor may start you at the lowest dose (25 mg).
- Take VIAGRA about 1 hour before you want to have sex. VIAGRA starts to work in about 30 minutes when you are sexually excited. VIAGRA lasts up to 4 hours.

Don't:

- Do not take VIAGRA more than once a day.
- Do not take more VIAGRA than your doctor tells you. If you think you need more VIAGRA, talk with your doctor.
- Do not start or stop any other medicines before checking with your doctor.

NEED MORE INFORMATION?

- This is only a summary of important information. Ask your doctor or pharmacist for complete product information OR
- Go to www.viagra.com or call (888) 4-VIAGRA (484-2472).

Uninsured? Need help paying for Pfizer medicine? Pfizer has programs that can help. Call 1-866-706-2400 or visit www.PfizerHelpfulAnswers.com.



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Ounces
of Tanzanite
Remain in
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**2 carats of
Genuine
Tanzanite
Save \$700!**

African Gem Cutter Makes \$2,689,000 Mistake...Will You?

This story breaks my heart every time. Allegedly, just two years after the discovery of tanzanite in 1967, a Maasai tribesman knocked on the door of a gem cutter's office in Nairobi. The Maasai had brought along an enormous chunk of tanzanite and he was looking to sell. His asking price? Fifty dollars. But the gem cutter was suspicious and assumed that a stone so large could only be glass. The cutter told the tribesman, no thanks, and sent him on his way. Huge mistake. It turns out that the gem was genuine and would have easily dwarfed the world's largest cut tanzanite at the time. Based on common pricing, that "chunk" could have been worth close to \$3,000,000!

The tanzanite gem cutter missed his chance to hit the jeweler's jackpot...and make history. Would you have made the same mistake then? Will you make it today?

In the decades since its discovery, tanzanite has become one of the world's most coveted gemstones. Found in only one remote place on Earth (in Tanzania's Merelani Hills, in the shadow of Mount Kilimanjaro), the precious purple stone is 1,000 times rarer than diamonds. Luxury retailers have been quick to sound the alarm, warning that supplies of tanzanite will not last forever. And in this case, they're right. Once the last purple gem is pulled from the Earth, that's it. No more tanzanite. Most believe that we only have a few years supply left, which is why it's so amazing for us to offer this incredible price break. Some retailers along Fifth Avenue are more than happy to charge you outrageous prices for this rarity. Not Stauer. Staying true to our contrarian nature, we've decided to **lower the price of one of the world's rarest and most popular gemstones.**

Our 2-Carat **Sunburst Tanzanite Ring** features marquise-cut gems set dramatically in gorgeous sterling silver. Each facet sparkles with the distinct violet-blue hue of the precious stones. Behind the shine you'll find that the exquisite silverwork of the setting calls to mind the detailed treasures being produced by Europe's finest jewelers. This is a ring designed to impress and it does not disappoint.

Now is the point where opportunity knocks. If you open that door today, you can own this spectacular ring for less than \$100. If you wait? We can't say for sure.

Your satisfaction is completely guaranteed. For our client-friendly approach, Stauer has earned a rare **A+ rating from the Better Business Bureau**, a rating we wish to keep. So, of course, your satisfaction is 100% guaranteed. If you are not completely aglow with the **Sunburst Tanzanite Ring**, send it back within 30 days for a prompt and courteous refund. But, please don't wait, our supply is dropping rapidly.

JEWELRY SPECS:

— 2 ctw genuine tanzanite — .925 sterling silver setting — Ring sizes 5–10

Sunburst Genuine Tanzanite Ring (2 ctw)—\$795

Now \$95 +S&P Save \$700

Call now to take advantage of this limited offer.

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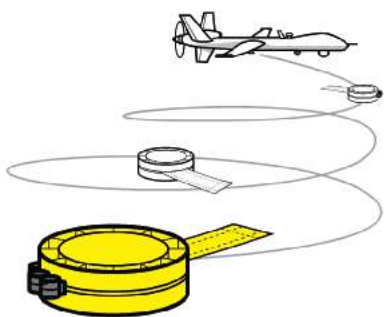
FUTURE OF WAR

WINGS AND FINS
UNFOLD UPON LAUNCHDIAMETER:
5.5 INCHESWEIGHT:
42 POUNDSWINGSPAN:
36 INCHESWARHEAD:
2.3 POUNDS

Right-Size Weapons for Robots

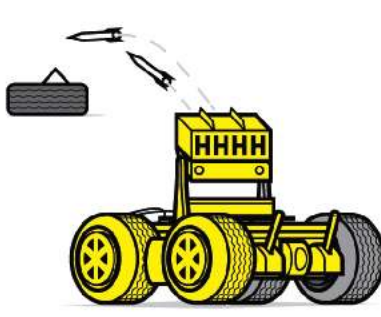
DEFENSE-INDUSTRY SCIENTISTS HAVE BEEN TASKED WITH CREATING DIMINUTIVE WEAPONS FOR THE HOST OF UNMANNED VEHICLES PROLIFERATING ON THE BATTLEFIELD. HERE'S A ROUNDUP OF SOME OF THE MOST PROMISING. BY DAVID HAMBLING

The Army's RQ-5A Hunter, a 23-foot-long unmanned aerial vehicle, is too small to carry the 100-pound, antitank Hellfire missiles used by larger aircraft. Instead, it is armed with the **VIPER STRIKE AIR-TO-GROUND MISSILE** (above). This laser-guided weapon glides for 6 miles, weighs a third as much as the Hellfire and causes less collateral damage. How small can air-to-ground weapons get? Air Force officials are publicly suggesting the development of 1-pound munitions that could kill an individual in a crowded area without harming innocents standing nearby.



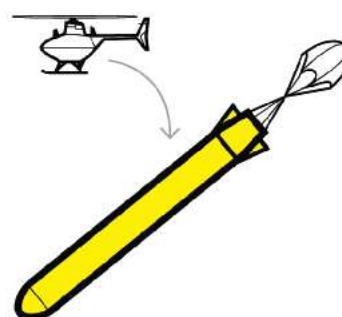
COMMON SMART SUBMUNITION

Developed by Textron Defense Systems, the 8.6-pound CSS is a little smaller than a coffee can but can destroy tanks. **CSS spins like a maple seed as it descends, scanning the area for its targets using laser and infrared sensors.** Spiraling at 300 feet, the system can observe 2 acres of ground. Once it identifies a target, the CSS fires armor-piercing metal slugs. If no target appears, the CSS deactivates in the air or self-destructs on the ground.



PINCHER

Produced by Israeli company Rafael Advanced Defense Systems, Pincher is a **ground robot armed with the world's smallest rockets.** The warheads are loaded with an incendiary mixture that destroys IEDs by quickly burning explosives without detonating them. Each miniature rocket is 8 inches long and effective at more than 20 yards; a pod of four rockets weighs just 10 ounces and creates little recoil. Currently a prototype, Pincher could be operational next year.



COMMON VERY LIGHTWEIGHT TORPEDO

At about 200 pounds, the CVLWT is less than half the weight of the smallest existing torpedo in the U.S. Navy's inventory. **An advanced shaped-charge warhead gives it the striking power of a much larger weapon.** The 9-foot torpedo, petite enough to be carried by unmanned submarines and drone helicopters, is currently under development at Penn State University, in association with the Naval Undersea Warfare Center.

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Rocker construction protects metatarsal bones and aids fluid stepping motions

Scientifically Engineered to Defy Pain, Defy Aging & Defy Gravity

This is my story

I used to be more active. I used to run, play basketball, tennis, football... I was more than a weekend warrior. I woke up every day filled with life! But now, in my late 30's, I spend most of my day in the office or sacked out in front of the TV. I rarely get to the gym -not that I don't like working out, it's the nagging pain in my knees and ankles. Low energy and laziness has got me down. My energy has fizzled and I'm embarrassed to admit that I've grown a spare tire (I'm sure it's hurting my love life). Nowadays I rarely walk. For some reason it's just harder now. Gravity has done a job on me.



Wear them and you'll know

That's what my doctor recommended. He said, "Gravity Defyer shoes are pain-relieving shoes." He promised they would change my life -like they were a fountain of youth. "They ease the force of gravity, relieving stress on your heels, ankles, knees and back. They boost your energy by propelling you forward." The longer he talked, the more sense it made. He was even wearing a pair himself!

Excitement swept through my body like a drug

I received my package from GravityDefyer.com and rushed to tear it open like a kid at Christmas. Inside I found the most amazing shoes I had ever seen - different than most running shoes. Sturdy construction. Cool colors. Nice lines... I was holding a miracle of technology. This was the real thing.

GDefy Benefits

- Relieve pain
- Ease joint & spinal pressure
- Reduce fatigue & tiredness
- Be more active
- Have more energy
- Appear taller
- Jump higher, walk and run faster
- Have instant comfort
- Cool your feet & reduce foot odor
- Elevate your performance

I put them on and all I could say was, "WOW!" In minutes I was out the door. I was invincible;

tireless in my new Gravity Defyer shoes. It was as if my legs had been replaced with super-powered bionics. What the doctor promised was all correct. No more knee pain. I started to lose weight. At last, I was pain free and filled with energy! I was back in the game. Gravity had no power over me!

Nothing to lose: 30 Day Free Trial*

So, my friend, get back on your feet like I did. Try Gravity Defyer for yourself. You have nothing to lose but your pain.

Tell us your story!
Login at:
Gravitydefyer.com
and share your experience.

Customer Satisfaction Speaks for Itself!

4 out of 5 customers purchase a 2nd pair within 3 months.



ABSORB SHOCK
Eliminate pain from every step.



REBOUND PROPELS YOU FORWARD
Reduce fatigue. Be more active



a \$129.95 value
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Med/Wide and
ExtraWide/XXWide Widths
WOMEN (Silver with Navy)
TB902FWBS
sizes 5 - 11
Med/Wide and
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*Shipping and handling non-refundable. Gravitydefyer.com!

• **SMUGGLER'S
TECH**

Narco Navy

In the late 1990s, U.S. Drug Enforcement Administration (DEA) agents debated the existence of craft they called Bigfoots, semisubmersible cocaine-smuggling boats that ride low in the water to avoid detection. These days, law enforcement officials know these custom-built vessels exist—45 have been seized in the past three years alone—but no one in the DEA had seen anything like the craft discovered this year hidden in a jungle in Ecuador, near the Colombian border. Following intelligence leads, DEA agents and local police found a homebuilt submarine, the first proof that cartels are fielding fully functional submarines to haul drugs. The diesel-electric sub has engine snorkels, electronics, a ballast system, a periscope and air conditioning, all of which speaks to a sophisticated manufacturer. "It looks like they built secondary and tertiary systems," says DEA Andean regional director Jay Bergman. A semisubmersible can cost up to \$1 million to build, but hauls enough profitable cargo (between 2 and 6 tons of cocaine) that smugglers will discard it after a one-way trip and return home on commercial airlines, Bergman says. Now, DEA agents wonder if more advanced subs are making repeat journeys—literally under the radar. "If it's the first, it won't be the last," Bergman says. "In the maritime domain, there's nowhere else to go." —BRIAN THEVENOT

**Law Enforcement
National Guard**

In August, the federal government sent 1200 guardsmen to the southern border. Governors can deploy the National Guard as well.

TOOLS: Night-vision binoculars, Humvee

**U.S. Coast
Guard Cutter**

High Endurance Cutters patrol the Pacific to spot and intercept illegal contraband heading toward the United States.

TOOLS: Over-the-horizon boat, helicopter, 76-mm deck gun

**Human
Intelligence**

The Colombian, Ecuadorean and U.S. governments share informant tips on when and how cartels will ship drugs.

TOOLS: Money, electronic surveillance

The Target

Drug subs are believed to navigate from South America to Mexico, where narcotics are offloaded and smuggled into the United States by land, hidden in vehicles.

Tijuana, MEX
\$12,650

Dallas, TX
\$18,500

Houston, TX
\$13,000

Mazatlán, MEX
\$8000

Location
Est. \$ / kilo
SOURCE: DEA

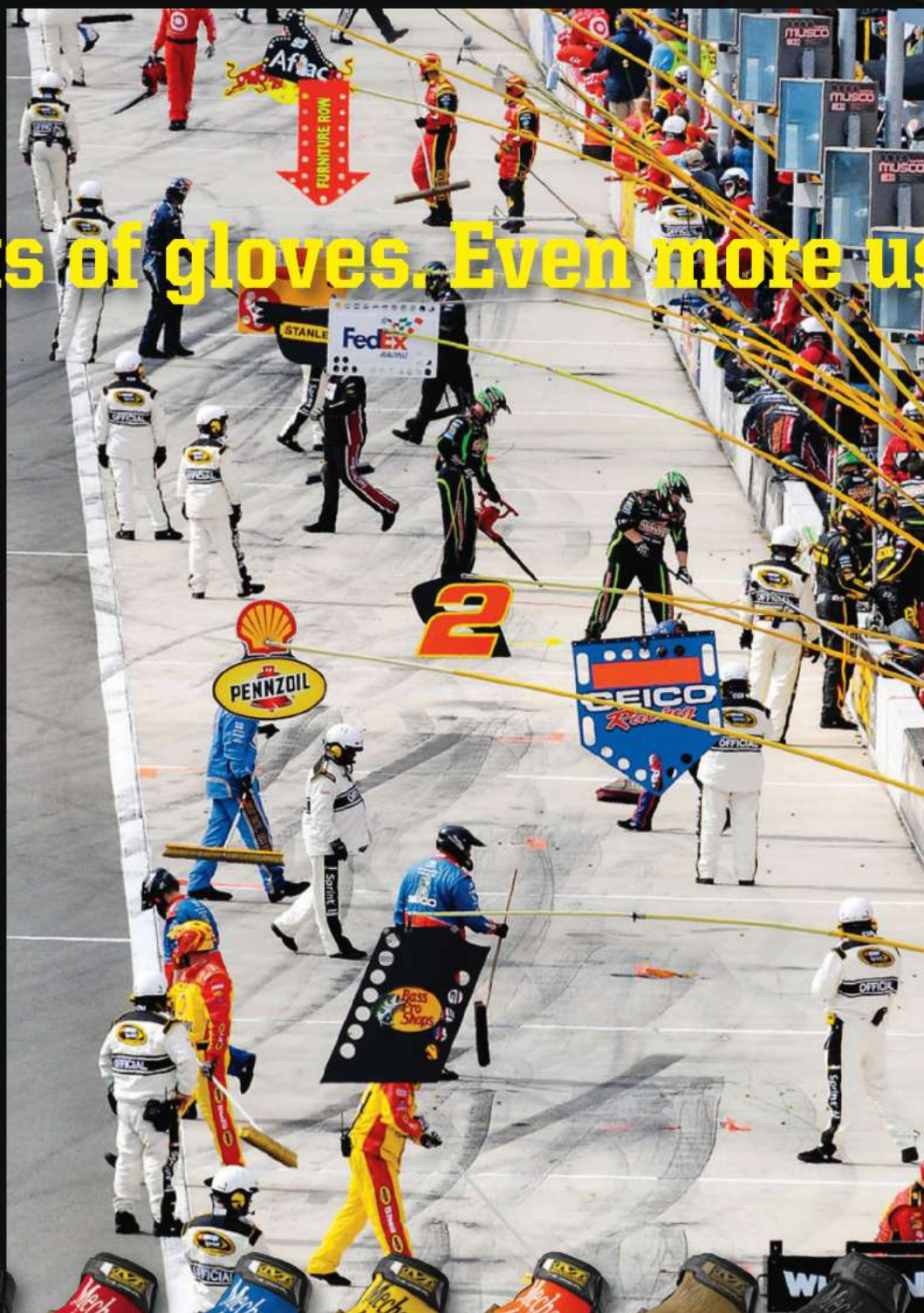
Chicago, IL
\$22,500

CARTEL DRUG SUB
SEIZED: Ecuador, July 2010
CAPACITY: 10 tons of cocaine
SUBMERGED DEPTH: 65 feet
ESTIMATED COST: \$5 million

Tumaco, COL
\$3000



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RECENT SCIENTIFIC STUDIES SHOW:



SCIENTISTS HAVE THEIR OWN LEXICON WHEN IT COMES TO WAITING IN LINES

JOCKEYING

The act of switching to a parallel line.

FAFFING

The time delay when a person gathers his things after paying at the checkout—an average of 3.17 seconds.

RENEGING

When a customer leaves a queue he believes he has spent too much time waiting in.

BALKING INDEX

Part of a 2010 equation that predicts when someone will turn away from a line that he feels is too long.

FIRST IN, FIRST OUT

The principle stating that the person who has waited in line longest will be served first.

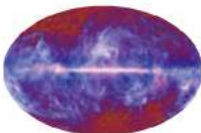
Linear Equations

W

aiting in line is a universally despised experience, but scientists around the world are dedicated to making it less odious. In June, Taiwanese researcher Pen-Yuan Liao published an equation that predicts when a customer will avoid a line if he feels it's too long. Liao's formula calculates the expected length of a line and the mean arrival rate to determine the number of customers who will retreat. His research, intended to inform stores' staffing needs, represents only one niche in the growing field of queueing theory. The owners of corporations, amusement parks, banks and fast-food chains can scan the monthly journal *Queueing Systems: Theory and Applications* for trends that suit their clientele. "There's no such thing as the perfect line," says MIT queueing theorist Richard Larson. "The trick is to convince people they're being treated fairly." Many people's aversion stems from bad design, Larson says. "Some large companies don't even know the kindergarten basics." — TARAH KNARESBORO

IMAGES FROM THE EDGE

Mapping the Echo of the Big Bang



Scientists using data from the European Space Agency's Planck satellite released their first "all sky" image of microwave radiation, collected after nine months of constant scanning.

The bright main disk of the Milky Way runs across the middle of the image (left), but cosmologists are more interested in what's behind it. They will digitally remove the Milky Way to reveal

the most detailed view ever of the microwave echo of the massive explosion marking the beginning of the universe, 13.7 billion years ago. Charting and measuring the

slight ripples in the microwave backdrop will allow researchers to test theories describing the initial moments of the universe's creation, including the prevailing idea that the universe

experienced a brief period of ultrarapid expansion. Planck, launched in May 2009, is scheduled to complete four all-sky scans by the time its mission ends in 2012.

— ALEX HUTCHINSON



**“everyone
deserves
to be safe.”**

SMART Teams.
Our latest safety innovation.

Everyone deserves to be safe. Which is why we've established SMART Teams—200 highly trained engineers and technical experts located across the U.S. to help ensure every customer is heard. Toyota SMART Teams are just one of the many new safety innovations at Toyota that are making us a more responsive, safety-focused organization. Because at Toyota, we know there's nothing more important to you than your safety. For more on our safety innovations, visit toyota.com/safety

Steve St. Angelo
Chief Quality Officer



toyota.com/safety

• GULF COAST CLEANUP

An Oil Spill's Worst Enemy

Few in the U.S. Coast Guard have as much experience cleaning oil spills as **Capt. Roger Laferriere**. A veteran of hundreds of spills—his first as an ensign during the Exxon Valdez crisis in Alaska—Laferriere served as incident commander for Louisiana for two months during the Deepwater Horizon catastrophe. He was responsible for surface operations, including the removal of oil from the state's 397 miles of coastline, giving him firsthand insight into the Gulf of Mexico's challenges. — GLENN DERENE



How does the gulf spill differ from the Exxon Valdez disaster?

The big difference, first of all, is that the oil is quite different. The Exxon Valdez oil was very thick and very viscous. This oil is actually a light to medium crude. By the time it goes through 5000 feet of water and then travels 50 to 100 miles to the shore, 30 to 50 percent of the oil has actually evaporated. So in Valdez, we literally had waves and waves of oil coming to shore. We did not see that level of shoreline impact here because of the nature of the oil.

Which strategies applied in the gulf were learned during Valdez?

One thing we have learned is to use commercial assets in the response. In Valdez, they called it the mosquito fleet; we hired the local fishermen to help us pick up oil, transport stuff, move supplies and do surveying. We were able to take that model and superimpose it onto this spill, using fishermen's basic knowledge of the waterways, the currents and the way the waves behave. We couldn't have done it without that.

What kinds of logistical challenges are unique to the gulf cleanup?

One challenge we've had is that the marshes are very vast, and in some cases it takes a 2-hour transit to places where we need to initiate cleanup. The other challenge that's much different is the weather. The temperature here is in the 100s, so we have tremendous heat stress. And in summer it's not uncommon to get thunderstorms three or four times a day.

Have any ideas submitted by the public been especially successful?

There was a local engineer who came up with a barge-based skimmer system. In other words, he took a barge, put some holes in the front of it and used it for actually skimming oil. It's called the Big Gulp skimmer. Just the way it sounds: You tow it, and it skims oil. For this particular oil, the skimming technology was a really great idea. So BP built four of them, and we put them into service. They've done an outstanding job because they can skim a lot of oil and move quickly in the water.

Clean Machines at Work in the Gulf

BY JUSTIN NOBEL



LAND : SANDBONI

Aka, the Cherrington Beach Cleaner. The metal wedge of this machine lifts several inches of sand onto a screen that sifts tar balls and oiled debris.



SEA : HEAVY-OIL-RECOVERY DEVICE

The brainchild of a local supertanker captain. These tough mesh bags, dragged by trawlers, each collect up to 4000 pounds of thick oil.



AIR : MZ-3A AIRSHIP

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Upgrade



The Unstoppable Saw

Portable band saws—which are basically turbo-powered hacksaws—can cut anything from iron pipes to armored cables. Versatile, yes, but at about 10 pounds, they are also fatiguing—especially when used to cut conduit above one's head. The **Bosch 18-Volt Cordless Band Saw (\$350)** weighs just 7.7 pounds (and that includes its lithium-ion battery). Its shockingly fast cuts proved such a pleasant contrast in tests against a competitive 18-volt model that we caught ourselves slicing steel and copper pipes thinner than onion rings to avoid running out of test conduit.

— HARRY SAWYERS

U

Mud Mule

tility vehicles offer more hauling power and cargo space than their ATV cousins, and they can be just as much fun to mud around in. Take the new **John Deere Gator XUV 825i** (\$11,200). Its 16.4-cubic-foot rear cargo hold can haul up to 1400 pounds of gas cans, tools, dirt or newborn cattle. Then, when the vehicle is unloaded, its 50-hp 812-cc three-cylinder engine can scoot at speeds up to 44 mph. During a recent test drive through the woods of South Carolina, we pushed the Gator to its limits on steep hills and hairpin switchbacks. We were especially impressed by independent front and rear suspensions that allowed the vehicle to absorb craters that looked like they'd have chipped the driver's teeth.



Step Right Up

→ The **Little Giant Select Step** (\$200) features articulating extensions, telescoping slides and kickstand legs that rise 5 to 8 feet in an A-frame on flat ground or stairs. Weighing 24 pounds and carrying 300, the rig has an AirDeck that serves as a top-step grip, a platform for paint buckets or a magnetic trough for tools.

AS
SEEN
ON TV



→ "Shake your way to firm and fabulous shoulders," says the ad for the **Shake Weight** (\$20). Each exhausting minute throttling the dumbbell's slippery handle generates 240 reps, according to the manufacturer's CEO, Johann Verheem. "You're constantly stabilizing the body to accommodate the vibrating mass in your hand," Verheem says.

BOTTOM LINE Could it build muscle? Maybe, but we'd never find out. The slick handle, awkward balance and uncontrolled gyrations discouraged testers from trying it more than once.

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INVITING PRESENTATION

Jump right in and play at your own pace with an intuitive interface that eases new players into the game. Civ veterans will appreciate the depth, detail and control that are highlights of the series.

ALL NEW FEATURES

A new hex-based gameplay map opens up exciting tactical combat and expansion strategies. City States become a new resource in your diplomatic battleground. An improved diplomacy system allows you to negotiate with fully interactive leaders. Custom music scores & orchestral recordings give Civ V the level of polish and quality you expect from the series.

SOCIALLY RESPONSIBLE

The packaging of this product is environmentally friendly: the case is a recyclable BioBox®, the paper is 30% post consumer waste and we've removed solvent inks in favor of soy and UV inks. We've replaced the 200+ page manual with an improved and interactive PDF that's also easier to use. We're also donating \$250,000 to education based charities; simply select your choice from the selected charities during the install process.†

WIDE SYSTEM COMPATIBILITY

Civilization V operates on many different systems, from high end DX11 desktops to many laptops. Enjoy unlimited installations on multiple PCs with your Steam account and take your Civ V experience with you everywhere you go.



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I will probably play Civ V for years."
– IGN, BEST STRATEGY GAME E3 2010

"Games like this remind us why it
is still good to be a PC gamer."
– GAME INFORMER, BEST OF PC,
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"A continued commitment to the elements
that make strategy gaming great."
– GAMESPY PC GAME OF SHOW,
STRATEGY GAME OF SHOW



"We won't be reachable for at least a week
after this game comes out. Sorry about that."
– ENTERTAINMENT WEEKLY.COM

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– BEST OF E3 2010

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Space Saver

Rule No. 1 of garage and tool-shed feng shui—keep as much stuff off the ground as you can. The **Oxo Good Grips Heavy-Duty Wall-Mounted Organizer (\$50)** makes it easy to move some of the worst space hogs to the wall—its 43-inch steel mounting rail is strong enough to carry 340 pounds of gear. A set of three double hooks is designed to hold tools, strollers and hoses, while two CamLocks secure poles and long-handled tools such as rakes and shovels.

Morphing Quarters

➔ Add a few friends, and a once-spacious tent can quickly become close quarters. When camping with a crowd, **The North Face Docking Station Tent (\$430)** can be augmented with two- and four-person appendages (sold separately) that add space for up to eight extra people. That brings the total capacity to 14. Roll-up walls make the rig ideal for spring, summer or fall getaways.



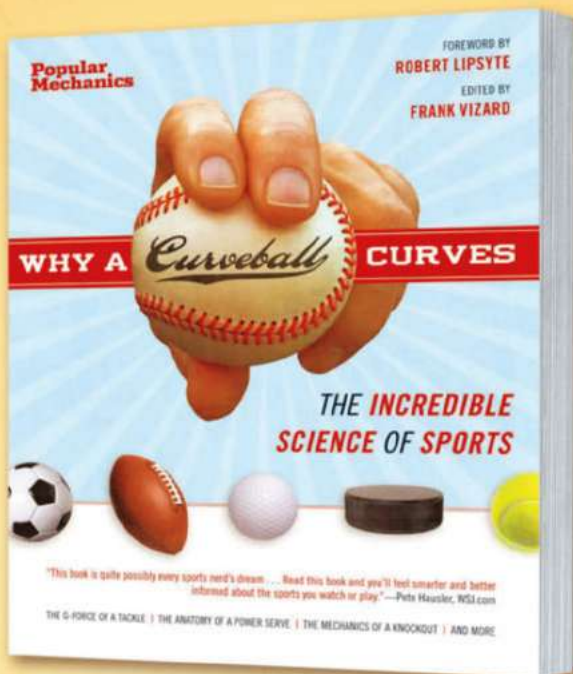
Slaying Vampires

➔ Whether you call it standby power or vampire drain, the slow trickle of power that plugged-in but fully charged (or turned-off) gadgets pull can add up. Like an OCD Buffy, the **Belkin Conserve Valet Smart USB Charging Station (\$40)** fights both vampire

drain and desktop clutter. When a device is fully charged or turned off, the Valet automatically cuts its power flow, and a clever system for wrapping away lengths of unused cords keeps work spaces tidy.



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ABUSIVE LAB TEST

Work Gloves

Workshops are full of hand hazards, and work gloves are all that stand between your fingers and scalding heat or sharp points. We put three gauntlets—an old-fashioned leather pair, a new-fangled synthetic pair and a cheap no-name cloth set (\$1.50 at our local hardware store)—through our gauntlet. **BY SETH PORGES**

Mechanix Wear
Padded
Palm
Gloves
(\$26)

Wells Lamont
Premium
Leather
Gloves
(\$15)

Tools
Cloth
Gloves
(\$1.50)



Abrasion Test

We put the gloves on mannequin hands and lightly pressed the knuckles, and then the fingers, against a 6-amp belt sander running at 1050 feet per minute for 5 seconds.

MECHANIX WEAR: While the mesh knuckles were obliterated, the only damage to the synthetic fingers was some tiny holes.

WELLS LAMONT: Although the leather had begun to develop sizable holes by the end of the 5 seconds, the gloves stood up to quick brushes against the belt.

TOOLS: The belt sander shredded the cloth almost instantly, leaving us very thankful we were using a sacrificial mannequin hand.

WINNER: Mechanix Wear for finger protection, Wells Lamont for knuckles

Heat Test

We warmed an iron skillet to 325 F, then timed how long we could bear to hold it. We repeated the test five times for each glove and averaged the results.

MECHANIX WEAR: The padded palm and reinforced fingertips allowed us to grasp the skillet for an average of 6.8 seconds.

WELLS LAMONT: A thick cowhide build allowed us to hold on for an average of 5.8 seconds—a close second-place finish.

TOOLS: Ouch! A thin layer of cloth was no match for hot iron. Average hold time: 3.4 seconds.

WINNER: Mechanix Wear

Puncture Test

We draped the gloves palm-down over a nail and used a hooked harness to add weights in 5-pound increments until the nail poked through. We then repeated the task with the fingers.

MECHANIX WEAR: While the reinforced fingertips withstood 45 pounds of pull, the rest of the glove gave way after just 25.

WELLS LAMONT: The thick leather proved nearly puncture-proof—it took 45 pounds of pull for the nail to wedge its way through both the palm and fingers.

TOOLS: The stitched cloth seams gave way after just 5 pounds of pressure.

WINNER: Wells Lamont

BOTTOM LINE

The Wells Lamont leather and the Mechanix Wear synthetic gloves offer comparable overall protection. If punctures are your chief concern, go with the Wells Lamont. If dexterity is paramount, the Mechanix Wear wins.

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Flexible Fievel

computer mouse is easier to use than a laptop trackpad, but the extra bulk typically makes it impractical for road warriors. When it's not being used, the curved **Microsoft Arc Wireless Mouse (\$70)** flattens out into a thin slate for compact storage in a bag. Bend the pointer back into shape and it turns on automatically.

Mightier

→ Sure, we loved previous generations of Livescribe's Pulse Smartpen, but the device, which records audio and time-codes it to your written notes, had its problems. First, it needed proprietary earphones. And second, it rolled around just like any other pen, making it difficult to record audio.

The new **Livescribe Echo Smartpen (\$170 for 4 GB; \$200 for 8 GB)** uses a standard audio jack, opening up a whole world of earphones and mics. Plus, it has a no-roll design and a more intuitive menu system and user interface.



Close Cut

→ These days, advances in manual razor technology are largely restricted to stuffing more blades onto a shaving head. If you want to see real innovation, we suggest looking over at electric-razor land. Take the **Philips Norelco SensoTouch 3D (\$300)**—a gadget that looks more like a sci-fi prop than a shaver. Three articulating heads tilt and swivel around facial contours, and a close look reveals that the heads are lined by

a series of holes of varying shapes, designed to pull in hairs of every length growing in every direction. (Philips engineers revealed that these fine patterns were created using a liquid-electrolyte etching process—cool!) The shaver is waterproof, can handle gels and features a digital display that shows exactly how long you

have left on a charge. For now, electric razors are not nearly as popular in the U.S.—where visions of masculinity involve square-jawed heroes who probably shave with a bowie knife—as they are in gadget-hungry countries like Japan. But we wouldn't be surprised if shavers like this cause more men to reconsider their morning routine.

Premium Streaming → When it comes to legal ways to stream TV shows online, Hulu has long been the gold standard. But the ad-supported service is hobbled by a lack of outlets (it takes some techy work-arounds to view Hulu on anything but a PC) and a limited library. **Hulu Plus** partially fixes these shortcomings—for a price: \$10 per month (plain ol' Hulu is still free) buys you access to a larger library and the ability to view video on a breadth of devices. In fact, if you have an iPhone or iPad, access to the Hulu apps alone may be worth the subscription fee. Still, despite the fee, the ads are still there.





✓Yes

Intermotor
Genuine Import Parts



✓Yes



✓Yes



✓Yes

STANDARD



✓Yes



✓Yes



✓Yes



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New Cars

Bridging the Gap

The big news for the sixth-
generation VW Jetta is its
larger back seat, which offers

almost as much rear legroom (at 38.1 inches) as a BMW 7 Series. The car will get a hybrid powertrain in 2012 (prompting CEO Martin Winterkorn to gush recently about a “bridge to the electric era”), but for now, buyers must choose among three engines: a 115-hp 2.0-liter four (\$16,000), a 170-hp 2.5-liter inline five (\$19,000) or an efficient 2.0-liter diesel (\$24,000) that uses a six-speed dual-clutch gearbox (DSG) to achieve 42 mpg. We’d wait until spring for the GLI (\$24,000), which pairs the DSG to a 200-hp 2.0-liter turbo and swaps the torsion beam for an independent rear suspension. — *G.E. ANDERSON*

2011
**VW
JETTA**

++
BASE
PRICE
\$16,000
(EST)

++ PM TEST DRIVEN



1

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2011
Kia Sportage2011
Mini
Countryman

↑

The Not So Mini

Expanding its lineup for folks who actually want to carry people and stuff, Mini will unveil the Countryman early next year. While a few inches shorter than the VW Golf, the Countryman comfortably seats four adults and offers 41.3 cubic feet of cargo room behind the rear seat. Like the Mini Coupe, the new vehicle is handsomely chic, inside and out—just not so cozy. While it's above average in terms of handling prowess, the big Mini feels less like a go-kart and closer to a four-passenger ATV. Optional AWD and short overhangs provide serious off-road potential. Cooper S models use the same punchy turbocharged inline four as the coupes, only now the engine makes 184 hp. Both manual and automatic transmissions will be offered. Expect to pay a premium for that Mini style—about 30 grand to start. —KEVIN A. WILSON

↑

TINNY NO MORE

Kia's Sportage follows its fraternal twin, the Hyundai Tucson, with substantial revisions and clean styling. The V6 has been shelved in favor of a 2.4-liter four-cylinder with automatic and manual six-speed transmissions. There's more power now—176 hp—200 fewer pounds and up to 31 mpg on the highway. The larger

engine will hardly be missed. Compared with the Tucson's, the Sportage's suspension has a slightly stiffer edge. During a test drive on Seattle's notoriously rough streets, we felt every change in surface texture, but the payoff was a nimble and maneuverable feel that belied the Sportage's relatively tall profile. Optional features include an AWD system

with a lockable center coupling, a cooled driver's seat and a huge panoramic sunroof. Kia will also debut the UVO infotainment system, integrating phones and MP3 players with voice-activated commands. Overall, the new Sportage is more solid and roomier than the outgoing model—but it should retain a friendly \$19,000 entry price. —BASEM WASEF

3

2011
Mitsubishi
Outlander Sport

↑

Outlander Light

The Sport is an abbreviated version of Mitsubishi's competent Outlander. It's 14.6 inches shorter and 400 pounds lighter (thanks in part to plastic front fenders). Consequently, it comes only with a 2.0-liter 148-hp four-cylinder, which provides adequate, but not eager, thrust. The most engaging model is the ES—with a five-speed manual gearbox—which runs about \$19,000. The SE trim includes a shifttable CVT and optional, lockable AWD. On California's sinewy blacktop, the newest Mitsu proved worthy of its name but compliant enough for a long-term relationship. —BEN STEWART



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2011
Ford Edge

Interbred Explorer

Compared to crossovers, “traditional SUVs are becoming more of a niche product,” George Pipas, Ford’s senior sales analyst, says. That explains why Ford radically altered the formula for its all-new, fifth-generation Explorer, ditching archaic body-on-frame construction and myriad other mechanical components derived from pickup trucks. But while the unibody 2011 Explorer shares parts with



the Taurus, the Flex and the Lincoln MKS and MKT, it rides on a unique version of Ford’s versatile D-platform. “It had to meet all of our truck durability-testing requirements,” one representative said. “When people look underneath, they’ll find more things unique to Explorer than not.” Under the hood, you’ll see either a 3.5-liter V6 or a 2.0-liter turbocharged Four. Promising good fuel economy, optional AWD and a seven-passenger body that melds sedan and SUV styling, the Explorer, which starts at \$28,965, has officially crossed over. — REX ROY



SHARPER EDGE

The revised 2011 Edge boasts refreshed body details, redesigned 22-inch wheels and a \$27,995 base price. The crossover’s V6 engine displaces either 3.5 or 3.7 liters, with up to 305 hp and 27 highway mpg. Neat, but what’s really cool is MyFord Touch, an optional interface on SEL models that connects the driver, the car and the Sync infotainment system. Nearly every function can be controlled using simplified voice commands or intuitive controls mounted on the steering wheel. Vibrant screens—two in the instrument binnacle and one on the center stack—display all the functions, and clean, capacitive-touch control buttons grace the center stack. It’s probably the year’s must-have option.

— LARRY WEBSTER



++

2011
Ford Explorer

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2011
Hyundai
Sonata Turbo

TURBO CHARGES

Eschewing the typical optional V6 for a turbocharged four-cylinder, Hyundai significantly ups the Sonata's performance and fuel economy. The Sonata Turbo's 2.0-liter DOHC engine is a version of the turbo motor first seen in the Genesis Coupe. Modified for front-wheel-drive duty, it delivers 274 hp at 6000 rpm (along with 269 lb-ft of torque between 1800 and 4500 rpm). That's 137 hp per liter, a notable milestone even among turbocharged engines. Hyundai predicts EPA fuel-efficiency ratings of 22 city, 34 highway and 26

overall. That's 50 percent better than the outgoing V6, and better than V6-powered competitors. The six-speed automatic transmission has a short first gear for snappy off-the-line punch and offers better efficiency than the five-speed it replaces. The car can be shifted manually via either a console-mounted shifter or wheel-placed paddles, and the

motor pulls cleanly across the rev band. With a class-leading power-to-weight ratio, the Sonata Turbo should start at under 30 grand and hit 60 mph in under 7 seconds. Still miss the V6?

— JOHN STEWART

STIFF Competition

After years of stubbornly offering its high-performance model in just one body style, Subaru finally makes the 2011 Impreza WRX STI available as either a spoiler-sporting sedan (\$33,995) or a five-door wagon (\$35,995). That may be the only thing more flexible about the STI, which has enough chassis changes to warrant appending its pink letter badges with "FF." Stiffer sway bars, harder springs and a lower ride height are just the start. For added rigidity, Subaru even switched to steel-ball-type bushings—where the front control arms meet the body. As a result, the STI is more composed than its predecessor, making it a solid competitor to Mitsubishi's Evolution. — JAMES TATE

2011
Subaru
WRX STI





3

2011
Ducati
Monster 796



Middle Child

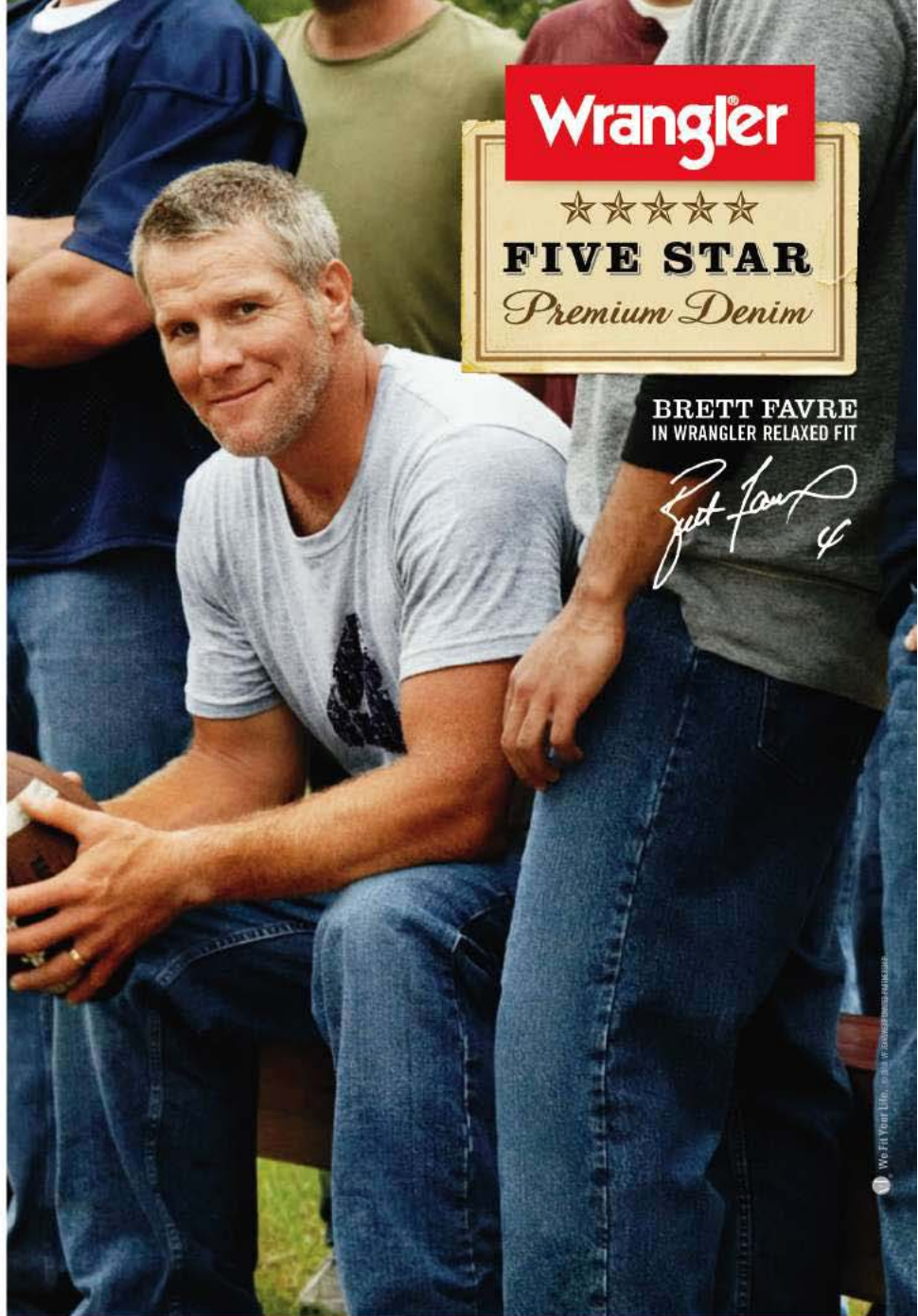
Sportbikes often outperform six-figure supercars, so it's tempting to dismiss a middleweight like the Ducati Monster 796 (\$9995) as a bike for beginners. But doing so could be dangerous, considering the 796's acceleration and handling. Bookended by the entry-level Monster 696 and big-bore Monster 1100, the midrung 796 features a fuel-injected 803-cc engine that produces 87 hp and 58 lb-ft of torque—which are relatively tame numbers compared to those of all-out, liquid-cooled superbikes. But the Monster 796 weighs only 373 pounds when equipped with its optional (\$1000) ABS, resulting in a power-to-weight ratio that demands respect even from the experts.

— BASEM WASEF



2011
Subaru
STI Sedan

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++
2010
Local Motors
Rally Fighter

Some Assembly Required

Do-it-yourselfers are building their own automobiles with the help of component-car kit-makers, and even mainstream manufacturers are seeing the value of cheap labor. **BY EZRA DYER**

This is a good time to be a gearhead with a DIY bent. The words “kit car” once evoked VW-powered Mercedes SSK knockoffs and disillusioned shade-tree mechanics with half-built projects in their garages. These days, a car customer inclined to pick up a wrench has more and better options than that sad figure from 20 years ago, the one coated in fiberglass dust and becoming familiar with a Mustang II’s front suspension.

“Technology cuts both ways,” says Dave Smith, president of component-car kit manufacturer Factory Five Racing. “On one hand, it results in production cars that aren’t serviceable—I open the hood of a new car and don’t even know what I’m looking at. But it also allows us to design build-it-yourself cars that are much more accessible than they used to be—and thus more fun.”

In the past year and a half, Factory Five has sold 250 kits of its latest car, the ‘33 Hot Rod, which evokes a 1933 Ford but is equipped with modern underpinnings. “It’s the most successful model we’ve launched,” Smith says.

Meanwhile, Local Motors (founded in 2007) is putting customers to work at

its Phoenix microfactory assembling its first vehicle, the Rally Fighter. For Local Motors, involving customers is both a requirement—since the Fighter doesn’t meet all federal crash requirements, it can’t legally be sold as a completed car—and a way of self-selecting enthusiastic buyers who’ll feel an affinity for the company and their own cars.

But you can’t just show up for 5 minutes and claim that you were involved in the build. Local Motors demands two weekends of wrenching. “You only need a basic level of mechanical aptitude,” says John Rogers, president of Local Motors. “Customers won’t be doing the skilled work, like welding or applying the wrap. But the things you’re doing will help you understand the car. At the end, if someone asks, ‘What’s that?’ you can honestly say, ‘I built it.’”

Factory Five’s kit cars demand a higher level of involvement, but Smith says advances in manufacturing allow a wide range of people to tackle a major project. Today, you may be buying a kit, but it’s been CAD-engineered

and CNC-machined to bolt together without generating a lot of profanity. “We’ve got equipment that was unheard of 20 years ago,” Smith says. “The technology has enabled more people to build their own car. Now it’s an assembly job rather than a fabrication job.”

Even GM is capitalizing on the emerging do-it-yourself market with the new Corvette Engine Build Experience, where buyers of the Z06 and ZR1 go to the factory and help construct the engine that will power their own car. Most Corvette customers probably wouldn’t see the attraction of paying an extra \$5800—the cost of the program—to go to work in a factory. On the face of it, that idea kind of seems like paying your pool guy to let you scrub your own algae. But a certain segment of the car-buying population is going to get it.

“The connection back to steel, to turning a wrench, is something that people want,” Smith says. “People are looking for a project, something they can do.”

PM



++
Factory Five
'33 Hot Rod

Dear Subaru,



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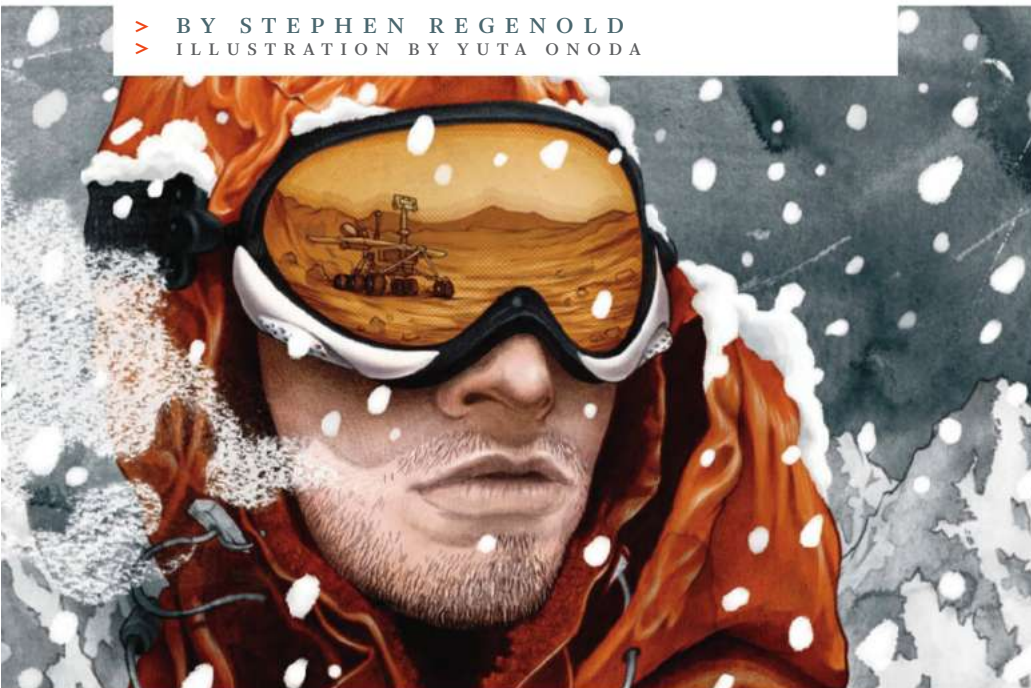
– Ginger C., Hood, VA. **Love. It's what makes a Subaru, a Subaru.**



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EXPLORING THE VOID

> BY STEPHEN REGENOLD
> ILLUSTRATION BY YUTA ONODA



POLAR TREKS CAN TEACH NASA WHAT TO LOOK FOR IN MARS ASTRONAUTS.

Mars surface,” says Gloria Leon, who studies the polar-space analogy at the University of Minnesota. “That environment will be similar in many ways to what polar explorers face on Earth.”

The comparison is not just physical; polar settings affect humans on a psychological level. After months alone on the ice, individuals often experience changes in their behavior, attitudes and values, says Leon, who co-founded the university’s Laboratory for Health and Human Performance in Extreme Environments in 1996. Since 1986 she has been studying expeditions, including Huston and Fish’s, to learn which qualities are held by explorers who perform well in isolation.

“It takes a certain type of person to be able to stay effective on a polar expedition,” Leon says. Using this information, she hopes to one day help NASA form a more compatible, psychologically sound space crew for missions to the moon, Mars and beyond.

Last April, when Huston plunged through the ice, Fish had to act in seconds before hypothermia incapacitated his partner. He knelt—“I remember my knees getting wet and the ice tearing underneath me,” he says—and hauled the gasping man onto the ice. Huston stripped down and dried off in a tent, and 2 hours later, the pair stepped back into their skis and continued north.

O

ON A STARK MORNING LAST APRIL AT LATITUDE

88 degrees north, John Huston and Tyler Fish were crossing the Arctic ice cap in a bid to become the first confirmed Americans to ski unsupported to the North Pole. The two men, both in their mid-30s, from Chicago and Ely, Minn., respectively, wore backpacks and harnesses attached to sleds laden with hundreds of pounds of gear. At 10 am, the ice opened beneath Huston’s skis, and he plunged from light into the darkness of the near-freezing water below.

Huston and Fish may as well have been on the moon. Rescue was thousands of miles away, days distant. The Arctic environment—minus 10 F, snow swirling across a white void—was inhospitably numbing. Even unearthly.

In fact, desolate polar regions have long been seen as analogous to outer space. From Siberia, where Soviet cosmonauts braved teeth-cracking cold, to the Canadian Arctic, where NASA still funds field research for Mars exploration, the remote reaches of Earth offer a parallel to what it might be like to endure the alien environment of a moon or planet far away.

“Imagine two or more people leaving the safety of a space habitat and going onto the



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ISOLATION RISKS ►

On the ground floor of a University of Minnesota medical building, Leon and the extreme-environment lab's director, Victor Koscheyev—a physiologist who formerly worked on projects with the Soviet space program—lead studies on topics ranging from hypothermia and expedition-induced stress to heat tolerance.

But as a psychologist, Leon focuses on the cognitive and behavioral challenges that polar explorers uniquely experience. Her research—applied over the years to a who's who of polar explorers, including Will Steger, Ann Bancroft and Richard Weber—is based on surveys from tent-bound adventurers and structured psychological interviews before and after the expeditions.

Each week on Huston and Fish's journey, which was officially called the Victorinox North Pole '09 Expedition, the two men answered questions about such topics as stress levels, mood, comfort, camaraderie, sleep, appetite and perceived physical exertion. Leon also monitored their progress online at the expedition's blog.

Her research indicates that drudgery—not physical peril—can weigh most heavily on polar explorers. Plodding for days across a stark white landscape is a lesson in dealing with monotony. “You enter into a different realm of existence on the ice,” says Huston, who trekked across Antarctica and Greenland on previous trips. “You get claustrophobic because you know you can't leave.”

The effects of isolation on performance are of great interest to NASA, which estimates that astronauts face a flight to Mars lasting up to six months, followed by an 18-month stay on the Red Planet. In the agency's Bioastronautics Roadmap, a 168-page document on risk-reduction strategies for space exploration, isolation is ranked alongside extraneous radiation, muscle damage and bone loss.

For space and polar explorers, the



John Huston and Tyler Fish camped on the Arctic ice cap during their 480-mile trek.

mental expedition can be just as challenging. “They are individuals, they are isolated, com-

munication will have a time delay,” says Robert Trevino, an aerospace technologist specializing in extravehicular-activity systems at Johnson Space Center. “On the psychological side, there are a lot of similarities.”

IN THE ZONE ►

Leon's research points to the unique formula required to thrive in an extreme environment. Many successful polar explorers, for example, reveal a strong “absorption characteristic,” which is the ability, Leon says, to become so engaged in what you are doing that you do not get overwhelmed by the greater task at hand.

In 2001, explorers Liv Arnesen and Ann Bancroft skied and kitesailed across Antarctica on a 1717-mile journey. Leon notes that, for Bancroft, becoming absorbed in the scenery was an important mental diversion during the 94-day trip. “Ann talked about slogging along but being drawn by the way the light would hit the ice or the view of multi-color glaciers,” Leon says. “It showed how a person knows the reality of where she is but can become so engrossed with thoughts and sensory perception that they take over.”

NASA's Bioastronautics Roadmap also cites psychological issues like interpersonal distrust, misunderstanding, poor communication and lack of group cohesiveness as factors that pose grave risks to future missions. But Leon has observed that taking care of each other—physically and emotionally—can improve not only individual but also group welfare.

During an all-female expedition in the early 1990s, for example, she interviewed skiers who divvied haul loads to take strain off a member who was slowed by a stressed leg. Cooperation on minor hurdles, Leon says, helps teams reach larger goals.

Key leadership qualities have also come to light through explorers' diaries: namely, a leader who takes a highly structured approach at the beginning, but who, over the course of an expedition, levels his or her authority to allow for a more democratic approach. Ernest Shackleton, Leon notes, used this technique.

Huston and Fish demonstrated one final trait she has observed: the ability to “accept a setback, plan ahead based on the experience and continue on.” After more than 480 miles, the men stood on the North Pole on April 25, 2009. They ate a meal of leftovers and drank scotch to celebrate their achievement. A few hours later, they boarded a Russian helicopter that hurtled south, carrying them back to Earth.

PM

U.S. GOV'T GOLD

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The United States Rare Coin and Bullion Reserve Vault Facility today announces the final release of U.S. Gov't Issued Gold Coins previously held in The West Point Depository/U.S. Mint. For a limited time, U.S. citizens will have the opportunity to purchase these \$5 Gov't Issued Gold Coins for the incredible "at-cost" price of only \$139.26 per coin. An amazing price because these U.S. Gov't Issued Gold Coins are completely free of dealer markup. That's correct, our cost. This may be your final opportunity to buy U.S. Gov't Issued Gold Coins "at-cost." The Gold market, which recently skyrocketed past \$1,200/oz., is predicted by experts to have the explosive upside potential of reaching up to \$5,000/oz. in the future. **Please be advised: our U.S. Gov't Gold inventory priced at \$139.26 per coin could sell out. Call immediately to avoid disappointment!** The United States Rare Coin and Bullion Reserve will release these U.S. Gov't Issued Gold Coins "at-cost" on a first-come, first-serve basis. Orders that are not immediately received or reserved with the order center could be subject to cancellation and your checks returned uncashed. Good luck. We hope that everyone will have a chance to purchase this special U.S. Gov't Issued Gold "at-cost." Order immediately before our vault sells out completely! Special arrangements can be made for Gold purchases over \$50,000.



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DISASTER- PROOF YOUR LIFE

Protecting your home and family from catastrophes is a task best done before the storm clouds gather. Here's how a targeted approach to disaster preparation can reduce your risk.

• BY JOHN GALVIN • ILLUSTRATIONS BY MERCÈ IGLESIAS

FOR THE PAST FEW YEARS, researchers at the Wharton Risk Management and Decision Processes Center at the University of Pennsylvania have been running a computer simulation to study how people choose to prepare for potential natural disasters. The simulation, called *Quake*, is a multiplayer game. All participants start out with a hypothetical \$20,000 in cash and a house, and as the game progresses, they must make decisions about how to use their money. A player can leave that money in the bank,

earning a Madoff-like guaranteed annual return of 10 percent, or pay for structural improvements to help the house withstand an earthquake. The winner is the player with the highest net worth—cash plus the value of the house—at the end of the game, usually 10 virtual years.

Nearly everyone chooses to keep the money in the bank. The strange thing about this result is that the researchers, Howard Kunreuther and Robert Meyer, warn the players that quakes are highly likely—the game, after all, is called

CONTINUED ON PAGE 63 →

2009's Los Angeles Station Fire consumed 160,000 acres and destroyed 89 homes.

Pour RV-grade antifreeze or, in a pinch, vodka into toilet trap to prevent freezing.



BLIZZARD:

THE THREAT: Winter storms can paralyze whole regions of the country

WHERE: Everywhere but the southern U.S.

WHEN: December to April

Severe winter storms can snow people in for days at a time, while heavy ice and snow routinely bring down tree limbs and power lines. Homeowners in cold-weather states are used to breaking out the shovels (and even the roof rakes) for the hard task of snow removal. But a clear driveway isn't an excuse for a drive—70 percent of winter storm fatalities occur in automobiles—so sit tight at home and stay warm. If the power's out, a generator will help keep the basic utilities running. But if you lack backup power and think you may be in it for the long haul, set up a "camp" inside your house with a tent, sleeping bags and your family all shut in a single room to consolidate heat. Long-lasting cold can burst water pipes, so prepare the house by turning off the water supply at the source; then open the lowest faucet and drain your pipes. But be sure to save some water for drinking, cooking and cleaning—eating snow is a dangerous way to hydrate, and can lead to a case of hypothermia.

WILDFIRE:

THE THREAT: Millions of acres of the U.S. burn every year

WHERE: Sunbelt states and Alaska

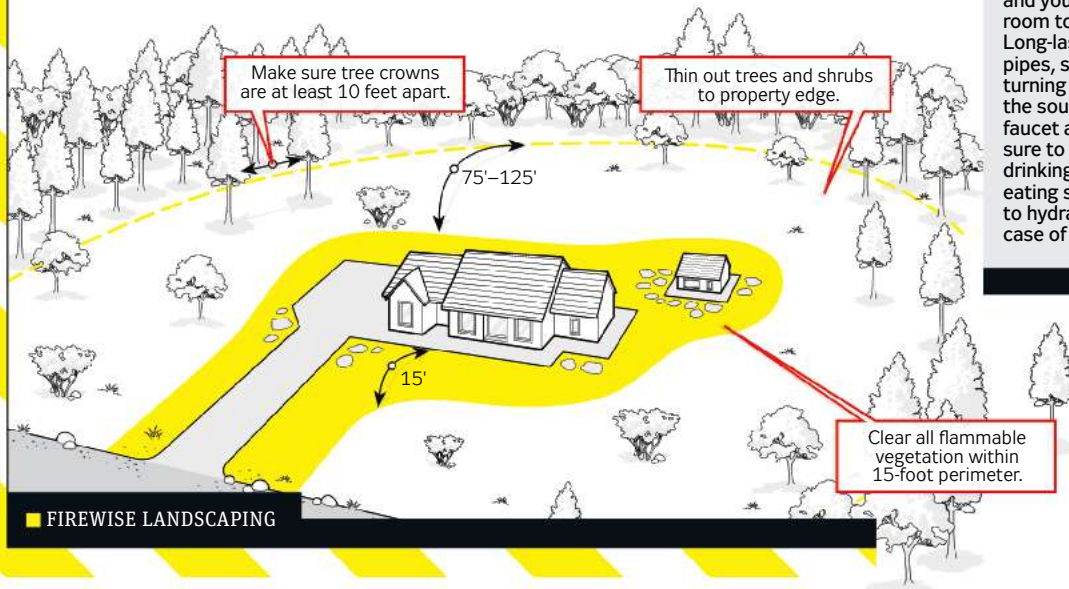
WHEN: June to September


Don't confuse a house fire with a wildland fire that's about to overrun your house. If you didn't evacuate earlier—and you

probably should have—your house is where you make your final stand. Shutting your windows against flying embers is an

obvious step, but just as important is to open the fireplace damper to ventilate deadly gas and smoke that will precede the fire.

Make sure to shut off gas or propane lines, but stop there. "Don't shut off the water—we can use that—and don't shut off the electricity," says Fred Stowers, a 24-year veteran of the Los Angeles County Fire Department, who helped combat last year's 160,000-acre Station Fire. "Turn lights on so we can see inside and tell the difference between things like drifting smoke and roaring flames."





Eight days of rain submerged the city of Atlanta in September 2009.



FLOODING:

THE THREAT: Floods cause an average \$5 billion in losses and 100 fatalities yearly—about 3800 towns are on floodplains **WHERE:** Mainly coastal states and the Mississippi Valley **WHEN:** Spring and fall

Sump pumps are the best defense against minor flooding and chronically wet basements, but if a river is rising nearby or a coastal storm surge is imminent, the best advice is to move your valuables to a high floor, then evacuate. And if there are flash-flood warnings, be quick about it. These floods move fast and tend to carry mud, trees and other dangerous debris with them. If you're in a flood zone—check your address with the FEMA Map Service Center (msc.fema.gov) to find out—plan an escape

route ahead of time. And never drive through moving water; it can be a deathtrap. Almost 50 percent of flood fatalities are car-related. Don't be lulled into a false sense of security by

the term "100-year flood," either. That doesn't indicate that a flood will occur only once a century. What it really means is that every single year there's a one-in-100 chance of that level

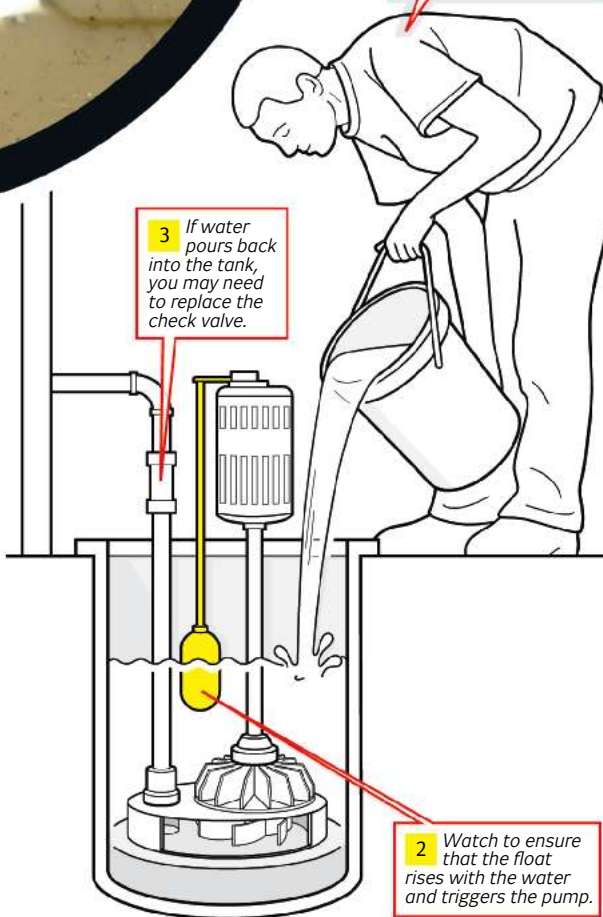
of flooding. If you live in a flood zone, the U.S. Geological Survey estimates that you've got a one-in-two chance of experiencing a flood in your lifetime.

■ CHECK YOUR SUMP PUMP

1 Every few months, remove the cover to your sump well and slowly pour water into the tank.

3 If water pours back into the tank, you may need to replace the check valve.

2 Watch to ensure that the float rises with the water and triggers the pump.





HOUSE FIRE:

THE THREAT: 400,000 fires each year kill almost 3000 and injure more than 14,000 **WHERE:** Anywhere **WHEN:** Most common in winter months

Every room should have two escape routes. In upper-story bedrooms, a fire ladder, such as this one from First Alert (\$70), can be a lifesaver.



More Americans die in house fires every year than in all natural disasters combined. When in doubt, escape the building, but if you judge that you can safely mount a fire-extinguisher battle, there are two rules you need to know. Rule one: Stay 6 feet from the flames so you don't torch the rest of your house by air-blasting a nascent fire across the room. Rule two: People often forget rule one and make things worse, so keep your escape route to your back when you pull the trigger. More than 50 percent of fatal house fires occur between 11 pm and 7 am (peak hours for all fires are 5 pm to 8 pm), so practice two ways out of every room at night. And make sure at least one

of them does not rely on a stairwell, which can easily become a deadly vortex of gas, smoke, heat and flame. "Homes are the only occupancy in the country allowed by code to have an open staircase," says house-fire expert John Norman, a retired chief for the Fire Department of New York. "We call them chimneys. They serve as channels for fire as it moves upwards." Finally, it may sound basic, but picking an outside rendezvous point is critical, so you can discover quickly who's made it out of the house and who hasn't.

BEFORE TROUBLE STRIKES

The *Quake* study falls into the field of behavioral economics, in which over the past 30 years it has been determined that people often fail to make rational economic decisions. In general, it seems, people are too eager to lock in financial gains and too willing to gamble that losses will never materialize. If this is unfortunate when it comes to retirement savings, it is positively dangerous in a world riven by natural and man-made disasters. "People might be aware that there are going to be hurricanes or tornadoes or earthquakes," Meyer says, "but they think the actual damage is something that happens to other people."

After Hurricane Katrina in 2005, a devastating midwest tornado season in 2008 and deadly flooding in Tennessee, Mississippi and Kentucky this past May, public awareness of disasters is surely at a high point. A 2009 Red Cross study found that more than half of all Americans had personally experienced an emergency in which they'd either lost power for three days, had to evacuate or had to provide serious first aid to others. Yet the same survey found that only 12 percent of Americans had taken adequate disaster-preparedness steps.

However, as the 12 percent who do plan ahead can attest, most disaster prep is pretty straightforward stuff. Jeff Swiney, a towboat pilot from Lafayette, La., has seen three major hurricanes hit his home in the past 10 years. His strategy for weathering storms is easy to execute because everything has been fully planned out in advance. "Nothing's basic when a hurricane is blowing down your house," he says. "By then it's too late, and that's when you see people fighting for the last bag of Doritos at the grocery store."

Once a person decides to take disaster preparation seriously, the first step is to assess the spectrum of threats. How would each type of disaster affect everything, from the structure of your home to the contents of your fridge?

From there, planning breaks down into two broad areas: general measures that apply to any situation, and targeted

← CONTINUED FROM PAGE 60

Quake. But players cling doggedly to that promised 10 percent rate of return. On occasion, the lab team has even told one of the players that the only way to win was to put the money into the house. Even then, he would typically delay for a couple of years, hoping to cash in before doing the home improvements. Then, predictably, an earthquake would come and wipe everyone out.

• Tornadoes can produce winds of 250 mph or higher. This past April, a deadly Mississippi tornado traveled more than 140 miles.



TORNADO:

THE THREAT: Approximately 1000 tornadoes hit the U.S. each year

WHERE: Most common in Plains states **WHEN:** Spring and summer, usually in early evening

tasks to protect against specific threats such as wildfires or hurricanes.

On the general side of the ledger, survival experts suggest that families plot escape routes and make sure that they know how to contact one another in a crisis. It makes sense to list all of the critical systems that support your daily life and home (hot-water heater, boiler, water pump, phone, electricity, Internet) and learn how they work. Then you can create a backup plan in case they fail.

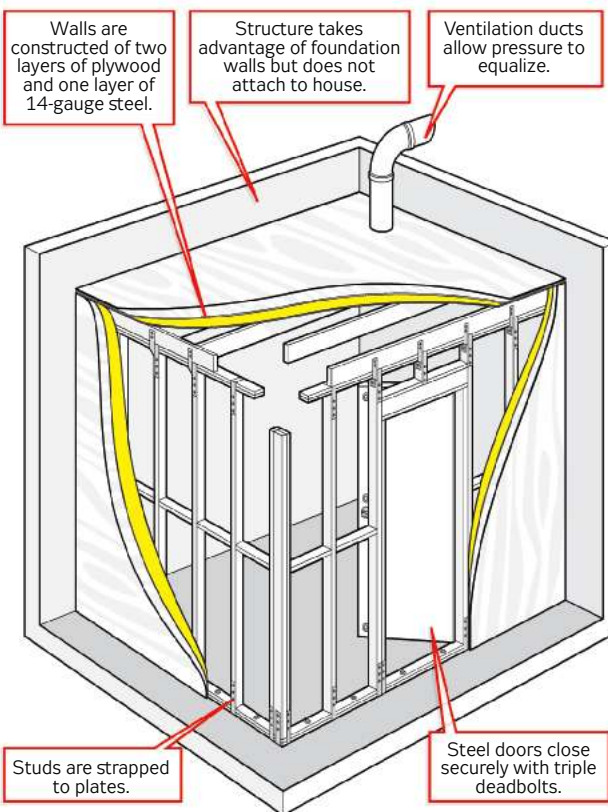
Once an immediate threat has passed, the survivors of any natural disaster need to focus on securing warmth, water and food—and it doesn't have to be difficult.

THE NEXT DAY

Heat and electricity sound like two different challenges, but both needs can be satisfied by a generator and fuel. During almost any natural disaster, the power may go out and stay out for a while. In such a situation, generators can seem like miracles. In warm climates, a backup generator keeps food cool and your lights and a/c running. In cold weather, generators can power either electric space heaters or fuel pumps to keep oil burners running. But you can't just buy any generator, stick it in the garage and expect to reap the benefits when the lights go dark.

Selecting and using this machine is

ANATOMY OF A SAFE ROOM



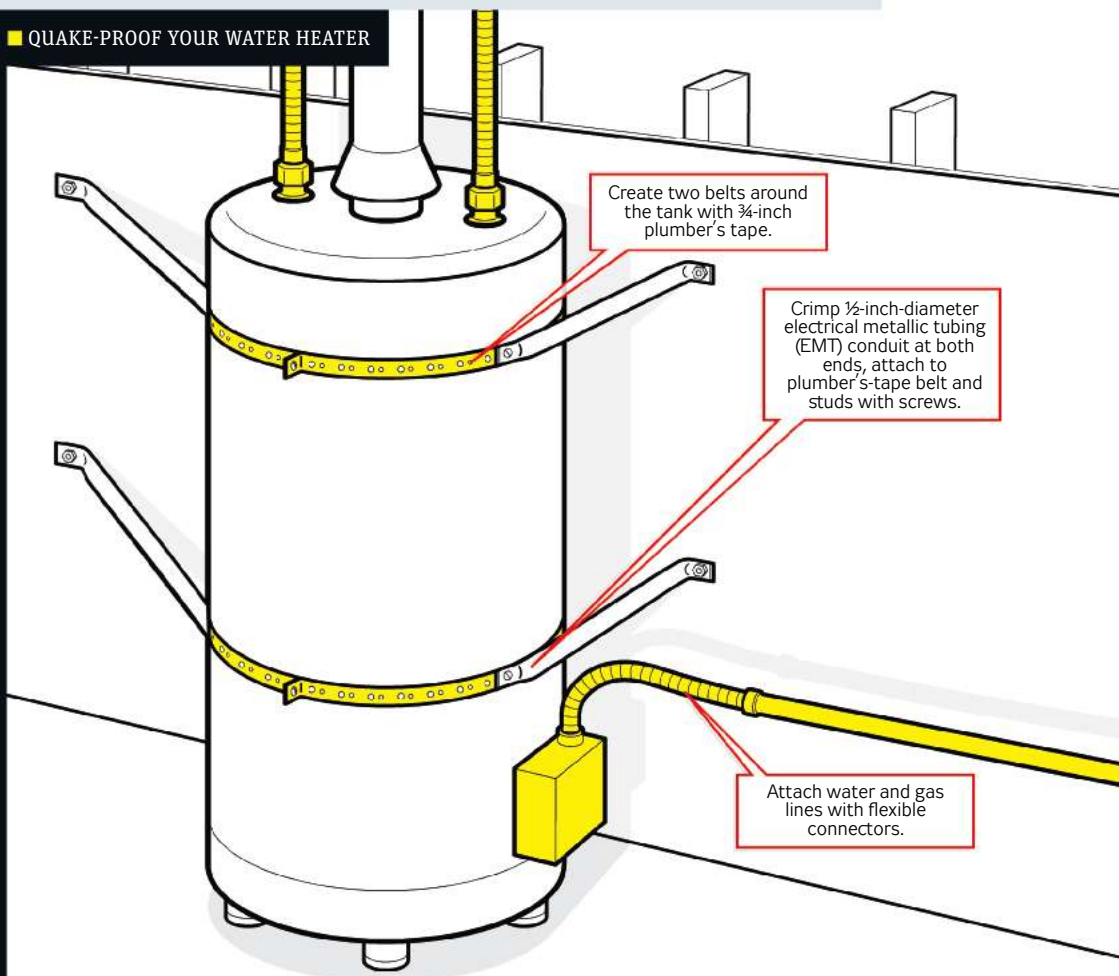
Tornado fundamentals are easy: Get to the lowest floor in the house and put as many walls as possible between you and the twister. In tornado country, residents often install underground or basement storm shelters. For homeowners who lack basements, researchers at Texas Tech University have developed plans for DIY aboveground safe rooms created by pouring concrete into foam forms. Plans for DIY retrofit shelters, such as the basement build-in pictured here, can be found at fema.gov/plan/prevent/saferoom/fema320.shtml. If a tornado catches you out in the open, conventional wisdom is to hide in a ditch, but Larry J. Tanner, one of the researchers at Texas Tech, who has investigated every major U.S. tornado in the past 12 years, disagrees. "You'll never see me in one," he says. "I've seen all sorts of things in ditches after a tornado—2 x 4s, propane tanks, rolled cars." Look for a covered culvert instead. "If you're in a city, stay away from grocery stores, gymnasiums or anything with a long roof span. Take shelter in large, sturdy buildings: Banks and hospitals are usually good."



EARTHQUAKE:

THE THREAT: The most destructive recent U.S. quake (Northridge, Calif., 1994) caused \$40 billion in damage and killed 61 **WHERE:** California and the Midwest **WHEN:** At least one great quake (magnitude 8.0 and up) hits somewhere in the world each year

■ QUAKE-PROOF YOUR WATER HEATER



Today there is no credible way to predict earthquakes, so when a big one hits a U.S. population center—and experts agree that there will be a big one—it will come without warning and it will be devastating. Most modern houses are bolted to their foundations, but older houses may be held in place simply

by their own weight. To earthquake-proof an older home, spend a few hundred dollars on half-inch anchor bolts and earthquake brackets to attach your home to its foundation and keep it from shaking or sliding free. Also remember to secure major appliances and freestanding bookshelves to the walls and install

flexible gas and water lines to prevent ruptures or leaks. Those busted lines can make the fiery aftermath of an earthquake just as deadly as the quake itself. If you smell gas, get out of your house immediately and keep an eye out for downed power lines. Finally, the most useful technology to have

around after an earthquake could be an old-fashioned battery-powered radio. "The power grid will be down, and the cell grid will be overwhelmed," says Mary Lou Zoback, a geophysicist with Risk Management Solutions. "It's going to be your lifeline for information."

The 2003 northeast blackout shut down 10 major cities, including New York (pictured), where thousands of subway passengers had to be evacuated.



BLACKOUT:

THE THREAT: Recent large-scale power outages have lasted up to three weeks

WHERE: Anywhere **WHEN:** Outages spike in summer, when a/c demand is high

Power outages are a routine side effect of other disasters, but sometimes a blackout can be a disaster in itself. The largest recent example in the United States was, of course, the

Northeast blackout of 2003, which left 50 million people without power and caused 11 deaths. All told, it caused \$6 billion in damage. That blackout was widespread, but it was hardly an

isolated incident. On average, a dozen large-scale blackouts affecting at least 50,000 people each occur every year. Like many disasters, blackouts introduce issues of food spoilage, water contamination and exposure to heat and cold that only get more severe as the outage lingers. The best defense is a generator, but it's also important to keep a flashlight and radio where you can

easily find them. In widespread blackouts, communication networks tend to suffer along with the grid. Landline and cell networks can get overwhelmed, but short texts will get through. A useful and free service called I'm Ok lets you create an emergency contact list so you can send mass e-mails with a single text message. Get an account at imokapp.appspot.com.



To prevent accidents during power outages, mark your cellar stairs with glow tape.

an exercise in load management. Before you shop, figure out which household appliances you want to keep running, the electrical load (in watts) that each one draws and how many hours per day they need to operate. Many retailers feature generator calculators to help you pick the right model.

Once you get the generator home, be sure to operate it safely. To avoid carbon-monoxide poisoning, never run a generator in an enclosed space—set it up outside and away from open windows and a/c vents. Large generators

work best when wired directly into your home's circuitry. Consider hiring an electrician to install a transfer switch so you don't have to plug individual appliances in separately.

After shelter, water is the most pressing need in times of disaster. Most of us can't survive more than three days without it, and natural disasters often knock water-treatment plants off-line. During floods, contaminated water can also back-flow into household water pipes. That means that an army of microbes is just waiting to infect your gut at exactly



HURRICANE:

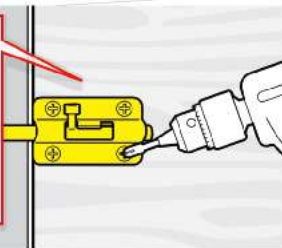
THE THREAT: Each year there are 6 to 8 hurricanes, causing an average \$5 billion in damage per season **WHERE:** Eastern and southern coastal states **WHEN:** Summer and fall, September is the cruellest month

■ QUICK AND EASY REUSABLE STORM SHUTTERS

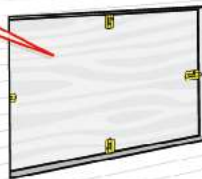
1 Measure the inside frame of your windows (make sure windows are inset at least 2 inches). Then drill one hole on each side of the sill. Use more holes for larger windows.



2 Cut $\frac{3}{4}$ -inch plywood to fit inside each window frame, then screw in 4-inch heavy-duty barrel bolts.



3 Label each shutter to match its window, then waterproof them with a coat of varnish.



The most important thing to have in place for hurricane season is a plan to get out of town. Towboat captain and 22-year Coast Guard veteran Jeff Swiney has had multiple hurricanes hit his Lafayette, La., home, and he knows a thing or two about disaster evacuation. "You've got to have predetermined trigger points and then act on them," he says. "Too many

people wait until it's too late, when the storm is overwhelming, and that's when they get hurt." Second only to the safety of your family should be the structural integrity of your home. The best time to build in hurricane protection is during new construction, when roof straps and permanent storm shutters can be added with little additional effort. But

existing roofs can be retrofitted with gable end braces and temporary storm shutters can be cut to fit in a couple of hours. Don't forget to bolster your garage as well, Swiney says—he braces the entrance with diagonally placed 2 x 4s. "Garage doors are weak," he says. "And if a hurricane-force wind gets inside, it will take your whole roof off."

the time when local hospitals are likely to be overwhelmed. Treating water is easy: Strain it, then boil for 1 minute or treat with chlorine bleach (1 tablespoon for 10 gallons) and you'll kill off most pathogens. But it's better to think ahead by keeping a three-day supply of bottled water (1 gallon per person per day) on hand. Cody Lundin, survival instructor and author of *When All Hell Breaks Loose*, takes it a step further. If disaster looms, he suggests filling everything in the house—from bathtubs to 1-gallon zip-lock bags—with tap water before contamination begins.

Food is the least essential of the survival essentials. People have been known to survive three long weeks without food. But who wants to go through that kind of suffering? As with water, it's relatively easy to build up a supply of food just by buying some extra dried beans, Campbell's soup and dried fettuccine every time you shop. Soon you'll be stocked up with little pain to the billfold.

If you've lost power, open your fridge only when you absolutely need to and your food will stay pretty cold—especially if you can power it for a couple of hours every day with a generator. If you have time before the bad weather hits, organize your fridge, putting the most perishable food toward the front, and save the stuff in the freezer for last.

Securing your heat, water and food may be the starting point of disaster prep—but turning your home into a real bulwark against disaster takes more effort. Study FEMA maps to determine the disaster profile of your area and learn as much as you can about how floods, hurricanes, wildfires and other dangerous events can affect your house and neighborhood. Then invest your time, energy and money accordingly. You might build structural reinforcements in case of an earthquake or practice smart landscaping to defend against wildfire—such measures are detailed elsewhere on these pages. And remember the lesson of *Quake* and similar studies: When it comes to natural disasters, the biggest risk is assuming that they can never happen to you.



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AMERICAN BEAUTY

→ TWIN
BROTHERS
TEAM UP TO
**RESTORE
A CLASSIC
FIRETRUCK.**
FIRST THEY
FOLLOW THE
RULEBOOK.
THEN THEY
THROW IT
OUT.

by ROY BERENDSOHN
photographs by SARAH SHATZ

→ Its firefighting days long over, a 1959 Ford rolls past peaceful Minnesota fields. The author and his brother spent five months restoring the vintage truck.

my brother carl grips

the rim of the steering wheel, takes a high step and hikes up onto the bench seat of the lanky 1959 Ford firetruck. Grabbing a metal handle, he swings the driver-side door shut. It makes a firm, mechanical clank that sounds like the breechblock on a shotgun as it slides home. The truck has no door locks, seatbelts or much of anything that we associate with modern vehicles. Even its small brass key looks better suited to a wood cabinet than to an ignition switch. Carl flips the battery kill switch, pushes in the clutch, pulls out the choke and twists the key. The truck rumbles to life with authority, filling the garage with the bygone but unmistakable odor of unburned gasoline vapor mingling with exhaust.

Sitting on the opposite side of the cab, I picture what the Ford was like when it was a working firetruck. A volunteer would have dived into the cab and run through the start sequence, then thrown the parking brake and hit the lights and siren as he roared out of the firehouse in second gear, shifting to third as the truck cleared the apron at the street.

My brother and I are not in such a hurry. We're not firemen, and our mission isn't to extinguish a blaze. It's to restore this fine old machine. On a winter afternoon in rural Michigan, we're taking it for a spin. Carl swings the five-speed shift lever hard to the right and up one notch. Easing up on the clutch, he gently backs the truck out of the garage and into the cold winter air. "Needs a throw-out bearing," he says, more to himself

than to me. A telltale whine emerges from the clutch.

He snaps the shift lever straight back, then rolls ahead in first gear. The old red Ford crunches the snow under its toothy eight-ply Goodyear Hi-Miler tires as we rumble down the long dirt driveway. With a sly grin, Carl turns the siren on and off, but his neighbor's Angus beef cattle stand motionless and seemingly serene.

Soon we're rattling along the dirt road that leads from Carl's homestead to a paved county road. It's an austere beautiful landscape. The wind has sheared the snow off the fields, revealing the stubble of last year's corn and soybean crops. Tracks from Carl's test of the truck's four-wheel drive crosshatch the snow in his own field. Farmhouses, some of them nothing more than tumbledown wrecks, line the road.

By current standards, the truck is primitive. The suspension is ridiculously stiff—we bounce over every rut and pothole. Carl has to double-clutch between second and third. The steering has so much slop that my brother has to make constant corrections to keep the truck on our side of the road. The heater has one setting: blowtorch.

No question, this truck is a relic from the distant past—our past. It was built the year my twin brother, Carl, and I were born, in Hempstead, N.Y. It's a sheet-metal barbarian with barely rounded corners, but to Carl and me it's an American beauty.



→ Carl (left) and I spent a lot of time looking for trouble, checking for loose fasteners, damaged threads and missing parts.



→ These plug wires have passed the test of time. To avoid breaking the insulators, use a pair of plug-wire pliers to work the boot loose from the porcelain.



→ Removing very old spark plugs that haven't been broken loose in many years can be dicey. There's a good chance of snapping the plug or damaging the threads in the cylinder head. Twist them out just a quarter turn, then loosen corrosion and carbon on the threads by soaking them overnight with penetrating oil or a 50/50 mix of ATF and lacquer thinner.

10,000 original miles, rare qualities in an unrestored 50-year-old vehicle.

My brother immediately entered into negotiations with the owner, Shane Buer, perhaps the world's most honest dealer of old cars and parts. Located in Dawson, Minn., Buer sent my brother more than a dozen photos detailing the truck's flaws. The two men settled on a price, \$2750, and Carl dispatched a car carrier to retrieve the firetruck. "It sat outside for two years or so, but the only thing we had to do to start it was clean the points a little and spray a little gas in the carburetor," Buer says. He was able to drive it right onto the car carrier.

The Ford was delivered to Carl on our birthday. As soon as the old truck came off the trailer, my brother corralled some buddies to pump new life

into it. In short order they replaced the truck's coolant and oil and rebuilt the carburetor and installed a reconditioned fuel pump, new spark plugs and plug wires, a distributor cap, a rotor and filters for air and oil.

Now, five months later, after flying from Philadelphia to Detroit, I'm driving through swirling snow to Carl's. I guess I expected a hero's welcome or to get razzed that I showed up after the heaviest work was done. Instead, neither happens. "Get dressed," Carl says, as I step out of the rental car, "we're cutting firewood."

That's my brother, a man of few words. He's a smart guy who has degrees in tool design and engineering and a master's in business administration. After high school, life took us on distinctly different paths. He moved to the Midwest to be in the heart of manufacturing. I split my time in the Northeast between journalism and construction, an oddly bifurcated life that I still maintain. Carl spent nearly 30 years in the industrial sector but now does data analysis for an insurance company. He's stubbornly independent. He heats his house with wood, and he's constantly building or remodeling something. The new workshop he just completed is bigger than my house. He's always been that way. Restless. Productive.

After we pile the firewood, we start up a kerosene heater in the corner of the shop and go to work. Half the challenge of restoring an old truck to its former glory is just getting past the dirt. It's to the credit of Ford's engineers that they designed a vehicle that can still run 50 years after it was built, even though every spark-generating, air-moving or fuel-carrying part is clogged with crud. "The air cleaner looks like it came off my lawnmower," Carl says. He plucks it out of a box of recently replaced parts. Everything in there looks like it belongs in a landfill for toxic waste.

Fortunately, other things about the truck are as tidy as can be. So complete are its documents that we know the date and mileage when Bean took possession (Sept. 9, 1959; 9 miles). A few weeks later, Carl and I were born. Such was the medical

the allure of old iron

THE VEHICLE I TRAVELED SO FAR TO help renovate rolled off the assembly line on a summer day in 1959 at Ford's then-new plant in Lorain, Ohio, a storied facility that made 7.5 million cars and trucks before it was shuttered several years ago. The Ford was built as just a naked F-350 cab and chassis. After Lorain, John Bean Division, a firetruck builder in Lansing, Mich., heavily modified the bare-bones Ford by adding a hulking Stahl utility-box body and aftermarket NAPCO four-wheel drive. Most important, Bean installed a firefighting pump with a state-of-the-art high-pressure fog setting. It also wired in lights and a siren and built a diamond-plate rear bumper wide enough for a firefighter to stand on.

Like all good finds, the truck just turned up. Carl was cruising the Internet one afternoon to find parts for a 1947 Ford grain truck that he's restoring and stumbled across an ad for the firetruck. The photograph on the posting showed it in hub-high snow and knee-high weeds, with a listing shack in the background. Carl was intrigued by the description: running condition with



→ My brother (right) and I were pleased to find that the old truck is very service friendly. Parts such as the window crank are easy to access.

technology of the day that the truck arrived with far more certainty than my brother and I did: My mother didn't know she was carrying twins.

Sliding under the truck on a piece of cardboard, Carl shows me the grease points. Each zerk looks like a new form of undersea life: dirt coral. He demonstrates how he wants me to handle this job. First, he carefully scrapes away dirt with a putty knife and a brass wire brush, then he uses a dental pick to open the end of the fitting. Finally, he injects fresh lubricant with a grease gun. My tutorial complete, I set about lubricating each grease nipple I can find. I lose track of how many I clean—the undercarriage is plastered with them. In this truck's era, if an engineer felt that a part needed heavy lubricant, it got a zerk.

While I deal with the dirty fittings, Carl tinkers in the engine compartment and debates whether we should replace a radiator hose. There's nothing like a burst hose to strand a vehicle far from home. It feels good to work together again, like when we were kids. Between passing tools and parts, we catch up a bit: a divorce, a marriage, kids and stepkids.

trucks—then & now

CALL ME OLD-FASHIONED, BUT INSTEAD OF WORKING ON today's vehicles with their artfully concealed fasteners and parts that require special tools, I prefer a truck on which only ordinary tools are needed and the heads of fasteners are easily accessible. Replacing the driver-side window is a joy. We remove the Phillips screws on a door panel and gain full access to the window crank mechanism. The rest of the job is a snap.

Even though we're twin brothers and we share a love of working with our hands, our techniques couldn't be more different. When I do mechanical work, I put on coveralls, gather my tools and plan my attack. To me, every job is about preparation, execution and cleanup. Carl, on the other hand, just dives in. If we were musicians, I'd be the classical pianist, and Carl would be the jazz soloist, a master of improvisation. Example: When I can't remove a broken cap from one of the Ford's brake-fluid reservoirs, my brother suggests a pipe wrench. The idea of using a plumber's tool on an old truck strikes me as almost scandalous, but it works beautifully.

My brother's philosophy—that results matter more than



→ The firetruck's detailed documentation includes the well-thumbed original manual. Those old guides have a lot of useful information.



→ Amazingly enough, you might still be able to find rebuild kits for this funky glass sediment-bowl fuel pump in the aftermarket. A previous owner installed a serviceable, if incorrect, modern pump with no bowl. Regardless, use a big, clear plastic fuel filter on older vehicles like this, because there's probably plenty of rust and junk in the tank.

the old machine holds its own among beautifully restored cars from the 1930s through the '60s. Old firetrucks are just cool. "I feel right at home," Carl says before going off to look at a Hemi Challenger.

Back at the shop, we tighten mechanical and electrical connections. Socking down those bolts makes for a cleaner garage floor and less oil spilled on the road. Likewise, getting the truck timed to 4 degrees before top dead center and replacing its Rube Goldberg coil with a new, more reliable version produces a vehicle that runs flawlessly.

Most of the work is pretty much by the book. Then we hit a snag, and Carl swings into improvisational mode. When the jack proves too short to fit a pair of shocks, he grabs a concrete block, flips it on top of the jack's pad, works the jack under a crossmember and pumps up the truck body to gain

the needed clearance. Left to my own devices, I'd probably saw a 4 x 4 to the exact dimension and place it on the jack. Fifteen minutes later I might have one of the shocks installed.

Maybe that's what makes working on old vehicles so rewarding: You battle entropy using everything at your disposal. Then you take your handiwork for a long drive. The very fact that it still runs nicely is a pleasure in itself.

Early evening shadows are stretching across the shop as we straighten up. A radio is tuned to a '70s rock station, and the scene is so evocative of our teenage years that I confess I've become a little wistful. Carl urges me to take Canby for a drive. "Go ahead," he says. "Take it for a good, long run."

I back the truck out of the garage and head into town. For some reason, I feel more exposed without a seatbelt as a driver than as a passenger, especially as I get the truck up to its top speed of 50 mph. (The truck's speedometer goes to 100 mph, but you'd have to drive it out the back hatch of a cargo plane to get anywhere near that velocity.)

Driving along with the windows down and the warm spring air billowing in, I get the truck's full effect. The rude howl of six snow tires blends nicely with the growl from the glass-pack muffler. Carl describes the serenade as "primal." I agree.

Double-clutching helps me make the all-important shift from second to third, but the first time I try it, I amateurishly bang the gears together. It sounds like a mower blade hitting a rock. It takes several miles, a deft touch and a couple of shifts before I have the second-to-third timing down.

Eventually, I turn around and head for home. It's getting dark, and passing trucks have their lights on. Farmland scrolls by, and as I crest a rise, I meet Carl coming the other way in his snowplow truck. He must have been worried that I'd broken down somewhere and come out to look for me. Seeing him makes me smile. It does a brother's heart good. **PM**

technique—emerged as far back as the summer of 1977, when he bought a ponderous '58 Oldsmobile two-door that we nicknamed the Fish Tank for its tendency to take on water after a heavy rain. If there was a tool or makeshift repair that we didn't employ working on that thing, I don't remember it. We kept the Olds running for years and kind of started to enjoy the sound of water sloshing around in the quarter panels.

As the truck's restoration took shape, Carl kept me abreast of its progress with daily e-mails. We begin calling it Canby, after the Minnesota farm town where it spent the bulk of its firefighting career. It was delivered there in the fall of 1959; the town paid \$9600 for it, a handsome sum in an era when in Minnesota, for another \$3200, you could buy a good house. The *Canby News*, a weekly paper that's still in business, reported the truck's arrival and ran a small picture of fire chief Art Betts, wearing a plaid wool jacket over bib overalls as he stood solemnly next to the vehicle. Painted on the truck's door was its identification: Canby Fire Department No. 1.

Paul Miller, an 85-year-old retired farm-equipment salesman, joined the Canby fire department in 1947 and served for 26 years. He fondly remembers the era. "When that whistle would blow, your heart went right up into your throat," he says. "You ran as fast as you could to the firehouse." Eugene DeWit, another volunteer, remembers driving Canby No. 1 to a fire in a hog house. "I set it to fog and walked right in," he says. "I had that fire out in 2 minutes."

I make another trip to Michigan a few months later and tail my brother as he drives the Ford to the Davis Auto Mart Spring Dust Off, a charity car show in Charlotte, Mich. At the show,

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HOW THE BLOWOUT HAPPENED

THREE MILE ISLAND, CHALLENGER, CHERNOBYL—AND NOW, DEEPWATER HORIZON. LIKE THOSE EARLIER DISASTERS, THE DESTRUCTION OF THE DRILLING RIG WAS AN ACCIDENT WAITING TO HAPPEN. HERE, ENGINEERS IN THE GROWING SCIENCE OF FAILURE ANALYSIS IDENTIFY SEVEN FATAL FLAWS THAT LED TO THE OIL SPILL IN THE GULF OF MEXICO AND DRAW LESSONS ON HOW TO PREVENT FUTURE CATASTROPHES.

SPECIAL REPORT BY CARL HOFFMAN

ADDITIONAL REPORTING BY DAVIN COBURN

APRIL 20 WAS A TRIUMPHANT EVENING FOR BRITISH Petroleum and the crew of Transocean's Deepwater Horizon. Floating 52 miles off the coast of Louisiana in 5000 feet of water, the oil rig was close to completing a well 13,000 feet beneath the ocean floor—an operation so complex it's often compared to flying to the moon. Now, after 74 days of drilling, BP was preparing to cap the Macondo Prospect well until a production rig was brought in to start harvesting oil and gas. Around 10:30 in the morning, a helicopter flew in

On April 21, 2010, rescue vessels in the Gulf of Mexico battle an inferno on the Deepwater Horizon—a fire fed by oil and gas spewing from a well that blew the previous day 18,000 feet below the deck of the drilling rig.

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four senior executives—two from BP and two from Transocean, to celebrate the well's completion and the rig's seven years without a serious accident.

What unfolded over the next few hours could almost have been written as a treatise in the science of industrial accidents. As with the Three Mile Island nuclear plant partial core meltdown in 1979, the chemical leak in Bhopal, India, in 1984, the space shuttle *Challenger* disintegration in 1986 and the Chernobyl nuclear plant explosions and fire that same year, there is never one mistake or one malfunctioning piece of hardware to blame. Instead, the Horizon disaster resulted from many human and technical failings in a risk-taking corporation that operated in an industry with ineffective regulatory oversight. By the time the blowout came, it was almost inevitable. "It's clear that the problem is not technology, but people," says Robert Bea, an engineering professor at the University of California–Berkeley. "It was a chain of important errors made by people in critical situations involving complex technological and organization systems."

Bea and other engineers subject catastrophes like Deepwater Horizon to the science of failure analysis for good reason: Studying industrial disasters can lead to understanding the root causes behind every accident, which is the critical first step toward improving safety and preventing future big bangs. If we learn from mistakes, failure can drive innovation, both technical and organizational. "A lot of intelligence came out of Three Mile Island," says Larry Foulke, former president of the American Nuclear Society and an adjunct professor at the University of Pittsburgh, knowledge that led to improvements like better control-room ergonomics and the standardization and accreditation of industry-wide training programs. Since Three Mile Island, there has not been another major accident in the U.S. nuclear industry.

The following lessons drawn from forensic engineering should spur changes in the oil industry and government agen-

cies that will lead to better risk assessment, more useful regulatory oversight, safer operating procedures and rapid crisis response. The blowout was a punishing lesson: 11 workers were killed and 17 injured in the accident itself. The resulting oil spill damaged the economy and environment of the entire Gulf Coast. But out of this calamity can come changes that will reduce the chances of such a tragedy occurring again, not just in deepwater drilling but in other high-tech, high-risk industries as well.

Success Breeds Complacency

A SIMPLE BUT COUNTERINTUITIVE fact led to the Horizon disaster: Wells, even ones drilled in deep water, had worked most of the time, just as the space shuttle and chemical and nuclear plants had functioned successfully, in some cases for decades. Although underwater drilling is complex and challenging, there are 3423 active wells in the Gulf of Mexico, 25 in water deeper than 1000 feet. Seven months before the blowout and about 250 miles southeast of Houston, the Horizon had drilled the world's deepest well—an astounding 35,055 feet.

What was impossible just a few years earlier had become seemingly routine as BP and Transocean banged out record firsts on the farthest frontiers of tech-

WHAT LED TO THE BLOWOUT

British Petroleum (BP) leases drilling rigs owned by Swiss-based Transocean to tap a hydrocarbon formation called the Macondo Prospect 52 miles southeast of Venice, La. The Macondo is 13,000 feet beneath the ocean floor in water 5000 feet deep. The potential yield is 100 million barrels—a midsize field. BP wants to complete the job in 51 days.

Oct. 7, 2009

BP begins drilling the well on a 5700-acre plot leased in 2008 for \$34 million. But the rig, Marianas, is damaged during Hurricane Ida and towed to a shipyard for repairs. It will take three months for its replacement, Deepwater Horizon, to start drilling.

Feb. 6, 2010

Horizon commences operations at the Macondo. Workers hurry to keep on schedule, bumping up the speed of drilling. Soon, the increased rate fractures the well bore, and gas begins to seep in. Engineers seal the bottom 2000 feet and reroute the well. The delay costs two weeks.

Mid-March

Transocean chief electronics technician Mike Williams asks senior subsea supervisor Mark Hay why he set the control-panel system to bypass its gas-shutdown function. According to Williams, Hay says, "The entire fleet runs them in bypass." A year earlier Williams noted that the rig's

general alarm and indicator lights were set to "inhibited," so they don't automatically trip when gas or fire is detected. In March, he also sees a worker holding chunks of rubber from the well—pieces of the crucial annular valve on the blowout preventer (BOP), a stack of safety valves atop the well. According to Williams, Hay says, "That's normal."

nology and geography. The same offshore techniques and equipment that worked in shallow hydrocarbon formations seemed to function fine at ever greater depths and higher pressures. The offshore rush was on, and nothing was going to stop it. "When you think you've got a robust system," says Henry Petroski, a professor of civil engineering at Duke University, "you tend to relax."

Other industries have lapsed into the same sense of false security. "By the time of Three Mile Island," Foulke says, "the nuclear industry had not had a major mishap in 25 years. When you get

an attitude that nothing bad happens, it leads you to believe that nothing ever will."

It's called hubris, and it set the stage for the Deepwater disaster. "In the event of an unanticipated blowout resulting in an oil spill," read the exploration plan that BP submitted on March 10, 2009, to the U.S. Department of the Interior's Minerals Management Service (MMS), which then managed and regulated offshore drilling, "it is unlikely to have an impact based on the industry-wide standards for using proven equipment and technology for such responses . . ."

That was nonsense. Although offshore blowouts occur frequently—there were 173 in the Gulf of Mexico alone from 1980 to 2008—there had never been one in deep water. In fact, neither BP nor any of its competitors had "proven equipment or technology" or any backup plan for a catastrophic failure

MACONDO PROSPECT WELL

March 30, 10:54 am

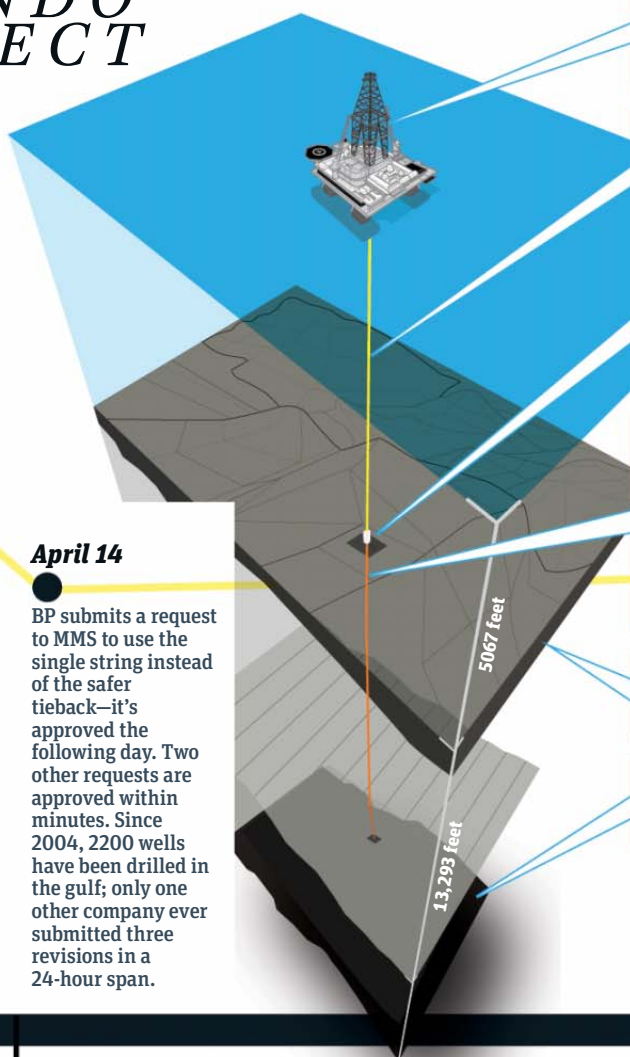
BP engineer Brian Morel e-mails a colleague to discuss using a 7-inch-diameter "single string" of casing down the inside of the segmented steel that extends from the wellhead to the well bottom. A safer option: a liner/tieback, which provides more barriers to gas flowing up the well. Morel notes: "Not running the tieback saves a good deal of time/money." But with a liner, says Ford Brett, a longtime oil engineer, "the well would have been much more fault-tolerant."

April 9

BP well site leader Ronald Sepulvado reports a leak in one of the BOP's control pods, which receive electronic shutdown signals from the rig and activate hydraulic rams to seal the well in an emergency. BP is supposed to notify the federal Minerals Management Service (MMS) and suspend drilling until the pod is operable. Instead, the company puts the malfunctioning pod in "neutral" to prevent leaks and continues drilling. It does not notify the MMS.

April 14

BP submits a request to MMS to use the single string instead of the safer tieback—it's approved the following day. Two other requests are approved within minutes. Since 2004, 2200 wells have been drilled in the gulf; only one other company ever submitted three revisions in a 24-hour span.



PLATFORM:

Deepwater Horizon semisubmersible oil drilling rig.

RISER:

Pipe that serves as conduit for drill string between rig and blowout preventer on seafloor.

BLOWOUT PREVENTER:

Stack of heavy valves on ocean floor that stops gushers by closing off well.

DRILL PIPE:

Jointed steel tube that connects rig equipment with drill bit in well bore; conduit for mud pumped into well for lubrication and pay-zone pressure containment.

FORMATIONS:

Layers of rock through which the drill string bores.

PAY ZONE:

Rock stratum containing oil and natural gas.

Deepwater Horizon burned for a day and a half



before sinking in the Gulf of Mexico on April 22.

at great depth. “The industry has not developed an oil spill plan for the low-probability, high-consequence event when everything fails,” says Greg McCormack, director of the Petroleum Extension Service at the University of Texas.

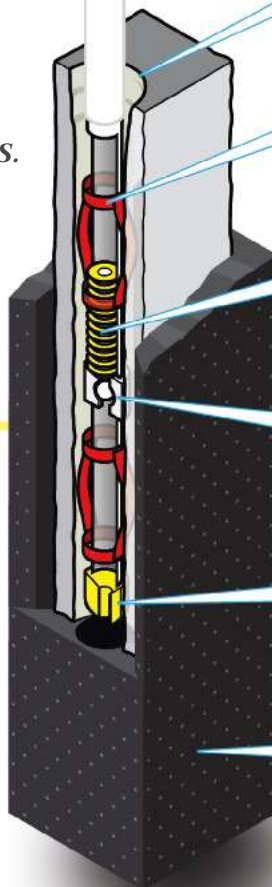
Promoters Can’t Be Enforcers

OIL AND GAS LEASES ARE THE federal government’s second largest source of revenue, after income taxes. Before the blowout, the responsibility for leasing federal mineral rights and collecting revenue from those leases belonged to the MMS. The MMS clearly placed its mandate to promote drilling ahead of its role as a safety cop. (After the disaster, the Interior Department disbanded the service and created the Bureau of Ocean Energy Management, Regulation and Enforcement, with an investigative arm to root out misconduct

and complacency.) In the MMS era, oil companies were referred to as partners, and MMS officials routinely received cash bonuses for meeting federal deadlines for offshore leasing. Although the Bureau of Land Management has a similar relationship with the oil industry, says Jeff Ruch, executive director of Public Employees for Environmental Responsibility, the consequences of a blowout on shore are much less severe. “The roots of the MMS,” Ruch says, “were to facilitate the work of its partners and to collect revenue—

TOTAL DEPTH

AT THE WELL’S BASE, CEMENT SLURRY IS PUMPED OUT THE CASING AND UP THE OUTSIDE TO PROTECT THE WELL AND PREVENT LEAKS.



CASING: Threaded steel pipe ensures integrity of well bore against thousands of psi from the surrounding formation. At the Macondo, the final casing segment was 7 inches in diameter.

ANNULUS: Space between casing and well bore wall.

CENTRALIZER: Bow-springed tool that centers casing in well bore to ensure even cement sheath.

CEMENTING PLUGS: Rubber plugs inside casing that separate cement slurry from other fluids to reduce contamination.

FLOAT COLLAR: Flapper valve that protects against the “U-tube” effect—flow-back of cement slurry when pumping ends.

GUIDE SHOE: Bullet-shaped steel component that directs casing to center of well bore.

PAY ZONE: When production begins, cement and casing are perforated—often with charges from perforating gun—allowing oil and gas to flow into well.

April 15,
3:35 pm

Halliburton’s Jesse Gagliano e-mails BP to recommend using 21 centralizers—collars that center the casing in the well to ensure an even cement job. BP eventually installs six. BP well team leader John Guide later testifies that the centralizers were wrong for the job. “Why couldn’t you wait to get the right centralizers?” a lawyer asks. “[It] never came up,” he replies.

April 15

The crew finishes drilling and plans to circulate fresh mud through the well and bring used mud from the bottom up to the rig. This cleans out gas bubbles and debris that can weaken the cement that will later seal the annulus. For the Macondo, this “bottoms up” should take 12 hours. BP overrides its operations plan and later cycles mud for 30 minutes.

Mid-April

A BP plan review recommends against the single string, which would create “an open annulus to the wellhead”—the annulus is the space between the steel casing and the formation wall—and make the BOP the “only barrier” to gas flow if the cement job failed. Despite this warning, BP decides to install the single string.

and the national policy was to increase revenue.”

Just 60 MMS inspectors oversaw rigs in the gulf. They examined oil spill response plans that were often boilerplate reproductions from one well to another. BP’s response plan for the gulf referenced seals and walrus, which aren’t found in that body of water, referred to a home-shopping network in Japan and listed scientists who were dead. No one noticed. The inspectors, Ruch says, “just made sure the companies checked the right boxes.” Since much of the drilling data necessary to complete environmental reviews was proprietary, MMS scientists were not allowed access to exploration and drilling details. When BP made repeated last-

minute changes to its drilling plan in the days before the blowout, the MMS approved them all, often within minutes. “That’s what happens,” Ruch says, “when the government is dependent upon industry for its expertise.”

A Cowboy Culture

FOR YEARS BP HAD PRIDED ITSELF on taking high-risk jobs in politically sensitive countries such as Angola and

BLOWOUT PREVENTER

THE BOP IS A 50-FOOT-HIGH STACK OF VALVES THAT CLOSES A RUN-AWAY WELL. FOR REASONS STILL UNKNOWN, THIS LAST LINE OF DEFENSE FAILED TO DEPLOY AT THE MACONDO.

SHEAR RAM: The last resort—interlocking steel blades that slam through the drill pipe and choke off a flowing well.

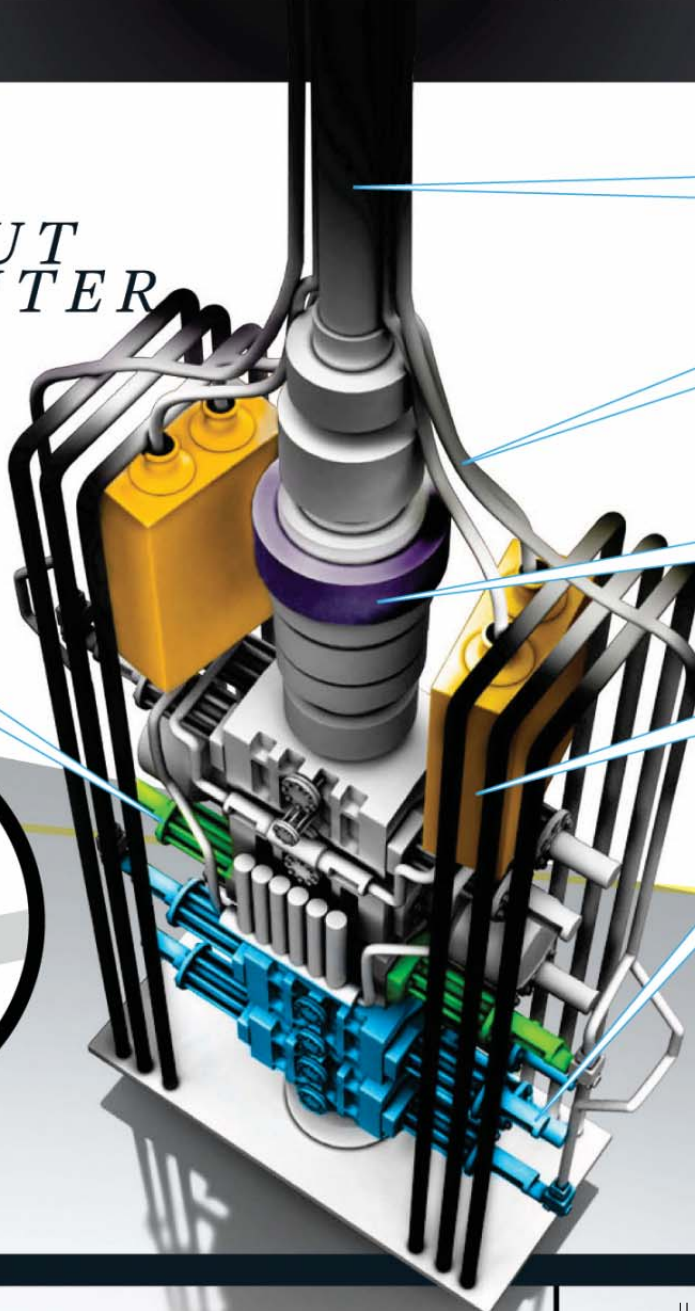
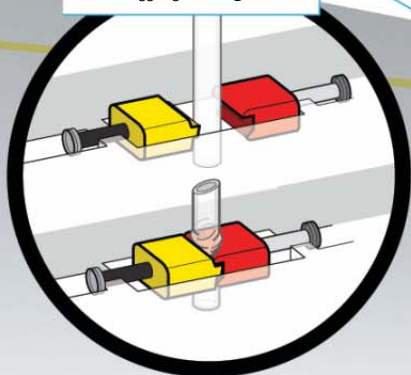
RISER: Connects rig to BOP, carrying drilling mud—and other fluids—from well bore back to the surface.

KILL/CHOKE LINES: Pressurized metal pipes extending from BOP along the riser to the surface that regulate shifting pressures of drilling fluid inside well bore.

ANNULAR PREVENTERS: Large valves, like rubber donuts, at top of BOP that seal open space around drill pipe.

CONTROL PODS: Receive electronic signals from rig and activate BOP’s hydraulic rams.

PIPE RAMS: Horizontally opposed rams that clamp onto drill pipe in an emergency, sealing annular space inside BOP but leaving pipe intact.



Azerbaijan and for pushing the limits of technology in the remotest reaches of Alaska and the deepest waters of the Gulf of Mexico—"the tough stuff that others cannot or choose not to do," according to former BP chief executive officer Tony Hayward. Within the industry, the company was notorious for its cavalier approach to safety. According to the Center for Public Integrity, from June 2007 to February 2010, BP's refineries in Texas City, Texas, and Toledo, Ohio, accounted for 829 of 851 industry-wide safety violations identified as "willful" by the Occupational Safety and Health Administration (OSHA). These were refineries, not oil rigs, but they demonstrate what OSHA describes as "plain indifference to . . . employee safety and health."

And Deepwater was not BP's first significant spill. In 2007, BP Products North America paid a criminal fine of more than \$60 million for violating federal environmental regulations in Texas and Alaska, including a 2006 spill on the North Slope of Alaska that resulted from BP's failure to address pipeline corrosion. The 200,000 gallons of crude that spread across the tundra formed the largest spill on the North Slope. Here's how Steve Arendt, a vice president of ABS Consulting and an industry expert who worked with the Chemical Safety Board's investigation panel on BP's 2005 Texas City refinery fire, describes the BP corporate culture: "'We have the matter in hand.' It might be a northern European cultural thing, but BP was convinced that the Texas City accident was a one-off, rather than something systemic and pervasive. They were arrogant and proud of the systems they had in place. They were in denial."

Executives of other oil companies told Congress that BP's well plans were outside industry norms. "It certainly appears that **not all** the standards that we would recommend or that we would employ were in place," said John S. Watson, chairman of Chevron. Marvin E. Odum, president of Shell, concurred: "It's not a well that we would have drilled in that mechanical setup."

The MMS had implemented a voluntary safety and environmental management program for the offshore industry.

In 2009, when the MMS tried to make the program mandatory, much like the OSHA regulations that govern onshore drilling, the industry objected so vigorously that the program died. "The regulations are fine as they stand," says Terry Barr, a Lakewood, Colo.-based petroleum geologist who has spent over 30 years in the oil and gas industries. "But there's an honor system—and this is where the industry is so unhappy with BP. When you send your paperwork to MMS, that's a recipe for what you're going to do, and you have to honor that. And 99 percent of the time, people follow what they say they are going to do. That was not the case in this well."

Blowing on the Dice

OIL AND METHANE GAS IN DEEP GEOLOGICAL formations are under tremendous pressure—insert a straw and up they shoot. The deeper the well, the higher the pressure, more than 9000 psi in wells 20,000 feet deep. During drilling, mineral-weighted mud pumped down the well lubricates the drill string and flushes rock chips to the surface. Most importantly, the dense mud's hydrostatic pressure keeps the fluids in the formation in check. Mud is, in fact, the primary line of defense against a blowout.

If oil, gas or water enters the well during drilling because mud weight is too low, the well is said to "kick." (Transocean testified before Congress that the Macondo well had kicked several times.) If the well is fractured or the cement bond between the casing protecting the drill string and the rock wall of the well isn't tight, gas bubbles can roar up the drill string or the outside of the casing and reenter the casing at its overlapping joints. Even if the methane doesn't come to the surface, it can "push the mud into the formation" with such power it fractures the hole and creates a leak, says Philip Johnson, professor of civil engineering at the University of Alabama.

What happened on the Horizon falls into the category of low-probability, high-consequence events that author Nassim Nicholas Taleb dubbed black swans—a common term in the

**April 20,
12:35 am**

Workers pump cement slurry down the casing, then use mud to push it out the bottom and 1000 feet up the annulus, to comply with MMS regulations for sealing a hydrocarbon-bearing zone.

Halliburton, the cement contractor, uses nitrogen-charged cement, which bonds strongly with rock but requires extra care and handling. If gas bubbles work into the wet cement, they can form channels that allow oil, gas or water to leak into the well.

**April 20, 1:00
am–2:30 pm**

Halliburton conducts three positive-pressure tests—increasing pressure inside the well to check that the cement seals hold—during the morning and afternoon. All are successful.

**April 20,
11:15 am**

Contractors brought to the rig to conduct a 12-hour cement bond log, which uses acoustic waves to test the seals, are sent home. "It was a huge error," says Satish Nagarajaiah, an engineering professor at Rice. "That's when they lost control of the well."

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Middle Ages for an impossibility, since at the time all swans were thought to be white. “The human perception of risk is an affective, subjective business,” says David Ropeik, an instructor at Harvard and author of *How Risky Is It, Really? Why Our Fears Don’t Always Match the Facts*. A classic black swan was the Chernobyl nuclear disaster in the Soviet Union in 1986. The reactor had no containment dome—engineers deemed the safety feature unnecessary because a meltdown was simply thought to be so unlikely. The design flaw, compounded by operator error, poor training and a lax attitude toward safety, contributed to an explosion that released widespread nuclear radiation. “Assessing risk is not a fact-based process of clear reason,” Ropeik says, “and subjective feelings always play a larger role than the facts.”

Neither the oil industry nor the MMS addressed the added risks of drilling in ever more challenging environments. “There was a lack of a sense of vulnerability within the industry,” says safety expert Arendt. “The gulf was one of the last cowboy environments, and the industry was blinded by its good performance.” Robert Bea adds: “Because BP and the MMS believed that the potential consequences were ‘insignificant,’ they were not prepared for the failures associated with the Deepwater Horizon’s operations, both in prevention and containment.”

Normalization of Deviance

AT THE ROOT OF BP’S CHOICES WAS WHAT BEA CALLS the normalization of deviance. The company had long grown used to operating at the margins of safety. It regarded red flags as normal, and those red flags cropped up repeatedly on the Macondo well, with the frequency accelerating in the four days before the blowout.

A series of delays added to the pressure on managers to ignore warning signs. Though drilling had begun on Oct. 7, 2009, using a different rig, the Marianas, that rig was damaged in a November hurricane. It took three months to bring in the Horizon and resume drilling. The well was scheduled

Two days after the blowout, a robot sub

for 78 days at a cost of \$96 million, but the real target was 51 days. BP urged speed. Mike Williams, Transocean’s chief electronics technician, told CBS’s *60 Minutes* that he heard a BP manager saying, “Let’s bump it up, let’s bump it up.” But in early March that increased drilling speed fractured the well, forcing workers to backtrack 2000 feet from the then-13,000-foot hole, plug the cracked section with cement, and carve a new path to the hydrocarbon-bearing formation, or pay zone. “Operations were faster and cheaper,” Bea says, “but not better—the operation records clearly show excessive economic and schedule pressures resulting in compromises in quality and reliability.”

Those compromises began piling up on April 9, when the well reached its final depth of 18,360 feet below the rig—1192 feet below the last cemented steel casing. A well is drilled in sections: Roughnecks bore through rock, install casing to line the hole, pour cement into the gap between the casing and the surrounding rock, and repeat the process with ever-narrower casing. To secure that final section, BP had two options: Run a single string of casing from the wellhead to the well bottom, or hang a liner from the last section of casing already installed and cemented, and

**April 20,
5:05 pm**

A loss of riser fluid signals that the annular preventer is leaking. Soon after, the crew runs a negative-pressure test on the drill pipe, during which they reduce fluid pressure in the well and watch to see if

hydrocarbons force their way through the cement or casing. The results suggest a possible breach, and a second test is ordered. Typically, before a test, workers install a lockdown sleeve to secure the top of the well casing to the BOP; in this case, BP does not.

**April 20,
6:45 pm**

The second negative-pressure test confirms the findings, this time by measuring pressure readings on the multiple pipes

that run between the rig and the BOP. The test shows 1400 psi of pressure on the drill pipe but 0 psi on the other pipes, suggesting that an influx of gas is raising pressure in the well bore.

**April 20,
7:55 pm**

Even with the test results, BP orders Transocean to replace drilling mud (14.0 pounds per gallon) from the riser and top of the casing with seawater (8.6 ppg) and, at the same time, add a cement

plug to the well 3000 feet below the ocean floor (mud line). This simultaneous operation is risky: If the cement plug doesn’t seal the well, mud becomes the first defense against a blowout. BP’s own investigator later calls the decision a “fundamental mistake.”

attempts to seal the runaway Macondo well.

DEEPWATER HORIZON BOP

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Dep
Alt

DEEPWATER HORIZON

MUD PIT: Waves of gas overspeed the diesel engines in the drilling area and find a spark. Six men in the pit and nearby shaker room perish.

DERRICK: A 240-foot geyser of gas and seawater shoots through the derrick, engulfing surrounding areas. Gas settles to the rig floor, which is engulfed in flames.

BALLAST TANK: The initial explosions on April 20 damaged the ballast-control system, causing the rig to list, then sink on April 22.

RIG FLOOR: Moments before the blast, four crew members pump drilling fluid from the mud pit into the well, trying to regain control. All four are killed.

April 20, 8:35 pm

Workers pump in 900 gallons of seawater per minute to flush the riser—but the flow rate of mud coming out jumps to 1200 gallons per minute. “It’s simple math,” petroleum geologist Terry Barr says. “They should have said, ‘The well’s flowing. Put the mud back in the hole. Kill it.’” The crew pumps more seawater.

April 20, 9:08 pm

Workers shut down the rig’s seawater pump for an EPA-mandated “sheen test” to determine if oil is floating on the water; it is not. With the pump off, the well continues to flow, increasing casing pressure from 1017 to 1263 psi. Over the next half-hour, pressure builds—and workers stop pumping water.

April 20, 9:47 pm

The well blows. Highly pressurized gas shoots through the BOP and up the riser to the rig. A 240-foot geyser gushes from the top of the derrick, followed by icy slush “steaming” with

evaporating methane. The “inhibited” general alarm means workers on the rig floor have no warning for what’s to come. The bypassed control-panel shutdown system, which is designed to stop the engines in the drilling shack, fails to trip.

then slide in a second steel liner tube called a liner/tieback. The tieback option cost \$7 million to \$10 million more than the single string, but it was far less risky, providing double barriers to gas flowing up the outside of the pipe. According to Congressional investigators, an internal BP document that appears to date from mid-April recommended against single string casing. Nevertheless, on April 15 the MMS approved BP’s request to amend its permit application, which claimed that using the single string made “the best economic case.”

Although single strings are common in shallow water, they are rarely used in deepwater exploration wells like the Macondo where high pressures exist and the geologic formation is not well known. A *Wall Street Journal* investigation found that BP used the cheaper, riskier single string method in the gulf far more than other operators.

As casing is lowered, metal collars called centralizers position the pipe in the middle of the well bore to ensure an even cement job that contains no spaces where gas can squeeze through. On April 15, BP informed Halliburton’s account representative, Jesse Gagliano, that BP was planning to use six centralizers on the final 1192 feet of casing string. Gagliano ran a computer analysis of a number of cement-design scenarios to determine how many centralizers would be necessary: He found that 10 would result in a “MODERATE” gas flow problem; 21 would reduce the potential gas flow problem to “MINOR.” Gagliano recommended that BP use 21 centralizers. Gregory Walz, BP’s drilling engineering team leader, wrote to John Guide, BP’s well team leader: “We have located 15 Weatherford centralizers with stop collars . . . in Houston and worked things out with the rig to be able to fly them out in the morning . . . We need to honor the modeling to be consistent with our previous decisions to go with the long string.”

Guide objected: “It will take 10 hrs to install them . . . I do not like this and . . . I [am] very concerned about using them.” On April 16, Brett Cocalis, BP’s operations drilling engineer, e-mailed

Brian Morel, another BP drilling engineer: “But, who cares, it’s done, end of story, will probably be fine and we’ll get a good cement job . . . So Guide is right on the risk/reward equation.”

On April 17, BP informed Gagliano that it had decided to use only six centralizers. Gagliano then ran a model based on seven centralizers and reported to BP on April 18 that the “well is considered to have a SEVERE gas flow problem.” If BP installed the additional centralizers, it would cost an estimated \$41,000 per hour for the completion delay. BP went with the six centralizers.

After a well is cemented, drillers routinely run a cement bond log, an acoustic test that measures how well the cement has bonded to the casing and surrounding formation. On April 18 a crew from oil services contractor Schlumberger flew out to the rig to perform the test. But BP told the crew it wasn’t needed and flew them off the rig on the morning of April 20. Gordon Aaker Jr., a failure analysis consultant with the firm Engineering Services, told the House committee investigating the blowout that it was “unheard of” not to

perform this routine test on a single casing well. He called BP’s decision to skip the cement bond log “horribly negligent.” BP did not respond to requests for comment.

Shifting the Burden of Proof

THE EVENTS OF THE WEEK PRECEDING THE BLOWOUT point to what Allan J. McDonald, author of *Truth, Lies and O-Rings: Inside the Space Shuttle Challenger Disaster*, calls switching the burden of proof, a reversal that leads to a kind of bureaucratic illusion. The closest analogy is the space shuttle, a system so complex and dangerous that a coldly factual analysis would show the spacecraft presented a risk almost too high to tolerate. During the *Challenger* accident investigation, the physicist Richard Feynman asked NASA for its failure rate. The answer: one in 100,000. Feynman was incredulous, pointing out that this meant a shuttle launch every day for 300 years with only a single mishap, when the demonstrated failure rate was between one in 25 and one in 60. “NASA’s figures were totally baseless,” McDonald says, “and were just backed into as a number that was acceptable to Congress.”

McDonald, who is the former director of Morton-Thiokol’s space shuttle solid-rocket-motor project, says that the company’s engineers knew there was a problem with the shuttle boosters’ O-rings. The seals, which kept blistering gases from escaping the motors, could turn brittle and leak in temperatures below 53 degrees Fahrenheit. On the morning of Jan. 28, 1986, the temperature in Cape Canaveral was 36 degrees.

But the company managers pressed forward—the mission had already been postponed six times because of weather and mechanical problems—and engineers were left having to prove the components would fail. “It’s a trap,” McDonald says. “Is it safe enough to fly? is the correct question, not that you have to prove it will fail. If you can’t prove that it will fail, then there will be zero failure rate!” If a system never fails, he explains, then why bother spending time and money on safety? That inversion of logic “changes the burden of proof, and that is a fatal mistake.” Thiokol’s engineers ultimately relented. The shuttle broke apart 73 seconds after launch.

By the time Halliburton’s Gagliano ran his models about gas flow and centralizers for the Macondo well, everyone but the drilling engineers was operating in a haze of justification and rationalization. Gagliano showed there might be gas leaks, and gas leaks increase the risk of a blowout. But the models didn’t *prove* that a blowout would occur.

Deepwater wells have one final line of defense: the blowout preventer (BOP), a five-story tower of valves atop the well bore that can, in principle, lock down and shut off a runaway well. The Macondo BOP, however, was severely compromised. One of its pipe rams—horizontally opposed plates that clamp around the drill pipe to block methane and fluids rising through the BOP—had been swapped out for an inoperable test version. The conversion is common in the industry, decreasing testing and operation costs but increasing risk.

Investigators also found that one of the BOP’s control pods had a dead battery, making it unable to receive the

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April 22,
3:11 pm

By now the Deepwater Horizon has been burning for more than 40 hours and listing for the past 33 because of damage to the rig’s ballast-control system. As the platform begins to sink, the riser attached to the BOP breaks. Fifteen minutes later, the rig is fully submerged. Coast Guard crewmen report “fire is still coming from the water.” The disaster on the drilling platform is over, but the worst offshore oil spill in U.S. history is just beginning.

April 20,
9:49 pm

Gas seeps through ducts into the mud pit, where a pair of engineers are responding to a frantic call for more mud to control the well. The engines suck in gas through their air intakes and overspeed. Engine No. 3 explodes, triggering an eruption that rocks the rig. The two engineers are killed instantly, along with four others in the adjacent shaker room. Five other workers also perish.

April 20,
9:56 pm

A worker on the bridge hits the Emergency Disconnect System to activate the BOP’s shear rams and seal the well. The rams don’t work. A battery on the BOP is supposed to power a deadman’s switch to trigger the rams if communication, hydraulic and power lines are severed. Because hydraulic lines were later found intact, BP believes the switch did not activate. Rig officers order an abandon ship.



THE



The shadow of the legendary video-game character Master Chief looms over *Halo: Reach*'s executive producer Joseph Tung and creative director Marcus Lehto. Photographed at Bungie Studios, Kirkland, Wash.

HALO EFFECT

> THE CREATORS OF A SEMINAL VIDEO-GAME SERIES ARE MAKING ONE FINAL EPISODE. IF THEY CAN MAKE IT TO ZERO-BUG RELEASE, THE GAME MAY PLAY FOR A LIFETIME.

BY ERIK SOFGE

THE HUMANS ARE LOSING. In a sprawling industrial site, a mix of open, dust-swept killing fields, claustrophobic hallways and obstacle-laden vehicle bays, 8-foot-tall mandibled aliens are cutting down team after team of *Homo sapiens* soldiers. Those aliens, called Elites, are not only larger than their opponents, they also possess force fields and advanced beam weapons that emit crackling blue and red plasma bolts. The Elites are among the toughest of the Covenant, a confederacy of alien species united under the banner of religious fanaticism and galaxy-spanning war.

But the humans who are fighting—and losing—are elite in their own right, cybernetic supersoldiers called Spartans. These commandos are decked out in their own force fields, which radiate from strength-enhancing powered armor. In the brutal calculus of this particular conflict, the aliens

PHOTOGRAPH BY ART STREIBER

POPULARMECHANICS.COM **89**



are stronger, but they should also catch more bullets and shrapnel from rockets and grenades. This is supposed to be a fair fight.

In the Kirkland, Wash., offices of Bungie, the studio behind the blockbuster series of *Halo* games, developers watch as thousands of these fights play out unequally. “We have heat maps that show, based on color, where people are dying a lot,” says Joseph Tung, *Halo*’s executive producer. “We can see which weapons are being used, how many deaths are occurring with each particular weapon. We mine quite a lot of hard data.” And the numbers spilling across computer monitors in Bungie’s converted supermarket headquarters are damning. It is mid-May 2010, and a week earlier Bungie had launched a free beta version of its upcoming Xbox 360 game, *Halo: Reach*. Since then, millions of players around the world have been putting the unfinished product through its paces on Microsoft’s online network, Xbox LIVE. In a game mode called Invasion Slayer, in which two teams of up to six players—one side alien, the other human—face off until one team scores enough total kills, the Elites are winning 60 percent of the time. A mere 10 percent discrepancy, but for the most anticipated game in the world, it’s a disaster. It points to the existence of an “exploit” that favors the Elites. Left unchecked, the exploit would send stat-obsessed players to blogs and online message boards until the only people left playing Spartans would be suicidal, uninformed or stubbornly loyal to the human race.

Halo: Reach is Bungie’s final installment in a series that changed the gaming industry and barged its way into pop culture (although Microsoft, which owns the franchise, can produce more *Halo* games). Collectively, the *Halo* games have sold more than 27 million copies and have almost single-handedly established Microsoft’s Xbox as the video-game console of choice for serious gamers. Fan dedication to the franchise is legendary. And the games have made Microsoft a fortune. *Halo 3*, the last full game in the series, raked in more than \$170 million in its first day of release. That’s more than double the highest-grossing single day for a movie—\$72.7 million for *Twilight: New Moon*, in November 2009. So Bungie’s final game is understandably a big deal.

Halo’s plot has always been a bit convoluted: There’s an interstellar civil war going on between factions of the Covenant, and humans are caught in the middle. Huge galactic weapons of mass destruction called Halos threaten entire civilizations. Players inhabit the body of a messianic supersoldier named Master Chief, who fights back against the aliens to ensure the survival of humanity. *Reach* is a bit of a risk, plot-wise, for Bungie. It’s a prequel, with no Master Chief as a central character. And it’s a tragedy—the team of Spartans are defending the planet Reach against a Covenant assault in the year 2552, and true to their namesakes, the Spartans are making a heroic last stand. The end of the game is clear from the beginning. *Reach* is going to be destroyed—



“THIS GAME IS DARKER THAN THE OTHERS,” LEHTO SAYS. “THE ALIENS NEEDED TO BE VILLAINS AGAIN.”

and all of its human inhabitants are going with it.

The enemies in *Reach* have also taken a turn for the malevolent. Creative director Marcus Lehto, who has been with Bungie from the start, asked the *Reach* team to revamp the Covenant, replacing their bursts of English dialogue (much of it intended as comic relief) with guttural alien-speak and giving their weapons a more sinister look and feel. “We needed the Covenant to be mean and terrifying,” Lehto says. “This game is darker than the others. They needed to be the villains again.”

But the dirty little secret to *Halo* is that its characters and plot were never the main reason for its addictive appeal. Sure, the environments and art direction are stunning, but what’s given the series lasting impact is its online game engine, which allows players from around the world to battle it out in teams, play capture the flag or engage in a free-for-all slaughterfest with every

virtual soldier for himself. In an industry in which online combat is the current coin of the realm (every title from *Call of Duty: Modern Warfare 2* to *FarmVille* has some form of networked gameplay), it’s easy to forget that this wasn’t always the norm. In fact, Bungie popularized the idea in *Halo 2*, the first mass-market game to take full advantage of the Xbox’s Internet connectivity.

And few game developers know how to attract dedicated players like Bungie does. Tung, who joined the company toward the end of *Halo 2*’s development, pointed out that since its release in 2004, *Halo 2* has remained one of the top-played games on Xbox Live. That ended earlier this year, when Microsoft pulled the plug on online play for original Xbox titles. But *Halo 2* players wouldn’t let go, refusing to shut their consoles down after the designated cutoff and forcing Bungie to keep its servers on for an additional 26 days. Six years and one generation of hardware after launch, *Halo 2* was still an online hit.

THE CLOCK IS TICKING. Not audibly, but there is a clock, a wide, red, digital readout mounted on the balcony that overlooks most of the workstations in this eclectic office space. The clock displays the countdown, in days, hours, minutes and seconds, until ZBR, or Zero-Bug Release. When it hits zero, the game, while not quite ready to ship, must no longer be generating new bugs.

Battling those digital glitches is the final stage of a project that has lasted more than three years. Most of that time went into the



> CHOOSE YOUR OWN ADVENTURE

Halo: Reach aims to outgun its predecessors with an arsenal of new weapons and vehicles. Players can also engage their creative sides by customizing their Spartan soldiers' armor or by constructing environments to duel each other in. This battle-zone builder in *Halo: Reach* allows any player to create enormous and complex worlds that can be shared online, opening up potentially unlimited arenas for gameplay.



creation of interactive environments, visuals and programming of the engine—the core framework of code that forms the foundation for nearly everything else. But the closing stages of game development are always a frenzy of bug killing.

Finding those bugs is the point of the massive public beta release. During an 18-day period, 2.7 million players logged a total of 16 million testing hours and uploaded 1.3 terabytes of screen shots and videos of moments that were glorious, bizarre, buggy or all of the above. The sheer variety of potential glitches is staggering. Textures, light sources and objects can blink in and out of existence; computer-controlled characters might blithely ignore the bullets slamming into them; or the game may simply freeze up and go black. One of the more surreal challenges for Bungie coders was a King Kong-size monster, called a Mule, whose skeleton kept inexplicably popping out of its body as it stomped after Spartans. Now consider that every new action of the millions of players opens up the possibility of yet another previously undiscovered software error, and the scale of the task explodes exponentially.

"If you're making a movie, you can tailor the experience down to the smallest detail," says Sage Merrill, sandbox design lead, who oversees the interaction between players in multiplayer modes. "For us, there's no way we can test all the possible iterations of everything every player's going to do

and what's going to happen. It becomes sort of this living entity."

Eliminating errors is one thing, but getting the feel of gameplay right is another challenge altogether. To keep the game interesting, it must be not only polished but also fun to play—challenging without being intimidating for inexperienced players. Bungie engineers analyze a constant flow of raw data to fine-tune the engine, from larger trends to second-by-second analysis of exactly what kind of weapon a given player is using when he pulls off a streak of wins without dying.

RESPONDING TO THIS DATA requires a deft touch—each tweak can generate new bugs or trigger negative feedback. "We've learned through experience that if you change the rate of fire of a particular weapon in the tiniest way, you will annoy someone," Tung says. "There's always someone who

loved exactly how that weapon fired previously. The whole time you're moving multiplayer forward, you're asking, How do you preserve what was great about it?"

Which is why a 10 percent win discrepancy is such a challenge. Bungie developers can boost the capabilities of the Spartans or degrade the strength of the Elites by degrees, but each change must be made with extraordinary care to keep bugs at bay and players happy.

Still, Lehto and Tung maintain that the studio's foremost goal is to make a game that its staff wants to play. Clichéd as that may sound, Bungie is a demanding, detail-oriented tribe. To make a game worthy of the staff, the last of the bugs must be exterminated and the balance between man and alien must be resolved. So at the end of the day on a Friday, after a week that saw some developers working as many as 16 hours at a stretch, a group marches upstairs to annihilate one another in the only conference room that hasn't been annexed as an office. This is a tradition of sorts, the Friday-night play test. They're trying yet another custom-built mode pitting Elites against Spartans. And after spending years working on nothing but *Reach*, they're having a blast playing, of all things, *Reach*. A lucky grenade bounce or a one-in-a-million head shot evokes that universal *Halo* question: "Did you see that?!"

The ZBR clock is still ticking. It reads 18 days, 7 hours and 30 minutes. That's fewer than three weeks to turn 60 percent into a balanced 50, and to turn *Halo: Reach* into the industry-redefining masterpiece that everyone wants and expects it to be. There are still dozens of artists and programmers in their cubicles, working toward that goal. But upstairs, the conference room is howling. Maybe the Elites are still winning. Maybe not.

PM

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diy

Home

Master shed man Joseph Truini sets up a scaffold.

The Shed Shortcut

A VETERAN BUILDER TAKES A QUICK ROUTE TO A GREAT SHED WITH A PRECUT KIT. *BY JOSEPH TRUINI*

→ **For years**, there have been three ways to get a shed: Build it yourself, hire someone to build it or buy a prefab model. A new method—constructing a shed from a kit—combines the sweat equity of building from scratch with the simplicity of using factory-cut components. All that's required are basic tools and novice-level carpentry skills. It's like doing a jigsaw puzzle with instructions: Fasten the parts together in the right sequence, and *voilà*—a shed is born.

I teamed up with Connecticut carpenter Tim Law to build this shed from Better Barns (betterbarnsandsheds.com). The compact 6 x 8-foot building has red-

INSIDE

x

CURB APPEAL + BACKUP POWER + RATTLING PIPES

1



FOUNDATION

Shed kits typically don't include the foundation. We used 4-inch-thick solid-concrete blocks to support the 6 x 8-foot shed. Each block was set down on compacted soil, leveled in two directions and checked one against another. We shimmed up low blocks with 2-inch-thick concrete patio

blocks, cedar 1 x 8s or asphalt roof shingles.

We set the pressure-treated floor joists onto the mudsills and fastened their ends with 3½-inch-long nails. We used the plywood floor deck to frame the four shed walls, positioning the studs and rough openings for the windows and doors.

cedar vertical siding, two barn-sash windows and a transom window above double doors. This kit costs about \$4800, not including shipping. The small kit joins the company's eight stock kits ranging in size from 10 x 10 to 10 x 16 feet, and in price from about \$4300 to \$8300. They are all available with either pine or cedar siding.

Our shed came with everything except the concrete-block foundation, roof shingles and fasteners. It included plans, necessary to obtain a building permit. Local governments often have shed-specific forms detailing the rules for "auxiliary structures." The permit application fee is typically \$50 to \$100—and it's a lot smarter to pay up and follow the rules than to be penalized later.

Shed kits are structurally sound by design, so you shouldn't run into roadblocks. There are just two major details to get right. First, follow setback guidelines when you're deciding where to build. Second, choose the right kind of foundation. This will be dictated by the building's size. A frame of pressure-treated landscape timbers staked into the ground may be all that's required, or you may need to pour a concrete pad. In our case, the rules permitted a concrete-block foundation.

Tim and I built the foundation, then installed roofing and trim on the 6 x 8-foot shed in a day. The parts fit perfectly, and the finished kit was indistinguishable from a scratch-built custom shed. I packed up my tools and headed home feeling just a bit tired and sore, but proud of the building we'd left behind.



2

FRAMING

After framing each wall, we installed the tongue-and-groove vertical-board siding while the wall was still horizontal. This premium kit included red-cedar siding, but less expensive pine siding is also available.

We installed the

windowless sidewall first, tipping it up into place and then screwing down through the bottom plate and into the floor frame. Once the first two walls were screwed down, we slid the second sidewall into place. This

wall has two barn-sash windows, so we positioned it on the side with the best views. You need at least two people to put up a shed kit, and the work would go quicker with three or four people.

Some labor-saving shortcuts kept the work manageable. For instance, the front wall, framed for double doors, was

installed last. Before doing that, we assembled the roof trusses—the precut rafters and ceiling joists joined together with plywood gusset plates, which are glued and nailed across the joints. We then placed the two gable-end trusses on top of the sidewalls. That way, we didn't have to lift the heavy trusses up and over the walls.

3



ROOF TRUSSES

With two gable-end trusses propped between the side walls, we installed the front wall. We tipped and fastened the gable-end trusses and installed standard roof trusses in between.



4

ROOF SHINGLES

We used precut pieces of ½-inch exterior-grade plywood to sheathe the roof. The plywood is cut precisely to create a space along the roof peak for installing a ridge vent.

We then covered the shed roof with slate-gray architectural shingles, which we chose because they are much more attractive than standard three-tab shingles.



5

WINDOWS, DOORS

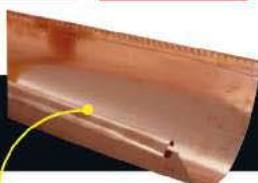
Our kit included sash windows on two walls and a transom window above the doors.

The transom is the kind of detail that's typically found only on custom-built sheds, not on prefab models. And the company supplied a pair of heavy-duty strap hinges to hang each swinging door. When considering a shed kit, remember that quality hardware is just as important as quality lumber.

SMALL JOBS

Toolshed Splurges

Classic, attractive, built-to-last exterior details can have an outsize visual impact, but their cost may be prohibitive when scaled to fit an entire house. Shrink the upgrades to a shed, though, and the costs are much less formidable. Here are four details that will add distinct character to an outbuilding, whether you are building a shed from scratch or assembling a kit.



COPPER GUTTERS Properly installed, a copper gutter can last 50 years. (Aluminum-gutter warranties typically last 20.) Half-round styles in 5- or 6-inch-diameter sizes cost about \$10 per linear foot, often sold in 10-foot sections.

WINDOW SHUTTERS Functional shutters aren't cheap, but on a shed with a

single large window, only one stately wooden pair is necessary. Consider Timberlane—with mortise-and-tenon joinery and hand-forged hardware, these shutters are the real deal. Match the iron tieback hardware (aka shutter dogs) to the shed's door hinges.

FLOWER BOXES Build window boxes of rot-resistant cedar or paint stock lumber with an exterior-grade acrylic. Build

the box in the shed and hang it outside as a test container for new plantings.

SPECIAL SHINGLES For a small roof, asphalt isn't the only economical option. Slate or copper shingles have old-fashioned appeal and a rich aesthetic. They also age well. As a modern option, new synthetic roof styles can offer a lifetime of performance. DaVinci Roofscapes pulls off a convincing replica of cedar shake and slate.

Classics:

Simple Do-It-Yourself Projects

Lean on Me

GETTING THE UPPER HAND ON CLUTTER WITH THE PM LADDER SHELF.

BY JOSEPH TRUINI

→ Informal. Versatile. Elegant.

That's the ladder shelf, a lightweight storage solution that's about as simple as it comes: two uprights and five shelves designed like trays. A ladder shelf can turn a room into a library, transform a cluttered corner into a home office or ease the chaos in a laundry room. Bang it together out of plywood and construction lumber and it suits a garage, workshop or utility room.

What I like best about this project is that it's so easy to build. An experienced person can tackle it in a weekend, a novice over the course of several days. The payoff is about 21 square feet of easily accessible storage space with a remarkably small footprint. Just fasten the shelf to a wall stud and you're ready to turn clutter into order.



FOLDOUT PLANS



Make the Uprights

➔ Each upright is a continuous piece of lumber with six spacer blocks glued and nailed to it. The shelves fit snugly between these blocks.

Cut 78-degree angles on the bottom of your uprights to allow them to lean against the wall [1]. At the top of these pieces, cut 12-degree angles, and then mark and cut the decorative curves [2].

Next, use a router and a $\frac{3}{8}$ -inch-radius cove bit to cut the cove on both front edges of the uprights and of the stock you're going to cut into spacer blocks [3]. Most of these blocks are 9 inches long, but the bottom blocks are 6 inches and the top ones on each side are 14 inches—those top pieces get the same curve as the uprights. Once that work is done, crosscut the blocks. Glue and nail them to the uprights using a piece of wood the width of your shelves as a spacer [4].



Build the Shelves



➔ Rip and crosscut the stock for the side and backsplashes of the shelves. Use a router and edge guide or a router table [5] to cut the grooves in these pieces to seat the shelf bottom. Finish the side splashes by cutting the 4-inch-radius curve on their fronts, and cut the eyebrow curve on each backsplash.

Next, rip and crosscut the bottoms. To assemble a shelf, squeeze glue into the

stopped groove in each side splash, push the shelf bottom into the groove [6] and nail through the side splash and into the bottom. Do the same on the opposite side, then slide the back on. Finally, use glue and brads to apply the front edging strip.

Next, prime, sand and apply two coats of paint to the pieces. But leave bare the gaps between the spacer blocks, where the shelves go.

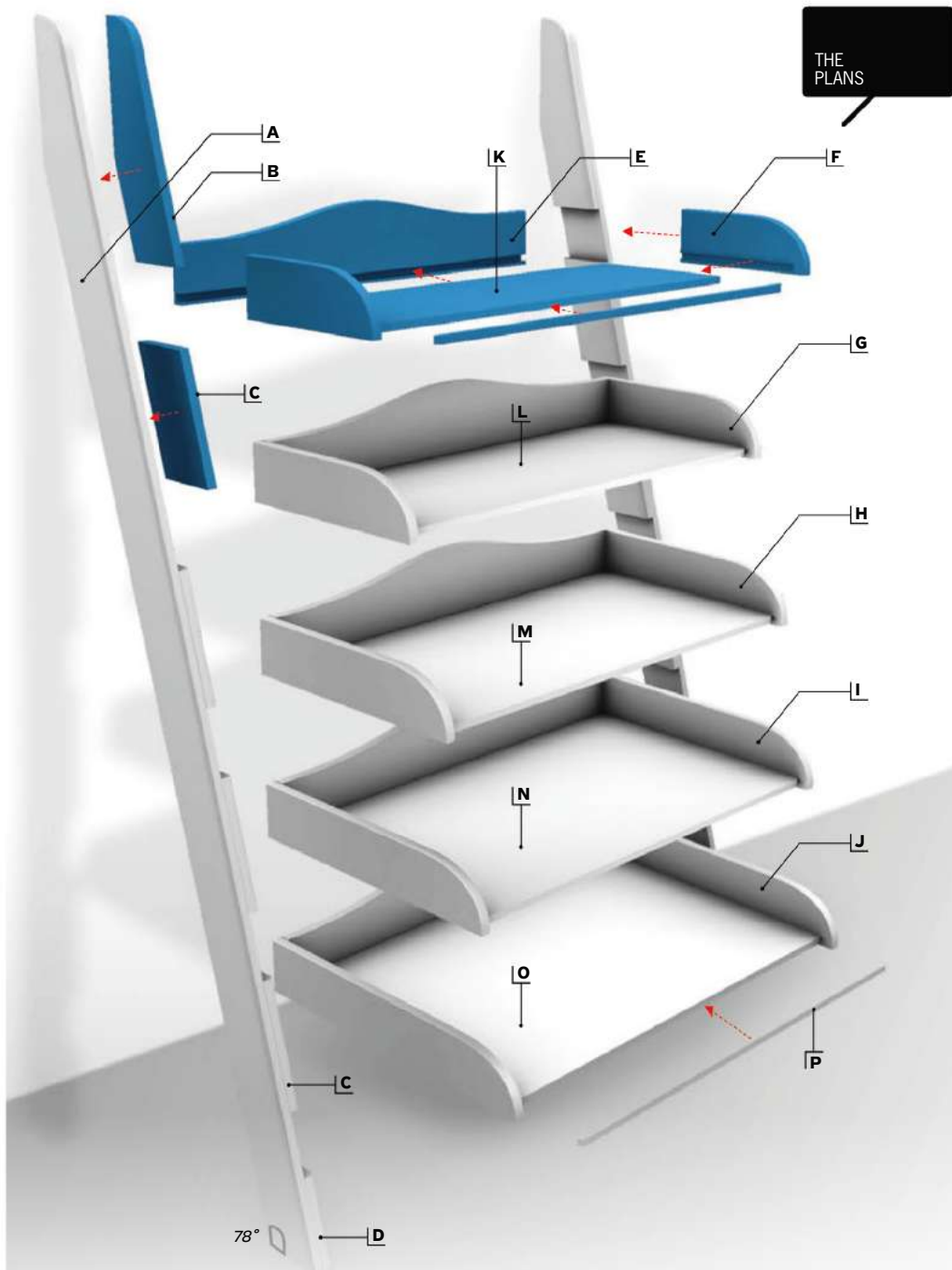


Join Shelves and Uprights

➔ To assemble the unit, lay an upright on the floor, and bore pilot holes through the inside of a side splash and into the side of the upright [7]. Turn this subassembly over and repeat the procedure for the opposite upright. Note that you should screw a $\frac{1}{2}$ -inch plywood spacer to the back of the top shelf to keep the shelves from touching the wall. That way, a bulge in the wall won't prevent the ladder

shelf from being fastened securely. Allow for this $\frac{1}{2}$ -inch spacer by offsetting the back of the top shelf $\frac{1}{2}$ inch from the back edge of the uprights. Align the lower shelves with the top shelf.

To install the unit, place it against the wall and check for level. Bore pilot holes through the back of the top shelf and into a wall stud. Drive in a pair of 3-inch drywall or trim-head screws. **PM**



Construction and Materials Notes:

Grooves: Each groove is $\frac{3}{8}$ inch deep by $\frac{1}{2}$ inch wide. Locate each $\frac{1}{4}$ inch from the bottom edges of the side splashes and backsplashes. Stop the grooves in the side splashes $\frac{5}{8}$ inch from the front edges.

Nails, Screws, Brads: Five $1\frac{1}{4}$ -inch finishing nails go through each top, bottom or spacer block into the uprights. Use three 2-inch finishing nails to nail each rear corner of a side splash to a backsplash.

As required: Hammer $1\frac{1}{4}$ -inch finishing nails through the side splashes into the shelf bottoms. Five $1\frac{1}{4}$ -inch flat-head screws go through each side splash into the upright.

As required: Use $\frac{3}{4}$ -inch brads for the edge banding on the shelves.

Misc.: You'll also need sandpaper, glue, primer and topcoat.

THE MEASUREMENTS

Key	No.	Size and Description (Use)	Key	No.	Size and Description (Use)
A	2	$\frac{3}{4}$ " x 4" x 76" poplar (upright)	I	2	$\frac{3}{4}$ " x 4" x 21" poplar (side splash)
B	2	$\frac{3}{4}$ " x 4" x 14" poplar (top block)	J	2	$\frac{3}{4}$ " x 4" x 24" poplar (side splash)
C	8	$\frac{3}{4}$ " x 4" x 9" poplar (spacer block)	K	1	$\frac{1}{2}$ " x $11\frac{3}{8}$ " x $33\frac{1}{4}$ " birch plywood (shelf bottom)
D	2	$\frac{3}{4}$ " x 4" x 6" poplar (bottom block)	L	1	$\frac{1}{2}$ " x $14\frac{3}{8}$ " x $33\frac{1}{4}$ " birch plywood (shelf bottom)
E	5	$\frac{3}{4}$ " x 6" x $32\frac{1}{2}$ " poplar (backsplash)	M	1	$\frac{1}{2}$ " x 17" x $33\frac{1}{4}$ " birch plywood (shelf bottom)
F	2	$\frac{3}{4}$ " x 4" x $12\frac{3}{8}$ " poplar (side splash)	N	1	$\frac{1}{2}$ " x 20" x $33\frac{1}{4}$ " birch plywood (shelf bottom)
G	2	$\frac{3}{4}$ " x 4" x $15\frac{3}{8}$ " poplar (side splash)	O	1	$\frac{1}{2}$ " x 23" x $33\frac{1}{4}$ " birch plywood (shelf bottom)
H	2	$\frac{3}{4}$ " x 4" x 18" poplar (side splash)	P	5	$\frac{3}{8}$ " x $\frac{3}{4}$ " x $32\frac{1}{2}$ " poplar (edging)



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Homeowners Clinic

by Roy Berendsohn

Q+A



Cold-Weather Curb Appeal

Last summer, we did a lot of landscaping and installed a new front door. The house looked good. Then, in September, I was away for a week—and I couldn't believe how drab it all appeared when I got home! Everything was brown and ugly, and it stayed that way until spring. How can I do better this year?

A Curb appeal is easy to achieve in the spring and summer. Pretty much any clean house with a decent front lawn looks okay. In the fall, it's a different story. That rich brown mulch you put down last spring starts to look a little weather-beaten, and the flowers you planted in May are way past their prime by Labor Day. Then leaves begin

to fall, and curb appeal vanishes overnight. It's enough to make you wonder why you worked so hard in the summer to keep everything looking nice.

Surprisingly, though, autumn is a great time of year to restore a landscape's vitality. Almost everywhere in the United States, temperatures cool off, rainfall increases and the weather is

more conducive to yardwork.

Begin with the lawn. If the grass is dry and brittle, start by applying 1 inch of water a week to help restore its texture and color. And if you fertilize only once a year, do it in autumn. There's less weed growth, so the fertilizer does the most good for the grass, not the weeds. Applying it in the fall not only greens up the grass but provides carbohydrates for the plants to store over the winter, which helps them bounce back the following spring. The potassium in fall fertilizer blends helps to improve the cold tolerance or, in horticultural parlance, the hardiness, of the grass.

Next, take care of the flower beds. Refresh their borders by cutting along the edges with a round-nose shovel. Turn over faded mulch using a bow rake. As for flowers and plants, fall mums, pansies and kale are a good bet to add color to the muted autumn landscape in almost any climate. Then, if you live in the northern half of the United States, ask your garden center about varieties that are particularly cold tolerant. For instance, Mammoth Mum was developed by the University of Minnesota for extreme hardiness. And, if you haven't added them already, consider planting evergreens, especially easy-to-manage varieties such as yews.

Next comes the house. Spider webs, light fixtures filled with dead bugs, a weather-beaten entrance mat, and mildew on siding and trim all conspire to make a house look uncared for—in any season. In autumn, these unattractive visual cues are heightened.

A quick once-over with a pressure washer or a morning's work with a broom and a garden hose is enough to take care of most of these problems. Use a shop vacuum to take dead bugs out of electrical fixtures. Once the lawn has sprung back to life, the gardening work is done, and the house is clean, your place can look great all the way until next spring.

Battery Backup

We lost power last winter, and now I'm interested in setting up some

backup power. I've heard about systems that use batteries that are trickle-charged from the grid. It seems like a good idea, but how much can you really power with batteries?

These systems are very practical and are a great way to power selected circuits—not an entire home—during a power outage. “The key,” according to Fred Banner, the owner of Banner Power in Rockville, Md., “is to determine what you need to run and how long you typically need to run it.” Banner’s company installs backup power systems that consist of either a battery bank housed in a cabinet and an inverter or a battery bank paired with a standby generator. For most homeowners, he says, the essential equipment to keep running is the refrigerator, the heating system, some lights, a sump pump and a well pump. In some cases a sewage ejection pump is added to that list.

Given that the average power outage will last only 3 to 5 hours, a bank of eight or 12 batteries is enough to handle the electrical load. There are several caveats. First, the system requires topnotch components that operate with peak efficiency. While you could probably cobble together a system from a local auto parts store and a home center, I wouldn’t recommend that. You’ll end up creating an inefficient system. Sure, it’ll supply some current, but standard automotive batteries will wear out quickly compared to deep-cycle batteries that are designed for backup power. Even if you don’t care about this, you’re liable to damage appliances or machines with under-voltage.

Also, when you’re choosing your system, be sure you’re calculating the load for your specific appliances. An Energy Star refrigerator might only need to run a couple of hours a day to maintain its internal temperature, but an old clunker might require so much current from the batteries that it will quickly run down the system’s charge.

It’s logical to ask what benefits this system offers compared with a backup generator. “The transition to battery power is seamless, silent and occurs automatically in 8 to 12 milliseconds,” Banner says. For prolonged outages, you can run on a combination of battery and generator power during the day

PROBLEM SOLVED

Coming Up Short

PROBLEM: Not enough wire to splice.

SOLUTION: Use an innovative new connector.

Among the more annoying jobs that a homeowner can tackle is making a minor electrical repair or modification in an older home. Usually the last inch or two of wire is beat up and the insulation is damaged. By the time you’ve cut back to clean conductor, there’s not enough wire left to make the new connection. It’s pure frustration.

Enter Ideal Industries’ new in-line wire connector, the SpliceLine. It’s a small tool-free connector that’s simply pushed into place. Strip

the end of the supply wire and slide the SpliceLine over the wire’s end. Strip the end of the new wire and push that into the other end of the connector. The wires both contact a diagonal conductor in the center. You can check the connection before the final hookup by inserting the probes of a continuity tester into the small port

below each wire. The SpliceLine’s slim design allows it to fit in tight spots and, since it isn’t a crimp connector, you can use it where a crimp tool won’t fit. The connector works with a range of wire sizes—12 through 20 solid and 12 through 16 stranded. A pack of 10 costs \$2. —R.B.

and switch to battery power at night. Battery-operated systems don’t produce carbon monoxide and, unlike a portable generator, which burns fuel even when it’s not supplying power, a battery backup system provides power only when called for.

A hybrid power system consisting of a battery bank and a generator is obviously more expensive than a generator by itself. A bank of batteries, a cabinet to house them, a high-efficiency inverter, cable and related components will cost at least \$1200, Banner says. Adding a small standby or portable generator would probably double that sum.

Replacing Historic Siding

I was replacing the siding on my 100-year-old house with cement board—until I received a stop-work order from the town. The house is in a historic district and, the town says,

the old wood siding was supposed to be replaced with a similar material. In my opinion, the new siding is an almost exact substitute for the old material. What’s your take on this?

Sorry to hear it. Few things can bedevil a homeowner like building codes, historic or otherwise. Towns often follow or adapt guidelines published by the National Park Service, which call for replacement only as a last resort. Cleaning, repairing or careful patching are the preferred restoration methods for historic structures. When siding must be replaced, the new material is supposed to be the same shape and dimensions as the old and made from a closely matching material. Unfortunately, in most cases a pretty good match just doesn’t pass muster.

So just what is a conscientious homeowner to do? The only way to know if the new siding will meet local

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PM DIY HOME /// HOMEOWNERS CLINIC Q+A

standards is to ask the town's historic district its opinion. If you really need to replace the siding, see if you can set up a meeting at the house and have a sample of your proposed replacement material on hand.

In many cases, though, old siding is in better condition than its surface suggests. The paint may have failed because of age, poor application or moisture-vapor movement from inside the house to the outside. It can be much less expensive to take care of problems that are causing the paint failure, rather than investing in new siding. That's true with any house, not just a historic one.

Chimney Creosote

My chimney has a thick formation of hardened creosote on its liner. I keep a nice hot fire using dry hardwood (mostly oak) in my wood furnace and I brush out the chimney every year. I've even tried using granulated creosote remover. What can be the problem?

Creosote happens, so to speak. It can form despite a homeowner's best efforts to burn wood cleanly. One problem can be a stove or furnace that operates with an aggressive thermostat that limits combustion air, says Ashley Eldridge, director of education for the Chimney Safety Institute of America. First, limiting combustion air makes the smoke rise more slowly. The longer the smoke's "residence time" in the chimney, the more heat it loses, and the more likely it is that water vapor and combustible byproducts will condense. Second, restricting combustion air increases smoke density. That speeds condensation, too. Over time, a thin film forms inside the chimney—each burn cycle adds a layer, and creosote starts to build up. In the worst case, this can result in a thick, glossy coating that chimney sweeps refer to as glaze.

The problem is worse in a chimney that runs up the side of the house, because its surface is exposed to cold temperatures and the smoke's heat loss is all the more dramatic.

Your first step is to hire a certified

chimney sweep to clean the flue. If the deposit is shiny and looks like a glazed surface, it's particularly dangerous because that means that it's dense and fuel-rich. To avoid the risk of a chimney fire, don't use the furnace until the deposit is removed.

Next, contact the dealer who sold you the stove or furnace (or the manufacturer that built it). Describe the problem. The thermostat could be defective, or there might be a better way to build a fire in it to optimize airflow. In most cases, a small, hot fire is your best bet to reduce creosote. But that does require you to refuel more often.

Shake, Rattle and Roll

The pipes in our house have started to rattle and squeak. How do we stop this annoying noise?

A common cause of this problem is water hammer: You'll hear a loud bang in the plumbing when someone shuts off a faucet, or when the solenoid closes on a dishwasher or a washing machine. (There are other sources as well.) The bang is followed by a rattle in the pipe. The solution is to install a water-hammer arrestor, essentially a fitting that acts as a shock absorber to cushion the impact of water slamming into plumbing. In some cases, the arrestor is soldered into copper pipes, but in other situations, such as the supply to a clothes washer, it simply threads on. In houses equipped with a pressure regulator on the incoming water line, sometimes the regulator needs to be adjusted or repaired to reduce incoming pressure.

Pipe rattling and squeaking can also be caused by loose hanger straps, pipe hooks and supports. Sometimes sloppy installation is to blame, but more often the part simply works loose, allowing noise-creating pipe movement. In other cases a plastic or metal pipe rubs against the framing lumber that it passes through, creating a squeaking noise. Most of these noises occur in inaccessible areas—inside walls or floors. If you can track the noise to an area in which the pipe is exposed, sometimes you can

refasten the pipe or install new hangers. For major remodeling jobs, you might consider a pipe-mounting system such as the Acousto-Clamp, a plastic pipe hanger that has a noise-insulating sleeve into which the pipe mounts.

A Sinking Feeling

I found a hole in a flower bed near the house's foundation and for the life of me I can't figure out what's going on. It wasn't there one day and then it suddenly appeared—if not overnight then in a couple of days. It's about a foot deep. We don't have problems like this anywhere else around the yard. What could it be?

There can be several causes. If it's animal activity, there's one likely indicator: The dirt that came out of the hole will be piled next to it. If you don't see a pile of excavated dirt, that doesn't rule out animal activity. It's also possible that an animal has burrowed down from another location and its tunnel has collapsed. Check around the house for a concealed entry point, such as a porch or a set of wood steps. Call an animal-control company if it turns out to be a critter problem.

Another cause of these mystery holes is when old clay-tile drain lines or bituminous-fiber sewer pipes (often called Orangeburg pipe) collapse. In other cases, tree roots grow into these pipes and push their sections apart. Soil above the gap can be washed down by rain and melting snow. For a while, the soil will be flushed out of the drain, but eventually the roots and dirt combined will clog it.

Because a collapsed sewer or foundation drain can lead to severe problems, you need to do some careful excavation to reveal the problem. You may be able to tackle the repair, but it's likely that you'll need a plumber or a foundation drain company.

PM

Got a home-maintenance or repair problem? Ask Roy about it.

Send your questions to pmmhomeclinic@hearst.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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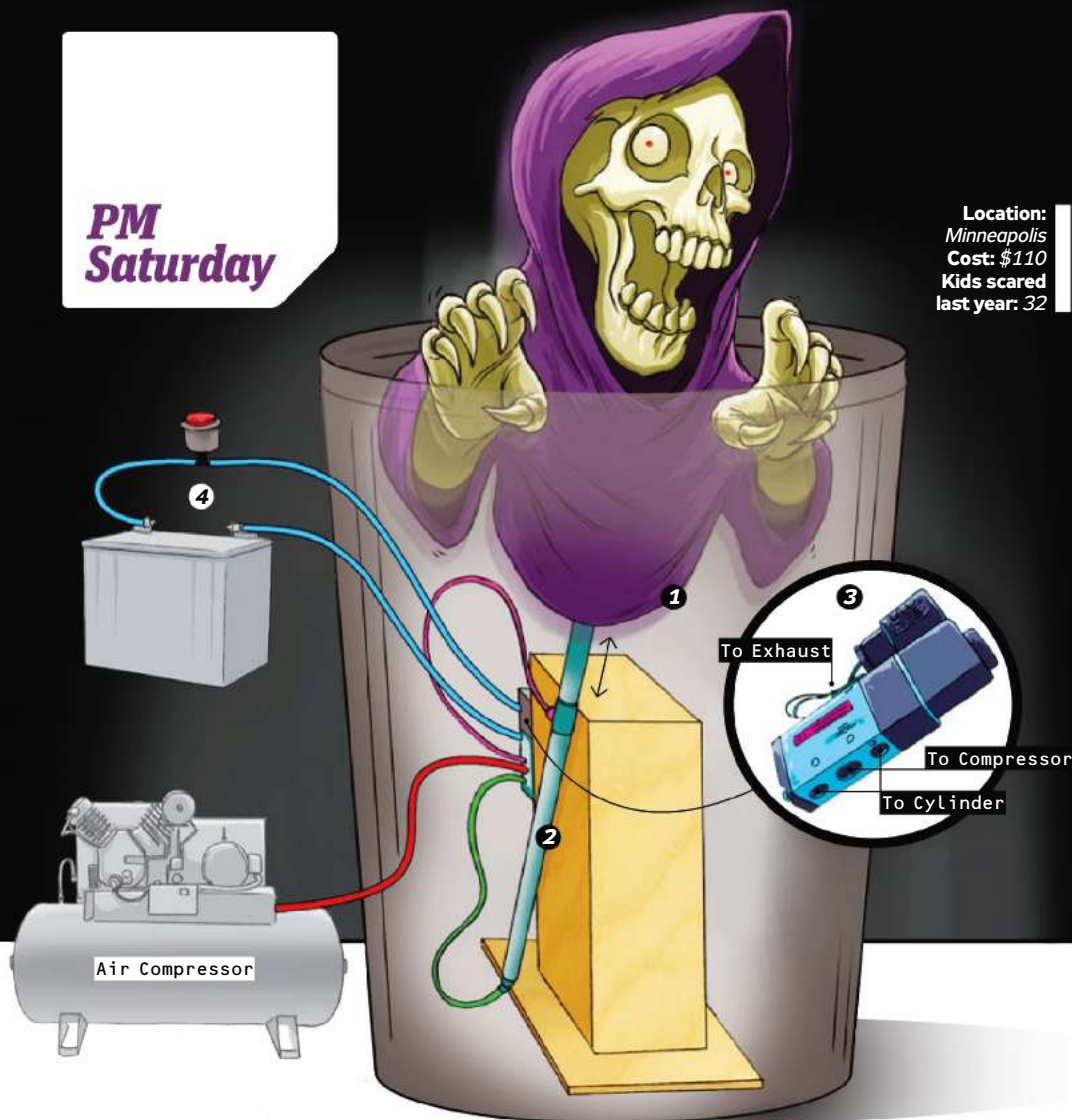
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THE GHOUL IN THE MACHINE

1 → A prop head—zombie skull, decapitated rat—hides in a garbage can. Using screws or tape, the head is fastened to a sliding cylinder. Hit a switch as a victim approaches, and the air-compressor-driven cylinder pops the head up out of the can like a demonic jack-in-the-box. The head, hardware and electronics can be bought at evilusions.com.

PNEUMATIC CYLINDER

2 → The heart of the system is a 3/4-inch-bore cylinder with a 12-inch stroke. A 1/4-inch pneumatic tube enters each end of the cylinder. A burst of air either extends the tube, projecting the head upward 6 inches above the can rim, or retracts the cylinder to conceal the head for the next victim. Mount the cylinder on a plywood bracket in the trash can. Then, connect the two plastic-tubing ends to the cylinder using push-on tube fittings.

SOLENOID VALVE

3 → To regulate airflow, a solenoid—a four-way, five-port model—is mounted on the plywood bracket inside the can. Two small ports connect air tubes from the cylinder. One large port, fitted with a 3/8-inch air hose, connects the solenoid to a compressor. Two other ports release exhaust, and two terminals connect the electricity.

SWITCH AND BATTERY

4 → A loop of low-voltage electrical wire leading to and from the solenoid opens and closes the valve. Connect a 12-volt DC power source, either an adjustable transformer or a 12-volt battery, at any point along the circuit. Wire a standard push-button switch (or a spare light switch) to the circuit. Test the action before showtime to make sure the head stays attached. Hit the switch just before handing out the candy, while you have the children's full attention.

**+ MORE TO DO
IN OCTOBER**



Blow Hot Air

→ at New Mexico's Albuquerque International Balloon Fiesta, a gathering of 600 hot-air balloons on Oct. 2–10. The event culminates in a "mass ascension"—yes, it's as spectacular as it sounds.

Bury Bulbs

→ in early fall, before the first frost. Spending winter underground gives roots a head start on spring.

See Stars

→ through a Dobsonian telescope you can build at home. Get it ready in time for World Space Week, starting Oct. 4, 53 years to the day after the Soviets launched Sputnik.

Count Birds

→ on Oct. 10, during the 16th annual Big Sit, an event that occurs along four U.S. migration routes—the Pacific, Plains, Mississippi and Atlantic. Get your friends, beer, binoculars and a front-row seat for the flocks.

Upgrade the Tailgate

→ by carving out a kettle-size hole in a steel-top folding table. Drop a legless Weber inside to make a mobile cooktop with a prep area for swine time.

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Winding Up Your Wiper Motor

FIXING BALKY WIPERS CAN BE AS SIMPLE AS A LITTLE GREASE, OR AS COMPLEX AS INSTALLING A NEW MOTOR. *BY MIKE ALLEN*

→ **'Tis a beautiful day.** Well, except for that one dark cloud that looms ahead, directly in your path through the countryside. Relax, it's a short summer cloud-burst, and you'll pass through it in a minute or two. Raindrops dance on your windshield, forcing you to turn on your wipers. The blades, however, only twitch. Uh-oh. A few seconds later, the now indispensable rubber strips make a low-speed swipe across the glass, smearing the bugs and grit into a translucent paste, groaning and squeaking every inch of the way. And then the coup de grâce: The blades stop cold directly in your line of vision. The good news is that you manage



Hiding inside the wiper assembly is a gearbox, along with some electronics.

INSIDE



WIPERS + ZDDP + TIRE THUMP

to safely steer to the curb and wait out the shower. But now you've got a problem—your wipers have quit.

First Things First

Did you check the fuse?

Okay, Sometimes It's Not That Simple

Actually, a wiper assembly that refuses to move might have a simple blown fuse. But usually fuses don't blow on their own. Even at full stall, the current draw of the motor should be well below the fuse's rating. If the fuse *is* blown, odds are there's something else wrong, like a shorted wiper-motor armature or faulty wiring anywhere along the harness between the motor and the switch. Even a mechanical problem like a seized bushing can make a fuse eventually fail.

The fuse is okay, or you've replaced it with one that has the appropriate amp rating. There's still no action? With the wipers and ignition on, whack the motor assembly with the handle of a screwdriver or a rubber mallet. If that gets things moving, you've got a bad commutator or an open winding on the armature. When the motor parks, if the brushes are sitting on the bad segment, no current flows. Whacking the whole business smartly can sometimes jolt things into motion. Because there are often a dozen windings on the armature, the motor runs fine until the next time it comes to rest on the bad spot.

Mechanicals

The mechanism on windshield wipers is as simple as could be. Inside that gear-box on the motor is a simple worm gear,

spinning a ring gear and bellcrank that translate the motor's circular motion to a linear one, back-and-forth. Simple joints attach the transmission arms to the wiper pivot shaft, which is fixed to the cowl by some sort of pillow block. Lack of lubrication, ice buildup or simple corrosion takes its toll and can slow things down. A loose joint will leave lost motion, which can cause the blades to either flop around or, worse yet, catch each other and get tangled.

The bad news: Sometimes it's difficult to access the area under the cowl. Worse news: If you go to the trouble of buying an aftermarket service manual in the hope that it will provide some guidance—any guidance—as to how to remove the cowl, it probably won't. Cars are complicated enough that not every single thing that needs to be taken apart can be fit into a bound book, and straightforward stuff like bodywork



1. Removing the cowl trim might make it easier to access all the whirly bits of the wiper transmission. A fingerful of white grease on all the moving parts is a must whenever you're working in the area. Check for sloppy fit and lost motion. Lube the pivot points as well.

2. On this truck, the resting position of the wiper blades on the windshield is trimmed out by loosening the transmission arm and sliding the pivot left and right, because the wiper arm only indexes on the shaft in one position.

often fails to make the cut. (Think about it: Is it ultimately more important to know the torque values for the connecting-rod bolts or where all the screws to the cowl are hidden?)

A favorite friction point is the bearing surface between the wiper shaft and its mounting block, which is often nothing more than a steel shaft running through a hole cast in plastic. A corroded steel shaft can swell up and bind. It's not a bad idea to dismantle the mechanism, wire-brush off any corrosion and reassemble the whole thing with a generous dollop of silicone grease.

Disintegrating rubber mounting blocks and crumbling nylon bushings can leave slop in the linkage or cause excess friction that makes the wipers run as though they're coated with molasses. There's no recourse but to replace these. Unfortunately, some of these parts have no part number from the dealer, requiring you to replace an entire expensive assembly—or improvise. We bought a transmission arm, complete with bearing block and pivot, at NAPA for a fifth of what the dealer wanted.

Motor Woes

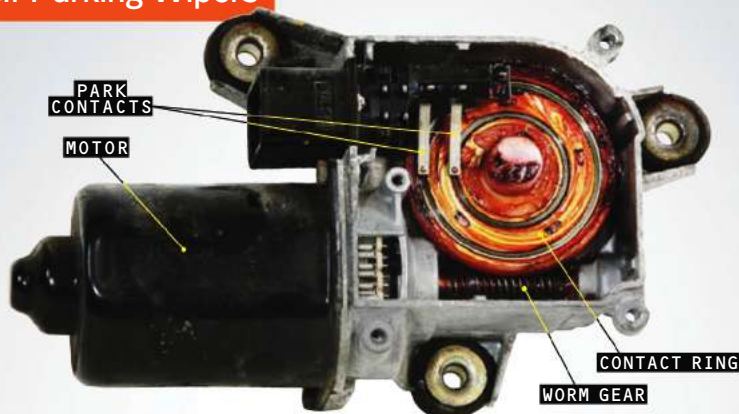
Is that motor assembly bad? Before you trot out and spend money on a new one, there are a few things to check out. Get a schematic diagram for the wiper system and parse out how it works. Generally, there are a couple of different windings on the motor for high- and low-speed operation. These will be supplied, respectively, with 12 volts when the key is on and the wiper switch is in, duh, high or low. Start by back-probing the connector to the motor to see if the 12 volts are making it that far. If so, pull the connector off and look for corrosion on the terminals. Check the park wire as well.

Got voltage? You might have one of those wiper systems that switch the ground side of the circuit on and off (which I think they do just to screw with my head). In that case you'll see voltage everywhere, even when the wipers are turned off. . . . Back to the schematic.

As a last-resort diagnostic, jumper 12 volts directly from the battery to the appropriate pin on the motor's power

HOW IT WORKS

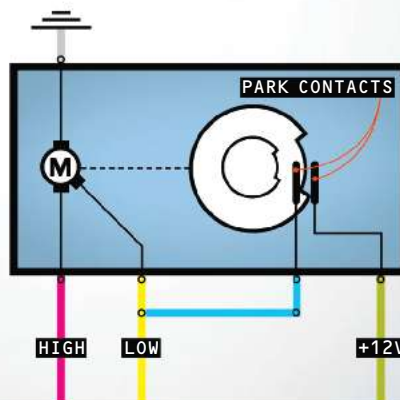
Self-Parking Wipers



Generally, the motor assembly is one of those things that have no user-serviceable parts inside and is inexpensive enough to make attempted repair pointless. If you have trouble finding a part for an oddball or collectible car, it may be worthwhile to open it up and poke around. Or maybe you're like me and just prefer to know what went wrong. The worm gear spins the ring gear as long as it's powered. When the switch is turned off, power continues through the always-hot park contacts—the two fingers that rest on the copper ring—instead of directly from the wiper switch.

There's a gap in the copper contact ring. As the ring spins, the park fingers drop into this gap, breaking the circuit and stopping the motor at the same spot every time. If you shut off your wipers and they stop immediately at some random spot on the

windshield, the park contacts are probably corroded or broken. A sousing with contact cleaner and a little touchup with a typewriter eraser should restore normal operation. Be sure to relube the gears before buttoning up.



connector. If there's still no sign of life, it's time for a new motor. Before you unbolt the old motor, detach the transmission linkage, which may have nice, plastic ball-and-socket joints, simple pins with nylon bushings and E-rings, or some other arcane method of carrying the motion across the car to both wiper arms.

Putting It All Together

Reassembly should be straightforward. Lubricate all moving parts, using sili-

cone grease on rubber pieces. (Avoid using petroleum-based grease on rubber parts—it will deteriorate them.)

Some wiper arms have a friction fit to the wiper post. To position the arms correctly, briefly cycle the power to the wipers to park them. Now attach the arms in their correct at-rest position. Other wipers have splines that mate in only one position, so if the arms don't rest properly when parked, you'll need to adjust the linkage elsewhere, probably at the middle pivots.

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Q

The Missing Zinc

I had a local speed shop rebuild the engine in my classic muscle car to as near to the original specs as they could, including all-new valvetrain, pistons, rings and bearings. I prepressurized the oil system, and the engine started right up. Within an hour's driving, the engine started to lose power and misfire. One of the camshaft lobes had failed, making the egg-shaped cam virtually round. There was a big divot carved out of that lifter to boot. The shop says that I used the wrong oil and that I should have used a zinc additive as well. I used a premium oil, the same one I use in my new car.



Improper startup prep is probably what caused this wiped-out cam nose and the dished-out lifter above.

A Ah yes, the missing zinc. Let me start with a primer on zinc/phosphorus antiwear additives: In the '50s, when cars began to feature overhead valves and started making serious horsepower, the camshafts needed more aggressive profiles, which were prone to rapid wear. That's when lubrication engineers discovered the utility of zinc dialkyldithiophosphate (ZDDP), which had previously been used in motors as an anticorrosive additive in modest quantities. The phosphorus and zinc in this molecule are attracted to bare iron, coating the microscopic asperities (high spots) where the cam nose slides over the flat surface of the tappet. This molecule-thick layer prevents iron-to-iron contact. After a few hours of operation, the two surfaces burnish each other to a nice, smooth, low-friction surface, microwelding is a thing of the past, and everybody's happy. Without the zinc and phosphorus, this localized high pressure, combined with the sliding friction, can microscopically weld the cam to the lifter, ripping out tiny chunks of metal. The industry standardized on 800 or so parts per million (ppm) ZDDP content in motor oil, and engines lasted a very long time. In fact, ZDDP levels eventually rose to 1200 ppm by the '70s.

Cut to the 1980s. Cars universally have catalytic converters installed to meet emissions requirements. Somebody figures out that zinc and phosphorus can contaminate the precious-metal reactor beds in the cats, reducing their

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effectiveness. Concurrently, in an effort to reduce internal friction and improve economy, more and more engines use roller tappets or roller rockers, eliminating sliding friction at the camshaft–lifter interface. Even engines that have non-roller-bearing camshafts have better, upgraded metallurgy and improved surface finish at that critical cam lobe–lifter interface. ZDDP levels were reduced to 1000 ppm, because higher levels were no longer deemed necessary.

Now it's 2010, and emissions requirements are even stricter. ZDDP levels have been reduced back to 800

ppm in the latest generations of motor oil, API's (American Petroleum Institute) SM and ILSAC's (International Lubricant Standardization and Approval Committee) GF-4 spec. Even if some oil gets past the rings or the valve-stem seals in your engine and is drawn into the intake through the PCV (positive crankcase ventilation) vent, the cat will remain pristine and your exhaust will smell like buttercups.

And this is right where your '60s muscle car gets the shaft. Too little ZDDP, especially in the critical first few minutes of engine operation, can destroy the surface finish of the cam lobes and lifters, especially on the high-lift cams, factory or aftermarket grind, used on the really fun cars. Lubrication

■ TOOL OF THE MONTH

Scan This

Sooner or later, everyone who owns a car has it happen: The dreaded Check Engine light comes on. Noncognoscenti know only that they'll need to take the car to a repair shop, maybe even to the dealer, to scan the computer for trouble codes. There are affordable code scanners and full-out scan tools around—but if you've got an iPhone, iPad or even an iPod Touch, there's a simpler, inexpensive solution. First, download the free goLink iPhone app, then buy the company's \$99 cable and plug it into your car's OBD II port, which is usually under the dash. Once it's hooked up, you can check the trouble codes, browse through a bunch of engine parameters while some faithful minion drives you around and turn off that pesky light. Use it to diagnose and fix



something as simple as a loose gas cap and you can recoup the cost of the cable by eliminating just one service call. But wait, there's more! The cable also works with CARbonga (Speedemissions; \$4.99 in the App Store), which checks all the car's safety systems and lets you monitor fuel mileage and carbon footprint as you drive.

Want more? Download DashCommand (Palmer Engineering; \$49 in the App

Store), which gives you a set of virtual gauges, displays rpm, hp and torque and uses the iPhone's accelerometer to provide a graphic representation of your acceleration, braking and cornering while hot-lapping a racetrack.

GoLink has just replaced the 10 grand or so of scan tools—and all the equipment I lug around to test cars—with an iPhone and a cable. I love it. —M.A.

engineers at Shell say that a stock engine with the original camshaft grind, stock springs with modest seat pressures and OEM-ratio lifters should be fine running these 800-ppm oils. After-market grinds, stiff springs and high-ratio rockers increase cam-to-lifter pressures and would be better off with higher levels of ZDDP in the mix. Regardless of the petroleum companies' take on this, most engine builders specializing in these specialty cars like to see that 1200-ppm number.

Back to your problem: Your engine builder should have provided you with instructions as to what oil to use, because there are options. Several companies make boutique oils that meet that high-zinc spec of yesteryear. Amsoil has several oils with appropriate levels of ZDDP in viscosities correct for your car. Some suggest using a modern diesel-rated oil—which I recommend against because there are a lot of additives in diesel oil that aren't appropriate for spark-ignition engines, and vice versa. If you can't find anything better at Walmart, however . . . Many mainstream petroleum companies have an oil marketed for older, high-mileage cars, and it usually has a healthy dose of ZDDP. If you need to know the ZDDP content of any product, ask for the MSDS (Material Safety Data Sheet) from the supplier, which will list everything in the bottle.

My favorite solution for veteran flat-tappet engines has been around for generations: General Motors' EOS. It was originally sold as an engine oil supplement (get it?) for high-performance engines, and it has the correct amount of ZDDP in a form that won't plug up the oil filter. GM dropped this product a few years back, and I was hoarding my last six cans. Then it returned as EOS Assembly Lube, not recommended as a supplement for routine use, but only for breaking in a new engine. If that's what it takes to get it past the EPA and onto the shelves, fine. There are other ZDDP additives on the market as well. My favorite is Comp Cams' Break-In Oil Additive, coupled with the use of GM's EOS or Comp Cams' Cam and Lifter Installation Lube.

One final thought: It's easy for the engine shop to blame the oil, but there

are plenty of other potential issues that can wipe a cam nose. I like to assemble high-performance engines that have stiff springs, lots of seat pressure and high-lift cams a little differently. I leave out the inner valve spring and even substitute lower-ratio rocker arms for the first few hours. This will substantially reduce cam-nose-to-lifter pressures, reducing wear. After a few hours at lower revs, I change the oil to get out all the wear metal and install the rest of the springs and the correct rockers. By then, the cam and lifter interface has been broken in properly.

One important caveat: Do not add extra ZDDP additives to an oil that has sufficient ZDDP already on board, in the time-honored American tradition of "if a little is good, a lot more is better." Excessive ZDDP is corrosive, and the optimal level is right around the 1200-ppm point already in most oils that meet the older standards.

A second important caveat: Oils marketed as racing oils may have a different additive package and may have less detergent, dispersant, viscosity-index improver and other good stuff in them. They're really intended for racing, and their short drain intervals make them unsuitable for street-driven vehicles. To confuse the issue, some products labeled as racing oil may actually contain the appropriate additive package and would be suitable for street use. Castrol GT Racing is one.

Thumper

I bought some tires, and it seems one is bouncing now. I have taken my car back to the store and found out they had put five weights on my rim: three inside and two outside. Is this vibration normal?

Looking at the cellphone photos you sent me, I count a total of 2½ ounces of wheel weights on your rim. That's a lot, but not excessive. Your tire technician is lazy, though—he's used five half-ounce weights, three on one side of the rim and two others on the outside. He should have used one ounce-and-a-half and another single 1-ounce weight, if for no other reason than that two weights are less likely to be thrown off the rim than five. Since the "bouncing" behavior you described suggests that

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CAR CLINIC Q+A

the tire may be out of balance, I'd go right back to the store. The technician needs to not only check for proper balance, but he also needs to make sure the tire is actually round.

Here's my plan for sorting it all out: Start by spinning the tire on the tire machine with a dial indicator, or at least with a pointer on the tread. Total out-of-round (the difference between the tire's highest point and lowest point as it spins in relation to the pointer) should be 2 mm or less. If it's more, mark the tire and rim with a tire crayon to peg where the tire was mounted relative to the rim and demount. Check the rim for roundness and true without the tire (which *should* have already been done). Discard the rim if it's bent.

Now remount and air up the tire 120 degrees from its original index position. Check for roundness again. If the high spot is still more than 2 mm higher than the low spot, break the bead and spin it another 120 degrees. If it's still egg-shaped after that, toss the tire.

If the tire-rim assembly is perfectly true but the assembly still wobbles when mounted on the hub, carefully wire-brush the wheel and the mating-hub surface to remove any rust, dirt or burrs. Smear the mating surface with antiseize compound and carefully torque the lug nuts with a torque wrench, not an air gun. That should cure any thumping. If the problem persists, diagnose further by mounting the tire on a different corner of the car and seeing if the problem follows it. If so, it's the tire or the wheel. If not, the axle's spindle shaft is bent.

Italian Tuneup

When the Check Engine light started to come on in my minivan, I was worried at first because the former Chrysler-dealer-turned-independent-repair-shop wouldn't do warranty work anymore.

I remember that in the 1950s some cars were prone to carbon buildup when driven too conservatively. One fix was to race the engine. I drive as fuel-efficiently as I can, so

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when the Check Engine light comes on, I accelerate as fast as the car will go for a few blocks. The light goes out, usually after I start the car the next time. Is the problem carbon buildup? Is there a better fix?

I'd start by getting a scan tool (which a lot of auto parts stores will let you borrow for a half-hour if you leave your driver's license at the register) and plugging it into the OBD II port to see what that trouble code actually is.

And a can of fuel-injection cleaner will do a perfectly good job of removing carbon from fluffed-up spark plugs. So will a 100-mile trip at expressway speeds. Winging the throttle at low speeds trying to burn the carbon off of the plugs will only PO the neighbors.

Overheated

I've had a chronic problem with my 2003 Chevy Venture's brake lights, on both sides. The bulb (3057LL) stops working because heat builds up and melts the plastic that the metal contacts are attached to. The filament is fine, but the melted plastic doesn't hold the contacts together anymore. I have seen a lot of Ventures with a burned-out brake light. Is there a way of fixing it without replacing the taillight assembly cartridge? The bulb's life is only a month or two. I have also tried electrical lubricant on it.

You're not the only one with this issue. All I can figure is that you—and a lot of other Venture drivers—drive in heavy traffic a lot, and the heat from the brake lights just builds up. Aside from ventilating the housing with a drill (just kidding—it probably won't help), I have only one good solution: Replace the bulbs with LEDs, which will generate virtually no heat. You don't have to do any wiring, just pick up an LED that directly replaces the 3057. I've seen these online for as little as 10 bucks. Be sure you get a bulb with red LEDs, not a generic white LED bulb. The red lens will pass nearly 100 percent of the red light but will filter out all of the blue and green components in the white bulb, which means substantially brighter brake lights from the red bulb.

A side benefit: LEDs illuminate immediately, but incandescent bulbs (such as your 3057) take nearly half a

second, roughly 400 milliseconds, to come to full brightness. That will give following traffic earlier warning that you're on the brakes.

Permanent Power

On my new Lincoln Town Car, the two cigarette plugs stay on when the ignition is shut off. This leaves accessories like radar detectors and cellphone chargers to draw current after the car is turned off, a sure way to drain the battery if you forget to unplug. The dealer says the plugs are wired directly to the battery. I would like to correct this if possible so I won't have to pull out the jumper cables if I leave something plugged in.

Yup, and that's why they're called power points, not cigarette-lighter sockets anymore. At least that's how they're labeled on my schematic diagrams for all the late-model Lincolns. Any teenager or decent mechanic can rewire one or both of your power points to power off when the key is off, perhaps by doing something as simple as moving a spade lug to a different position on the junction box. At worst, someone would have to splice a wire.

But before you go to all that trouble, are you sure you really need to? A cellphone charger would take a couple of weeks to run your battery down.

You Big Sap

I'm forced to park under a tree. Early spring brings tree-sap drops that form on my hood and roof. Commercial products claiming to remove these stains don't even come close to working. Cleaner waxes are simply a waste of time and effort. Any ideas?

1. Don't park there. (Duh.)
2. Use a car cover.
3. Go to the auto parts store or department and get bug and tar remover. Follow the directions. **PM**

Got a car problem?

Ask Mike about it. Send your questions to pmautoclinic@hearth.com or over Twitter at twitter.com/PopMechAuto or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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THE PROBLEM: Out of the box, it can be difficult getting many common file formats onto an iPad.



SOFTWARE SOLUTION: Apps like Air Sharing HD and Dropbox make it easy to transfer large files from a PC to an iPad.

HARDWARE SOLUTION: Apple's Camera Connection Kit lets you plug a camera or memory card directly into an iPad.

Move Any File Onto an iPad

GETTING ALL YOUR MEDIA ONTO APPLE'S TABLET CAN BE TRICKY. HERE'S HOW. *BY ANTHONY VERDUCCI*

➔ **During the past few decades** of personal computing, moving files onto our computers has been a fairly straightforward process. We've stashed them on a drive—be it floppy, zip or USB—and then plugged the drive into a computer. The machine recognizes the drive and, a few drags and drops later, the files are copied.

But Apple's iPad is a different sort of beast, with remarkably few gateways for files to pass through. The device has no USB jacks, and users typically need to use Apple's proprietary 30-pin jack in order to shuttle files onto the tablet.

INSIDE

MOTION-CONTROLLED GAMING + 3D TV POWER DRAW

And to do that, they need to go through iTunes. In other words: Our decades of drag-and-drop training don't apply to the device.

This reliance on iTunes as a gatekeeper presents a significant problem: The software doesn't do a very good job of handling many common types of files. Despite continual updates from Apple, iTunes still feels like it was only designed to get music (and maybe the occasional movie) onto iPods—not to shuttle PDFs, text documents and huge numbers of photos onto an iPad. For many of these tasks, iTunes can feel woefully inadequate.

And that's not the end of the iPad's file problems. Once you've moved a file onto the tablet, it can be tough to find it and do what you want with it. This is because, unlike just about every PC ever made, the iPad has no user-accessible system of folders that you can employ to organize and open files. Instead, files tend to exist within the bubble of an individual app and can be accessed only from within that app.

Despite all this, you actually can get almost any type of file onto your iPad—you just may need to go around iTunes.

First things first. There's one very easy way to get smaller files onto your iPad: E-mail them to yourself. You won't want to do this with massive files, or a massive number of small files, but sending yourself a single photo or Word document as an attachment and then opening it on the iPad is quite simple.

For pictures, open the e-mail, hold your finger against the image for a second and select the "Save Image" option that pops up. The iPad will save the picture in its pre-installed Photos app.

If you open a text attachment from within the iPad's Mail program, a button will appear at the top right of the screen that says "Open In..." Tap it and then select a program. (If you want to edit text documents on your iPad, we recommend Apple's Pages, a \$10 word-processing app. If you just want to read the document, the \$1 GoodReader is adequate.) But be careful: Because the iPad shuttles separate copies of the

document to each app that you open it in, changes made to one version of the file will not show up in any others.

Unfortunately, using e-mail as a gateway to the iPad is unwieldy and impractical for large—or large numbers of—files. To handle these cases, you need another approach.

Hardware Solutions

→ Photographers rejoice:

Photos are the one area in which Apple has given us a hardware bridge to the iPad. The company sells a product called the iPad Camera Connection Kit (\$29), which allows users to easily offload large numbers of pictures onto an iPad. The kit comes with two dongles that plug into the iPad's 30-pin dock connector. One of the adaptors acts as an SD memory card slot, while the other gives you a USB jack for plugging in cameras directly.

When a camera or memory card is connected, the iPad automatically opens the Photos program and allows users to pick which pictures they want to offload. This is especially useful for travelers who are looking to pull photos from their cameras but are traveling without a full-fledged laptop (the photos can be transferred to a computer later by syncing it up with the iPad). One caveat: Even though the Camera Connection Kit can give the iPad a USB jack, it is one with limited functionality. While it can also handle some USB keyboards and headsets, it does not recognize USB storage devices (I tried).

Software Solutions

→ **A number of third-party apps** are designed to link your iPad to either online storage services or your home-base computer. These programs typically allow you to gather and open all sorts of files. One of the most powerful is Air Sharing HD, a \$10 iPad app that tricks your computer into thinking your iPad is an external drive, allowing you to easily drag and drop files onto it. The best part is that it's done over Wi-Fi, so

KNOW YOUR STUFF

The Right App

→ An iPad can open just about any type of file—as long as you use the right app. Here's a handy list of programs for opening common files.

FILE TYPE	APPS
IMAGES: <i>.jpg, .tiff, .gif, .png</i>	MangaView, Photogene
DOCUMENTS: <i>.doc, .docx, .pdf</i>	Pages, DocReader, GoodReader, ReaddleDocs
COMICS: <i>.cbr, .cbz, .pdf</i>	CloudReaders, Stanza, Comic Book Viewer, Comic Zeal
VIDEOS: <i>divx, xvid, .wmv, .mov</i>	Media Browser, xyplayer



you don't even need to plug the iPad into your computer. There's also Dropbox, a free app that works in conjunction with the cloud-based storage service (2 GB of storage is free, 50 GB is \$10 per month). You can play all sorts of media files from within the app. Still, this one has some kinks to be worked out—it crashed when I tried using it to push large movie files onto my iPad.

If you need to pull large numbers of PDF, zip or CBZ files (that last one is commonly used for digital comic books), I suggest CloudReaders. This free app is very easy to use and allows you to pull these files from a computer either over Wi-Fi or by using a USB cord to sync the tablet with iTunes. If you do it over Wi-Fi, the app gives you a URL to type into your computer's Web browser. Go to the address and follow the instructions on pulling the files from your computer and sending them to your iPad. If you want to use CloudReaders over USB (the faster method), go to the Apps tab within the iPad section of iTunes, click on "File-Sharing" and then select "CloudReaders." From there, you can move these files directly onto your iPad from within the familiar confines of iTunes.

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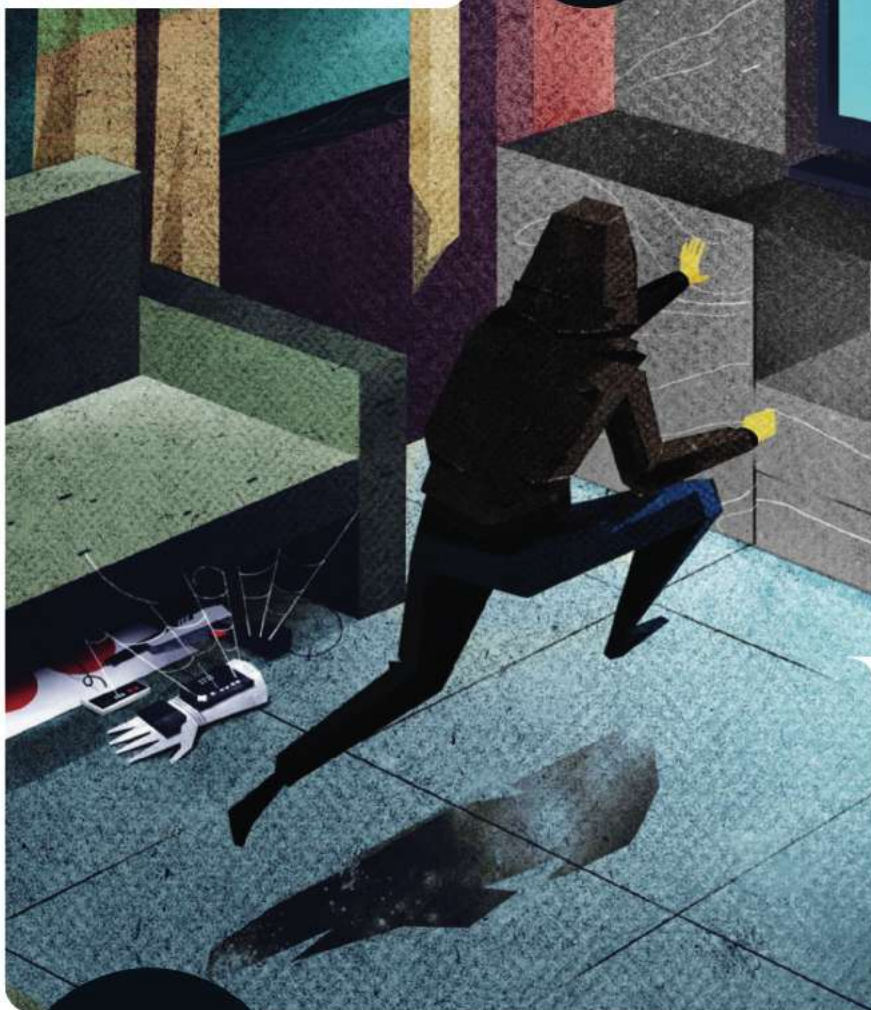
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Digital Clinic

by Seth Porges

Q+A



Q

Making Motions

Between the Nintendo Wii, Sony PlayStation Move and Microsoft Kinect, I'm having a hard time telling all these motion-controlled gaming devices apart. What are the main differences between these systems?

A My mother recently confessed that she had never played a video game. Ever. Hearing this news, I did what any good son would do: I bought her a Wii. Within minutes of setup (on her hulk of a CRT TV), I understood the genius behind the system—despite countless news reports over the past four years attesting to the Wii's appeal to a wide

demographic, it took seeing my mother wave her way through a game of tennis to truly understand how Nintendo had managed to sell more than 70 million of these things since it was introduced in 2006. For nongamers who may be intimidated by complex control schemes, the ability to literally jump right into a game is very appealing.

The gaming world has noticed this success: By the end of this year, all three major consoles will have some motion-control capabilities. I've tested all three. Here's what you need to know about each of them.

→ Nintendo Wii

It has been four years since I bought my first Wii. And while the system's motion-control abilities have been improved with the aid of the Motion Plus accessory (which allows for so-called one-to-one motion control for some games), the tech is still the most primitive of the batch. Whereas the other systems use cameras to track you or your controller's exact physical position, the Wii uses a simple (and not nearly as accurate) IR emitter to monitor movement.

But the aging Wii still has a trump card: four years' worth of games.

→ Sony PlayStation Move

Like the Wii, the Sony PlayStation Move (\$50 to \$100) add-on controller detects movement and relative position. But where the Move trumps the Wii is in its ability to tell the precise

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location of the controller in relation to the TV. It does this by using the PlayStation Eye camera accessory to follow a glowing orb on the tip of the controller. By pairing these two data sources, the Move can generate an incredibly accurate representation of your movements.

→ Microsoft Kinect

When the world first saw Microsoft's Kinect more than a year ago, it was known as Project Natal, and it seemed

straight out of science fiction. The Xbox 360 accessory used depth-perceiving cameras to transform flailing limbs into onscreen actions. It worked so well we gave it one of our annual Breakthrough Awards. And it's coming out as a real product this November.

Kinect's lack of a controller limits the types of games that can be made for it. But we would bet our flatscreens that Microsoft is thinking far beyond gaming. Kinect will be integrated into the Xbox's

robust media capabilities, offering users a way to navigate through music and movies with a few simple waves. If Microsoft eventually builds the technology into Windows, it could change the way we interact with our PCs.

3D Power Draw

Do 3D TVs use more power when they are showing 3D instead of 2D images?

As part of a recent test of 3D TVs, we measured the power consumption of three models and found that all consumed significantly more power when they were displaying 3D images than the same image in 2D. The tested models: a 52-inch Sony LED-lit LCD, a 46-inch Samsung LED-lit LCD and a 50-inch Panasonic plasma. For the test, we played a scene from the Blu-ray version of *Monsters vs Aliens* in both 2D and 3D, using the out-of-box default settings, and recorded the high and low range of power consumption for each model. Our watt meter showed that the Sony's consumption fluctuated between 88 and 116 watts while showing 2D, and between 120 and 139 watts in 3D. The Samsung bumped from a 2D range between 109 and 155 to a 3D range of 135 and 156. And the biggest 3D power premium belonged to the Panasonic plasma, which jumped from a usage of between 150 and 172 watts all the way up to a range of 290 to 332 watts.

So, yes, you can expect a 3D TV to use a whole lot more power when it is asked to display 3D content. These spikes in power consumption are almost certainly the result of a 3D TV's tendency to increase its brightness when it moves into 3D mode as a way of counteracting the dimming effect of the polarized shutter glasses. The upshot of it all is that, with only a handful of 3D Blu-rays on the market, few people will be using this feature enough to significantly affect their power bill. At least not yet.

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Got a technology problem?

Ask Seth about it.

Send your questions to pmdigitalclinic@hearsst.com or over Twitter at twitter.com/sethporges. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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What Went Wrong

(CONTINUED FROM PAGE 87)

“deadman” signal from the pod. This last-ditch control triggers a shear ram that severs the drill pipe, shutting down the well. Even with a charged battery, the shear ram may not have worked—one of its hydraulic lines was leaking. MMS regulations are clear: If there is a BOP “control station or pod [that] is not functional” the rig must “suspend further completion operations until that station or pod is operable.” Eleven days before the blowout, the BP representative in charge on the rig noted the leak in a daily operation report and alerted the home office in Houston. However, BP did not shut down completion operations, initiate repairs or inform the MMS.

Even a fully operational BOP has design flaws. A shear ram’s blades can’t sever the joints connecting the 30-foot sections of drill pipe—and joints make up 10 percent of the string. In fact, internal Transocean documents show that when it bought this particular BOP in 2001, the company identified 260 separate ways it could fail. During a Congressional hearing, Rep. Bart Stupak, D-Mich., asked: “How can a device that has 260 failure modes be considered fail-safe?”

Broken Chain of Command

BY APRIL 20, WITH THE UNTESTED cement sheath in place on the final 1192 feet of casing, workers prepared to seal the Macondo well and move on to the next drilling job. A dispute arose during a planning meeting around 11 am—11 hours before the rig exploded. Accounts vary: One Transocean worker testified that BP wanted to replace the protective column of drilling mud with lighter seawater before closing off the well; Transocean strenuously objected but eventually relented. Other witnesses say the argument was whether to conduct a negative pressure test—a procedure that reduces pressure in the well to see if gas and oil enter—even though it was not part of the drilling plan.

The argument revealed the inher-

ent conflict on the rig. BP, which was paying Transocean \$500,000 daily to lease the Horizon, wanted to move as quickly as possible. With its costs covered, Transocean could afford to focus more on safety and well control. Safety expert Arendt believes some of the problems are systemic to offshore drilling. “Onshore, you have one plant owner and, normally, one large contractor to deal with,” he says. “Offshore, you have the lease holder, the platform owner, the drilling contractor and one or two critical drilling and well service contractors. This creates the potential for mixed messages and a conflict between economic versus safety priorities.”

Transocean conducted two negative-pressure tests; BP’s Don Vidrine and Transocean’s Jimmy Harrell, the two companies’ top officials on the rig, deemed them to be successful, and preparations began to install a cement plug to seal the well. At 7:55 pm, BP engineers decided that the plug was holding, so they told Transocean workers to open the BOP’s annular valve to pump seawater into the riser to displace the mud, which was piped to the *Damon B. Bankston*, a supply ship tethered to the rig. At 8:58 pm, drill-pipe pressures increased. At 9:08, with pressure continuing to build, workers stopped pumping.

Here, there were eerie echoes from the Union Carbide chemical plant spill in Bhopal, India, which killed an estimated 20,000. In Bhopal, water leaked into a tank containing 42 tons of methyl isocyanate, setting off a deadly chemical reaction. Workers in the control room watched pressure build in the tank, but never shut the system down as three backup systems failed, and the deadly gas spread over a densely populated village.

Remarkably, after a 6-minute hiatus, workers on the Horizon resumed displacing mud with seawater, despite the slew of signals—kicks and pressure spikes—that warned something was wildly wrong. “Normally, on any well,” says the University of Texas’s McCormack, “if you have a problem, you stop and solve it.”

At 9:31, once again the workers stopped pumping seawater; at 9:47

monitors detected “a significant pressure buildup.” A few minutes later, methane coursed from the drill pipe, transforming the rig into a giant unlit blowtorch. From the decks of his supply ship, Capt. Alwin Landry saw “mud falling on the back half of my boat, kind of like a black rain.” Then came a green flash and a white liquid—a frothy mix of mud, water, methane and oil—boiling out of the derrick. First Mate Paul Erickson saw “a flash of fire on top of the liquid” and then watched men jump from the rig, as a distress call came in. “Mayday, mayday, mayday! The rig’s on fire! Abandon ship!”

“The scene was very chaotic,” rig worker Carlos Ramos told *The Wall Street Journal*. “People were in a state of panic . . . There was no chain of command, nobody in charge.” Throughout the rig, workers struggled to reach the two usable lifeboats. Some yelled to lower them, some wanted to wait for more workers, others simply leaped into the sea 75 feet below.

On the bridge, Capt. Curt Kuchta argued with a subsea supervisor over who had the authority to hit the Emergency Disconnect System to activate the shear rams, thereby sealing the well and detaching the rig from the riser. It took 9 minutes to activate the system, not that it mattered—the BOP failed. The Horizon was never disconnected, oil and gas continued to surge up from below, feeding an inferno that soon engulfed the rig. Although the vessel had muster stations and emergency plans, crew members had never practiced safety drills without warning to simulate a real disaster.

In the end, 11 men died, the disaster cost BP billions, and the environment of the Gulf of Mexico may be irrevocably altered. President Obama’s ambitious plans to open up vast areas to offshore drilling have been shelved. But worst of all, says Ford Brett, president of Oil and Gas Consultants International, the blowout “wasn’t an accident in the traditional sense, like when someone just hits your car. It was an accident that was totally preventable.” **PM**

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A man in a green button-down shirt and blue jeans stands in a workshop, applying a white material to a dark boat hull. The workshop is filled with wooden planks and various tools. A teal banner in the top left corner contains the text 'This Is My Job'.

This Is My Job

Building a Kevlar Guideboat

1. MAKE A MOLD

Each Kevlar composite boat starts with a 300-pound fiberglass mold cast from one of the company's wooden models. Molds take one month to build, and make up to 400 boats. "It involves endless sanding and polishing," Martin says. "Any flaw in the mold is in every boat that emerges from it. It has to be perfect."

2. APPLY SKIN COAT

Martin lays a dry sheet of fiberglass over the mold. Next, he pours in a pigmented polyester resin and rolls it along the entire form, using a paint roller and a small brush taped to a 2-foot stick to get the resin into the bow and stern. After the resin hardens overnight, Martin sands it with 60-grit paper.

3. LAYER KEVLAR

Over the skin coat goes a solid sheet of Kevlar and a layer of overlapping 50-inch fiberglass squares. That's followed by a second layer of Kevlar. Martin uses a corrugator to roll out the air between layers, then adds a final sheet of fiberglass.

4. FINISH BUILD

After adding the seat cleats and another layer of fiberglass over flotation tanks at each end, Martin applies a gel coat to keep the outside color uniform. "We have about 20 minutes to roll and paint the inside of the boat before it starts to cure on us," he says. Finally, the mold is removed, and a deck and gunwales are added to give the boat structure.

✕ BOAT BUILDER

Name: JUSTIN MARTIN
Location: N. FERRISBURGH, VT.
Age: 31
Years on Job: 12



Justin Martin never planned to build boats for a living. After high school, he took a summer job working with his older brother constructing composite canoes. Twelve years later, Martin is a head builder at Adirondack Guideboat, which specializes in a rugged boat that's light enough to be portaged but large enough to carry three men, two dogs and a hunting bounty. In addition to the company's legendary custom-built wooden guideboats, Martin and his brothers churn out more than 200 Kevlar boats each year. Working with his family is what Martin loves most. "We can build an entire boat without saying a word," he says. "We've always worked together. I can't imagine it any other way." —ERIN SCOTTBERG

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