Instrument Development Laboratory

The Instrument Development Laboratory (IDL) designs, builds, and deploys advanced state-of-the-art instrument systems and custom application software in support of the ongoing experimental research efforts in the W.R. Wiley Environmental Molecular Sciences Laboratory (EMSL). As depicted in Figure 1, IDL staff members support EMSL researchers and users by providing a wide variety of design and fabrication services for hardware and software, custom engineered solutions to research problems, and experience in the interface and control of commercial instrumentation. Most EMSL user projects have unique needs; IDL staff members are especially skilled in the integration of commercial and custom hardware/software packages to suit the exact specifications of specific research projects.

Capabilities

Some of the IDL's most recognizable expertise and capabilities fall into the following areas:

- high-voltage expertise
- radio frequency expertise
- high-speed analog and digital systems
- digital signal-processing and field-programmable gate array technologies
- databases
- laboratory automation
- data acquisition
- instrument control
- common communications methodologies
- software design and implementation (C, C++, Visual Basic, .NET, JAVA)
- embedded systems

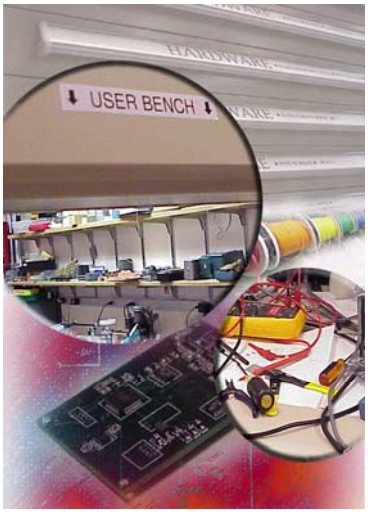

Figure 1. IDL and its staff members provide a wide variety of technical support to EMSL staff and users.

The IDL Design Laboratory offers a staffed electronics and fabrication shop for EMSL research staff and facility users. IDL customers will find a fully stocked parts supply, electronic components and small hardware, test, and measurement equipment available for checkout, and ready assistance during business hours. For immediate hardware assistance, customers may access the IDL electronics laboratory and receive assistance from any IDL staff member. For work that is limited in scope and not time-consuming, there usually is no charge to EMSL staff for services. For larger projects, staff may also access the IDL electronics laboratory and speak with an IDL staff member, who will happily assist the customer in defining the work to be done and begin the process of designing solutions.

Custom Software Design, Development, and Support are critical services offered to IDL customers. IDL staff members specialize in several key services related to research: data acquisition, instrument control, laboratory automation, systems integration, data analysis and visualization, data management and archiving, and handheld and embedded systems. Using a modular code design model as their basis, IDL software developers can efficiently develop software in a number of languages, tools, and scripts (e.g., Visual Basic, Java, C, C++, .NET, Labview, Assembly, Access, and SQL Server). In addition, software developers are skilled in a number of instrument control strategies, including General Purpose Interface Bus, Serial (RS-232), infrared, Transmission Control Protocol/Internet Protocol, Analog and Digital I/O, and high-speed event counting and timing.

The IDL Support Queue is accessible by customers via e-mail (idl-support@emsl.pnl.gov). The queue is monitored daily, and customers are encouraged to submit their requests for any type of service offered by IDL.

The IDL Website at http://idl.emsl.pnl.gov provides a full description of IDL capabilities, access to the support queue, team highlights, recent projects, statement-of-work access, and a downloadable business plan.

IDL Technical Support is readily available to assist research by providing software modifications, troubleshooting, equipment fabrication, and research instrumentation support.

Future Directions

The IDL must play an integral role in the EMSL recapitalization effort. EMSL users and resident scientists will drive the selection and development of new instruments and methods; the role for this group must be to work with the scientists to provide insights into what is possible from a technology standpoint and expert opinions on the best and most efficient means of accomplishing the task. Past instances where research staff have, for instance, purchased $10K digital to analog converter boards that were not optimal for their needs points to the necessity of constant and facile communication between IDL engineers and scientific staff and users.

Some of the technologies that have the potential to "change the game" in environmental molecular science capabilities are detailed below. These technologies may offer the possibility of ten times the increase in speed or signal to noise, or they may make new measurements feasible. Continuing communication of these capabilities to EMSL staff and users must be an important component of the group's strategy to maximize impact on the EMSL recapitalization effort.

- **Instrument automation and remote control** continue to evolve as software tools improve and network bandwidth increases. Automated instrument control can provide huge efficiency increases, freeing up EMSL staff and user time to analyze data, write up results or perform other research activities. New capabilities are currently being developed in Microsoft Visual Basic .NET, while old applications in Microsoft Visual Basic 6 will need to be ported to .NET.

- **Remote instrument control** offers the possibility of making EMSL capabilities available to users remotely, minimizing travel cost and time, and maximizing impact to the user community. The group proposes to develop a project plan, including timeline, cost, technical approach and milestones, to implementing remote control of heavily used instruments that can accommodate such a capability. Technologies such as these are essential to maximizing the IDL's impact in support of the user community.

- **Field programmable gate array (FPGA) technology** is being exploited in a new field known as reconfigurable computing. Programmable logic implements algorithms instead of sequential stored instructions. Performance gains of several orders of magnitude are possible with select algorithms. This dramatic improvement is clearly applicable to supercomputers and needs to be fully exploited if EMSL is going to remain on the leading edge of computational sciences. This effort must include FPGA architecture investigation, inter-FPGA communication, algorithm design and implementation, and testing and validation.

- **Digital signal processing** needs to be more extensively exploited to improve the performance of existing instruments. Doubling the signal-noise ratio of a given instrument is equivalent to acquiring a second instrument without the cost, support, and floor space.

- **Information management (informatics)** has become both a challenging problem and an area where the IDL has had a large impact. Proteomics research results in large datasets requiring information management systems that enable high throughput. The data production from imaging research can easily exceed the data volume produced by proteomics. These two emerging areas have highlighted the importance of information management. Facility staff have developed several man-years of experience with the PRISM system, and this technology is readily transferred to the imaging domain. As more and more projects and users rely on data management, an obvious need for a common platform emerges. It is essential to build this capability in EMSL. The development to date has been completed on projects specific to proteomics and imaging. The value of this system is seen in all aspects of the mass spectrometry research and in the proteomics capability utilized by many user projects, as well as to the Genomes to Life protein complex project, and a number of DOE Office of Biological and Environmental Research- and National Institutes of Health-funded projects. Continued development of the informatics capability will allow EMSL to support more users and increase the amount of research that can be accomplished with limited resources.

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