PicoSystem Self-Powered, Wireless Sensor Platform

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“The US sensor market is worth $10.3B per year”

Source: Fredonia Group
Wired vs. Wireless

The majority of sensor data is still painfully wired. Wireless Sensor Networks (WSNs) provide a huge opportunity to displace current technology.

Source: Dust Networks
Expectations for WSN have been very high, however WSNs have yet to replace wired alternatives at mass scale.

The WSN market has high potential that has yet to be realized:
- 2010 Entire Sensor Market: $10,300
- 2010 WSN Market (Projected, 2005): $5,300
- 2010 WSN Market (Actual): $439

What has slowed WSNs growth?
Cost savings have yet to disrupt the marketplace.

Additionally, end users reveal three key concerns:
- Reliability
- Ease of Use
- Battery Life

Source: ON World
The Piconode significantly improves upon existing technology. It uses a novel radio that dramatically reduces power, size, and...

### Lowers costs by 6X compared to WSN alternatives

- **Cost savings:**
  - 6.25X Less Power (in µw)
  - 40X Smaller (in cm²)
  - 6X Cheaper (in US $)

### Extends battery lifetime by 4X

- **Battery Life:**
  - 6.25X Less Power (in µw)
  - 4X Battery Life (in years)
Introducing the Piconode

Development of the Piconode began at UC Berkeley 20 years ago and has shown dramatic progress over time.

Research Institutions Involved

Project Lead

Jan Rabaey

Piconode Size Improvements

2000

2003

2005

2011
The Piconode Platform

The Piconode is constructed on a CMOS platform that includes BWRC’s ultra low power radio. Components are interchangeable depending on application needs.

**Sensing Component**
- Temp
- Humidity
- Motion
- Pressure
- Light
- Sound
- Current

**CMOS Chip**
- Processor
- Memory
- Analog to Digital

**Wakeup and Tx Radio**

**Power Management**

**Storage Component**
- MEMS Supercap
- Alkaline
- NiMH
- Printable Battery

**Harvesting Component**
- Solar
- Thermal
- Mechanical
- Vibration
- Line

**Data Flow**
The PicoSystem integrates the Piconode, a Receiver Stack, and an Analytics stack.

- **Piconodes**: A number of Piconodes are deployed to collect and send data on a wireless mesh network.
- **Receiver Stack**: Receivers and repeaters collect data and send it to hardware via a backhaul network.
- **Analytics Stack**: Software and/or hardware responds to data and provides value-add services.
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The PicoSystem presents three opportunities for commercialization:

1. Established corporations integrate as-is technology into offerings.
   - Sensors: Texas Instruments, Johnson Controls, Lockheed Martin
   - Data Aggregators: TOSIBA

2. Team builds new business around extended technology IP.
   - DUST Networks
   - Aurora Biofuels

3. Team builds new business around vertically integrated offering.
   - PicoSystem
The PicoSystem enters a beachhead market within a vertically integrated company and expands horizontally into new markets over time.
Application Focus

The PicoSystem can be used in numerous applications. To manage scope, the team limited its deep-dive analysis to Cleantech, where 18 applications were identified.
Of the 18 applications, we recommend focusing first on the lighting control market and subsequently the HVAC local temp sensing market.
Occupancy and auto-dimming controls are a $13B market...

Sales opportunities would exist within retrofits and new buildings through:

- **General contractors and subcontractors**
- **Design consultants**

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**US Electricity Expenditure**
- Commercial: $275bn
- Other: $69bn

**Commercial Building Electricity**
- Lighting: $43bn
- Other: $26bn

**Commercial Bldg Lighting Only**
- Addressable: $13bn
- Non-Addressable: $13bn

2010 Projections | Sources: EIA, Adura
The PicoSystem couples lower cost equipment with innovative analytics to succeed in the lighting control market.
The PicoSystem: Lighting Control

The Piconode’s small size and low cost bring novel configurations and applications within reach.

A. Monitor Integration

B. Task Lighting

C. Office Furniture

D. HVAC diffusers

Analytics use occupancy, desk light level, temperature, and ID tags to optimize the worker environment.

Enhances lighting, HVAC, maintenance, and **productivity**.
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The team recommends five actions to progress the PicoSystem’s viability in the marketplace

1. Use wireless mesh
2. Offer licensing exclusivity
3. Test and improve performance in harsh conditions
4. Keep range stable as voltage decreases
5. Build out the integrated PicoSystem
To succeed, the business will need to advance the technology, hire leadership, build partnerships, and overcome financing hurdles.

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Initially, the company will depend on vertical integration as a barrier to competitive threats. Over time, the company will develop patentable technology.

- Design and deployment know-how will be a significant source of value for the customer.
- Not patentable, but experience and expertise will be difficult for competitors to copy.
- The company will initially depend on its ability to provide integrated systems (hardware, software, deployment) as a barrier to competitive threats.
- Software will be developed in-house and will be proprietary.
- Future developments of gateway hardware will be patentable.
- Future developments of node hardware will likely be patentable.
- Highly specialized integration know-how will provide a defensible position.