EMEM 280: Measurements, Instrumentation, & Controls

Course Context and Relevance

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Fall Quarter, 2006-1

What is Engineering?

"As an aspiring engineer, you have much to learn. You must master the foundations of all engineering disciplines: basic math, physics, and chemistry. You must study the specialized subjects of your chosen discipline, for example, circuits, mechanics, materials, or computer programming. You also must learn how to stay on top of technological advances by embracing a program of lifelong learning." (cont.)

Horenstein, M. H. (2002). What is Engineering? In *Design Concepts for Engineers* (2nd ed., pp. 1-2). Upper Saddle River, NJ: Prentice-Hall, Inc.

What is Engineering?

"Your college courses will provide you with the knowledge and mathematical skills that you will need to function in the engineering world. However, you also must learn about **the primary mission of the engineer: the practice of design. The ability to build real things is what sets an engineer apart** from professionals in the basic sciences." (cont.)

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What is Engineering?

"While physicists, chemists, and biologists draw general conclusions by observing specific phenomena, an engineer moves from the general to the specific. Engineers harness the laws of nature and use them to produce devices or systems that perform tasks and solve problems. This process defines the essence of design. You must become proficient at it if you want to become an engineer."

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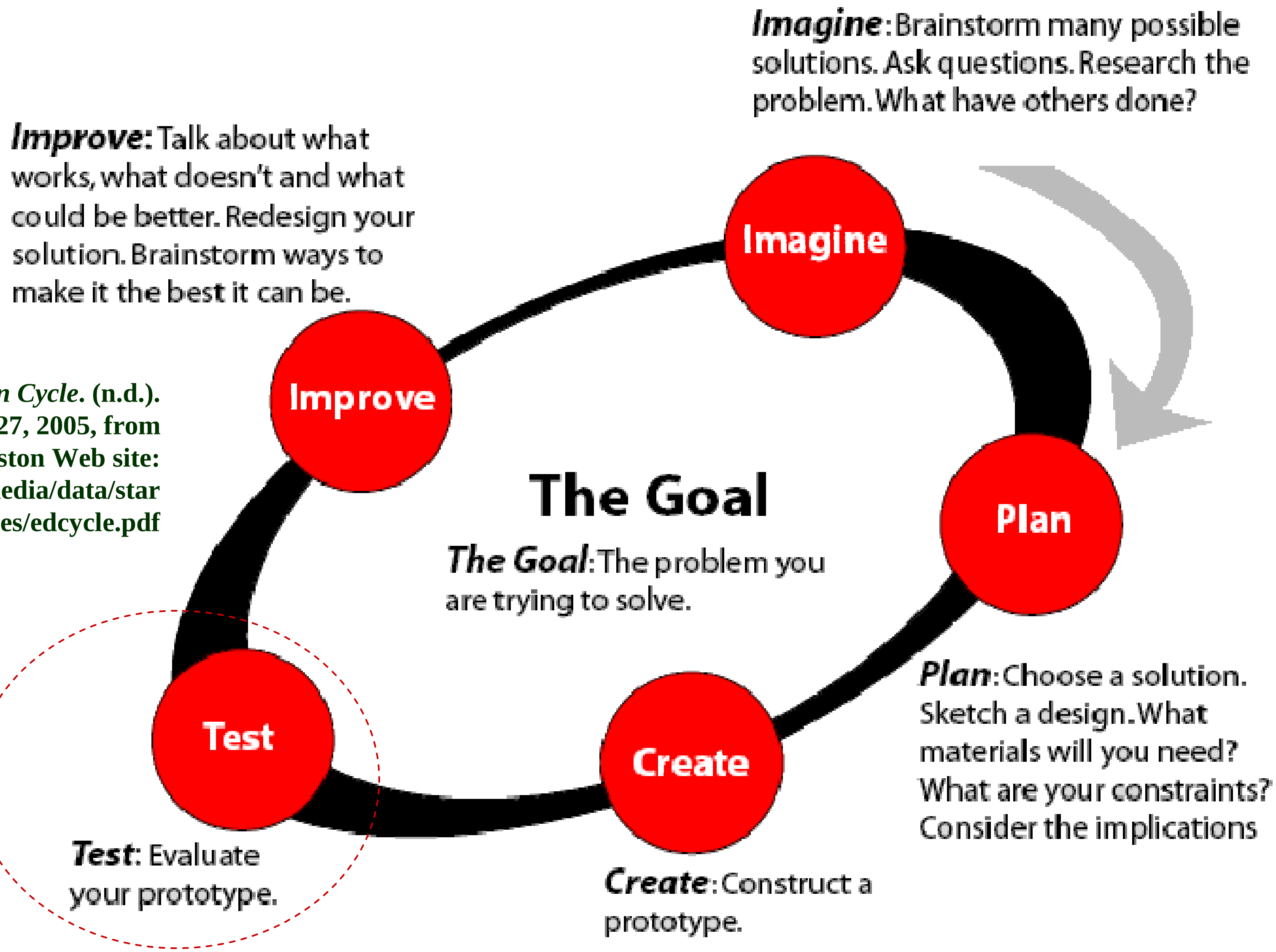
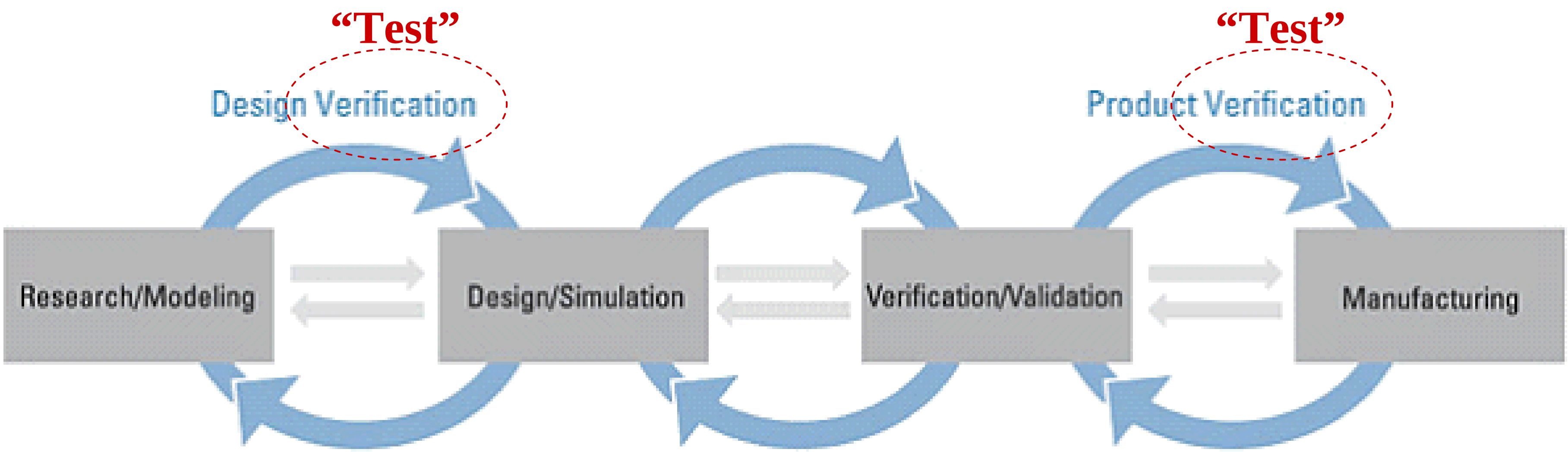
The Engineering Design Cycle



***Engineering Design Cycle*. (n.d.). Retrieved November 27, 2005, from Museum of Science, Boston Web site: http://www.mos.org/automedia/data/starwars/foreducators/resources/edcycle.pdf**

The context of this class!

The Engineering Design Cycle (Better)



Note smaller loops in cycle!

NI SignalExpress Interactive Measurement Software Connects Design and Test. (n.d.). In NI Developer Zone (White Paper No. WP2483). National Instruments. Retrieved November 27, 2005, from http://zone.ni.com/devzone/conceptd.nsf/webmain/551493EA39B75E1F86256EE300676DF2

Broad Categories of Test

- Validation test: as in the design cycle
- Production test: manufacturing quality control
- Exploratory test: research, experimentation, academic pursuits
- Observational testing: supervisory purposes (like the weather)
- Automation & control: not really testing, but commonly associated with test & measurement

Design Cycle Specifics: Automotive Component Development (An Example)

Development Step	Description	Typical Testing Activities
Project Initiation	Customer request arrives Make business case Identify technical requirements	(none)
Conceptual Design	Commit to program Develop product specifications Create test & validation plan	Analytical/computer modeling of design concepts
Design Selection	Narrow field of possible designs Make prototype parts Design production processes	Physical evaluation testing of prototypes (Break parts)
Production Approval Process	Freeze design Build prototype production line Make pre-production parts Finalize material suppliers	Physical validation testing of pre-production parts (Don't break parts)

Humphrey, W. (2004, October 26). *Testing & the Automotive Industry*. Invited lecture presented at Freshman Seminar Class, Dept. of Mechanical Engineering, RIT.

Design Cycle Specifics: Automotive Component Development (An Example)

Virtual Testing

- Finite Element Analysis: make use of computer modeling and analytical tools early in engineering process to help refine designs before "cutting metal."
- Failure Mode Effects Analysis: use analytical tools to make testing more effective.

Physical Testing

- Begin testing with first development prototypes.
- Use design tools to maximize utility of tests (Design of Experiments, Robust Engineering).
- Goal with early prototypes is to break parts! (Identify unsuitable designs and/or features.)
- Validation testing is critical
  - No more broken parts!
  - Goal is to certify to customer that parts meet all specifications.

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Design Cycle Specifics: Automotive Component Development (An Example)

Why so much testing?

- Design & Production Process need to be virtually flawless
  - Remember: 13,000,000 vehicles per year
  - How good is good enough? How many defects will you tolerate?
- *The Cold, Hard Truth*: 99.9% is NOT Good Enough!
- If it were:
  - The Post Office would mis-deliver or lose more than 385,000 pieces of mail per day
  - More than 50 babies would be dropped by the doctor during birth every day
  - Two planes would fail to land safely at O'Hare Int'l. Airport every day
  - US Automakers would build almost 13,000 cars per year which would fail to start – right off the assembly line!

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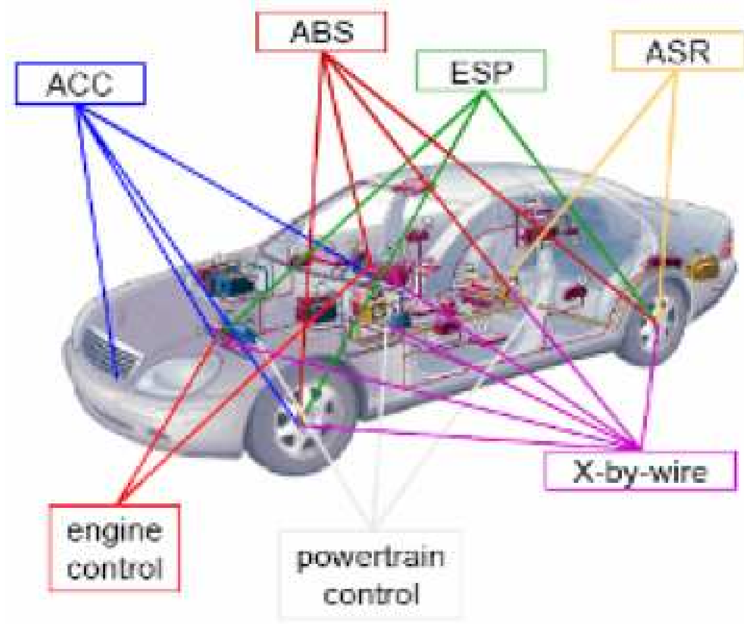
The Bigger Picture

Like it or not, as an engineer you will be part of a design environment that requires test and measurements…but what if you are not the frontline test engineer? Why do you still need to appreciate this stuff?

The Bigger Picture (Zooming In)

"Under the thin metal skin of a modern automobile, a multitude of sensors gathers information so essential that without it the vehicle won't run. The sensors continuously monitor hundreds of vital signs such as ignition and valve timing; exhaust quality; throttle position; intake air temperature and pressure; wheel slippage; tire inflation; steering-wheel position; and even linear and lateral velocity and acceleration.



Next generation automobiles--those due to hit the road in the next five years--will have sensors that do even more. By the year 2002, as you cruise down the road in your new car, sensors will surreptitiously test the condition of the engine oil and battery charge, measure the real-time combustion pressure in each cylinder, calculate the instantaneous torque of the engine, determine the size and position of front-seat passengers, and even scan the road ahead with radar to look for hazards."

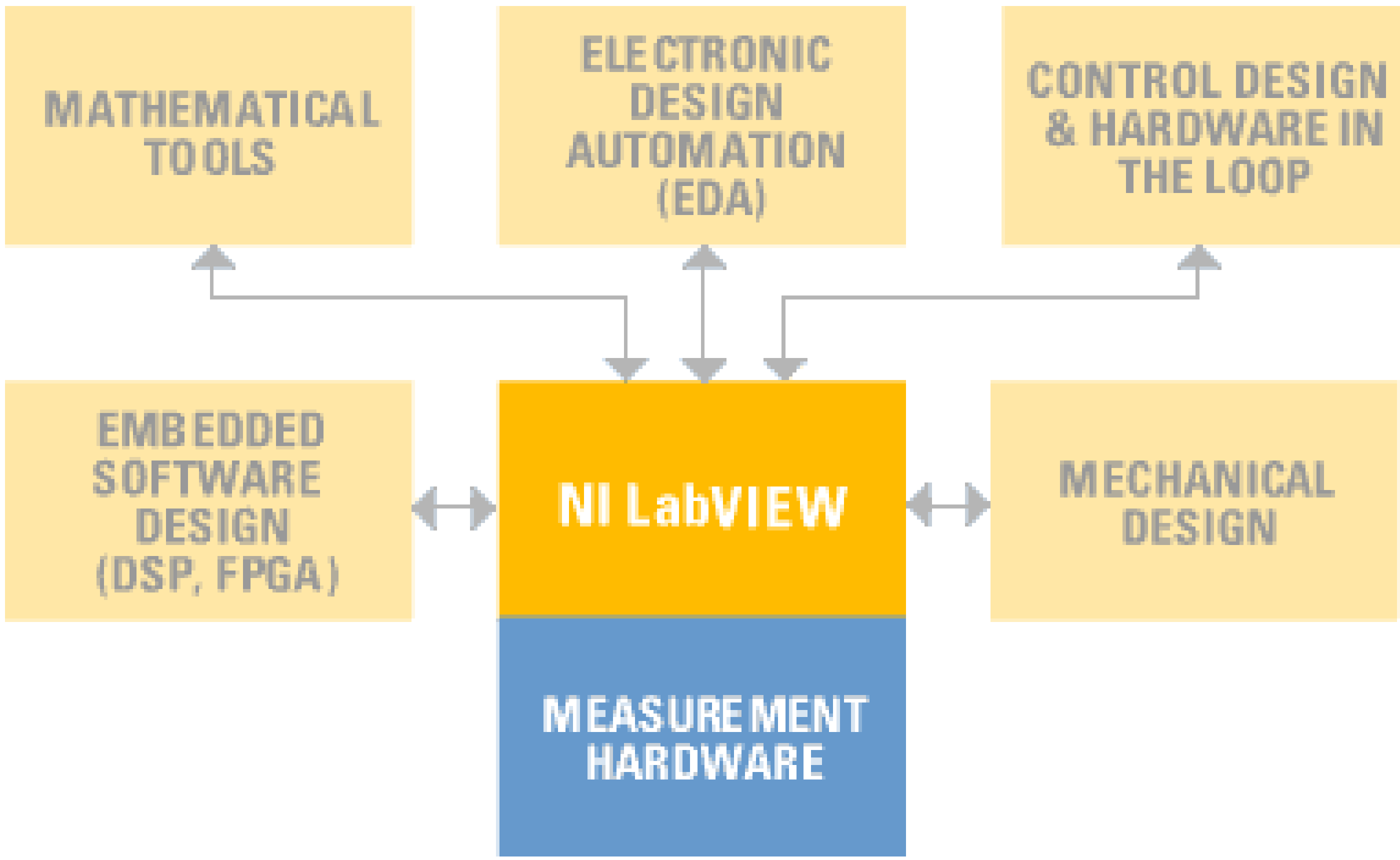
Gottschalk, M. A. (1997, October 6). Sensors Make Cars Smarter. Design News. Retrieved November 27, 2005, from HighBeam Research Web site: http://static.highbeam.com/d/designnews/october061997/

The Bigger Picture

Sensors, electronics, and data continue to proliferate: RFID, biometrics, consumer data, GPS, cell phones, computers, MEMS, wireless, the Internet, smart systems, etc.

…And other countless examples of why engineers—even "generic" mechanical engineers—need to appreciate the fundamentals of test and measurement to survive.

Integrated Design with LabVIEW

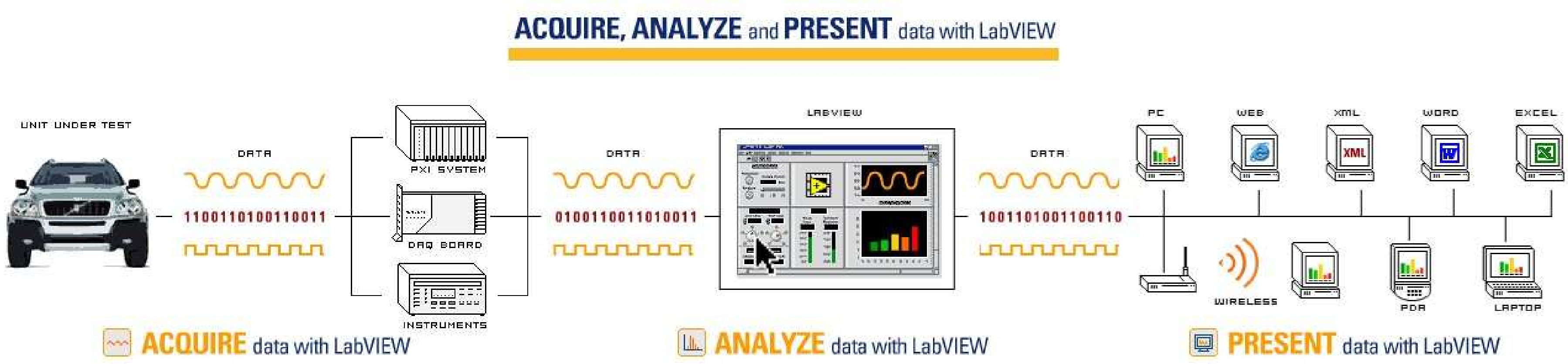


http://www.ni.com/design/

Integrated Design with LabVIEW

"NI LabVIEW is the graphical development environment for creating flexible and scalable test, measurement, and control applications rapidly and at minimal cost. With LabVIEW, engineers and scientists interface with real-world signals, analyze data for meaningful information, and share results and applications. Regardless of experience, LabVIEW makes development fast and easy for all users."

http://www.ni.com/labview/



Integrated Design with LabVIEW

NATIONAL INSTRUMENTS

LabVIEW™

Graphical Development Platform
for Design, Control, and Test

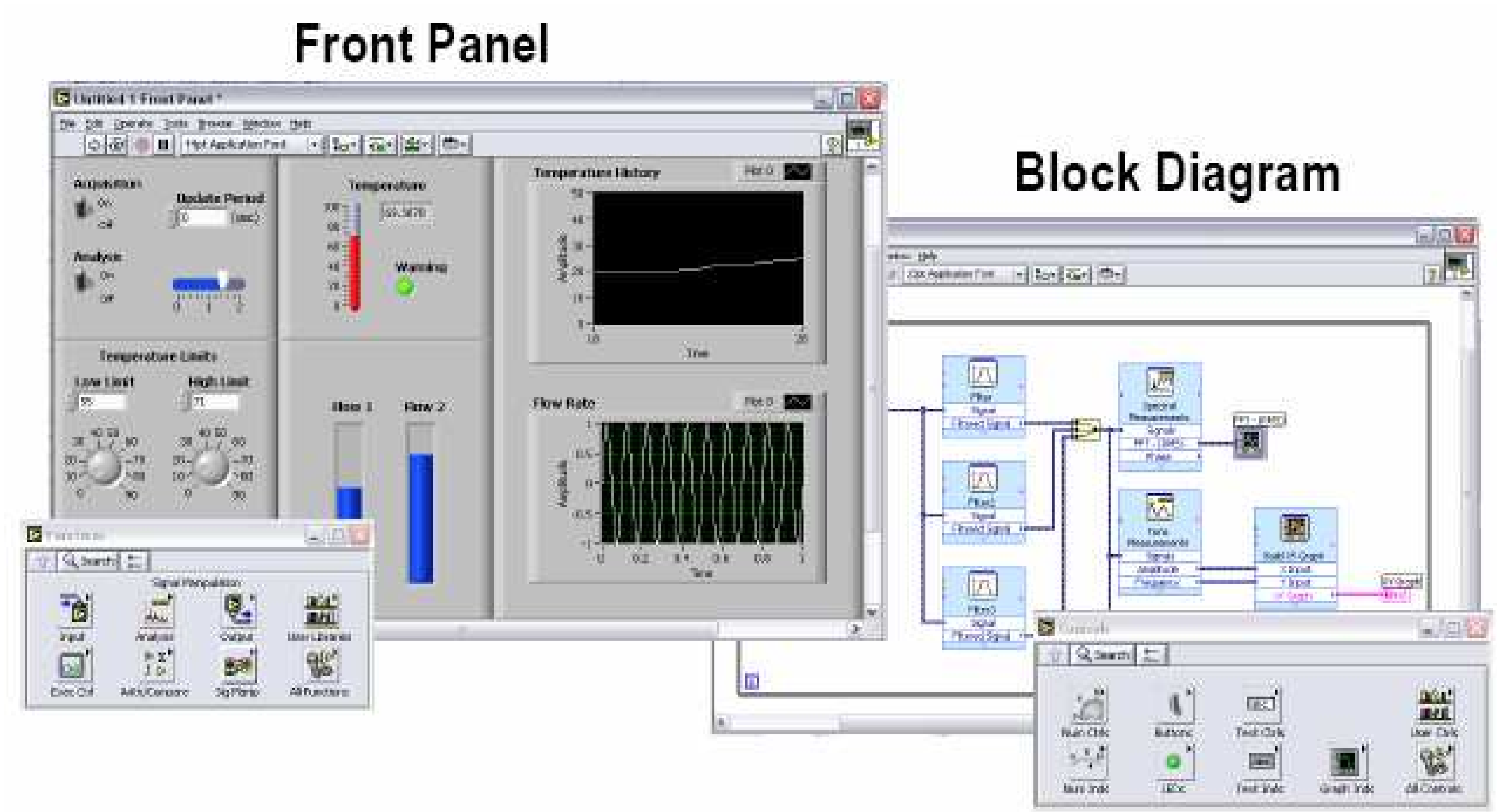
- Intuitive graphical programming language designed for engineers and scientists
- Hundreds of built-in functions for I/O, control, analysis, and data presentation
- High-level, application-specific development tools and libraries
- Deployment to desktop, mobile, industrial, and embedded targets

Integrated Design with LabVIEW

Who Chooses NI?

Eighty-five percent of Fortune 500 manufacturing companies have adopted NI virtual instrumentation.

LabVIEW Introduction



http://www.ni.com/swf/presentation/us/labview/aap/default.htm

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References

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