

# Wireless Sensors Enterprise-led Network

## Consolidated Vision & Purpose

### Wireless Sensors – “The Fifth Revolution”

There have been four revolutions that have shaped modern society,

Agrarian revolution (ca. 5000 BC)

The industrial revolution (1800's)

The computer revolution (1980's)

The internet/WWW (1990's)

'The next revolution will be driven by cheap sensors coupled to microprocessors and lasers'<sup>1</sup>

## 1 Vision for WSN Worldwide

A world where wireless sensor networks are employed to improve our quality of life, through the provision of accurate, real-time information about things that really matter to people, such as personal health, environmental (air/water) quality, tracking of food quality and bio/chemical threat detection, and to enterprises, such as real-time business information, operational efficiency, and value growth.

A world where explosive growth in the use of sensors in the coming decades will lead to the pervasive omnipresence of wireless sensors, in our cars, streets, homes, offices, factories, hospitals, retail premises and on our person.

A world where the common thread in all predictions, namely that there will be billions of sensor applications, most of the sensors being wireless and many sensor nodes being very small, is driven by a technology revolution that provides a great opportunity for Irish industry.

## 2 Who are we?

A network of committed organisations drawn from Industry (indigenous SMEs and multinationals, comprising both technology providers and users), university research centres and government agencies, who share a common vision of the importance of wireless sensor networks in our future economy and shaping our future society, and are united in a common desire to promote wireless sensor network research, development, and successful commercialisation.

## 3 Why have we come together?

We communally believe from our various perspectives that WSNs will have a profound impact on our lives in the not-too-distant future; development and delivery of functional technologies in this area will generate tremendous business opportunities for early leaders, both in terms of the technology itself, and in terms of its impact right across the broad sweep of modern industry sectors and services.

We seek to stimulate the development of a new growth sector for Ireland through the convergence of technologies and capabilities and the influencing of strategic national investment in order to provide revolutionary solutions to European and global markets.

We seek to institute support mechanisms and linkages to improve and expedite the transfer of technology from academia to market deployment. The group has come together to drive the commercial exploitation of WSN technology in Ireland by leveraging research, marketing and education.

We seek to identify and develop business opportunities for our organisations.

We are committed to pursuing world-class research and developing innovative commercial products in the Wireless Sensor arena. Our aims are to position Ireland as a world leader through the development of the core competencies required for next generation wireless sensors, and to exploit these core competencies through focused research projects and swift technology transfer to the Irish industrial base.

We seek to pool our experiences from a variety of backgrounds, e.g. R&D activity in Europe on intelligent (automotive) sensors, ...

## 4 Key Applications

There will be many applications for wireless sensors where space, flexibility, cost or mobility will dictate that the sensors be wireless. The field is broad and varied with the following being some of the key areas (not prioritised, not exhaustive):

- Utility Meter Reading
- Automotive – sensors for engine control, driving assistance and comfort control.
- Environmental monitoring – Environmental sensors for pollution monitoring.
- Healthcare – medical sensors for monitoring vital signs of a patient, for remote diagnosis and for automatic dispensing/delivery of drugs
- Industrial installations are turning to wireless sensor network as opposed to wired networks because installation costs are less and flexibility is greater.
- Food quality sensors for monitoring transport and storage conditions.
- Personal fitness sensors to monitor heart rate etc. during exercise.
- Building Automation – Building management system sensors for lighting control, air-conditioning control and security.
- Early detection of chemo/bio hazards & threats

The key applications may be classified according to the dominant characteristic, e.g.:

- Low Cost: Suggest this be driven by the margin sensitive automotive sector;
- Wireless and Battery-less systems – Consider RFID Technology, potentially in the food and pharma sectors;
- Ad-hoc robust networks – Self forming networks capable of forming for defined durations.

The killer application is the billion dollar question – in the USA, military considerations are likely to dominate for the foreseeable future (chemo/bio threat detection, people/object sensing etc.; in Europe, domestic/service products may have a higher profile; sensors in the home, in cars, in the environment, food industry (quality tracking), wearables, fisheries. Wireless in the medical and healthcare environments is a key area.

## 5 Commercial and economic drivers

Every economic sector will employ WSNs to improve efficiencies, track and predict problems; industries using WSNs will have a clear technological and competitive advantage over non-users.

Many of the core technologies are already well advanced – low power communications chipsets and standards (ZigBee, Bluetooth, 802.11...) and others are being developed; some demos are already being realized (mainly in the USA using MOTES). These are rapidly becoming validated and effective technologies in need of a killer app.

## 6 Top 3 Key Technological Issues and Drivers

### 6.1 Issues

Development of novel sensor technologies, which are commercially viable with sustainable competitive advantage in the global market, a key example being the integration of chemical sensors and biosensors into WSN world.

Availability of low cost, low power energy efficient design (consider rechargeable and battery-less/energy harvesting operation as a goal), low bandwidth, long distance/range (100s of m or order of Kms) wireless communications.

Highly Integrated – Fully integrated sensor, signal conditioning, processing and wireless interface on a single die.

A global standard for automotive electronics and applications to include 2 frequency options, possibly more. The RF link should ideally be suited for energy transmission.

### 6.2 Drivers

Increasing impact of wireless comms on the way we live – this trend will continue and demand new sources of information about many more aspects of our lives.

#### Possible Research Agenda

##### Networks

Wireless sensor have particular network requirements. Power minimisation will limit the range and consequently, data must be passed from sensor to sensor across the network. In addition the network must self-configure without intervention and the network must re-configure automatically as sensors are added or removed. Standards such as IEEE 802.15.4 and Zigbee will help but applications will be diverse and non-standard solutions will be required. Research is required into:

- Ad-hoc routing protocols to implement star and peer-to-peer network topologies
- Medium access control layers for sensors.
- Application level protocols for sensors.

##### RF Circuitry

Communication with wireless sensors is by RF links in one of the licence free frequency bands. Commercial off the shelf RF transceivers are available in some frequency bands. But transceiver variations will be required to facilitate operation in alternative frequency bands, narrower channel bands as the number of users increase and integration of RF and other electronics in single package to reduce size. Research is required into:

- RF transceivers in the 2.4GHz, 5.8GHz and 24.125GHz bands
- Improved receiver filtering to facilitate narrower channel bands
- Miniature antennae.
- Integration of RF circuitry with other circuitry such as microcontrollers.

##### Power

The energy source of the sensor must be capable of powering the sensor for a number of years without recharge or replacement. Improvements are required in energy storage devices such as batteries, fuel cells, miniature flywheels and ultra-capacitors. Methods of “scavenging” or “harvesting” power from the environment also need to be developed. Research is required in Ireland into

- Methods of harvesting energy from phenomena such as vibration, sound, light, wind or thermal variation.
- Miniature fuel cells that can operate at room temperature.
- Miniaturisation / Manufacturing technology

##### Sensors

The development of novel sensor technologies, which are commercially viable with sustainable competitive advantage in the global market, is a vital item for the technology agenda. Research is required in Ireland into

- The integration of chemical sensors and biosensors into WSN world

##### Systems Integration

Miniaturisation will require new manufacturing technology. Flexible circuits, miniature chips, flip-chips, system in package etc. will be important. Irish industry must be capable of designing and manufacturing product that will be manufactured by new technologies. With this in mind, it is proposed that the Irish universities:

- Carry out sufficient research to stay abreast of manufacturing developments and provide an up-to-date prototyping capability.
- Research and achieve leadership position in computer aided design and computer aided manufacturing tools for new manufacturing technology.

## 7 Unique differentiator for Ireland

Ireland is a small, dynamic, country, with a strong economy and long-term commitment to large scale investment into university/industry R&D; realization of the critical importance of R&D for sustainable wealth by ALL stakeholders; willingness of all players (people, organizations..) to work together for the common good is rare (multinationals, SMEs, Universities, Government...); this is rare and is a key strength that we MUST build (hence critical importance of the network programme – it must deliver resources and get things happening NOW).

The bringing together of chemistry, biology, engineering, computing, communications, networking, prototyping & manufacturing, and deployment/testing strategies into a coherent initiative will make us unique. This can be achieved quickly because of the dynamic manner in which the agencies are reshaping their research priorities, and because of the Government's commitment to innovation and research.

We should aim to have first widespread commercial deployments. Consider integrating possible Irish customers/end-users into the network and using them to help define and trial applications.

Ireland has some differentiating advantages in the following areas:

- Existing sensor expertise in Irish industry  
Ireland has a small core of companies already producing wired and wireless sensor products. They have developed their own niche areas and should be assisted in developing wireless sensor network products. Active areas include automotive sensors; automated metering; temperature instrumentation; gas monitors; industrial process control; building management.
- Areas of expertise in Irish research institutes  
Research institutes such as the NCSR and NMRC have expertise in developing sensors. Some of these sensors may be suitable for developing into WSN products.
- Agriculture  
Our natural resources favour agriculture and it has become a well developed industry in the country. Products that reduce production costs, improve crop yields, track animals, detect onset of birthing, monitor animal health etc. would be very marketable. Ireland could become world leader in innovative agricultural wireless sensor products.
- Food processing  
Food processing is an important industry in Ireland. Food quality monitoring and traceability has grown in importance with consumers. Ireland could focus on becoming world leader in innovative food quality sensor products. For example, miniature sensors could be developed to monitor the temperature and humidity of perishable goods such as meat and dairy produce during transport and storage.
- Medical Devices  
Ireland has a thriving Medical Device industry with R&D laboratories in several multinationals. It is predicted that there will many new developments in wireless worn monitors, automated wireless drug delivery systems, remote diagnosis. Ireland could focus on becoming a leader in some of these wireless medical applications.
- Servicing Multinational Corporations (MNCs )  
Ireland is host to several world leading semiconductor, pharmaceutical and industrial control MNCs. Irish industry could develop WSN products that improve manufacturing processes and test methods for these companies.

## 8 Current views / Ideas / Practical actions

Suggestion: we need to create a place where these technologies are demo-ed in a real-life situation (translational facility). Ireland has a number of core competencies in place in the University sector, and industries that are well informed about the emerging market needs. These need to be brought together in an appropriate framework to catalyse R&D partnerships.

Suggestion: The research should be focused at all times on the commercial needs of the clients of Universities, i.e. Irish Industry, with this in mind all research projects should be reviewed regularly by a technical and commercial steering committee drawn from industry, and where deemed necessary by changes in the economic environment, have the authority re-focus the research direction.

Suggestion: Get some market data. For example what could be main applications, main industries; which volumes, which type of complexity, etc. A 3-5 view is needed to get industry funding signed off.

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<sup>1</sup> Michio Kaku, Professor of Theoretical Physics, City College of New York, quoting Paul Saffo, Director of the Institute of the Future, in 'Visions - How Science will Revolutionize the 21st Century', Anchor Books, 1998.