

The Bridge

Linking Transportation Research and Practice



Creating a sustainable winter operations program

By Trevor Kuehl, Student Intern, *Center for Technology & Training*

At most local road agencies in the U.S., the use of salt and chemicals to keep winter roads clear has increased dramatically in recent years. However, rising material costs, concern about environmental impact, and growing evidence about impact on infrastructure have made sustainability in winter operations a prominent topic among the general public and media outlets. Sustainable practices in winter operations can benefit an agency's public image and the environment, and Mark DeVries, Superintendent of the McHenry County Division of Transportation in northern Illinois, knows there are easy ways to incorporate sustainable practices into winter maintenance operations.

A common definition of sustainability is: "Meeting the needs of the present without compromising the ability of future generations to meet their own needs." In McHenry County, DeVries has been working on applying this philosophy using new winter

maintenance technologies and practices, including proper material storage techniques, sustainable salting, plow driver education programs, and anti-icing and pre-wetting programs.

When we allow salt into our water system it doesn't break down or disappear, it stays there until it's removed.

Mark DeVries – McHenry County Division of Transportation

Too much salt

McHenry County started a push toward sustainable winter maintenance when DeVries realized just how much salt the state of Illinois was using every year. "The Illinois state bid for salt in 2008 was for 1.8 million tons," DeVries said. He calculated that it would take six times the volume of Chicago's Soldier Field to hold that much salt. DeVries was concerned about such a large amount of salt being introduced into the water cycle because it is not subject to any significant natural removal mechanisms. "When we allow salt into our water system it doesn't break down or disappear, it stays there until it's removed," he explained. In addition to environmental

See **Sustainable** on Page 4

More inside

- What's best: Salt, sand, brine, or all three? 3
- Proper calibration (download from the Web) 5
- No "silver bullet" in winter maintenance materials . . . 6
- Tech writing for transportation pros (Part 2 of 3) . . . 7
- Underbody wash 8



Gearing up for the battle ahead

The 730-foot Canadian Progress—operated and managed by Seaway Marine Transport of St. Catharines, Ontario—delivered 20,000 tons of road salt to Mattila Rock and Dock, LLC in Hancock, MI in late September. The ship took almost five hours to unload the salt, which is trucked to five Western Upper Peninsula counties. This year's salt delivery to the Western U.P. was down about 10,000 tons because several county garages still had salt left over from last year's mild winter.

Kelly Foeness/Daily Mining Gazette

Are you curious?

Albert Einstein enjoyed figuring things out. Regarding curiosity, which he considered a foundational character trait of anyone working in any field of discovery, he said, *“The important thing is to not stop questioning. Curiosity has its own reason for existing. One cannot help but be in awe when he contemplates the mysteries of eternity, of life, of the marvelous structure of reality. It is enough if one tries merely to comprehend a little of this mystery every day. Never lose a holy curiosity.”* Pretty deep stuff.

As if acknowledging the complications that can arise from constantly questioning and contemplating “the marvelous structure of reality,” Einstein also said, *“If I had only known, I would have been a locksmith.”*

I don’t know much about locksmithing, but I assume the work is pretty straightforward—you use specific tools to open locks. I’m sure it’s challenging and that there’s an art and technique to doing it well, but I know it’s nothing like the field of Physics where math, chemistry and forces of nature collide to create incredible things.

Winter maintenance is not like locksmithing, it’s more like Physics. Sure, there’s an art and technique to it, but there’s way too much science involved to call it straightforward.

This issue contains three stories about winter maintenance. The people about which these stories were written approach the puzzle of winter maintenance with a healthy curiosity. They continually



question and contemplate, trying to understand a little more every day. They constantly experiment, think, and write things down. It’s not necessarily easy; I’m sure they sometimes wish they could do something less complicated—like locksmithing.

I’m sure Einstein would have enjoyed working with them.

The Bridge

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LTAP Steering Committee

The Local Technical Assistance Program (LTAP) is a nationwide effort financed by the Federal Highway Administration and individual state departments of transportation. It intends to bridge the gap between research and practice by translating state-of-the-art technology and practices in roads, bridges, and public transportation into terms understood by local and county highway or transportation personnel.

The LTAP Steering Committee makes recommendations on, and evaluations of, the activities of the Local Technical Assistance Program based on discussions at the Technology Transfer Interchange and Advisory Committee meeting. This meeting is held annually and is open to all rural and urban agencies, and individuals concerned with the transfer of transportation technology in Michigan.

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What's best: salt, sand, brine, or all three?

Saginaw County Road Commission determines best combination for de-icing roads

By Trevor Kuehl, Student Intern, *Center for Technology & Training*

Subtle differences in the application of de-icing materials can result in dramatic variations in winter driving conditions. Brian Wendling, managing director of the Saginaw County Road Commission (SCRC), became concerned when he noticed that winter road conditions in his county sometimes changed dramatically at district lines. "In some areas you could be driving on a plowed and salted road with little or no snow or ice, and then cross a district line and run into roads that were icy or completely covered with snow," Wendling said.

He knew that mixing salt with other de-icing materials such as mineral-well brine, which is a by-product of natural gas wells, can make salt more effective. However, he could find no established standard for mixing and applying such materials. To solve the problem, Wendling and his winter maintenance team conducted a series of tests to establish a standard mixture and application rate for all districts within Saginaw County.

The big test

The SCRC winter maintenance team combined rock salt and sand with varying proportions of mineral well brine to produce ten different mixtures for testing. Materials were chosen based on availability and ease of application.

The tests were conducted in the parking lot of a vacant shopping mall on ten 100-foot long test strips. Each strip was the width of a 20-foot wide two-lane road. After a significant snowfall, vehicles were driven over each test strip to simulate traffic and to create a mat of snow and ice on which to test each mixture.

The plow trucks used for the test applied the mixtures using identically-configured Component Technology GL 400 spreaders. Mineral well brine was added to salt or sand using a pre-wetting system mounted on the rear of each plow truck. The test strips were plowed in both directions and the de-icing treatments were applied to the "roadway" on the return pass in a 20 foot spread. A different mixture was applied to each test strip.

Photos were taken every two hours throughout the day to document changes in road conditions.

Observations

The SCRC team examined the photos to estimate a percent of bare pavement in each. They then entered all data into a spreadsheet and analyzed it. The details of the tests are summarized in the table below.

Mixture ten, which contained only mineral well brine and sand, was found to be the most effective and least expensive per lane mile. However, the SCRC team decided it wasn't a good option for a couple of reasons. "The cleanup costs would have been high, especially in the urban areas," Wendling said. "And we assumed some of the performance was due to the sun warming the sand on the day of the test. If not for the sun I don't think we would have seen that much bare pavement."

Results

To choose the best mixtures, the SCRC team considered the performance and cost per lane mile of each. Ultimately, they decided to use two different mixtures: one with

salt and mineral well brine for urban areas (see *Test 4*, below) and another with sand, salt and mineral well brine for rural areas (see *Test 8*, below). "We didn't want to use sand in the urban areas because we would have to clean it out of the storm sewers in the spring. In the rural areas we don't have to worry about cleanup because there are no sewers." Wendling explained.

The real value

Wendling's experience is a great example of the value of the scientific method for problem solving. Given the lack of a standard for mixing and applying de-icing materials in Saginaw County, he and his team devised tests, gathered and analyzed data, and found solutions. The process was neither difficult nor expensive, and the payoff goes way beyond safer roads or better management. Wendling and his team not only learned a lot about de-icing, they also assembled a set of data that they and others can use to learn even more in the future. 

	Sand (yd ³)	Salt (yd ³)	Brine (gal)	Application Rate (lb/mi)	Cost per Mile	% bare pavement
Test 1	0	10	0	400	\$8.32	36
Test 2	0	10	62.5	350	7.43	18
Test 3	0	10	100	300	6.45	22
Test 4	0	10	120	250	5.41	33
Test 5	6.7	3.3	62.5	400	3.92	51
Test 6	6.7	3.3	100	350	3.52	58
Test 7	6.7	3.3	120	300	3.06	60
Test 8	6.7	3.3	120	250	2.55	70
Test 9	10	0	120	400	1.83	53
Test 10	10	0	120	300	1.37	85



The Saginaw County Road Commission (SCRC) found that a mixture of sand, salt and mineral well brine performed best and cost the least per lane mile (*Test 8*). However, because of the cost associated with cleaning sand out of storm sewers, they decided to use a mixture of salt and brine (*Test 4*) for urban areas, and a mixture of sand, salt and brine for rural areas only.

Sustainable, from Page 1

concerns, reinforcing steel in bridges, pavement, and other structures can degrade over time due to exposure to salt, compromising their integrity and resulting in millions of dollars in repairs.

Store correctly and use carefully

According to DeVries, proper material storage is a good first step toward establishing sustainable winter operations. Salt and other materials used in winter maintenance should be stored in secure, covered structures that protect the salt from exposure to precipitation. Storage sites can cause contamination if they leak or if there are spills when materials are being loaded or unloaded. For this reason, salt should be stored well away from residential areas, bodies of water and vegetation.

Once storage sites are secure, “sensible salting” practices should be implemented to cut back on the amount of material used. *Sensible salting*, a term coined by the Salt Institute, is defined as “Applying the right amount in the right place at the right time.” DeVries explained that when too much salt is used, not all of it dissolves on the roadway; the extra material can build up and present a skid hazard for vehicles. If too little material is used it can quickly get diluted with melted ice and snow, and then re-freeze on the pavement. Using correct amounts of material is not

Our certification program requires anyone who conducts winter maintenance on our roads – public or private – to go through a half-day training seminar on equipment maintenance and adjustments.

Mark DeVries – McHenry County Division of Transportation

only cost-effective and safe, it is also environmentally friendly because it minimizes runoff that can impact the environment.

More information about sensible salting is available from the Salt Institute (see “Additional Resources on the Web,” at the end of this article).

Telling isn't training

DeVries stresses that educating and working with drivers is an essential aspect of sustainable winter operations. McHenry County started a mandatory training program to ensure their drivers would know how to calibrate their equipment and how to keep them up-to-date on maintenance practices. “Our certification program requires anyone who conducts winter maintenance on our roads – public or private – to go through a half-day training seminar on equipment maintenance and adjustments,” DeVries explained. “And all of our drivers calibrate their trucks and spreaders every year to ensure that they are applying the correct amount of material.” To track progress, DeVries collects and posts data on how much material each driver uses. “Most drivers welcome this, because they want to know how their performance compares to other drivers,” he said.

To provide an additional element of education, drivers should have some sort of weather forecasting service or temperature monitoring device available to them. McHenry County uses a

Maintenance Decision Support System (MDSS), which provides real-time updates on weather conditions and road temperature using a network of sensors installed on their trucks. This data allows drivers to adjust the amount of material they are applying as they plow, saving money by preventing waste. If an MDSS is not available, alternative methods such as truck-mounted temperature sensors or weather consultants can also be used to keep drivers informed of changing conditions.

Wetter is better

Advanced techniques, such as anti-icing and pre-wetting are the final elements of a sustainable winter maintenance program. Anti-icing involves applying a brine or similar material to roadways before a snow event to keep ice and snow from bonding to the pavement. “It takes four times as much material to remove ice as it does to prevent it from forming,” DeVries explained. Anti-icing can be done with traditional chemicals, but there are also organic



Anti-icing involves applying a salt brine or similar material to a roadway before a snow event to keep ice and snow from bonding to the pavement. The right lane of the road above was treated with 85% brine, 10% Geomelt and 5% Calcium Chloride. The left lane was not treated.

products such as Geomelt™ – a product made from liquid left over in the processing of sugar beets – that are effective for preventing the formation of ice. Anti-Icing treatments can be applied by plow trucks fitted with spray-bars, or by special sprayer trucks. Since anti-icing liquids can be washed clear of roadways if rain falls before a snowstorm begins, it is important to take weather conditions into consideration when applying anti-icing treatments.

Pre-wetting involves adding a liquid to rock salt before it is applied to the roadway. Wetting salt before it hits the pavement decreases “bounce and scatter,” which prevents waste. “Pre-wetting saves as much as 26% of a load of salt – you only lose 4% of the salt off the road,” says DeVries. Since salt has to be in a liquid brine in order to melt ice, pre-wetting speeds up the ice-melting capability of salt. Pre-wet material can be purchased from a distributor, it can be manufactured on site, or applied at the spinner using special on-board pre-wetting attachments.

Since 2002, McHenry County has been using organic additives to enhance the performance of their pre-wet salt. “Organic additives have been widely used to inhibit corrosion, but we’ve found that carbohydrates in the organics actually improve the performance of our salt,” he said. “And they provide very good residual value; the sugars help the solution stick to the pavement longer so we don’t have to reapply as often.” McHenry County’s

standard prewetting mixture is 85 percent brine, 10 percent organic additive, and 5 percent Calcium Chloride.

Get everyone together

The biggest key to establishing sustainability in winter maintenance operations, DeVries said, is a spirit of collaboration. Road agencies have to work with their staff, with surrounding counties, and with the general public to educate, obtain support for, and implement sustainable practices. And the practices should be implemented through a controlled evaluative process, and they should be documented, verified, and re-examined on a regular basis to assure effectiveness, cost savings and efficiency. "Getting everyone involved and making the progress clear are big keys to continued success," DeVries said. "If people know their opinions are valued and that the changes being made are making a difference, they won't be afraid to continue to change and try new things." In winter operations, change is good because even small changes can make a big difference, both economically and in terms of environmental impact.



Additional Resources on the Web

McHenry County Division of Transportation
www.co.mchenry.il.us/departments/dot/

Salt Institute
www.saltinstitute.org/

For direct links to these resources and more, go to:
www.MichiganLTAP.org/pubs/Bridge

PROPER CALIBRATION:

Are your solid materials spreaders and liquid distribution systems calibrated properly?



By Duane E. "Dewey" Amsler Sr. P.E.,
AFM Engineering Services

Download here:

www.saltinstitute.org/content/download/9657/62271

Five steps to a sustainable winter maintenance program

1. Store Salt Properly



Storage facility should be located away from residential areas, bodies of water and vegetation. The structure should completely contain the salt and protect it from the elements.

2. Salt Sensibly



The *Salt Institute* coined the phrase *sensible salting* to encourage winter maintenance crews to apply only the amount of salt necessary to reach a locally-determined level of service.

3. Educate and Train



Understanding how salt works and knowing how to use and calibrate equipment properly can save significant amounts of salt every season by preventing waste. An MDSS, truck-mounted sensors, or weather forecasting service can also help.

4. Anti-ice and Pre-wet



Anti-icing involves applying an anti-icing liquid to the pavement to prevent ice and snow from bonding. Pre-wetting refers to the practice of wetting rock salt before applying it to the road. Both practices result in significant cost and labor savings.

5. Collaborate



Internal staff, neighboring agencies, and the general public should all be informed and involved in the process of adopting and implementing new winter maintenance practices.

Photo credits (from top): CTT, CTT, McHenry County Division of Transportation, Kent County Road Commission, CTT.

No “silver bullet” in winter maintenance materials

After four years of testing pre-wetting materials, Manistee CRC decides a combination is best

By John Ryynanen, Editor, *Center for Technology & Training*

Over the past four winters, Jerry Peterson, manager of Manistee County Road Commission (MCRC), and his winter maintenance crew have been experimenting with various anti-icing materials. To help measure results, they keep meticulous records of snowfall amounts, types of precipitation, air and pavement temperatures, and a variety of winter maintenance costs. If you compared the data they collected in 2007 to that in 2008, you would notice that snow events in Manistee County increased 30% in 2008, but that MCRC used 24% less rock salt (sodium chloride) and saved approximately \$140,000 in material, equipment, labor and overtime costs that year.

Upon closer examination of the data you'd find the difference-maker: an agricultural by-product of sugar beet production. The environmentally-friendly material is marketed under a variety of brand names. Peterson refers to it as “beet juice.” When MCRC first started using beet juice to pre-wet their rock salt in 2008, Peterson was delighted with the results. Today he remains impressed but he's learned that a combination of materials is actually more effective and less expensive. “We saw dramatic early results with the beet juice,” Peterson said. “But now we know that no single product or material will solve every problem.”

Quick burn vs. long, slow melt

Calcium chloride is the other main weapon in the MCRC winter maintenance arsenal. Peterson's crew uses a 32% mix of pure calcium chloride and salt brine to pre-wet their rock salt in certain conditions. “The calcium chloride mix provides a quick burn on the pavement, but it doesn't last long,” Peterson explained. “It's perfect for early winter and late spring when we only need it on the road for a short period of time. It's also less expensive than beet juice.”

In mid-winter when snowfall is heavy and the pavement temperature rarely rises above freezing, MCRC uses the beet juice product to pre-wet their rock salt. “We've found that the beet juice helps the salt stick to the pavement longer. In mid-winter it allows us to use less salt and requires fewer applications,” Peterson said.

Until two years ago, MCRC also used BOOST™ to pre-wet some of their rock salt. BOOST is a proprietary blend of calcium chloride and de-sugared molasses; it is specified in the MDOT winter maintenance contract for use on state trunk lines in Manistee County.

To compare the performance of BOOST and the sugar beet product, Peterson conducted a side-by-side test. The results were clear.

“Over the course of one week, we used about 20 percent less salt with the beet juice product, and it kept the pavement clear longer.” Peterson said.

Based on the results of the test, the local MDOT Transportation Service Center granted Peterson permission to use the beet juice product to pre-wet rock salt for state trunk lines in Manistee County.



A Manistee County Road Commission (MCRC) truck stops for a new load of salt. MCRC uses a combination of materials for pre-wetting their salt. “No single product or material will solve every problem,” Jerry Peterson, manager of MCRC, said.

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Testing continues

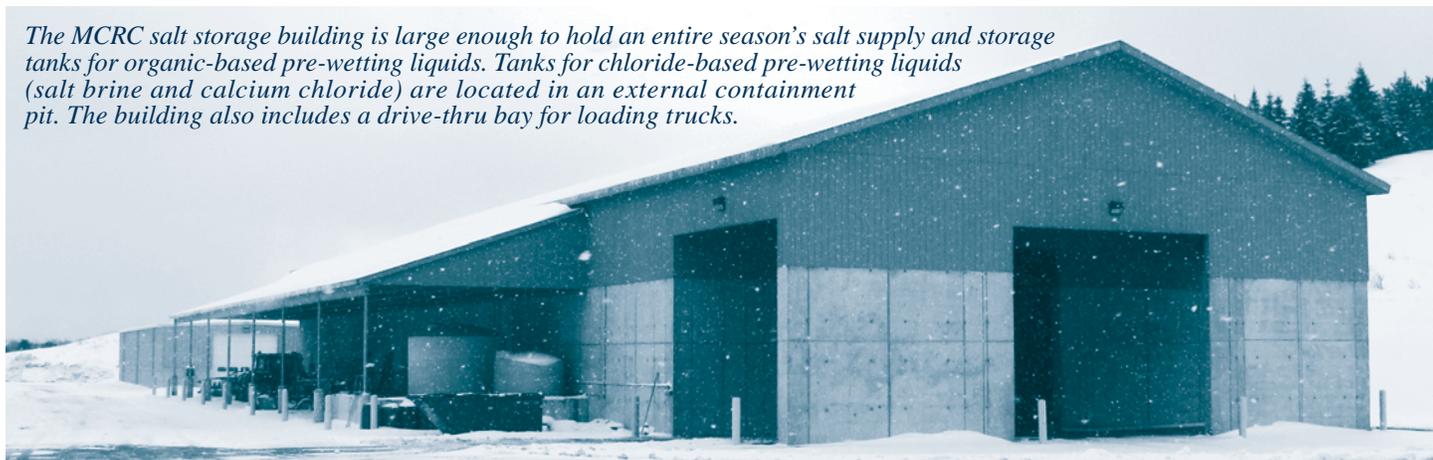
For the coming winter, Peterson is planning to try a 50/50 mix of the beet juice product and pure calcium chloride. “We're thinking the calcium chloride will provide the burning action we need to remove ice quickly, and then the beet juice will stick on the pavement to prevent hard-pack from forming.”

Peterson insists that localized testing is the key to finding the material that performs best. “I don't expect anyone to accept our results as the answer to their problems because conditions can vary so greatly,” he said. “If you think something might work for you, the best thing you can do is try it.”

Truck drivers are the key

Even with all the new understanding he has gained through material testing and meticulous record keeping, Peterson stresses that driver training is the most important aspect of the MCRC winter maintenance program. “Our drivers are the most important link,” he said. “They see the road conditions real-time. They need to know when to use each material, how fast each works, how much to put down, and anything else that will help them keep the roads clear.”

The MCRC salt storage building is large enough to hold an entire season's salt supply and storage tanks for organic-based pre-wetting liquids. Tanks for chloride-based pre-wetting liquids (salt brine and calcium chloride) are located in an external containment pit. The building also includes a drive-thru bay for loading trucks.



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Technical writing for transportation professionals

Define your purpose, gather background information, and organize your thoughts

By Richard Kronick, freelance technical writer and writing trainer. *Reprinted with permission from Minnesota LTAP, University of Minnesota.*

This article is the second in a three-part series. Part three: *The structure of a proposal* will be published in the next issue.

My first article in this series showed how to quickly size up your readers and their needs (see the September 2010 issue of *The Bridge*). Once you've done that, the next logical step is to define your purpose. It's "logical" because your purpose should literally grow from what you know about your readers and your relationships to them.

Define your purpose

You can define your purpose for any business document by answering three questions:

- What's in it for me?
- What's in it for my readers?
- What do I want my readers to do?

Taking a few minutes to actually write out the answers to these three questions will help you stay on track as you write. You'll be more likely to choose words and sentences that contribute to your stated purposes—and less likely to wander off to topics that don't contribute. In other words, writing out your purposes should make you a more powerful and efficient writer.

The answer to the first question—What's in it for you?—will help you decide how much time and effort to put into writing the document. It's worth spending a lot of time to produce a great proposal if it will get you a big project. On the other end of the scale, let's say you're writing a one-line e-mail, and all it says is: "We changed the meeting from 2 p.m. to 3 p.m." You might think there's absolutely nothing in this document for you. But we all judge the people who write to us partly based on the quality of their spelling, grammar, punctuation, and clarity. So at the very least, your professional image as a business person is on the line with literally every document you write—even a one-line e-mail.

Though all three of these questions are important, the third one stands a bit above the other two like an Olympic gold medalist on the reviewing stand. The fact is, we write all business documents to convince someone to do something. This means, in a real sense, no matter if you call it a proposal,

report, letter, memo, or e-mail, all business documents function as proposals. If all that happens after people read your report is that they think but don't act, your document has failed. That means you should always answer the third question in behavioral terms: Name the action you want readers to take.

Gather background info

After getting to know your readers and defining your purpose, the next step is to gather background information. I have just one tip for you at this point: Before you start gathering background information, make a shopping list of all your sources of information—the documents you need to gather, download, or purchase, and the people you need to call, e-mail, or see. I call it a "shopping list" because it has the same value as your supermarket shopping list: It makes you more comprehensive and more efficient. It tends to prevent those "V-8 moments" when you slap your forehead and say, "Nuts! I can't write this because I forgot to get [fill in the blank]!"

Organize your thoughts

After you've come to terms with your audience, your purpose, and your background information, you're ready to organize your thoughts. But this is one of the most common stumbling blocks in business writing. At the beginning of my writing seminars when I ask the attendees what their business writing problems are, someone always says, "I know what I want to say, but it gets all mixed up when I try to write it."

The solution to this problem is to create an outline before you start writing so you know where you're going before you take the first step. Now I know that many of you, after reading the previous sentence, are rolling your eyes and thinking, "Outlines! I hated outlines in school!" Well, I sympathize with you because I know that, while everyone is told to create outlines in school, few teachers actually show kids how to outline. Sure, your teachers showed you to use Roman numerals for your main topics and A's, B's, and C's for your sub-topics. But that's just the superficial mechanics. You arrive at a good outline by taking two steps:

- Create a pile of ideas by mind-mapping.
- Apply logic to the pile of ideas.

Mind-mapping

A mind-map is a one-person brainstorm on paper. It's easy: In the center of a blank sheet of paper, jot down some shorthand for the main idea of the document you're planning. Circle it. Then, in Tinker-Toy fashion, make a short connecting line extending from your circle in any direction. At the end of that line, write the next relevant thought that comes to mind and circle it too. Now just keep going! In a few minutes, you'll have branches, sub-branches, and sub-sub-branches. For complex documents, I start with an 11 x 17 sheet because I know there will be dozens of nodes in my mind-map.

Why mind-map? Because at this point in the planning process, you have lots of ideas bumping around in your head, but they're probably not well organized. This is the natural result of the previous steps I have suggested. So the goal of mind-mapping is not so much to organize (though you'll do some of that too), but just to get your thoughts down on paper before you forget them.

The four kinds of logic

Now go to step 2 above: Apply logic to the pile of ideas you generated by mind-mapping. What kind of logic, you ask? Good question! Here's a wonderful thing: There are only four kinds of logic—that is, four reasonable ways to organize any information:

- Order of importance
- Time order
- Pro vs. con
- Cause and effect

That's it! In the entire history of humankind, no one has ever come up with any other ways to organize information. They are the four tools in your logic toolbox.

Order of importance is also called "top-down" reasoning. You start with the most important idea and go in order of lesser and lesser importance. In a proposal, it means you start with whatever is most important to your primary audience—the decision makers. Why? Because decision makers are always people at the tops of organizations. And those people are so busy that they are only willing to give your proposal a few

See *Tech Writing* on back page



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Underbody wash system cleans from the inside out

Manistee County Road Commission (MCRC) Mechanic, Paul Wehrmeister, devised an innovative system for thoroughly rinsing corrosive salt and anti-icing chemicals from the frames of MCRC plow trucks. The system consists of 14 adjustable high-pressure spray nozzles mounted on a 2-inch plastic pipe. The pipe is permanently attached between the frame rails of a truck, and the nozzles are aimed at the inside of each rail. A quick-couple hose attachment allows convenient connection to a standard garden hose in the garage.

Mechanics mount the system on the trucks as part of the standard build practice. “We build



our plow trucks from the frame up, so it’s easy to attach the wash system when we first get a new chassis in the garage,” Wehrmeister explained. After attaching the wash system to the frame, they add a sheet of stainless steel on top of the frame to contain the spray under the vehicle, and then they mount the sander.

Material cost for the wash system is approximately \$150.00, and it takes one mechanic about three hours to build and mount it. For more information, contact MCRC Manager Jerry Peterson at 231-889-0000. 

Tech Writing from Page 7

minutes to grab their attention and make sense. So you simply must hit them with the most important idea right away or they quickly lose interest and stop reading. Remember: It’s most important as defined by the primary audience.

Time order is the order of meeting minutes, procedures, trip reports, and many other business documents. For example, I’m using it as the overall logical structure of this series of articles.

Pro vs. con is the logic of every good sales pitch. First you tell people all the positives about whatever you’re selling. Marketing professionals call them “features and benefits.” If you do a good job of explaining the positives, your readers

will then be willing to accept the negative part of your message, which is that there’s no free lunch. Reasonable people know there’s a cost for every good thing—and it isn’t always just money.

Cause and effect logic has another name: The Scientific Method. It’s what Sherlock Holmes used to solve every case—and it’s what every engineer uses to solve engineering problems: 1) Make observations and gather data. 2) Analyze and synthesize the data. 3) Arrive at a solution. That’s science, right?

So to create an outline, start by picking one of these four kinds of logic as your overall organizing principle. You’ll then find that you need to again pick one of the four at each

subordinate level of your outline. When you’re finished, you’ll have layers of logic within logic within logic, but it will all be the same four kinds! This process makes outlining roughly 1 million times easier than it was in school because your teachers didn’t show you how to do it.

Now you’re ready to write. 

Richard Kronick is a freelance technical writer and writing trainer specializing in transportation, civil engineering, and architecture. He has presented more than 1,000 business writing and technical writing seminars around the world. He can be reached at www.richardlkronick.com.