IEEE 1451.4 Standard Working Group
Face-to-Face Meeting, Nov. 29 to Dec. 1, 2000
NIST and Aeptec International, Gaithersburg, MD
Meeting Minutes, issued 12-11-00

Chair: Steven Chen
Secretary: Paul Hufnagel

November 29, 2000:
Attendance:
Jim Bosecker, Aeptec/3E, jbosecker@aeptec.com
Mark Buckner, ORNL, bucknerma@ornl.gov
John Capriotti, Aeptec/3E, jcapriotti@aeptec.com
Steven Chen, Aeptec/3E, schen@aeptec.com
Mike Dillon, The Modal Shop, mdillon@modalshop.com
Thuan Dinh, Aeptec/3E, tdinh@aeptec.com
Michael Dunbar, Crossbow Technology, mdunbar@xbow.com
Garritt Foote, National Instruments, garritt.foote@ni.com
Paul Hufnagel, Kistler Instrument Corp, phufnagel@kistler.com
Charles Jones, Edwards AFB, Charles.Jones@edwards.af.mi
Max Klein, Scitefair, kleinmax@aol.com
Kang Lee, NIST, Kang.Lee@nist.gov
Torben Licht, Brüel & Kjær, trlicht@bk.dk
Carlos Lopez-Reyna, Scitefair, clopez@bellatlantic.net
John Mark, Kistler Instrument Corporation, jmark@kistler.com
Tremont Miao, Analog Devices, tremont.miao@analog.com
David Potter, National Instruments, david.potter@ni.com
Martin Shay, Aeptec/3E, shay@aeptec.com
Peter Woo, Aeptec/3E, woo@aeptec.com
Jay Zemel, Scitefair, zemel@ee.upenn.edu

1) Agenda:
- a) Four subgroups will review sections of the Draft:
  - Introduction and Foundation; Sections 1, 2, 3, 4 and Annexes.
  - Description Language; Sections 5, 6 and 7.
  - Electrical Connections; Section 8.
  - T-Block Structure; Section 9.
- b) Subgroup Reviews, 9am each morning.
- c) Presentation by D. Potter, National Instruments, Commercial Interest in IEEE 1451.4
- d) Presentation by D. Potter, National Instruments and M. Dunbar, Crossbow; Wireless network for Sensors
- e) Presentation by C. Lopez-Reyna; T-Block Development
- f) Presentation by C. Jones, Edwards AFB; User's Guide

2) Commercial Interest in IEEE 1451.4: D. Potter
- a) The 1451.4 Draft is presently weighted toward piezoelectric accelerometers. This is not intentional, but is a consequence of the original membership of the working group, which was accelerometer manufacturers. The assistance of other sensor manufacturers has been sought at one time or another, with limited interest.
- b) Many data acquisition channels measure temperature, with either thermocouples or resistance temperature devices (RTD). Users must often type sensor data into the data acquisition system.
- c) Strain gages also represent a large number of data acquisition channels.
- d) User demand will cause reluctant manufacturers to adopt IEEE Standard 1451.4.
- e) Allowing an extra pair of connections for the TEDS will allow users to add a TEDS to any sensor, whether or not the manufacturer has chosen to install TEDS.

f) Question on practicality of supplying TEDS data as a barcode (or other, more dense printed code) label, for very cost-sensitive applications.
g) Variations in sensor parameters with time require TEDS to be updated periodically.
h) Virtual TEDS requires an association between UUID and data stored remotely.
i) Release of IEEE Std 1451.4, by December 2001, requires that the Draft be submitted to the IEEE Standards Association for balloting, by January 2001.
j) The inclusion of new ideas into the Standard relies upon interested parties to champion the ideas and write sections of the Standard.

3) CrossNet®: Wireless Network for Sensors: M. Dunbar, D. Potter

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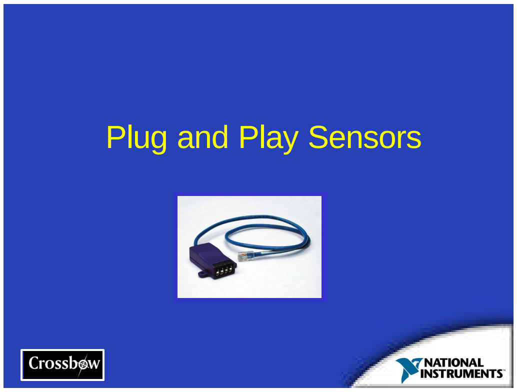

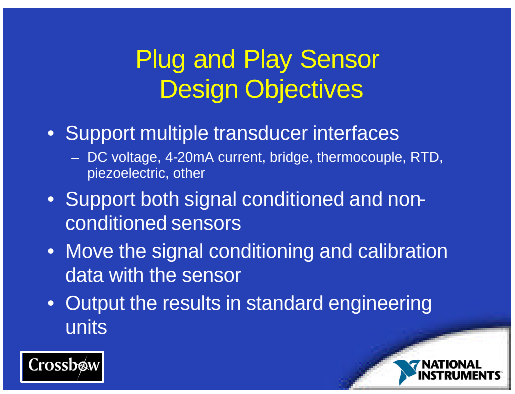

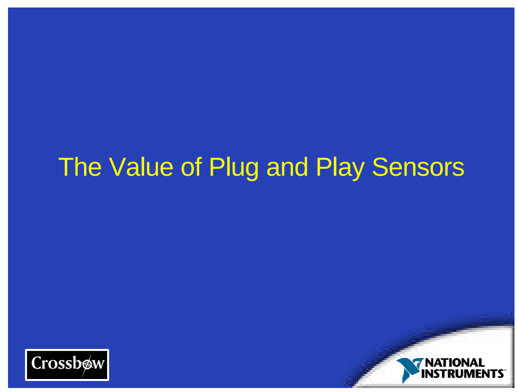

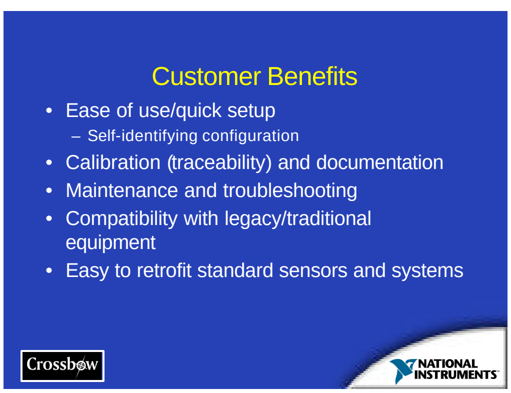

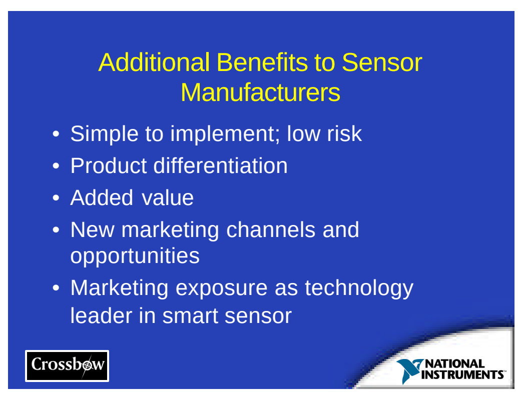

Markets and Scope

- Research and design, laboratories
- Manufacturing, process control
- Industrial monitoring, data logging
- Maintenance and service
- Machine control and monitoring
- Manufacturing test, quality control
- Test and measurement, data acquisition

Crossbow | NATIONAL INSTRUMENTS

Existing CrossNet Solution

- Use only IEEE 1451.2 information model (not physical interface) for TEDS (Transducer Electronic Data Sheet)
- Create SCEDS (Signal Conditioning Electronic Data Sheet).
- Output conditioned high level analog signal for the measurement unit (node) to digitize.

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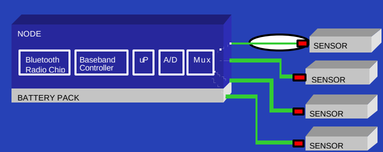
CrossNet Node & SIO



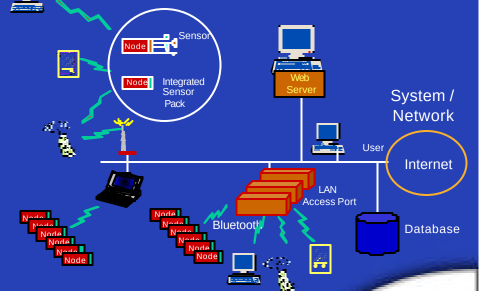
Crossbow | NATIONAL INSTRUMENTS

Existing SIO Communications

- 7 lines in total
  - Power
  - Ground
  - Signal (high level 0-5V DC)
  - Reference
  - Enable -- used to determine that a sensor connection exists
  - 2 lines (transmit, receive) for digital communications of TEDS data

Crossbow | NATIONAL INSTRUMENTS

Wireless Sensor Network



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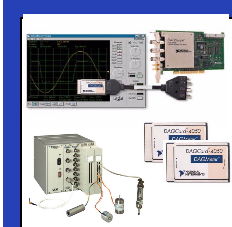
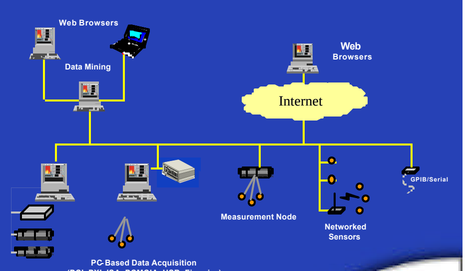
NI Sensor-Based Data Acquisition



- Standard Multifunction I/O DAQ Boards
  - Industry de facto standard
  - Onboard analog input, output, digital I/O, counter/timers, and SPI
- Signal Conditioning
  - Interfaces to non-conditioned sensors

Crossbow | NATIONAL INSTRUMENTS

Networked Measurement & Automation



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Plug and Play Sensors: Before and After Comparison

Before:

- Wire sensor to measurement channel
- Locate calibration data
- Manually enter sensor/calibration into software (Eng units, range, linearization, etc.)
- Configure measurement channel for correct gain, range, signal conditioning
- Verify that C) and D) combine to yield valid data
- Take measurement

After:

- Plug sensor into measurement channel
- Take measurement

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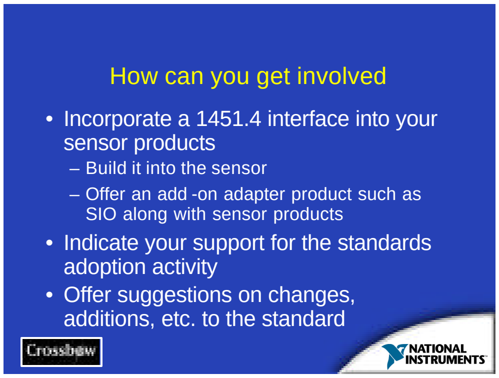

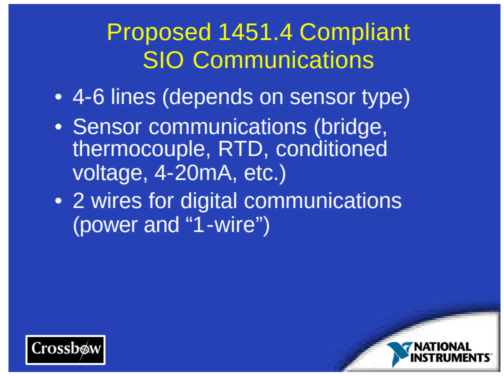

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a) Goals of CrossNet® are similar to those of 1451.4. Sensors identify themselves to data acquisition and other systems. Plug and play is mandatory.
b) The 1451.2 TEDS model, less the interface, is utilized on sensors. TEDS is housed in the connectors. A seven-line serial interface, adaptable to 1451.4, is used as the Smart I/O™. The Bluetooth® RF transmission standard is used as the physical layer.
c) A Signal Conditioning Electronic Data Sheet (SCEDS) is used, along with a seven-wire interface, which may be adaptable to IEEE 1451.4.
d) The CrossNet® Smart I/O Configurator is analogous to the 1451.4 TEDS Editor, allowing data to be written into, and recovered from, the memory.
e) Do the similarities of 1451.4 and CrossNet® allow Crossnet® to be included in 1451.4? Crossbow is willing to make CrossNet® compatible with 1451.4. The present 1451.4 Draft appears to have sufficient latitude in the TEDS definition to allow this. A caveat is voiced , warning that excessive latitude in the TEDS definition could be taken as a lack of definition, and may hinder adoption of the Standard. Countering this admonition, the T-Block creates an object template to prevent lack of definition, while allowing flexibility.
f) Upcoming workshop on RF physical layers, mentioned by K. Lee.

4) T-Block: C. Lopez-Reyna
a) The T-Block is the interface between the transducer and the software.
b) The defined architecture of the common object model allows the identification of different transducers.
c) The T-Block will be compatible with IEEE Std 1451.1.
d) The T-Block is a defined set of rules, not an implementation.
e) Behavior is illustrated with UML diagrams, rather than with Mealy-Moore charts, for more comprehensive descriptions of behaviors.
f) Three components in the T-Block, which will be discussed at this meeting, are:
- Common Object Interface; defining the connection to application programs, will be proposed.
- Common Object Model; which can be encapsulated, will be completed.
- T-Block Behavioral Model; will be completed.
g) It is also desirable to study definitions in the Description Language.
h) The T-Block acts as a manager of the TEDS content.
i) Long discussion on the fabrication and usage of T-Blocks and templates. Is there a truly general structure for TEDS, since only a small body of data is general (serial number, manufacturer and UUID, for example) and most is specific to the transducer? Chair requests proposals on alternate or new TEDS templates, such as a pointer to virtual TEDS.
j) Action: National Instruments, propose templates applicable to their typical users. Action: M. Buckner, propose a template for a virtual TEDS.

5) Agendas for sub-group meetings:
a) T-Block/ DL:
1) Chapter 9, complete definition of T-Block.
2) Syntax in DL difficult to use or understand.
b) Sensor Connections/ Electrical Specification:

1) Chapter 8, Generalize to minimize bias toward piezo electric sensors and accelerometers.
2) Add references to diverse set of transducers.

c) Draft/ Outline:
   1) Review of Chapters 1, 2, 3, 4 and annexes, for grammar, flow, etc.

d) Meet in sub-groups for balance of day.

6) Adjourn Nov 29 Session at NIST, 4:45pm EST.
   a) Meeting to move to Aeptec facilities, for duration of meeting.

November 30, 2000:
Attendance:
Mark Buckner, ORNL, bucknerma@ornl.gov
Steven Chen, Aeptec/3E, schen@aeptec.com
Mike Dillon, The Modal Shop, mdillon@modalshop.com
Michael Dunbar, Crossbow Technology, mdunbar@xbow.com
Garritt Foote, National Instruments, garritt.foote@ni.com
Paul Hufnagel, Kistler Instrument Corp, phufnagel@kistler.com
Charles Jones, Edwards AFB, Charles.Jones@edwards.af.mi
Max Klein, Scitefair, kleinmax@aol.com
Kang Lee, NIST, Kang.Lee@nist.gov
Torben Licht, Brüel & Kjær, trlicht@bk.dk
Carlos Lopez-Reyna, Scitefair, clopez@bellatlantic.net
John Mark, Kistler Instrument Corporation, jmark@kistler.com
David Potter, National Instruments, david.potter@ni.com
Jay Zemel, Scitefair, zemel@ee.upenn.edu

7) Report of Physical Layer/Electrical Subgroup: P. Hufnagel
   a) Participants: Dunbar, Foote, Hufnagel, Miao, Potter, Woo, Zemel.
   b) Transducers using 4-20mA loop power may have diode protection to allow reverse polarity access to TEDS, but many do not. The best plan for adding TEDS is to define an additional pair of connections, which could optionally share the loop connections on an appropriate transducer.
   c) Resistance Temperature Devices (RTD's) are constant-current excited resistors with voltage drop proportional to temperature. Introduction of diodes to select TEDS may affect current accuracy, due to reverse diode leakage. RTD's are best equipped with TEDS by adding a second pair of connections.
   d) Thermocouples (TC) produce mV-level signals from a low resistance source. Series diodes are precluded by the error they produce and reverse current can't be applied due to the low resistance.
   e) Strain gages and piezo-resistive sensors change resistance proportional to mechanical strain. The number of configurations for connecting these sensors makes the addition of an extra pair of connections the most consistent technique for adding TEDS.
   f) Chemical cells may be potentiometric (example: pH glass electrode) or amperometric (example: O_2 sensor). The first is characterized by mV signals proportional to ion concentration, with a cell resistance > 1E8 ohms, precluding any auxiliary connections for TEDS, on the cell. The second type produces a current output proportional to ion concentration, with a load resistance near 0 ohms. In both cases, TEDS is best added via a second pair of connections.
   g) Actuators, voice-coils and motors typically are excited by voltage or current, which changes polarity to produce motion in both directions. An additional pair of connections may be the only way to add TEDS to these devices.
   h) Piezo-electric and capacitive transducers (quartz sensors, ceramic sensors and actuators, capacitive microphones, for example) typically are characterized by very high resistance (> 1E9 ohms) and/or high voltages and/or reverse polarity during operation, precluding the placement of TEDS on the signal connection. The addition of a separate pair of connections appears to be the only way to add TEDS to these transducers.

Complicating the issue on microphone capsules, the connections to these devices are also defined by an IEC standard.

h) Findings of the Subgroup:

1) Draft Section 8.6.1, which defines Class 1, current reversal TEDS access, on a single pair of wires, is presently worded with a bias toward piezo-electric accelerometers. The wording must accommodate applications where digital data shares the power connection (three-wire sensors, for example, with power, signal and common-return connections, with TEDS between power and common, accessible by reversal of the power polarity). The terminology for Class 1 will change to "Alternate Analog/Digital". **Action: P. Hufnagel.**
2) Existing Draft Section 8.6.2 defines a three-wire connection for a legacy product. This definition will now be called Section 8.6.3, named Class 3, and supplied with a circuit diagram to clarify its operation. The terminology Class 3 will be "Separate Analog/Digital". **Action: T. Licht, supply circuit diagram for inclusion into Draft.**
3) A new Draft Section 8.6.2 will define 1451.4 Class 2 Transducers, which contain TEDS, accessible via an additional pair of connections. Polarities of the connections and addition of diodes and pull-down resistor will be such that Class 2 is compatible with the waveforms illustrated in Section 8.5, and may be connected as a Class 1 device, when this is possible and desirable. Terminology referring to devices of Class 2, will be either "transducer" or "sensor/actuator", since this class can refer to both types of devices. The terminology for Class 2 will be "Additional Digital Connection". **Action: D. Potter and G. Foote, supply circuit diagrams descriptive of various Class 2 applications, to be included in the Draft.**
4) The introduction to Section 8.6 will have references to "single wire" removed, since this term refers only to Case 1, which is now called "Alternate Analog/Digital".
5) Section 8.1 will be expanded to include descriptive sections 8.1.1, 8.1.2, and 8.1.3, with illustrations of Class 1, 2, and 3 TEDS connections. A pull-down resistor will be added to the illustration of Class 1. Wording will be freed of bias toward piezo-electric accelerometers. **Action: P. Hufnagel.**
6) Section 8.2 will be revised to add references to Classes 1, 2, and 3. **Action: P. Hufnagel**
7) Diversifying the selection of transducers using 1451.4 TEDS will require the addition of an equally diverse range of measurement units to the templates. It may be possible to accommodate these with a "cafeteria" listing of physical and electrical units, which may be associated with each other.
8) Question on the selection of physical units, whether to be expressed in SI base units, product of powers notation ($m \bullet s^{-2}$) or units familiar in the art($g = 9.8 \bullet m \bullet s^{-2}$).
9) 1451.2 describes all units as SI base units.
10) Some transducers may not fit into the compact TEDS, since they are described by several characteristics, not a single sensitivity (A thermistor is described by a resistance and slope at a reference temperature and a change in slope over a range of temperature. The transfer function is non-linear. A best-fit function is also a possible way to describe the device.)
11) **Action: G. Foote to propose an example of data required in TEDS, to convert a voltage reading to temperature.**

8) T-Block Subgroup Report: C. Lopez-Reyna

a) Object Model
- Fully Compatible with IEEE Std 1451..1
- A/D and D/A must be added to the T-Block.
- Structural Diagram must be modified.

b) Behavioral Model
- Support for A/D and D/A to be added.
- Isolated API layer for simple recovery of TEDS data, when other functions are not required by the application.

c) Object Interface

d) **Action: For the 12-7 Telcon, M. Buckner will produce a behavioral simulation of the transducer block.**

e) **Action: For the 12-14 Telcon, C. Lopez-Reyna will evaluate the transducer interface model in UML.**
f**) Action: For the 12-21 Telcon, J. Mark will prepare a transducer object in UML.**
g) **Action: For the 12-28 Telcon, C. Jones will prepare a node list.**
h) **Action: M. Buckner will forward to C. Jones, UML detail diagrams.**
i) These demonstrations will validate completion of the T-Block.
j) The object model and UML model have been defined.
k) Transducer interface needs to be debugged and the client-server architecture needs to be validated.

9) Draft Outline Subgroup Report: S.Chen, T. Licht
a) References to network transducers has been eliminated.
b) Standard 1451.4 defines Mixed-Mode Transducers.
c) The introduction needs to be edited for readability and clarity. **Action: All members read and make suggestions to improve this section.**

10) Discussion on 1451.4 Compatibility with IEEE Std 1451.1:
a) All 1451 Standards must contain the base 1451 functionality.
b) Certain 1451 I/O functions must extend to all 1451.x Family Standards.
c) Questions raised on the need for 1451.4 to be involved in defining TEDS outside of the sensor. The 1451.1 model defines an input channel, including the characteristics of the sensor and the signal conditioning. The 1451.4 TEDS refers only to the sensor, leaving the signal conditioning open.
d) Does the signal conditioning also need to have TEDS, and to what standard would this TEDS conform?
e) Will the T-Block contain references to the signal conditioning?
f) Question on the appropriateness of calling the 1451.4 interface model a "T-Block", if all of the requirements of the 1451 T-Block model are not included.

11) Adjourn 4:30 pm EST

December 1:

Attendance:
Steven Chen, Aeptec/3E, schen@aeptec.com
Mike Dillon, The Modal Shop, mdillon@modalshop.com
Paul Hufnagel, Kistler Instrument Corp, phufnagel@kistler.com
Charles Jones, Edwards AFB, Charles.Jones@edwards.af.mi
Kang Lee, NIST, Kang.Lee@nist.gov
Torben Licht, Brüel & Kjær, trlicht@bk.dk
Carlos Lopez-Reyna, Scitefair, clopez@bellatlantic.net
John Mark, Kistler Instrument Corporation, jmark@kistler.com
Jay Zemel, Scitefair, zemel@ee.upenn.edu

12) T-Block:
a) T-Block will be modeled section-by-section, in Ilogix Rhapsody.
b) The 1451.4 interface will be partitioned into a T-Block, compatible with 1451.1 and a transducer interface block, which will either be owned by the T-Block, or used by a non-1451 application.
c) The separate interface layer will allow evolution, accommodating new Dallas family codes.

13) User's Guide: C. Jones
a) The flow of the Guide will be from simple to complex.
b) It will include an elementary example at the outset and evolve to complex, specific examples.

14) General discussion on the release of the Draft for ballot:

a) Technical writing is required. **Action: C. Jones appointed as technical editor.**
b) Possible conversion of the Description Language to XML, by B&K.
c) Advisability of forming a 1451.4 Consortium, to provide funding for the completion of the T-Block and implementation of the Description Language in XML. The resulting work would be published for potential users, as a help in the adoption of the 1451.4 Standard.
d) Release Schedule for 1451.4:
-Draft to IEEE, 2-28-01
-1st ballot complete, 3-31-01
-Working Group response to comments complete, 5-25-01
-Package Standard for IEEE complete, 7-31-00
-Final Ballot complete, 9-15-01
-Publication, less printing and binding, 12-31-00
e) Balloters require IEEE Standards Association membership.
f) Ballott committee membership:

	B&K	ENDEVCO	KISTLER	PCB	WILCOXON	NIST	SCITEFAIR	USAF	USN	3E	NATIONAL INST	CROSSBOW	AGILENT	INDIVIDUALS
MANUF.	X	X	X	X	X							X	X	
DAQ	X		X	X							X			
INTEGRATOR	X		X	X			X			X		X		
USER	O	O	O	O	O	X	O	X	X	X	O	O		
INTERESTED													X	

X= COMPANYIS IN THIS CAPACITY
O= COMPANY HAS CONTACTS OUTSIDE TO FILL THIS CAPACITY

15) Adjourn 2:00 pm EST:
a) Next meeting, 12-07-00.