Agenda

26 June 07

7:00-8:30	Registration	All
8:30-8:40	Administrative Remarks, Instructions, Introductions	Ms. Angela Clemons
8:40-9:30	Sensor Tape Program Overview	Dr. Jennifer Ricklin, DARPA/STO
9:30-10:00	PREVENT Blast Dosimeter Program	Dr. Dave Clifford, DARPA/DSO
10:00-10:30	Break	
10:30-11:00	Macroelectronics: Current Progress and Future Needs	Dr. Bob Reuss, Chemistry & Electronics Technology
11:00-11:30	Printed Electronics Inks & Technologies	Dr. Bruce Kahn, Consultant
11:30-12:00	RF LINK Performance Based On Novel Printed Electronic Components	Dr. Chris Fazi, Army Research Lab
12:00-1:00	Break	
1:00-1:30	Printed Electronics for low cost sensors and communication systems	Dr. Daniel Gamota, Motorola
1:30-2:00	Situation Data Advisor Concept & Systems Overview	Dr. John Kelly, Rockwell Collins
2:00-2:30	Overview of DoD Combat Medical Care Tech Challenges	Dr. Annie Sobel, DARPA DSO
2:30-3:00	Break	
3:00-4:45	Five-Minute Overviews	
4:45-5:15	Question and Answer Session	
5:15-5:30	Closing Remarks	Dr. Jennifer Ricklin, DARPA/STO

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Sensor Tape

Convergence of Printable Electronics and Medical Monitoring

Proposers Day

26 June 2007

Dr. J. Ricklin
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A Good Day Gone Bad

Motivation

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The Problem

- ✓ Traumatic Brain Injury as a results of exposure to blast

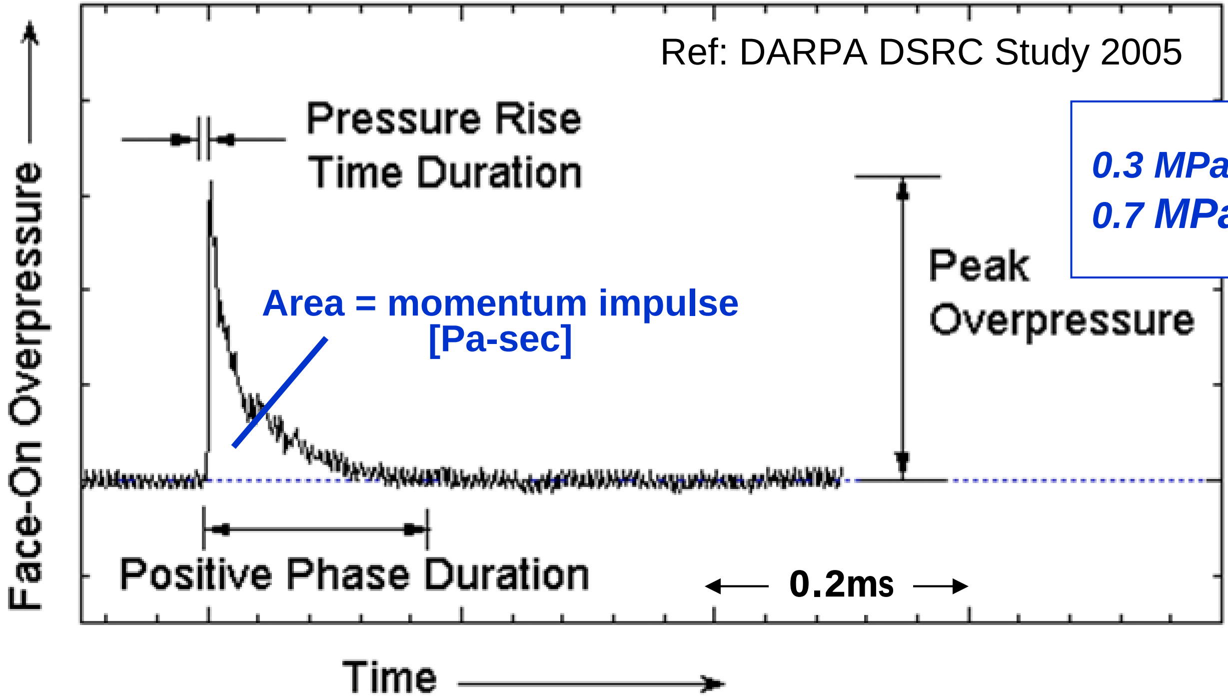
- ✓ It has been suggested that over 50% of injuries sustained in combat are the result of explosive munitions including bombs, grenades, land mines, missiles, and mortar/artillery shells (Coupland & Meddings, 1999).

- ✓ From previous wars it has been estimated that approximately 20% of all combat-related military casualties have sustained a brain injury.

- ✓ The rate of combat-related brain injuries in soldiers returning from current conflicts in Iraq and Afghanistan appears to be higher than in previous wars. Nearly 30% of all combat-related injuries seen at Walter Reed Army Medical Center from 2003 to 2005 included a brain injury.

A Very Quick Event

Blast Over Pressure



0.3 MPa → internal injury
0.7 MPa → fatal

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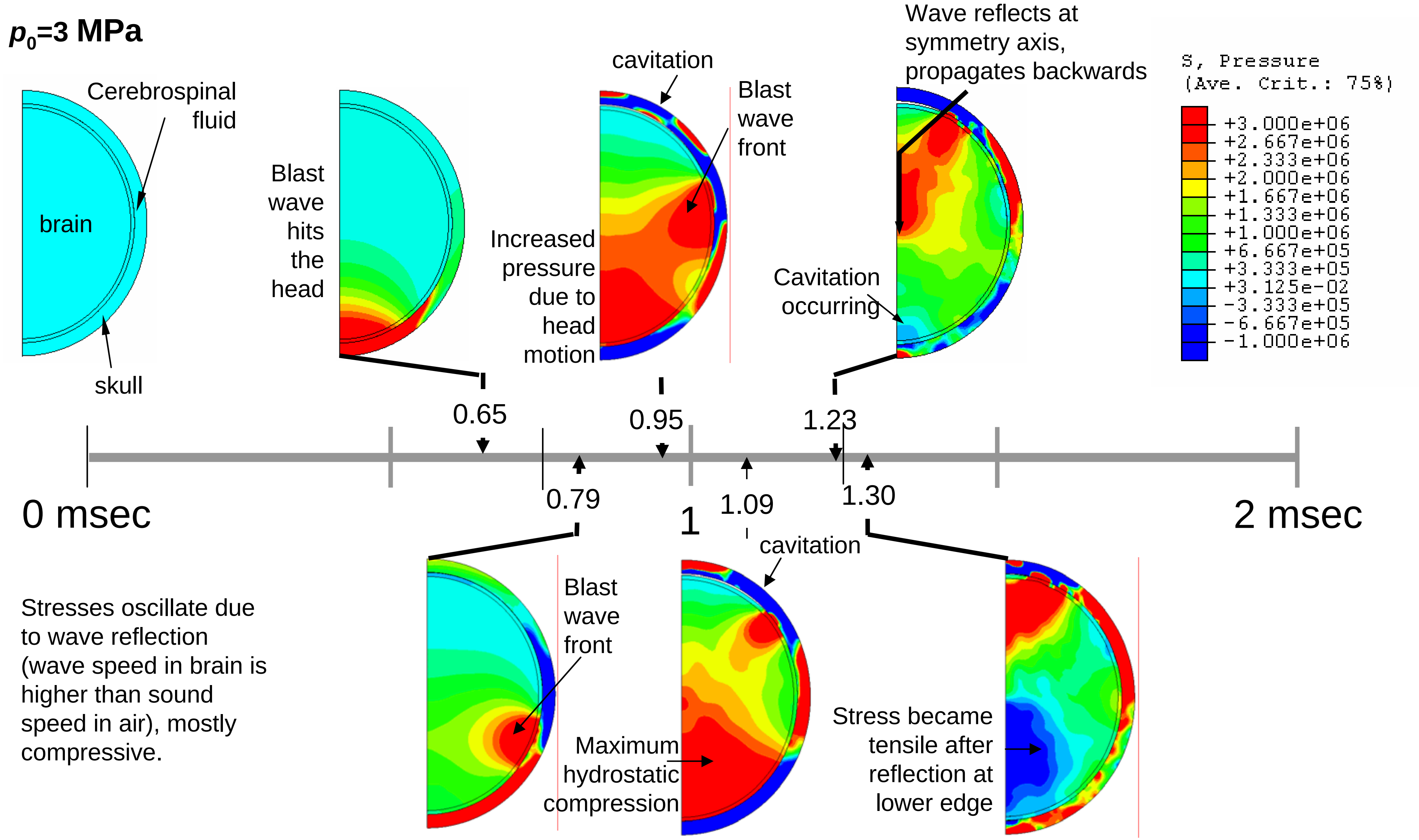
Blast Effects

Modeling



Stresses oscillate due to wave reflection (wave speed in brain is higher than sound speed in air), mostly compressive.

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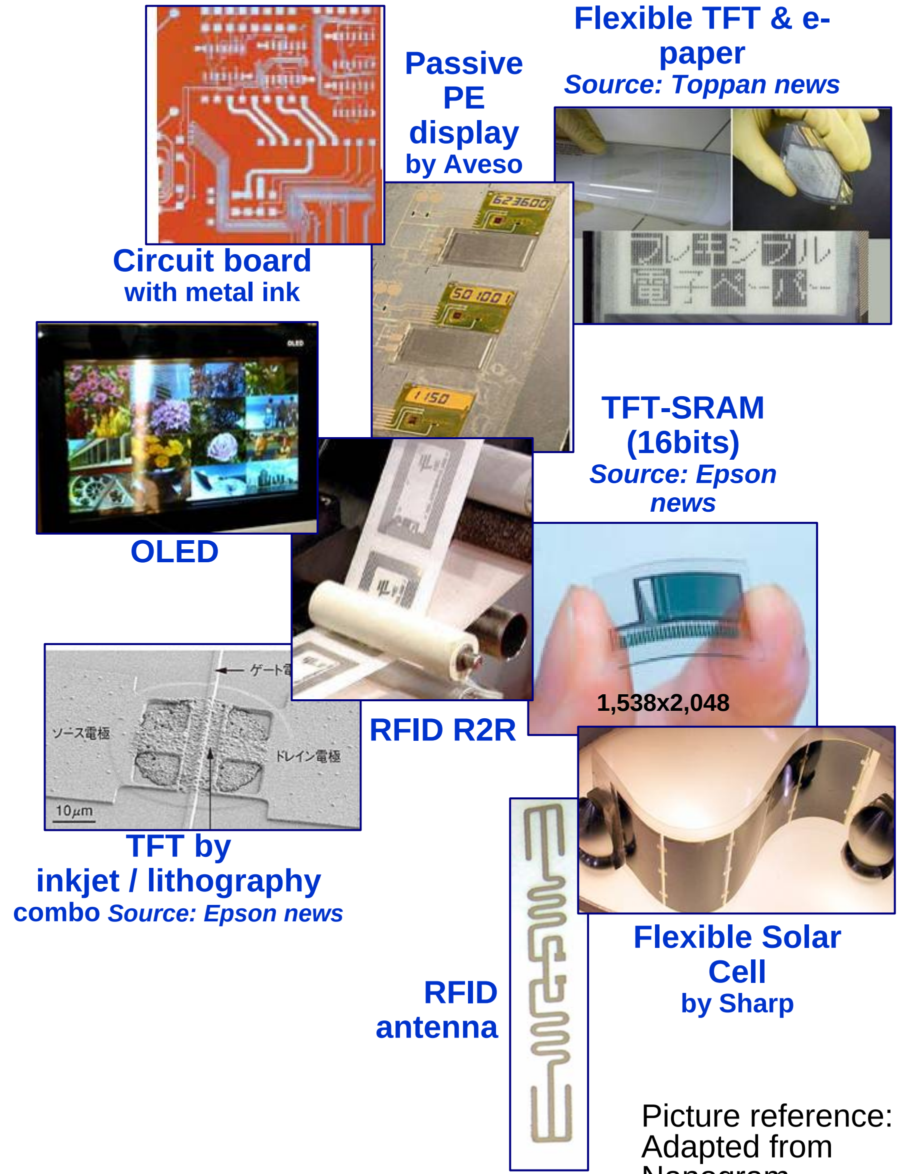
Convergence
Printing-Ink-Electronics-Medicine

- **There are approximately 170,000 troops in Iraq and Afghanistan as we speak**
- **All are potential victims of blast exposure**
- **In order to monitor exposure, any device MUST be affordable**
- **Printable Electronics appears to offer cost advantages with adequate performance for this and other medical applications**



Picture reference: Adapted from Nanogram

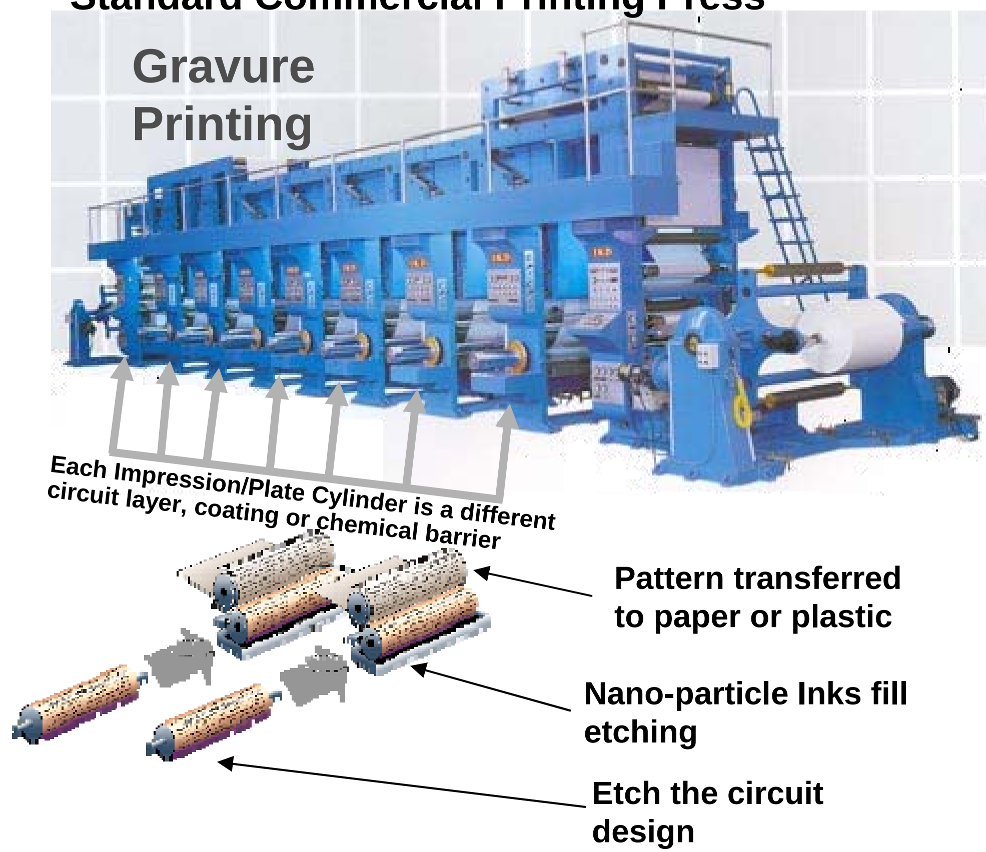
Exploiting the Printing Industry: Potential To Change the Electronics Paradigm

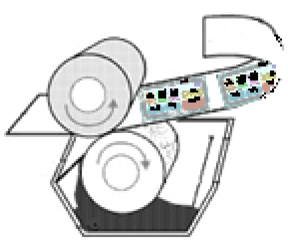
Strategic Technology Office

Cost of electronics could be similar to the cost of printing a newspaper

- Production print in 100’s of feet per minute
- Multiple layers (like ink colors)
  - Conductor/semiconductor/insulator instead of RGB
- Compatible with inline flow production
- Enables rapid changes in design rules
- However – Limits on Performance
- Compared to Si:
  - ✓ Much lower manufacturing cost
  - ✓ Much lower capital cost
  - ✓ Technology less mature (similar to Si in the 1970s)
  - ✓ Highly flexible (thin, conformal, low observable form factor)
  - ✓ Rapid prototyping & production

Standard Commercial Printing Press





Print-On:
- ✓ Memory
- ✓ Battery
- ✓ Sensors

Sensor Tape will exploit advances in print-on electronics

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Printed Electronics Product Evolution and Potential

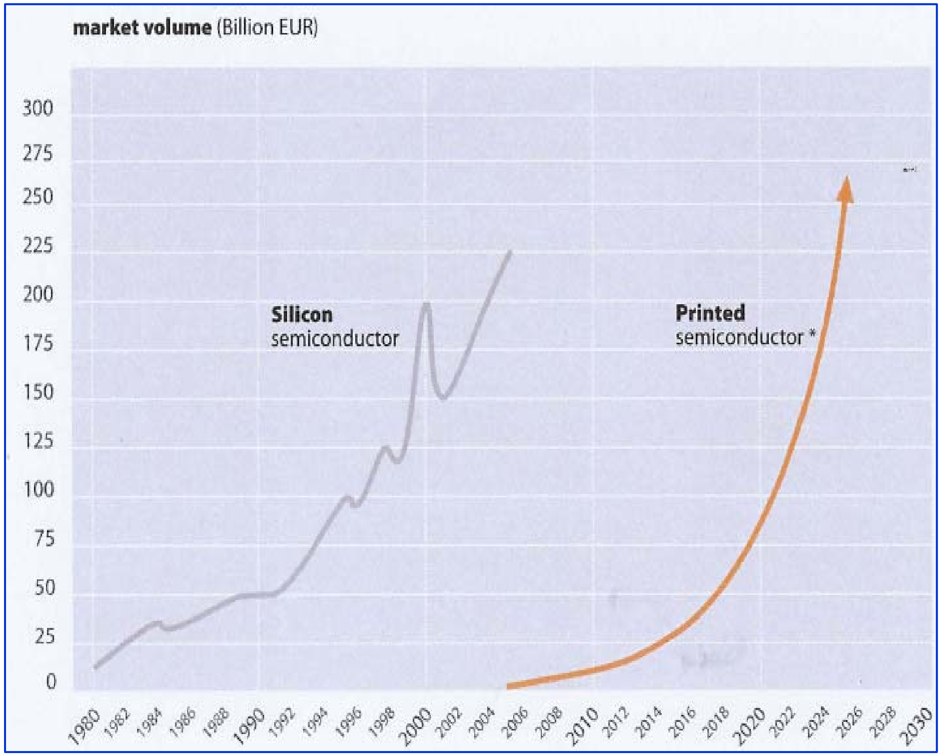
1ST GENERATION
Passive components
- Capacitors, resistors, conductors, inductors
- RFID antenna

2ND GENERATION
Active printed devices
- TFTCs for ePaper, eBook
- Thin-film Solar Cell
- m-Battery

3RD GENERATION
All printed active devices
- Color Display w/TFT- PLED
- Complete RFID circuit
- SRAM, CPU

FLEXIBLE SUBSTRATE

- **Printable Electronics is on the cusp of becoming a multi-billion dollar industry**
- **Advances have been made in "ink" technologies, printing processes & control, and electronics design**



Reference: Adapted from Nanogram

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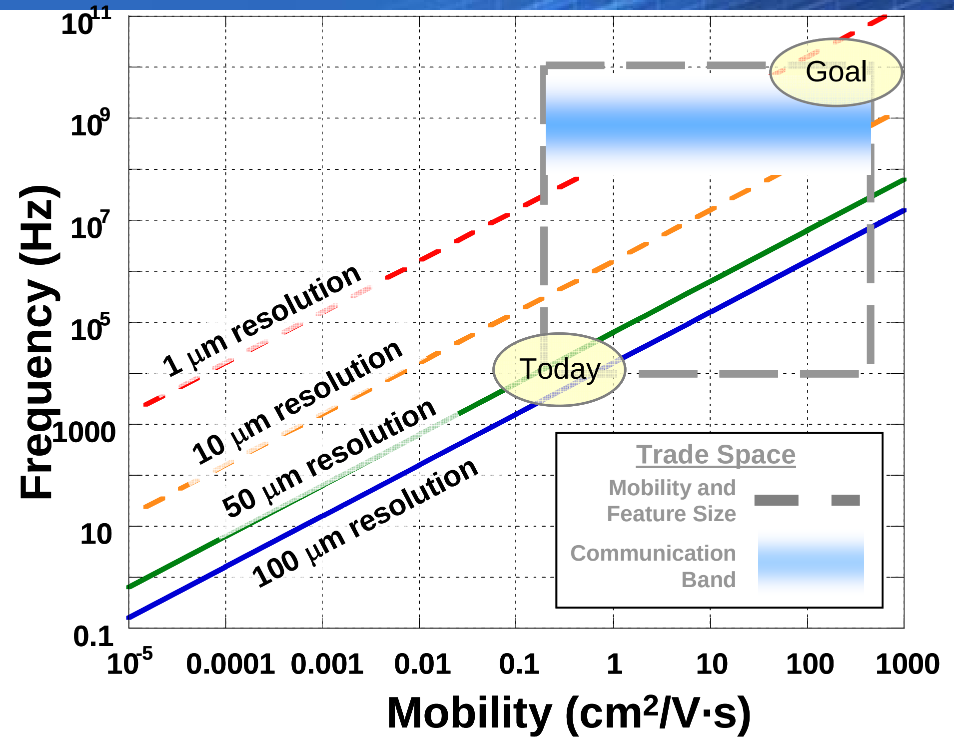
Enabling Printing

- **Better Ink is *part* of the solution**
- **Higher resolution printing enables finer feature sizes leading to higher performance**
- **Innovative printing techniques may lead to even higher performance**



Printing Methods

	Printing Method	Lateral Resolution (micrometers)	Average Dry Thickness (micrometers)	Benefits	Critical Processing Parameters
CONTACT	Gravure	>3	0.5 – 3.0	✓ Commercially available ✓ Low-cost, high-speed parallel processing ✓ Commercially available functional inks ✓ Demonstrated repeatability	✓Particle size distribution in ink ✓Solvent evaporation rate ✓Rheological properties ✓Substrate surface energy ✓Imprint load ✓Printing speed
CONTACT	Flexo	>40	0.8 – 2.5		
CONTACT	Offset	>15	1 – 5		
NON-CONTACT	Inkjet	>50	0.3 – 20.0	✓ CAD data driven enables fast change-over "on the fly" ✓ Suitable for printing on 3D substrates	✓Particle size in ink ✓Rheological properties ✓Solvent compatibility ✓Stability ✓Substrate surface energy ✓Jetting distance
NON-CONTACT	Micro Dispensing	>50	2.0 – 250.0		

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Notional Volume Production Cost

End of Phase Two Cost Estimate

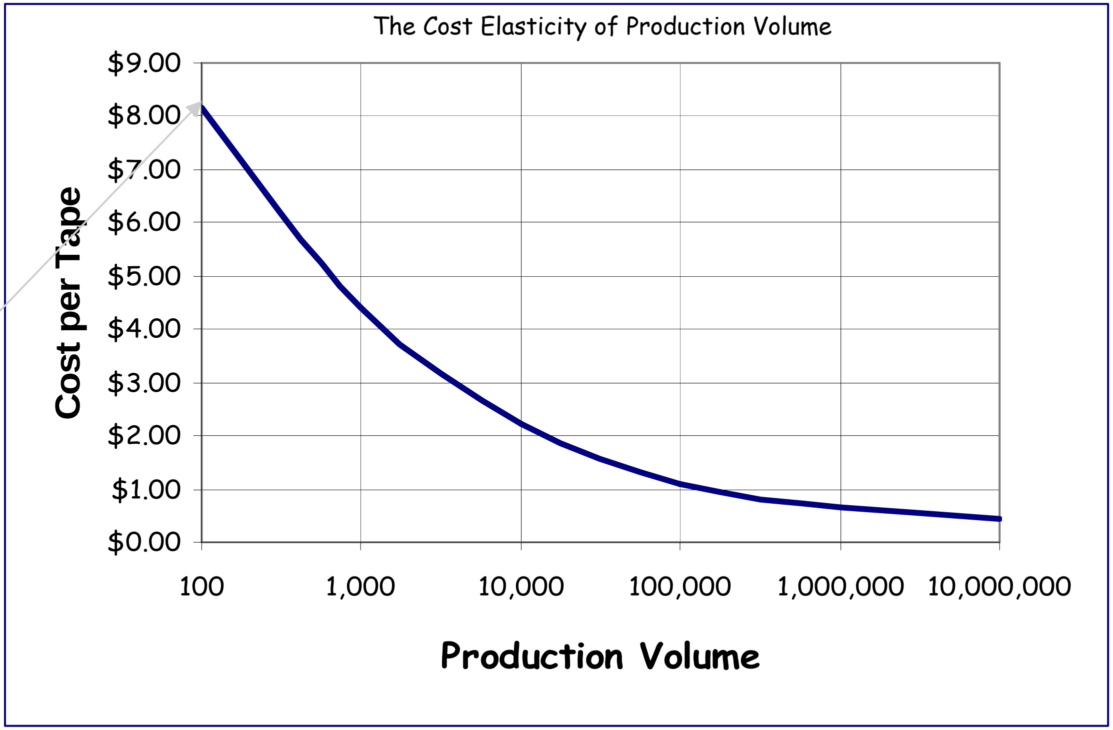
- **Sensors:** **$1.16**
- **Battery:** **$0.60**
- **Circuitry:** **$2.80**
- **Memory:** **$2.40**
- **Antenna:** **$0.40**
- **Integration:** **$1.10**

Total*:	**$8.16**

**Based on prototype production volume (100 pieces) and non-negotiated pricing for raw materials. Notional Tape cost reduction will be observed during higher volume manufacturing.*

Source: Motorola Study

Cost Elasticity



Program Goals

- Objective: develop low-cost medical sensor systems using print-on inks and compatible technologies to support DoD missions
  - helmet (or body-mounted) blast dosimeters to measure the cumulative effects of blast exposure
  - basic patient physiological monitoring devices to assist in combat medical care, patient triage, and physiologic monitoring in support of physiologic performance
  - other innovative medical devices that incorporate print-on electronics and related enabling technologies
- Each system should consist of a patch-like sensor device, and a monitoring unit for communicating with the sensor tape patch.
- Proposals may address one or more systems of interest, but must propose a full and complete program for the development, test, field demonstration and, if necessary for the proposed device, Food and Drug Administration (FDA) approval of each system.

Meeting the goals of this program will likely require furthering print-on electronics and ink formulation technologies

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Schedule

BAA Released	20 June 2007
Proposals for Initial Selections Due	13 Aug 2007
Announcement to Proposers	1st Qtr FY08
BAA Closing Date	19 June 2008

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Programmatics

- Proposals should be for the full scope of development, e.g. an end-to-end system
- Proposals addressing only individual component-level technologies will be considered non-compliant
- Teaming strongly encouraged: anticipate multidisciplinary research organizations teaming with a major systems integrator for coordination and support
- Phased program
  - ✓ Phase 1 is the base program; Phase 2 is an option
  - ✓ Phase 1 Go/NoGo metrics determine potential for continuation to Phase 2
  - ✓ Multiple awards possible based on technical diversity, multiple sensor systems

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PHASE 1

- Develop and demonstrate the proposed sensors, and the communications capability for the patient monitoring device.
  - ✓ A design using all print-on sensors is strongly desired and encouraged, including the patient monitoring device communications capability.
  - ✓ Hybrid solutions that meet the required size, form factor and cost metrics will be considered.
- Required deliverables:
  - ✓ At least twenty-five sensors for Government testing
  - ✓ Demonstrate ability for sensors to communicate with brassboard central control unit
  - ✓ Analysis of the cost of the proposed sensor tape patches when produced in lots of 100,000 (should be less than $1.00)
  - ✓ For those devices that require FDA approval, a detailed plan and list of required documentation to complete an FDA approval process.

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PHASE 2

- Integration of all components (sensors, communications, memory, etc) onto a flexible substrate, scaled and packaged to in-service system size, weight and power, with adequate shelf life and field durability
- Develop a monitoring unit (preferably hand-held for the patient monitoring device) for communicating with the sensor tape patch, along with suitable algorithms for data extraction and display.
- Required deliverables:
  - ✓ Ten monitoring unit prototypes
  - ✓ 1000 sensor tape patches for each system developed.
  - ✓ FDA approval for the devices that require it
  - ✓ Demonstration of the developed systems in suitable field exercises

Blast Dosimeter

Object: Develop a low-cost, flexible blast dosimeter to register and record cumulative physical blast effects received by military personnel incident with explosions such as bombs or demolitions.

- **Small and light-weight so that it can be worn near the head, or mounted in or on a helmet**
- **Should not exceed the area of a standard 4 x 4-inch medical pad, with a minimum of a 1-inch bend radius**
- **Able to record shock wave (pressure over time), and acceleration over time.**
- **Also desirable that it be able to measure acoustic levels and light intensities that may be associated with any blast or explosion**
- **Data recorded on the dosimeter should be easily transferable to the military member’s record on a periodic basis using a device reader/recorder.**
- **Cumulative blast exposure history should be recorded so that if these exceed a prescribed level the patient could be flagged for appropriate follow-up evaluation.**
- **Should be operable for not less than seven days after activation.**
- **Low cost - less than $1.00 per dosimeter for lots of 100,000**
- **Blast Dosimeter Device Reader/Recorder should be able to extract and display the full blast history for the duration the dosimeter was active**

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Blast Dosimeter Go/NoGo Metrics

Phase	MOCA	Program Metrics
1	To Be Specified by Performer	1. Deliver at least twenty-five blast dosimeter sensors to the Government for testing to demonstrate that the blast dosimeter sensor meets or exceeds the performance goals stated above (PIP para. 2.2.1.). 2. Provide an analysis for the cost of the blast dosimeter patches in lots of 100,000 which shows each patch will cost no more than $1.00. 3. Prove through test and analysis that blast dosimeter patches shall not exceed the overall dimensions of a 4 x 4 x 0.1-inch patch and will operate for seven days or longer.
2	To Be Specified by Performer	1. Produce flexible blast dosimeter patches that do not exceed a 4 x 4 x 0.1-inch overall size and will operate for seven days or longer. 2. Deliver at least 1,000 blast dosimeter patches meeting the above criterion to the Government for testing to demonstrate that the blast dosimeter patches meet or exceed the performance goals stated above (PIP para. 2.2.1.). 3. Demonstrate, in an operationally representative environment, a fully integrated Blast Dosimeter System, including Blast Dosimeter Device Reader/Recorder, that meets or exceeds the performance goals stated above (PIP para. 2.2.1.). 4. Achieve the $1.00 or less per unit cost objective for the blast dosimeter patches in lots of 100,000.

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Blast Dosimeter Measurement Goals

Physical Measurement	Units	Range Goal	Accuracy Goal
Blast Pressure	Amplitude – psi	0-50 50-150	± 1 psi ± 5 msec
	Duration – msec	5-200	± 5 msec
Acceleration – 3 axes, 3 ranges	g (due to large dynamic range, multiple bands may be used)	0-500 500-1000 1,000-20,000	±1% ±5% ±10%
Acoustic Levels	Decibels (dB)	100-300	± 10dB
Light Intensity	Lux (lx)	0-400,000	± 5%

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Patient Monitoring Device: Sensing Patch

Objective: Develop a low-cost flexible medical monitoring patch, and monitoring unit (preferably hand-held).

- Should not exceed the area of a standard 4 x 4-inch medical pad, with a minimum of a 1-inch bend radius.
- Operable for at least 72 hours after activation
- Via a monitoring unit periodically report patient status, provide information when interrogated, and alert caregivers when measured parameters exceed threshold values.
- Report sensor failure and provide alerts when available power is 40% or less.
- Goal unit price of less than $1.00 per patch.
- Capable of measuring
  - ✓ body temperature
  - ✓ respiratory rate
  - ✓ heart rate
  - ✓ blood oxygen level
  - ✓ pulse wave form
- Multiple patches each capable of measuring one or more of these physiological states will be considered.
- Communications capability to a monitoring unit, with a communications range of at least 200 meters.

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Patient Monitoring Device: Monitoring Unit

- **Hand-held unit designed to be carried by medical personnel such as a medic, EMT or nurse.**
- **Include a human-machine interface capable of initiating, identifying, monitoring, and interrogating multiple patient monitoring patches simultaneously.**
- **Produce metadata and files in formats appropriate for, and interoperable with, the Battlefield Medical Information Systems Tactical-Joint (BMIST–J) and the Medical Communications for Combat Casualty Care (MC4) systems.**
- **Option to be powered by battery (AA preferred) and by external AC (110/220 Volts, 60/50 Hz) and DC (12 Volts) power.**
- **Capable of interfacing to existing military tactical wireless radios.**

Patient Monitoring Device Go/No Go Metrics

Phase	MOCA	Program Metrics
1	To Be Specified by Performer	1. Deliver at least twenty-five medical monitoring sensors (or sets of sensors) to the Government for testing to demonstrate that the sensors meet or exceed the performance goals stated above (PIP para. 2.2.2.). 2. Provide an analysis for the cost of the medical monitoring patches in lots of 100,000 which shows each unit will cost no more than $1.00. 3. Prove through test and analysis that medical monitoring sensor patches shall not exceed a 4 x 4 x 0.1-inch overall size and will operate for 72 hours or longer. 4. Demonstrate the ability to communicate sensed patient information from a medical monitoring sensor to a brass board central control unit at a range of at least 200 meters, at 5-minute intervals, when a threshold value has been triggered and when the sensor is interrogated.
2	To Be Specified by Performer	1. Produce medical monitoring patches that do not exceed an overall size of 4 x 4 x 0.1 inches and will operate for 72 hours or longer. 2. Deliver at least 1,000 medical monitoring patches meeting the above metric to the Government for testing to demonstrate that the medical monitoring patches meet or exceed the performance goals stated above (PIP para. 2.2.2.). 3. Develop a hand-held monitoring control unit that can simultaneously monitor multiple medical sensor patches within a range of at least 200 meters. 4. Achieve the $1.00 or less per unit cost objective for the medical monitoring patches in lots of 100,000. 5. Demonstrate, in an operationally representative environment, a fully integrated Medical Monitoring Sensor system that meets or exceeds the performance goals stated above (PIP para. 2.2.2.), and that is capable of: (a) communicating at a range of at least 200 meters; (b) accurately transmitting sensor data at 5-minute intervals, when a threshold value has been triggered and when the sensor is interrogated.

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Patient Monitoring Device Measurement Goals

Physiological Measurement	Units	Range Goal	Accuracy Goal
body temperature	°F and °C	15°C to 45°C (59°F to 113°F)	± 0.1°C (0.18°F)
respiratory rate	Breaths per min.	3 to 150 breaths per minute	± 3 breaths per minute
heart rate	Beats per min.	30-250	±2 bpm or ±2%
blood oxygen level	Percent saturation	1% to 100%	70% to 100% ± 3 digits
pulse wave form (EKG)		20 to 250 bpm	± 1 bpm or ±1%

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Other Innovative Measurement Devices

- **Other novel medical sensing and reporting devices, and related applications that could be developed using print-on and compatible technologies.**
- **For example, devices that can measure hydration levels (biochemical measurements such as electrolyte concentrations), or blood glucose levels**
- **Proposals should be for a complete system and cover the full scope of development to FDA certification.**
- **Similar to the concept for Patient Monitoring Devices, there should be a means to communicate with the device to extract or transmit information as appropriate.**
- **Proposals should address the device's concept of operation, military medical utility, cost benefits over existing capabilities (if any exist), and analysis and/or references that show technical feasibility**

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??? Any Questions ???

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