GOVERNMENT D3

DIGITAL DESIGN DATA • issue 1

profiling the Government User

Digital Design Data (D3) features real-world applications for the Autodesk Government User in the areas of General Design, Building Design & Facilities Management, GIS, Civil Design, Manufacturing and Mechanical Design.

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CAD Overlay, Inventor Help the Power Flow At Grand Coulee Dam

Immense. Gigantic. Stupendous. Monumental. Titanic. When you see it, the words you could use to describe Washington's Grand Coulee Dam just don't do it justice. It's just plain big.

Started in 1933, the Grand Coulee Dam is an engineering marvel, the largest concrete structure ever built. Onlookers often have trouble finding the right superlatives to describe it. The dam is 5,223 feet long, spanning the length of 17.5 football fields. From the reservoir floor to its highest parapet, Grand Coulee Dam extends more than 550 feet into the heavens. If the Statue of Liberty were reconstructed on the reservoir floor, the dam would surpass its height more than five times.

Grand Coulee Dam fills three primary roles. First, it is a major provider of electrical power to the Northwest. Second, water pumped from behind the dam provides irrigation for over half a million acres of the Columbia River basin. Finally, by strictly regulating the Columbia's highly variable flow rate, the dam provides much-needed flood control to the river basin.

Grand Coulee Dam *continued on page 12*

U.S. BUREAU OF RECLAMATION

Engineers at Grand Coulee Dam used Autodesk CAD Overlay to scan more than 17,000 Raster images of existing drawings, including this one of an access road for the dam's 500-kilovolt switchyard.

ALASKA DOT & PF

Most of Alaska's highways are two-lane roads – like the Richardson Highway, which runs from Valdez to Fairbanks.

Autodesk Design Standard Ensures Consistency at The Alaska DOT

In Alaska, where proximity to the polar regions makes each year an extreme cycle of dark wintry days and sunny summer nights, they have a joke about the seasons. It goes like this:

"You know about our four seasons in Alaska, right? Winter, Still Winter, Almost Winter, and Construction Season."

Ask around at the state's Department of Transportation and Public Facilities and you're likely to hear that joke a few times. In fact the Alaska DOT, as the agency responsible for the constant stream of road, bridge, airport and harbor projects that Alaskans must navigate every summer, may even be the reason the joke started.

Obvious circumstances explain the agency's schedule. From October through mid-May, ice, snow, darkness and sub-

Alaska's Design Standard *continued on page 9*

Dublin, Ohio, Turns to MapGuide to Power Its Web-Based GIS

In the public mind, America's big cities usually assume a heroic profile. They have the hardest problems, but they also have the biggest budgets – so they hire the best administrators, and are the first to adopt new technologies. If a fabulous new tool for governments came along, you would expect Buffalo to lead, and Poughkeepsie to follow.

But quite often, the truth is that smaller cities lead the way.

The city of Dublin, Ohio, a community of 34,000 northwest of Columbus, is known for a famous golf course – Muirfield Village, designed by Jack Nicklaus, where Tiger Woods has won the PGA Memorial tournament three years in a row. Dublin holds the corporate headquarters of Wendy's, the fast-food chain, and several large research and technical facilities. But in the basement of the Municipal Building on Emerald Parkway, humming inside a Windows NT server, the city also boasts one of the most complete and accessible Geographic Information Systems (GIS) in Ohio – or anywhere else in the United States, for that matter.

CITY OF DUBLIN

Because Dublin's online GIS and its engineers both use the Autodesk design platform, new survey data (above) from construction sites can be updated onto the GIS quickly.

Dublin's GIS has won acclaim because the city dedicated itself to gathering all the digital graphic data it could find, correlating it with stacks of municipal and county information, and then making it all available to its employees and the public with simple, Web-based interfaces. The result is that workers as diverse as city planners, surveyors, utility engineers and financial analysts – as well as ordinary citizens on the Internet – are able to view the city as an intricate cross-section of maps, photographs and other diagrams, each layer filled with useful information.

The linchpin of Dublin's GIS is Autodesk MapGuide®, an interactive platform that brings map and design data out of the "back office" to desktop PCs or mobile devices via a Web browser.

BUILDING THE BASE MAP

The establishment of a robust GIS in Dublin is partly attributable to the efforts of Peter Husenitza, who became the city's first information technology director in 1997, and his GIS coordinator, Vance Cerasini. In previous positions at other Ohio cities, both men had worked separately with Autodesk specialist Jim Davenport. Draft-Co, Davenport's company, has helped local agencies throughout Central Ohio to

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D³ – Digital Design Data features stories of how Autodesk solutions are innovatively applied by government users. If you think your own agency or team would make a good case study for *D³*, please contact us at the number below, or e-mail Kerry Marple at kerry.marple@dlt.com.

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Autodesk products mentioned in this issue of *D³*:

AutoCAD
Autodesk Land Desktop
Autodesk Inventor
Volo View Express
Autodesk Map
Autodesk Civil Design
Autodesk Mechanical Desktop
Autodesk Raster Design *(formerly CAD Overlay)*
Autodesk MapGuide
Autodesk Survey
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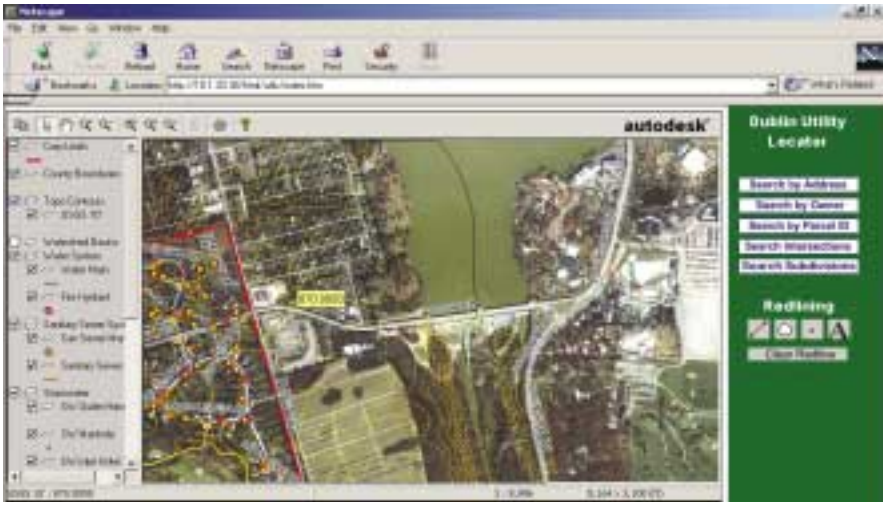
digitize their paper maps and introduce satellite photography – in places like Hilliard, Springfield, Findlay, Upper Arlington, Jackson County and Washington County.

Before the GIS was assembled, Cerasini says, the city's map data consisted mostly of piles of paper. Because Dublin had grown over the years, annexing pieces of surrounding land, its property parcel maps were dispersed among tax records in three different counties. With help from interns and part-time staff, the city methodically gathered reams of information on private and public property lines from the counties and converted them to digital format in AutoCAD®, joining them together to form a "cadastral file" of survey boundaries. (This base map is updated quarterly with new information from the counties, as property lines shift.)

The city then stitched together aerial photography from several county sources, and supplemented this with new satellite photos, which are also regularly updated. The property lines and orthophotos, plotted together on a common coordinate system, formed the foundation of the city's GIS – and today they remain its most popular features.

> *"People can sit at their desks, open MapGuide, and print a street map or water atlas…and never have to call us for help."*
>
> — Vance Cerasini, GIS Director
> City of Dublin

But the city didn't stop with parcel layouts and aerial imagery. On top of this base, Dublin officials began to add layers of information to the map, starting with infrastructure and utility features that are important for engineers: water pipes, gas mains and electrical lines. They added stormwater drains and sanitary sewers. Then they just kept on going, adding street paving and maintenance dates for the public works division. Police and fire incident reports for the police department. Road centerlines and edges. Zoning and ward boundaries. City and county limits. School and architectural districts.



CITY OF DUBLIN

Using icons in the left-side bar, users of Dublin's Web-based GIS can navigate through its map layers – in this case to show the utility locator (above), which superimposes utility line graphics over aerial photos of the city.

Floodplains and watershed sub-basin drawings. Topographical features like hill contours, ponds and rivers. Community subdivisions. Parking lots and "impervious areas." Snow routes… bike paths…fire hydrants…You get the idea.

"We have 60 different layers," says Cerasini. "And the great thing is, everybody uses everything. We created a truly shared spatial data environment that the entire city feeds from. Various departments and divisions maintain their own specific parts of the information in the GIS, but nobody keeps their data to themselves – there are no 'data empires,' and no redundant data."

MULTIPLE WAYS TO USE DATA

As many as 200 employees throughout the city government view map data from Dublin's GIS via Autodesk MapGuide, which is built onto the city's in-house, Web-based intranet. A free tool, MapGuide Viewer, allows any employee to use the system's pan-and-zoom functionality. They can query the GIS by typing in street names, addresses or homeowner names. Or they can specify the layers they want to see, then drag their cursor across the area they want to magnify. On the public GIS site, the interface is substantially the same, for public Internet surfers from Columbus to Kalamazoo – though the city provides a somewhat narrower selection of information layers, and residents' names are removed.

"The different divisions of the government are spread out all over the place, which is why it's great to have the data right there on the city intranet," Cerasini says. "We're all tied in with a T1 connection, so people can sit at their desks, open MapGuide, and print a street map or water atlas. People can be as self-sufficient and independent as they want, and never have to call us for help."

- **Utilities:** A special utility locator on the intranet GIS shows water pipes and other underground infrastructure throughout the city. If a water main breaks, engineers or maintenance chiefs can quickly display the location of the nearest shutoff valve and dispatch field crews there. Or if a homeowner calls the public works department wondering what utility lines are buried in their side yard, anyone who answers the phone can provide the answer.
- **Building permits:** The city's building permit system has been expedited by linking it to the GIS, and conversely, officials in charge of code enforcement can check the latest satellite photos on the system to see if someone built without a permit. Banks or prospective home-buyers get quick answers to questions about the floodplain boundaries around a given property, without forcing someone to pore over hard copies.
- **Planners:** For the city's planners, the satellite photo layer is a favorite. Planners check the GIS to see concentrations of trees and wetlands, but also to keep an eye on sprawl. "The high-resolution imagery is an impor-

continued on next page

Dublin's Web-Based GIS *continued from previous page*

tant tool for long-term growth management as well as zoning and code enforcement issues," says Planner Holly Susong.

- **Financial uses:** City financial analysts use the GIS to research properties for potential acquisition by the city, and to prepare the maps they include with grant applications. Landscape architects in the Facilities Division go on the system to find property owners and their acreage, check private property boundaries, develop mailing lists, and send links to consultants who are working on specific projects.
- **...And mosquitoes:** No job appears too small for the GIS. When the city recently became concerned about controlling mosquitoes, one division used the photo layer to pinpoint all the ponds that couldn't be seen from the road.

TERMS

GIS Software: A geographic information system (GIS) gathers data from several different sources and makes it accessible through multi-layered maps, which often share a common coordinate system. GIS software allows mappers, infrastructure management professionals and civil engineers to reshape the landscape and deliver essential services such as electricity, water, government services, telecommunications and more.

Autodesk MapGuide: MapGuide allows people to access map-related services and information in a user-friendly format from almost anywhere via the Internet, an intranet, or from a handheld computer.

AutoCAD: AutoCAD is a widely used Autodesk program that allows users to create, view, manage and re-use information-rich drawings and design information, and share them with partners, consultants and constituents. (CAD stands for computer-aided design.)

Orthophotos: An orthophoto is a digital aerial image of a neighborhood, city or other terrain that is "rectified" onto a geographic coordinate grid, and used by engineers and surveyors for accurate mapping and surveying of a land parcel.

Base map: A base map, usually built from an orthophoto, shows land parcels with accurate, precise statistics. It's called a "base" because other maps for the same area, showing different features and data sets, can be overlaid on top of it.

Cadastral file: A cadastral file, or cadastral map, collects survey data about the man-made boundaries for a given area—such as plats and private/public property lines—along with information such as addresses, legal descriptions, code numbers or coordinates.

CRIME ANALYSIS AND CONTRACTING

The GIS base map helps emergency response teams to see street layouts quickly, and when paired with other kinds of applications, the GIS can become even more powerful. Dublin has integrated the base map with crime analysis software from HTE, and the combination allows the city's police to produce detailed incident histories within defined areas.

"It gives the police a means to be proactive," Cerasini says. "They've actually taken some of these reports and maps to court and used them as a foundation to get a search warrant. When you show the number of crimes in an area relative to where a suspect has lived, it can be very compelling to a judge."

CITY OF DUBLIN

Dublin's Web-based GIS allows the public to search for a particular intersection, such as the Emerald Parkway crossing (left), or to query the map to show only Dublin's parks, such as the park featuring "Field of Corn" (above), an array of 109 six-foot-high concrete ears built by Columbus artist Malcolm Cochran.

At the request of its engineers, Dublin added a download feature for outside contractors to the public Internet side of the GIS. When contractors are designing road projects, they can go to the public site (http://gis.dublin.oh.us/) and pull down base maps, drainage drawings, utilities and aerial imagery.

But the city also takes in map and design data from contractors. If a contractor adds a new section of utility line or digs a stormwater drain, they send the revised facility maps back to the city. Because both the city and its contractors use an AutoCAD design standard, the GIS' utility layer can quickly reflect the changes. "If we weren't on AutoCAD, we'd be doing conversions from other formats all the time," Cerasini says. "But because we're centralized on AutoCAD, we can update the GIS facility maps almost immediately when the new plans come in." The same holds true when the city's in-house engineers and surveyors make changes to the GIS system's facility map, because they design their road and utility projects using AutoCAD-based Land Desktop from Autodesk.

STABLE ARCHITECTURE

The Dublin GIS runs on Windows-based hardware with a 3-year-old Pentium 2450 microprocessor. "You don't even have to have optimum hardware for it to run well," Cerasini says. "From an IT architectural standpoint, MapGuide's just such an efficient product. It comes out of the box completely stable. One day we had more than 100 people hitting the Internet GIS externally, and I never got a call from an internal person saying the volume had caused a problem."

Cerasini says MapGuide runs almost as fast over a 56K dial-up connection as it does on his office T1. That's important, because he envisions a near future in which Dublin's police have real-time access to the GIS in their cruisers – via a 56K wireless connection. "We'd like to put a MapGuide application in a patrol car so the officers can see aerial imagery when there's a crime happening," he says. "And if they get a domestic violence call, for example, we want them to be able to look at a property and see how many people live there."

"What's holding that back right now is the wireless bandwidth, but I expect they'll figure that out before too long," Cerasini says. "But believe me, if we can get a 56K connection out to a patrol car or a service truck, we can make it work." Given the success Dublin has had with the rest of its mapping ideas, one is inclined to believe him. ■

New York County's Engineers Save Time With Land Desktop

New York's Steuben County is famous for just what you might guess: Steuben crystal. The maker of fine crystal animals, bowls and candlesticks took its name from the county, and its parent company, Corning Inc., took its name from one of Steuben County's largest cities, where it is headquartered. Corning's factory still makes the Pyrex® cookware that made it famous 80 years ago, but since then the old glass works has become a global giant, churning out high-tech products like fiber-optic cable and the silica windows for NASA spacecraft.

At 1,600 square miles, Steuben County is one of the largest counties in New York, slightly smaller than the state of Delaware. But it is a largely rural place, latticed throughout with rivers and streams, with vineyards rolling among the Finger Lakes in the north and Amish villages nestled in the south. With few town-maintained bridges, the burden of taking care of the county's infrastructure often falls upon the county Department of Public Works (DPW).

The county has 678 miles of road to look after, and chances are that each of those roads depends on a series of large and small bridges to get across the streams that criss-cross the county. In all, the county maintains more than 700 of these bridges, about half of them smaller than 20 feet long. "We've got a lot of water up here," said Kent Longacre, a CAD specialist with the DPW.

To track and design bridge projects, along with other tasks such as realigning roads and rebuilding intersections, the DPW relies on Autodesk Land Desktop® and its companion products, Survey and Civil Design. With labor-saving engineering and design tools that are easy to learn, the department's small staff is able to handle projects that it might otherwise have to hire contractors for.

TROUBLED WATER

Each year in the fall and winter, when the leaves are off the trees and won't obscure the surveyors' sightlines, the DPW inspects its bridges and selects a number of them to survey and improve. Using a Leica surveying gun that allows them to enter labels for features as they work, county surveyors measure the GPS coordinates of the banks of a river leading up to a bridge, including trees, buildings, or other landmarks. They download their raw data into Autodesk® Survey, which creates a field book and captures the labels.

> *"[Civil Design] will automatically calculate the transitions in and out of a road curve, the necessary angles and elevations, because the DOT standards are already built in."*
>
> — Kent Longacre, CAD Specialist, Steuben County Dept. of Public Works

From this data, DPW engineers can create a map of the stream with terrain features in a "real-world" coordinate system, adding in local watershed details if necessary. "Land Desktop allows us to look at vertical profiles and sections of the river, which we can check against previous maps to see if the banks are eroding and need reinforcement," said Longacre.

A bridge structure may need repairs if it has deteriorated or is "skewed" improperly along the stream, channeling water the wrong way. In a downpour, fast-moving water could overwhelm such a bridge, degrading its banks or even undermining the road surface above. If the bridge needs to be realigned or repaired, DPW engineers plan the improvements using Autodesk® Civil Design, sometimes designing new concrete beams, sending the drawings out to a beam supplier. "We're one of the few counties in New York that does our own bridge design and construction in-house," Longacre said.

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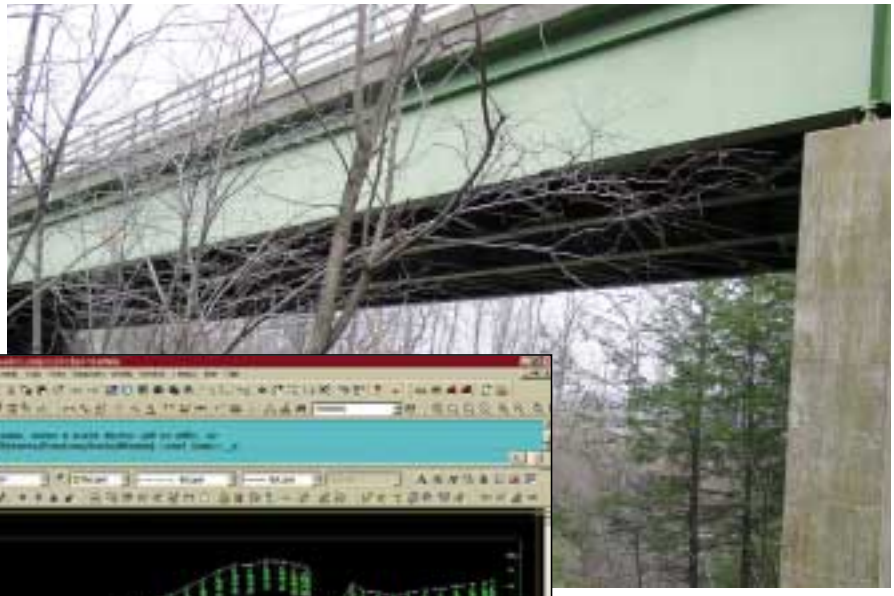
Building Bridges in Steuben County *continued from previous page*

In addition to bridges, the Steuben DPW regularly selects parts of its road system for safety improvements – flattening out stretches of hilly or bumpy road, extending sight lines, realigning dangerous curves. On a road where the surface has deteriorated over the years, causing the pavement to dip up and down, surveyors will take vertical measurements at intervals and then view the road's topography. Using Land Desktop, engineers can create a digital terrain model of the road, looking at several profile cross-sections – "slices" of the road that they can compare with previous years (see sample at right). Land Desktop shows them precisely where the road has deteriorated and calculates how much "fill" the DPW will need to make it level and safe again.

The same volume-measuring features in Land Desktop allow Longacre to monitor how high the surface levels are rising from month to month in the county's two landfills.



STEUBEN COUNTY DEPT. OF PUBLIC WORKS

Above: The Steuben County DPW used Autodesk's land development suite to design repairs to this bridge near the west side of Keuka Lake.

Left: This "profile view" in Land Desktop shows the current vertical grade and elevations for a stretch of road where Steuben's engineers are designing a realignment.

DANGEROUS CURVES

Realignment work on road curves has several elements. Sometimes a curve will need to be "superelevated" so that its outer edge is higher, the same way auto racetracks have steeper banks around their curves. Banking the road this way allows a driver to move around a corner at highway speed without veering off into a ditch. Sometimes the angle of the curve is too tight, or it is elevated on the wrong side due to the pressures of years of traffic; these flaws show up when engineers survey the road and view its topography in Land Desktop. Civil Design makes it simpler to design a realignment that brings the road up to various standards for geometry and sight distance mandated by the New York State Department of Transportation (DOT).

"Civil Design has variables for things like banking, speed tables and superelevations," said Longacre. "It will automatically calculate the transitions in and out of the curve, the necessary angles and elevations, because the DOT codes and standards are already built in. That makes it a lot easier to do those calculations when you're mapping out the realignment."

The DPW also appreciates the ability to do what Longacre calls "what-ifs." Autodesk Civil Design "allows us to do three or four different scenarios for changing a curve, which is a real benefit," he said. "To help us make the right decision, we'll do several models of the same road realignment. We just put different numbers into a table and [Civil Design] has an extension that will immediately adjust the drawing in front of you."

After plotting and printing the different options, they show them to the agency's chief engineer. "We point to the particular positives of each, and he can choose the best one," Longacre said.

COLLABORATION

Having a central repository for drawings in the DPW allows different engineers and drafters to collaborate, building on other people's work. "We're all networked, so one of us can call up the site plan from the database, rename it as a new file, and use it for something he has to do," Longacre said. "My colleagues here don't have to design things from scratch on paper any more; they can just work off my drawings, and vice versa."

Another benefit of in-house design is that the agency's maps are more accessible. "For example, the other day the head of our road construction crews wanted to see a cross-section, so he just walked over to the designer and she pulled it," Longacre said. "If we had given the job to a consultant, we'd probably have to mark up a drawing and send it out, and it would take much longer."

"The bottom line is, if we can do highway designs ourselves, we save the taxpayers money," Longacre said. "And we're doing a pretty good job of handling it ourselves." ■

More Information

To learn more about Autodesk's land development products, contact DLT Solutions at 888-447-ACAD (2223) or visit www.autodeskgovernment.com.

Denver's Airport Soars With Accessible GIS, Engineering Data

With a massive network of facilities to manage above and below ground, Denver International Airport uses MapGuide to deliver 100,000 drawings to utility engineers and other staff via their Web browsers.

It's no exaggeration to say that Denver International Airport (DIA) must be managed as if it were "a small city." In fact, it's more like a large city. DIA is one of the largest airports in the world – the first one to land three airplanes at the same time, on parallel runways, in bad weather.

Finished in 1995 at a cost of almost $5 billion, DIA sprawls across 53 square miles, twice the size of New York's Manhattan Island. It is populated by 23,000 employees and 106,000 passengers, coursing daily through 89 gates to 1,450 flights. For passengers, it offers a chapel, an Islamic prayer hall and a 365-foot, glass-enclosed pedestrian bridge that spans the airfield. Snaking underneath the airport are a giant automated rail system, sewers, baggage conveyors, utility tunnels, 5,000 miles of fiber-optic cable and 11,365 miles of copper cable – enough, as the airport points out, "to run from New York City to Buenos Aires, Argentina."

The airport's caretakers monitor its many-layered infrastructure through a series of online models and GIS maps. While the hundreds of thousands of drawings in the airport's Oracle facilities database are different file types – DWG, ARC, raster, vector – by the time they reach DIA's end users, most have been converted to Autodesk Map™ files. The airport standardized on Autodesk software, a good fit since AutoCAD was already the front end for its facilities management system.

DIA engineers maintain the airport's labyrinth of facilities with a cluster of Autodesk products – including AutoCAD, MapGuide, Autodesk Map, Land Desktop, Survey and Civil Design. DIA's engineering office has made a hefty 166 gigabytes' worth of maps, drawings, plans and other documents available online to the airport and airline staff. Beyond the Oracle back-end system, this network runs on a mix of Unix and Windows NT servers, with a Windows front end.

FAST RESPONSE FOR UTILITY ENGINEERS

Several groups of users need fast GIS information about the airport – not just engineers and facilities people, but contractors, consultants, property managers and administrators preparing reports. 3-D drawings display the airport's complex baggage-handling systems below ground and airspace patterns above it. "We often prepare map and design data for these offices, producing it on hard copy, CDs, e-mail and other formats," said David Dixon, the network administrator who oversees the airport's Geographic Information Systems (GIS) and Engineering Records group.

DIA needs Web-ready mapping software because many of those end users, particularly facilities engineers, also need to pull maps on their own from a browser-based interface. Some general users also read maps on the airport's Web-based intranet, which serves 1,000 people. Because Autodesk Map and MapGuide embrace several kinds of map data and quickly serve maps out into Web formats, they function better in such a situation than many less flexible GIS programs in the marketplace, which can take hours to convert files.

The airport's utility engineers need detailed GIS charts and schematics to maintain systems such as HVAC (heating, ventilation and air conditioning), electric wires and fixtures, and escalators. If a water line breaks, engineers want to pull up a plan, pan and zoom to the correct place, locate the shutoff valve and quickly relay its position to the field. But the airport has neither the time nor the budget to spend on training every desktop map user. That's the kind of work environment Autodesk products were invented for.

"My customers don't have time for training," Dixon says. "But they're pretty good at 'mousing around' on their own. Our engineers and contractors need to be able to find map data directly, through a straightforward interface. That way they don't have to wait in somebody's office for help."

> *"You can see electrical, plumbing, fire protection, communication [features]. Basically, you can custom-build your own model of the airport."*
>
> — David Dixon, GIS network administrator, Denver International Airport

AN INTERACTIVE MODEL

Using AutoCAD and Autodesk Map, Dixon's staff has found ways to make DIA's 100,000 CAD drawings more accessible. One was to create a many-tiered, interactive model of the airport that can be configured to reveal whatever information the user needs. "It has two main components: facilities and land maps," Dixon says. "You can look at the terminal, or underground, the roads, or the outside topography. You can construct it on your desktop to see electrical,

continued on next page

Mapping and Design at Denver Airport *continued from page 7*

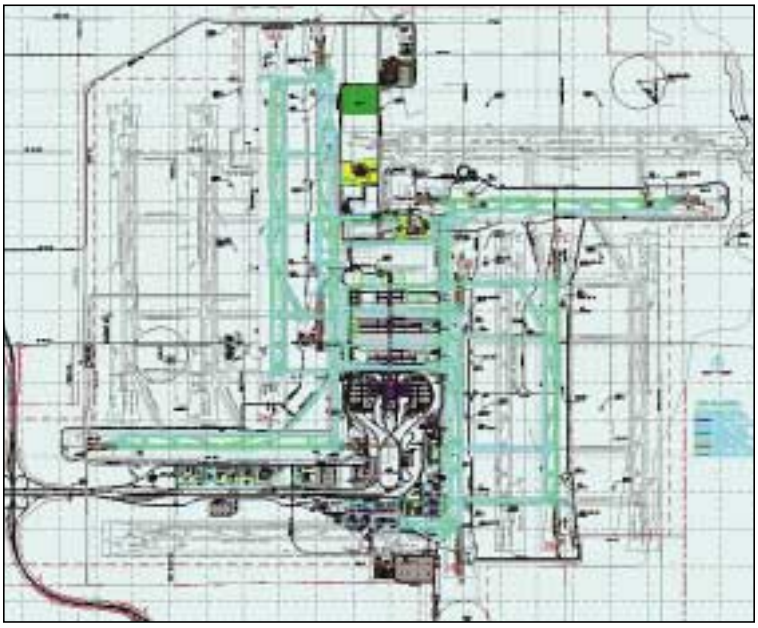
plumbing, fire protection, communication. Basically, you can custom-build your own model of the airport."

"When you offer the huge amount of data we do, the first thing you learn is that no one wants to wade through it all," Dixon says. "So we offer 'quick picks,' where you can hit a button and get what you're looking for instead of getting bogged down in a huge database."

Another way was to widely distribute Autodesk's Volo™ View Express, a free viewer that allows users to review and mark up CAD drawings without AutoCAD software. The program makes it possible to deliver map data out to a broad range of people who aren't necessarily familiar with using CAD maps. "We have 100 downloads of Volo View," Dixon says. Autodesk also allows managers to broaden the number of "authorized" users of its products with a distributed license pool – a feature the airport uses.

MapGuide. The engineers who use maps of DIA's underground utility locations use MapGuide, a browser-based interface that quickly delivers map data from several different GIS and CAD file formats. MapGuide also allows an office to generate statistics from maps and the way they are used, and its Internet platform – which comes packaged with Cold Fusion Web development tools – is designed to enable online collaboration. In addition to their own employees, most large airports deal with contractors, consultants or airlines that require access to facilities maps during construction projects or for regular maintenance. To facilitate this, MapGuide turns internal GIS maps into Web pages that can be shared by password-protected users or the general public.

MapGuide is intuitive enough to serve as the front-end interface for any electronic document management system that deals with GIS diagrams. At DIA's Engineering Records division, Dixon is contemplating that option.



DENVER INTERNATIONAL AIRPORT

DIA serves up thousands of facility maps (above) to its engineers. The airport's drawings are in several formats, all of them quickly converted through Autodesk Map and MapGuide.

"Right now our front end is Microsoft Access, but most of the engineers and inspectors who are our chief customers come at things from a more visual standpoint," he says. "They think in terms of the actual facility instead of queries and searches. As it stands now, because there are so many places where the data resides in Oracle, it can almost require an expert to find."

Land Development. With so much ground to cover among the plains surrounding the airport terminal, DIA surveyors and builders often have to modify their land maps (or generate new ones) to reflect improvements to roads, drainage, runways and other work. They take their "point" measurements outside with GPS devices or other surveying tools, then download that data into Autodesk® Land Desktop. Using the companion products Survey and Civil Design, the surveyors manipulate the survey data, shape terrain models if they need, and sometimes overlay their work with GIS facility diagrams to create multi-layered maps.

While it makes sense for any agency to use interlocking software modules once it has invested in one product, Dixon says his main criterion was simply to make sure the airport's maps remain useful to people. "The data sets we manage are large," says Dixon. "We try to keep them current by keeping them relevant, whether it's to a surveyor or a facilities manager. We try to stay user-driven – find out what programs our users like and go with them, if we can stay within our budget."

DIA has also begun managing pavement maintenance with a GIS product called Paver, developed in a U.S. military research lab. To maximize the useful life of DIA's 48 million square feet of pavement, engineers can track repairs and regular upkeep by clicking on GIS road and runway diagrams. This brings up special maps that show the pavement's deterioration rate and maintenance schedules.

The airport's GIS system has been a huge success in increasing productivity and enabling field technicians to respond efficiently to maintenance needs. And DIA engineers have envisioned future systems that once seemed outlandish, such as crews with handheld devices that display GIS data they download from on-site chips. Given the advances already in place, that day may not be far off. Until then, Denver's giant, space-age airport – the largest public works project in the world – is an open book to any employee with a computer. ■

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Alaska's Design Standard *continued from page 1*

> *"Our road system is very limited, and project locations are often very remote… That's why we're interested in visualizing projects with 3-D presentations and photo overlays."*
>
> — Angela Parsons, engineering assistant, Alaska DOT

ALASKA DOT & PF

zero temperatures make construction in the state almost impossible. That leaves a window in between during which any field work by the agency's surveyors, engineers, geologists, designers and contractors can be done.

The conditions that the Alaska DOT operates in – harsh climate, limited daylight, vast distances – mean a narrow margin for error in an enterprise that involves scores of variables. Road and runway designs must be checked against actual features in the field. Survey point data must be taken and retaken until every necessary land attribute is recorded. Soil samples must be gathered, sensitive environmental areas mapped, private property boundaries measured, utility lines marked. Sometimes a single DOT project can reflect the contributions of 20 or more people, depending on its complexity.

To keep them all speaking the same language, the Alaska DOT for years has standardized its design process on Autodesk products such as AutoCAD, CAD Overlay and Land Desktop. Many users in the agency also work in other design formats, often shifting back and forth several times a day. But when designs move from one workstation to another – from an engineer to a drafter, from an outside consultant to a project manager – they are quickly translated into AutoCAD files, per the department's policy. Most of Alaska's design community operates that way; perhaps more than any other state, Alaska operates on a common Autodesk standard.

FOR SURVEYORS, 16-HOUR DAYS

The Alaska DOT does more than build roads. Huge expanses of Alaska are not traversed by highways, so residents rely on a network of small airports. Tour boats and merchant ships frequent the state's long coastline. So, in addition to the 5,000 miles of road and countless bridges it must build and maintain, the DOT also builds runways at 261 rural airports and operates the state's "marine highway" system of waterways, harbor facilities and ferries.

But looking at the life cycle of a single project helps illustrate how different divisions within the agency use mapping and design tools. In the DOT's Central Region, which is based in Anchorage and is about the size of California, a typical project might involve realigning a stretch of highway whose curves have made it unsafe – essentially rebuilding the road along a new right-of-way. That process generally begins by taking aerial reconnaissance photographs of the job site.

In Alaska, aerial photos must be taken during a brief window in either spring or fall, when important terrain features are not obscured by winter snow or thick summer foliage.

continued on next page

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Alaska's Design Standard ***continued from previous page***

Surveyors then visit the site and travel its length, armed with tools like Electronic Distance Meters (EDMs) and sophisticated Global Positioning System (GPS) devices. Surveyors plot a "centerline" for the realigned road, and measure precise coordinate positions – called points – for ground-level features like utility lines and private driveways, and landmarks like the slope of a hillside, the edge of a stream bed or the corners of a nearby building.

In the summer, an Alaskan surveyor's work days are often 16 hours long, as they scramble to get the most out of the extended daylight. This compensates for the short days of winter, when the sun rises at 10 a.m. and sets between 2:30 and 4 p.m., and instruments can freeze up. At the office, surveyors download their point data into Autodesk's Land Desktop, where they construct a digital terrain model – a detailed drawing showing elevations and topographical features, whose surfaces are rendered as a shifting mesh of triangular faces.

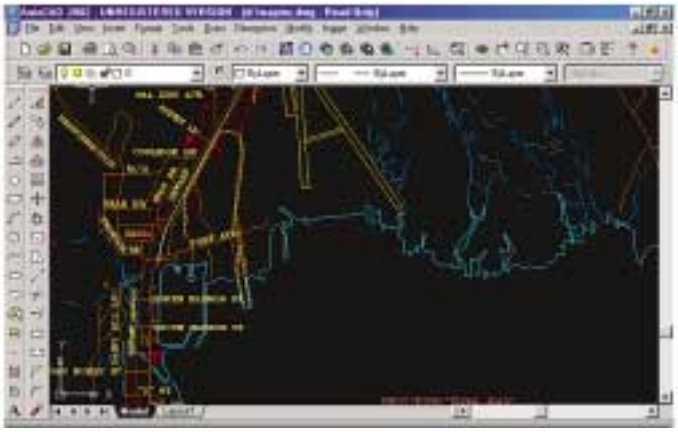
ENVIRONMENTAL CONCERNS

This model then goes out to a series of specialists, who flesh out the road's design in stages and estimate its costs. "Preliminary designers" lay out a basic alignment for the road, keeping it within certain required thresholds – for example, curves cannot exceed a certain sharpness. Checking maps from the state Department of Natural Resources, they prepare an environmental document assessing what sensitive areas might be affected, such as wetlands. If several environmental concerns come up, designers will incorporate those features into large AutoCAD drawings of the project displayed at public hearings.

"When I'm drawing in Land Desktop, I can choose from an archive of possible road alignments, which saves time," said engineering assistant Charlie Wagner. "The elements of a design break down into various objects, and you can change their properties by right-clicking instead of navigating through menus. I'm a right-click kind of guy."

Over in the Right-of-Way section, engineers consult subdivision plats to see whose private property lines the project may cross, and estimate the cost of buying the land.

Using Autodesk® CAD Overlay® or a similar tool, an engineer takes the aerial photos and layers them beneath the base map – "rectifying" the photo by matching its landmarks. A stop sign in the aerial photo, for example, is paired with that sign's survey point on the layer above, and the photo image swings around until the two layers correspond. The adjustment is called a rubbersheet. Then the engineers add private property boundaries to the emerging drawing. When the drawing leaves their shop, the land is ready to be bought.



ALASKA DOT & PF

This AutoCAD drawing from the Alaska DOT shows new harbor facilities in Seward, a port town where cruise ships and coal barges dock.

TESTING THE SOIL

Meanwhile, the DOT's Materials Group sends geologists to the project site to drill test holes several feet deep along the length of the proposed road. These reveal a cross-section of the earth, showing whether the mixtures of gravel, clay and sand can support a highway. The position of each test hole is marked on the evolving design, and the section uses AutoCAD to produce vertical diagrams showing how each soil sample breaks down.

Sometimes the geologists find permafrost in the ground – beds of frozen ground, often with layers of peat on top. If the permafrost is exposed, the soil can collapse. So crews must remove the soil, provide an insulated layer or compress it.

"What's unique about our state is that our road system is very limited, and project locations are often very remote and hard to get into," said Angela Parsons, a Materials Group engineering assistant. "If you can't drive out to check an alignment, you may have to fly, which can be restricted by weather and cost. That's why we're interested in visualizing and planning projects with 3-D presentations and photo overlays."

AVALANCHE!

In the project design's last stage, drafters use Autodesk Land Desktop to polish the design elements gathered along the way into a final drawing. Randy Stefanich, one of the designers who finishes drawings at this stage, is completing plans for a project along a stretch of the Seward Highway that was hit by massive avalanches in February 2000. The slides killed two people, and for days they cut off several towns on the Kenai Peninsula that had no link to Anchorage other than the highway.

Because the highway was carved out of steep, mountainous terrain, with railroad tracks and a lake just beneath, there is no room to realign it. So Stefanich is finishing up work on an avalanche dam – a "long, skinny pile of dirt" to protect the road. Fittingly, the dam will be perched near a town called Moose Pass.

"I've been designing since we did it on mainframes, and what used to take us six weeks, I can now do in five or ten minutes," Stefanich said. "On the Moose Pass project, for example, I can do ten versions of a line or a grade in one day. You can fine-tune your design much more than you ever could before, and the end result is a better project."

MOVING TOWARD GIS

That's the life cycle of a DOT project. But down at the agency's headquarters in Juneau, planners are looking beyond particular projects, using mapping and design tools to develop a digital database for the entire

road system. Placing all of Alaska's public roads on a common coordinate grid is the first step toward building a Geographic Information System (GIS), which would unify data currently scattered among different formats and stacks of paper.

"The big problem in Alaska is the lack of digital data, especially for the transportation infrastructure. We haven't been mapped by the U.S. Geological Survey the way the Lower 48 states have," said Kerry Kirkpatrick, manager of the DOT's Statewide GIS Mapping office in Juneau. "So we started a multi-year project in which we drive every public road in the state with Differential GPS equipment to capture their centerlines. This is the foundation on which we can layer features like accident data, speed zones, traffic counts, culverts, bridges and guardrails."

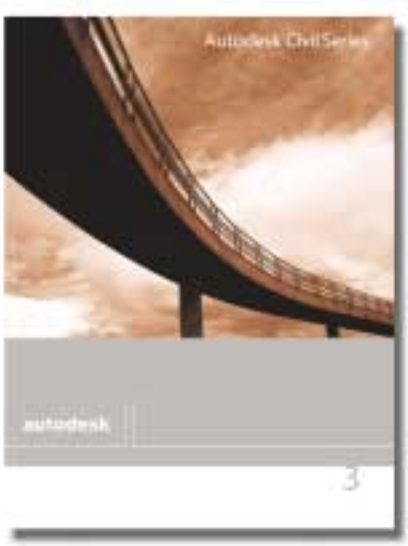
Capturing a road centerline basically means driving the road while a Trimble GPS device in the vehicle determines location fixes, based on a constellation of satellites overhead. But here again, Alaska doesn't make things easy. Tall trees, tunnels and mountainous terrain sometimes block the satellite signals. So when the road's GPS track is downloaded back at the office, it can have spikes, voids or wandering vertices.

"Cleaning up the GPS data has turned into a huge task," Kirkpatrick said. So the DOT is investigating a system that would back up the GPS device with a gyro compass, a barometric altimeter and a digital mileage instrument. These would help keep the road's coordinate path continuous regardless of satellite interference. Until then, the DOT's GIS office in Juneau has been importing the raw GPS centerlines into AutoCAD to clean up the spikes and voids.

PAUL SOLDERS / ALASKA DOT & PF

An overpass carries Alaska's well-traveled Seward Highway over Canyon Creek, 60 miles south of Anchorage.

The GIS office also uses AutoCAD to create display maps and graphics that are shared throughout the state government, including large mural maps for conferences. "In other software packages you start drawing by selecting a page format, but AutoCAD allows us to work with various projection systems that model the real world," said DOT Analyst Programmer David Oliver. "By working with real-world coordinate systems, we're able to incorporate data from other sources directly into a drawing and have it fall into the right geographic location." ■



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Grand Coulee Dam *continued from page 1*

Lake Roosevelt, the reservoir created by the dam, stretches over 150 miles to the Canadian border. Water from the reservoir surges past the largest turbines in the United States, expelling water at a rate of 110,000 cubic feet per second. A cubic foot of water is roughly the size of a basketball, and Grand Coulee's largest generators are fed by pipes carrying up to 35,000 cubic feet of water per second. Imagine standing at the aperture of a 40-foot-wide tube, with 35,000 basketballs rushing at you every second.

Recognized as the largest hydroelectric power plant in the U.S., the Grand Coulee power plant provides electricity to Washington, Oregon, Idaho, Montana, Wyoming and Northern California. To keep the power flowing to those customers, engineers at the Bureau of Reclamation regularly perform inspections and repairs on the almost 70-year-old facility. Their task is made more difficult because they have relied on paper drawings created in the 1930s and '40s to guide their efforts, each drafted using a variety of scales and specifications.

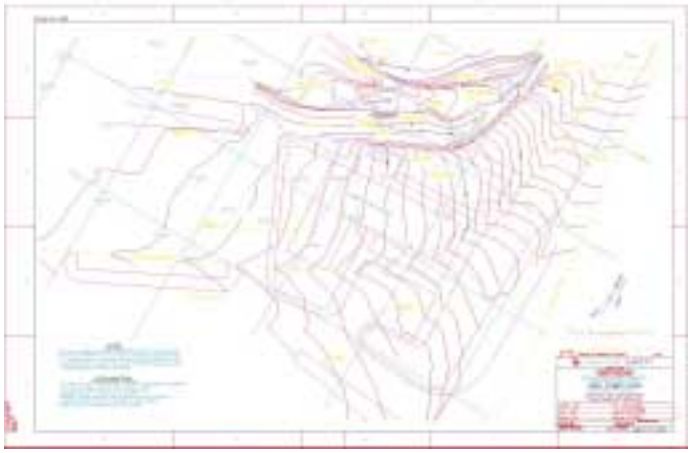
To do their work faster and more efficiently, the bureau's engineers turned to Autodesk products such as AutoCAD, CAD Overlay and Autodesk Inventor™.

BRINGING NEW LIFE TO OLD DRAWINGS

In the 68 years since its creation, the power plant has accumulated more than 200,000 construction and maintenance drawings. According to Clark Perman, a supervisory civil engineering technician at the Grand Coulee Power Office, even accessing a single drawing had become a Herculean endeavor: "I remember times that we spent two or three days looking for a couple of drawings."

Acquiring a drawing was a cumbersome process that entailed requesting a map, finding it amidst the plant's voluminous archives, and physically picking it up somewhere – often by car, at offices up to 5 miles away. The process, operating at peak efficiency, could take a day.

To streamline operations, Perman and his team began scanning the archived drawings and storing them in a database. Starting in 1999, so far they have scanned and vectorized about 25,000 documents (17,000 of which are scanned images) and reduced the time needed to access critical engineering resources from days to minutes. Using Autodesk CAD Overlay, the scanned raster images can be easily accessed and edited from an employee's desktop PC with AutoCAD or converted to vector format, in which they're fully interoperable with the family of Autodesk design products. Using Autodesk, engineers at Grand Coulee have seen immediate gains in productivity; devoting the time they once spent locating and recreating archived drawings toward tasks that directly impact the facility's operations.



U.S. BUREAU OF RECLAMATION

Converting their paper document archives into online files allowed engineers at Grand Coulee's power plant to access drawings faster – such as this topographic map of the area around the dam's administration building.

Perman recently oversaw the drawing end of the upgrading of Grand Coulee's three power plants for fire protection. He relied heavily on the images within the database his team had compiled, accessing and updating over 300 database drawings using CAD Overlay.

"CAD Overlay has been a fantastic time-saver for us," explains Perman. "Now we can just change a dimension on a scanned image and in minutes, we have an updated drawing in a standard format. We no longer have to draw the whole thing over in AutoCAD."

INVENTOR ELIMINATES COSTLY REDESIGNS

When the Grand Coulee power plant makes repairs, it must suspend a portion of its operations, which means lowering power output and losing revenue. To minimize down-time, repairs need to be done right the first time. Alan Lackner, a powerhouse mechanical engineer, designs replacement parts for many of the dam's key components.

To ensure his designs are completely accurate the first time, Lackner has adopted Autodesk Inventor, a 3-D solid modeling platform, using it in approximately 90 percent of his projects. Lackner introduced the program to Grand Coulee. "I got a glimpse of what Inventor could do at a workshop, and I immediately got the ball rolling from there," he recalls.

The machinists responsible for fabricating parts in Grand Coulee's in-house machine shop have welcomed the use of Inventor. "It makes conveying what you're trying to manufacture 100 percent easier, because with Inventor you can actually see what a part is supposed to look like, prior to production," Lackner says.

Autodesk Inventor's collaborative interface allows Lackner to quickly create and share multiple views and cutaways with the machinists, supplying the full range of data points needed to make a specific part. This dramatically reduces the confusion and back-and-forth dialogue that once consumed time among Grand Coulee's project engineers. "I no longer get phone calls constantly asking, 'what did you want here? What did you want there?' " Lackner says.

However, Autodesk Inventor faced its greatest test when the plant had to replace a huge, 40-year-old coaster gate. Given the time and cost associated with

More Information

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such a project, plans called for the new parts to last another 40 years. The time frame: two weeks. The cost: $500,000 — just to remove the old gate, not including the cost of shutting down one of Grand Coulee's 24 power generators.

The dam's coaster gates serve as valves to stop water from entering the penstocks, the pipes that feed each individual turbine. The gates shut during maintenance procedures, or as an emergency device to prevent water from flowing to the turbine. This particular gate consisted of 20 feet by 30 feet of solid steel, weighing about 120 tons.

Autodesk Inventor's assembly-animating features and 3-D modeling capabilities allowed Lackner to simulate the motion of the coaster gate's moving parts. Without building a physical model, Lackner was able to design the new gate's parts and determine their interoperability with one another.

"Once it went to the machinists, everything went together the first time with no redesigns," Lackner expands. "I designed it one time, and checked all my clearances on Inventor with the Constraints Function, to make sure I could actually have motion. It worked out perfectly."

> *"I designed it one time, and checked all my clearances on Inventor… It worked out perfectly."*
>
> — Alan Lackner, mechanical engineer, U.S. Bureau of Reclamation

An aerial view of Grand Coulee Dam.

Redesigning the gate's parts would have been costly. The stock material alone for one part — a valve stem — costs almost $3,000, and the machinists' labor for the task is valued at $1,000. Autodesk Inventor allowed Lackner to work out all potential problems and ensure the manufacturing and installation of the parts would be done only once.

In the past, engineers would have made several different 2-D drawings for each part, calculating and checking clearances manually using multiple drawings, which would have made costly mistakes far more difficult to catch. "You don't see all your mistakes on 2-D drawings, but when you have a 3-D model, your mistakes are right in front of you," Lackner says. "They're very obvious."

The engineers at Grand Coulee encounter, on a daily basis, the challenges associated with a structure of its size and age. Autodesk products have empowered them to meet those challenges – saving the taxpayers both time and money, while ensuring the safe and efficient operation of one of the great wonders of the world. ■

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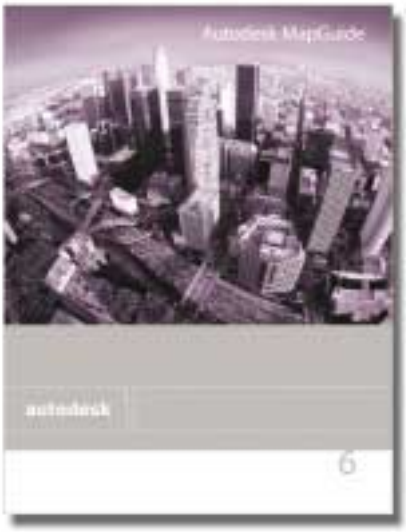

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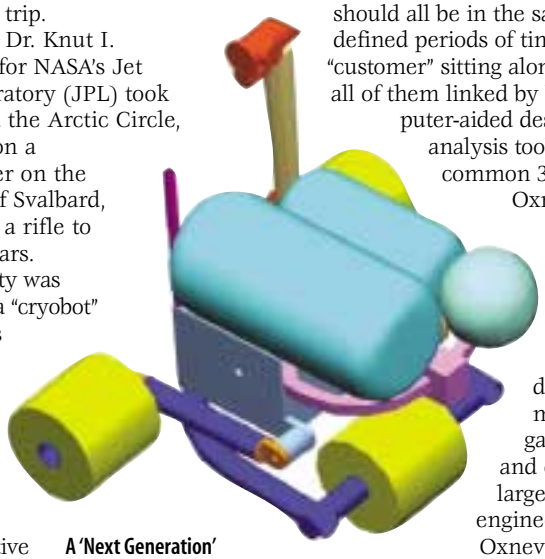
New Tools Accelerate Design at NASA's Jet Propulsion Lab

For most aerospace engineers, a day at the office involves peering into a computer screen under a fluorescent lamp. But sometimes you get to take a field trip.

Last summer, Dr. Knut I. Oxnevad's work for NASA's Jet Propulsion Laboratory (JPL) took him well beyond the Arctic Circle, where he stood on a windswept glacier on the desolate island of Svalbard, Norway, holding a rifle to fend off polar bears.

Oxnevad's party was preparing to test a "cryobot" intended for Mars exploration – a robot that bores through ice by shooting hot water through a nozzle, taking measurements as it descends. A native Norwegian who trains and directs design teams at JPL, Oxnevad thinks Svalbard would be a good place for NASA to do more sub-zero testing of probes that are destined for Antarctica, Mars or other icy planets.



A 'Next Generation' design team at the JPL used Mechanical Desktop, Inventor and other high-end tools to conceive a Mars Rover (above, in its "folded" mode).

Back in sunny California, in his JPL office at the foot of the San Gabriel Mountains near Pasadena, Oxnevad works not only to build particular spacecraft and Earth probes, but to popularize an approach to engineering design that he developed. Oxnevad's "Eight Principles of Concurrent Design," described in various papers and seminars and realized by his own teams at NASA, accelerates the design of projects from concept through prototype – "by a factor of four to ten," he says.

It is a process that he says would not have been possible a few years ago, before the arrival of powerful Windows-based computers and fast, easy-to-use analysis, design and simulation tools like Autodesk® Mechanical Desktop®, Inventor and VIZ.

RETURNING TO REAL-TIME DESIGN

Oxnevad's concurrent design methodology is built on a foundation of earlier theories that sought to make engineers work in parallel with each other instead of sequentially. He has gone a step further, believing designers and engineers with specific tasks should all be in the same room, for defined periods of time, with the "customer" sitting alongside them – all of them linked by high-end computer-aided design (CAD) and analysis tools that share a common 3-D geometry.

Oxnevad says that with slight modifications, his approach could be applied to designing automobiles, oil and gas platforms, and other types of large and complex engineering systems.

Oxnevad's Next-generation Project Development Teams (NPDT) are supported by and include experts from most of the engineering and science divisions at JPL. His teams have provided support for developing the Mars Rover – a sort of lightweight, remote-controlled tricycle whose inflatable wheels resemble three giant yellow balloons – as well as the Mars Outpost drill, a Venus probe, an orbiter destined for Jupiter's moon Europa, the Loihi Deep Ocean Volcanic Vent Probe, and a number of spacecraft payloads.

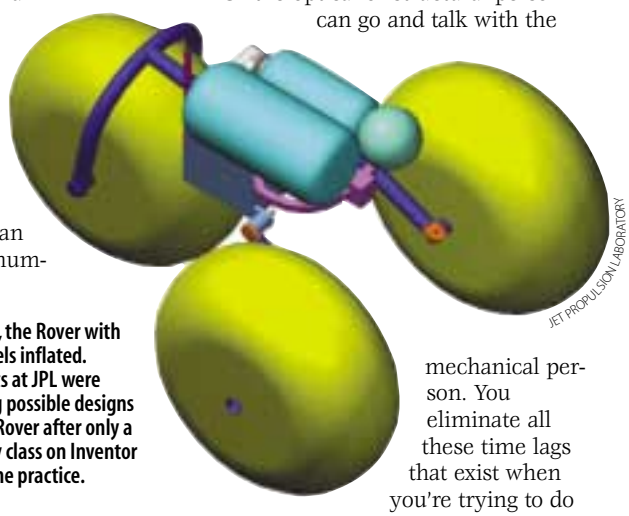
In 1998, the Loihi probe was taken on the manned submarine *Nautille* down to 1.6 kilometers deep, then inserted into a thermal vent to look for life beyond 300 degrees Celsius. Operated remotely by two people in a submersible resting on the ocean floor near Hawaii, Loihi beamed back digital pictures and analog video clips as it sank to depths no human could survive. With pride, Oxnevad says his team had developed the Loihi probe from initial concept to "machine shop-ready engineering drawings" in only three weeks.

CONNECTING DIFFERENT TOOLS

In a typical concurrent design team, several engineers are assigned to stations that contribute essential elements to the emerging design. There's usually a session leader; a person using Autodesk's Mechanical Desktop for mechanical engineering tasks; another handling lenses and cameras with an optical tool like TracePro or Zemax; another doing structural analysis on Nastran software; another checking heat transfers with Thermal Desktop; another handling electromagnetic radiation; another refining the design into a 3-D simulation with Autodesk® VIZ, and other posts. The idea is to create a real-time environment in which all the possible consequences of any design decision — part size, material type, whatever — are almost immediately known.

"As the design begins to come together, you go to the thermal station and he wants to know where the sunlight would hit a part of it," Oxnevad says.

"Or the optical or structural person can go and talk with the mechanical person. You eliminate all these time lags that exist when you're trying to do things through offices."



JET PROPULSION LABORATORY

At right, the Rover with its wheels inflated. Students at JPL were drafting possible designs for the Rover after only a one-day class on Inventor and some practice.

The "customer" also participates in the sessions, which generally last three to four hours. Oxnevad says this helps to ensure realistic expectations. "Before, sometimes people would just set designers going on ideas that didn't

JET PROPULSION LABORATORY

Dr. Knut Oxnevad directs a Team I session at JPL. He says real-time, "concurrent design" methods would not have been possible before the arrival of today's fast, intuitive design tools.

make sense, and they would build something, then come back three months later and say it doesn't work," he says. "This way, if the customer says 'I want wheels that are much smaller than that,' then we can say 'you can't have them, the rocks will be too big.' "

NEW USER INTERFACES WERE KEY

A key element of Oxnevad's approach was establishing a "common CAD geometry" that several different design and analysis tools could operate in. "The interactions between subsystems are crucial – all the pieces have to fit together," he says. "That's why we started using Mechanical Desktop. Once people learned how to use it, it was very powerful. And importantly, it hooks into all the other software platforms we use, like Nastran, Thermal Desktop, the optical tools."

One of the ways Mechanical Desktop "hooks into" other tools is by quickly converting files that are coded in a sharable NASA standard called STEP, which stands for STandard for the Exchange of Product model data. The format was designed to make files interoperable among different tools. "I saw in Mechanical Desktop a very solid STEP translator, and we became very good at importing STEP files for rovers, landers, parts of things, and then modifying them systematically," Oxnevad says.

But just as important as the strong new interfaces connecting different tools was the fact that the tools themselves were easier to use, and faster. "If we had tried to use CAD tools for concurrent design a few years ago, it wouldn't have worked," Oxnevad says. "They ran on mainframes and Unix stations and were not user-friendly. But these new user interfaces are intuitive, and you can generate CAD models very quickly." The last ingredient was the arrival of computer hardware that made CAD software fast enough to keep up with a roomful of brilliant engineers.

INVENTOR AND THE ARRIVAL OF 3-D

The JPL's design teams also use both Autodesk Inventor, a 3-D solid modeling platform, and VIZ, an AutoCAD-based "visualization environment" with a multimedia design palette. During his sessions at Marshall Space Center, Oxnevad has also experimented with rapid prototyping, in which a 3-D CAD file is converted into the STL file format, which renders the object's surfaces as a mesh of triangles. This file is then sent to a machine that produces an actual plastic object within a few hours.

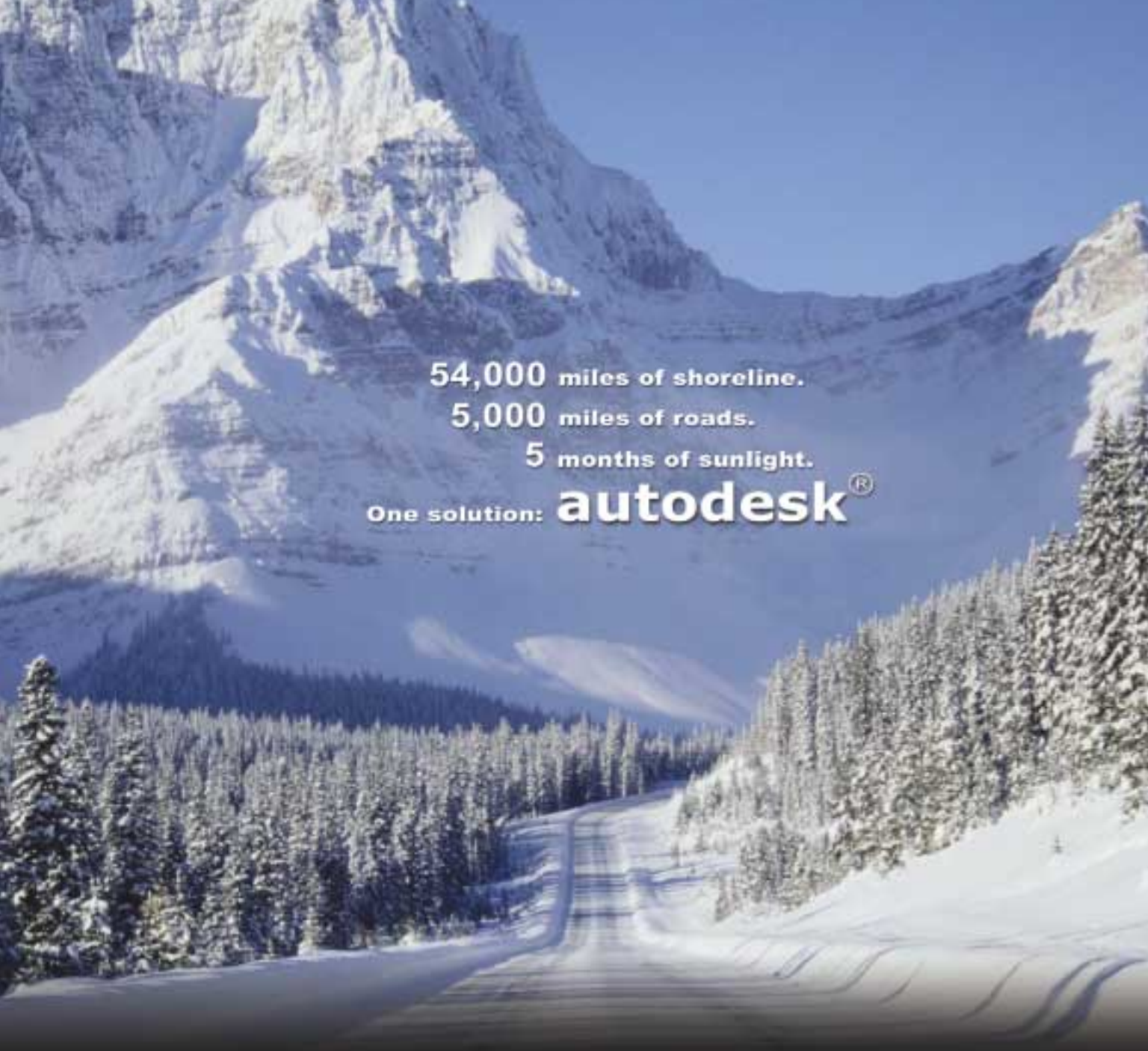
Oxnevad says his teams like Inventor because it can handle the large assemblies they import into the program. He is most impressed, though, by how easy Inventor is to learn and how quickly its users can produce sketches. In summer 2001, he trained a group of students from the Student Undergraduate Research Fellowship (SURF) and had them support the rover studies conducted by his Mars team. The students were given only a one-day class in using Inventor. "At the end of 10 weeks, they were making real designs for the Mars Rover on it," he says.

Oxnevad spends a fair amount of time traveling and explaining his approach at agencies and conferences. He says his seminars are well attended, and that support for concurrent design is building rapidly. "It's nice to watch. It's like a wave," he says. "Because it's more than a design process, it's a problem-solving process. It's just a better way of working together." ■

> *"Mechanical Desktop has a very solid STEP translator, and we became very good at importing STEP files for rovers and landers, then modifying them systematically."*
>
> — Knut Oxnevad, Jet Propulsion Laboratory

JET PROPULSION LABORATORY

A submersible on the ocean floor near Hawaii took this photo of JPL's spear-shaped Loihi Deep Ocean Probe.



With highways, runways, bridges and harbors to build, the Alaska Department of Transportation and Public Facilities has a lot of work to do – but only a brief window each year in which to get it done. From October through May, Alaska is simply too dark and too cold to do construction.

So in the summer, the agency's crews work extra-long days to compensate. And when a project is in design, products like Autodesk® Land Desktop, Autodesk® Survey and Autodesk® Civil Design keep the DOT's surveyors, engineers and designers on the same page. That's because the DOT, like most of Alaska's design community, adopted an AutoCAD® standard years ago.

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