Smart Sensor Systems
720 SW 14th Street
Loveland, CO 80537
(970) 663-0006
www.SmartSensorSystems.com

Product Data Sheet

Bluetooth Sensor Development Kit

Introduction

Smart Sensor Systems' Bluetooth Sensor Development Kit provides the hardware and software needed to integrate your transducer (sensor or actuator) into a Bluetooth wireless sensor network that complies with the IEEE 1451 standard. In the nomenclature of IEEE 1451, the transducer is known as the Transducer Interface Module (TIM) while the sensor network controller is known as the Network Capable Application Processor (NCAP). These are shown in Figure 1.

The Bluetooth Sensor Development Kit allows you to develop a wireless, IEEE 1451-compliant TIM that uses your sensor or actuator hardware. Your TIM will benefit from the many features of IEEE 1451 like Plug & Play, automatic sensor error correction, ease of sensor network installation, and simplified sensor replacement to name a few.

Furthermore, you'll be able to wirelessly connect up to seven Bluetooth TIMs to a single NCAP at distances up to 30 meters. Figure 2 illustrates this Bluetooth wireless sensor system.

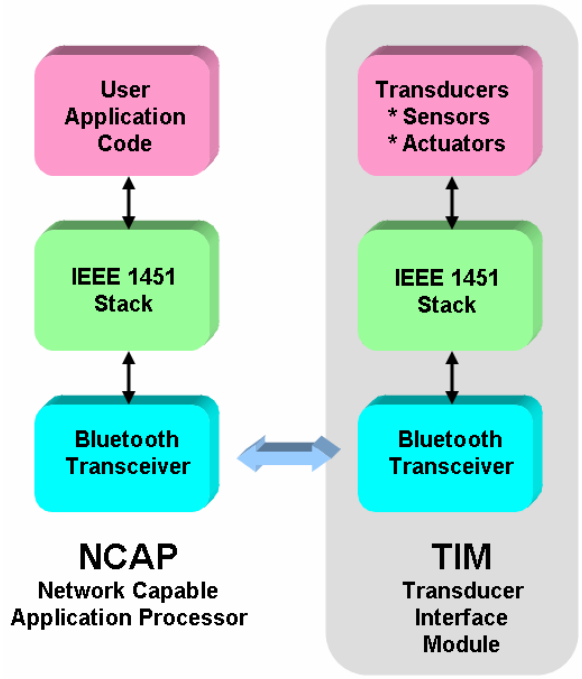

Figure 1: The NCAP and TIM defined by the IEEE 1451 standard

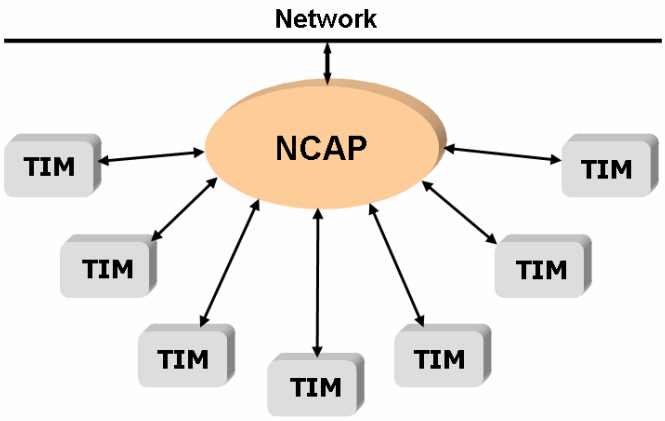

Figure 2: Bluetooth supports up to seven active TIMs at distances up to 30 meters.

The design of the Bluetooth Sensor Development Kit is focused on minimizing the effort for sensor manufacturers to either convert existing sensors to be IEEE 1451 compliant or develop new sensors that are IEEE 1451 compliant. Smart Sensor Systems has developed the IEEE 1451 software stack that you'll need for the TIM along with the driver software to interface to the Bluetooth transceiver. Also included in the Development Kit is a high-resolution A/D converter and a breadboarding area where you can add your own sensor hardware and any signal conditioning that you require. The A/D converter input subroutines supplied with the Development Kit make it straightforward to integrate your sensor hardware into the TIM.

On the NCAP side, the Development Kit provides a second Bluetooth transceiver and a sufficient subset of the IEEE 1451 software stack to allow you to validate operation of your TIM. Also provided with the NCAP is a simple GUI that allows you to exercise your TIM.

Smart Sensor Systems' flexible and modular TIM design makes it straightforward to transition from a TIM development environment to a TIM production environment. In fact, it's possible to deploy Bluetooth-based TIMs in production that are based on the exact same set of boards that are used in the Bluetooth Sensor Development Kit. To understand how this is achieved, we'll first look at Smart Sensor Systems' TIM architecture.

Smart Sensor Systems' Transducer Interface Module (TIM) Architecture

The TIM architecture is based on a modular design to allow customers to choose the TIM components that best meet their particular needs. The printed circuit board stacking technology of the PC/104 standard (www.pc104.org) is used to provide maximum flexibility. Figure 3 shows the three printed circuit boards included in Smart Sensor Systems' TIM design; the Radio Board, the Processor Board and the Interface Board.

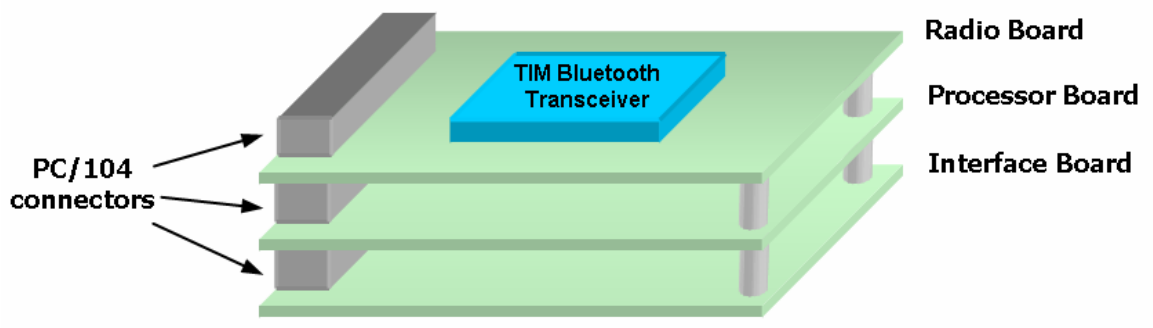

Figure 3: Smart Sensor Systems' TIM contains a Radio Board, a Processor Board and an Interface Board

1. **Radio Board** – The Radio Board contains a Bluetooth transceiver chip from CSR, Cambridge Silicon Radio. The Radio Board also supplies power to the other TIM boards and contains a 3.3 VDC voltage regulator and a 5 VDC voltage regulator.
2. **Processor Board** – The Processor Board contains the STMicroelectronics STR710FZ2 32-bit ARM microprocessor and a JTAG (Joint Test Action Group) 20-pin connector to permit software downloading and debugging.
3. **Interface Board** – The Interface Board contains a four channel 20-bit A/D converter plus a breadboarding area for the customer to assemble their sensor or actuator circuitry.

Figure 4 shows the PC/104 connectors that connect the three boards together and the standoffs that maintain the required separation between the boards. It is important to understand that the signals on the TIM's PC/104 connectors have been assigned to optimize the functionality of the TIM and are **not** assigned per the PC/104 specification. Therefore, commercially available PC/104 computer products are not interoperable in Smart Sensor System's TIM. Likewise, Smart Sensor System's TIM boards are not interoperable in PC/104 computer products.

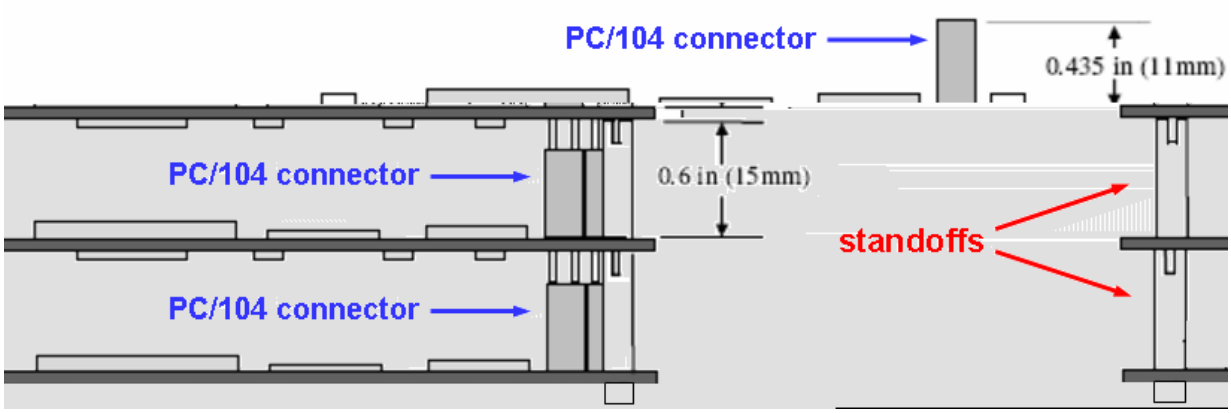

Figure 4: Interconnecting & Spacing Between the Boards of the TIM

Smart Sensor Systems' modular TIM design has a number of important benefits:

1. **Supports Multiple Wireless Technologies** – The modular design of the TIM supports development of different wireless products. For example, the Bluetooth Radio Board can be replaced by an 802.11 Radio Board when it's available.
2. **Allows Optimum Microprocessor Selection** – A Processor Board can be designed based on the microprocessor that best meets your needs in terms of cost, power consumption, performance, etc. Smart Sensor Systems will be supporting a number of different microprocessors.
3. **Provides Flexible Interface Options** – In addition to the 20-bit A/D converter on the Interface Board, breadboarding space is provided for the customer to integrate their own sensor circuitry. In the future, Smart Sensor Systems will offer Interface Boards in other configurations.
4. **Simplifies Development of Multiple Transducer Products** – Multiple Transducers can be developed by simply swapping out one Interface Board and installing another – the Radio Board and the Processor Board don't need to be changed.
5. **Expandability** – The TIM's modular design allows stacking of additional boards (beyond the standard three boards) when they're needed. One possible additional board would be a board containing a battery.
6. **Standalone Operation** – The TIM operates from a single DC power supply, making it straightforward to power the TIM from a battery for standalone operation.
7. **Simplified Troubleshooting** -- Boards can be stacked in any order for troubleshooting because the PC/104 connectors make the same connection to every board. This allows a problematic board to be placed on top of the stack or on the bottom of the stack, whatever is most convenient for troubleshooting.
8. **Multiple Packaging Options** –The PC/104 standard board size allows packaging in a wide variety of off-the-shelf PC/104 enclosures.

While the TIM's modular architecture is especially suitable for development and prototyping (and even low volume production), it is likely that, long term, sensor manufacturers will want to further customize their TIM designs to optimize cost, package size, etc. Please refer to the later section "Options to Produce Your TIM" for more information on this topic.

Bluetooth Radio Distances Greater Than 30 Meters

The Bluetooth Sensor Development Kit supports distances of up to 30 meters between the NCAP and the TIMs as noted in the introduction and Figure 2. Smart Sensor Systems is investigating an enhancement to the Radio Board to support distances of up to 100 meters. There is a tradeoff – with increased operating distance, the power consumption likewise increases.

Architecture of the Bluetooth Sensor Development Kit

Now let's look at the architecture of the Bluetooth Sensor Development Kit shown in Figure 5.

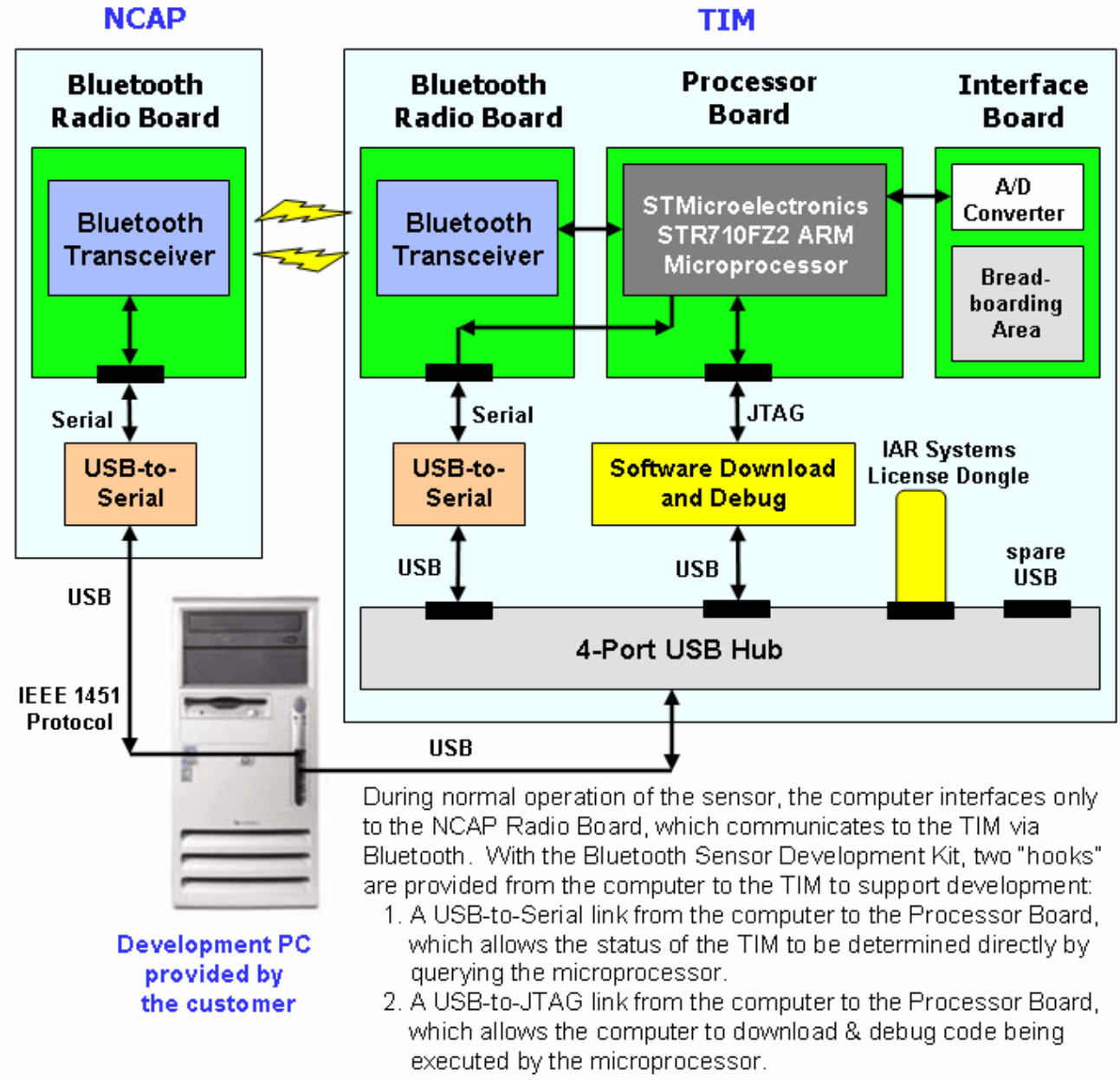

Figure 5: Architecture of the Bluetooth Sensor Development Kit

The Development Kit contains an NCAP Bluetooth Radio Board and a modular TIM. The Development Kit's TIM contains the same three boards as the standalone TIM – a Radio Board, a Processor Board and an Interface Board. The fact that the standalone TIM uses the same boards as the Development Kit's TIM simplifies the process of transitioning from a development environment to a deployment environment.

The customer-supplied Development PC interfaces to both the NCAP hardware and the TIM hardware via USB. A USB-to-Serial adapter is included to interface to the NCAP's Bluetooth Transceiver chip because the interface from USB to the Bluetooth Transceiver chip is serial.

The Development Kit contains a 4-Port USB Hub (see the bottom of the TIM in Figure 5).

- The first USB port is connected to a USB-to-Serial adapter to permit the Development PC to determine the status of the TIM by querying the TIM's microprocessor.
- The second USB port interfaces to a module which connects to the JTAG connector on the Processor Board. This JTAG-connected module is used by the Development PC to perform software downloading and debugging of the code being executed by the microprocessor.
- The third USB port contains an IAR Systems License Dongle. IAR Systems is the vendor of the Integrated Development Environment (IDE) that is used by, and recommended by, Smart Sensor Systems for development of the microprocessor software. The License Dongle is required in order to use the IDE.
- The fourth USB port is a spare.

Figure 6 is a picture of the Bluetooth Sensor Development Kit, specifically the TIM components.

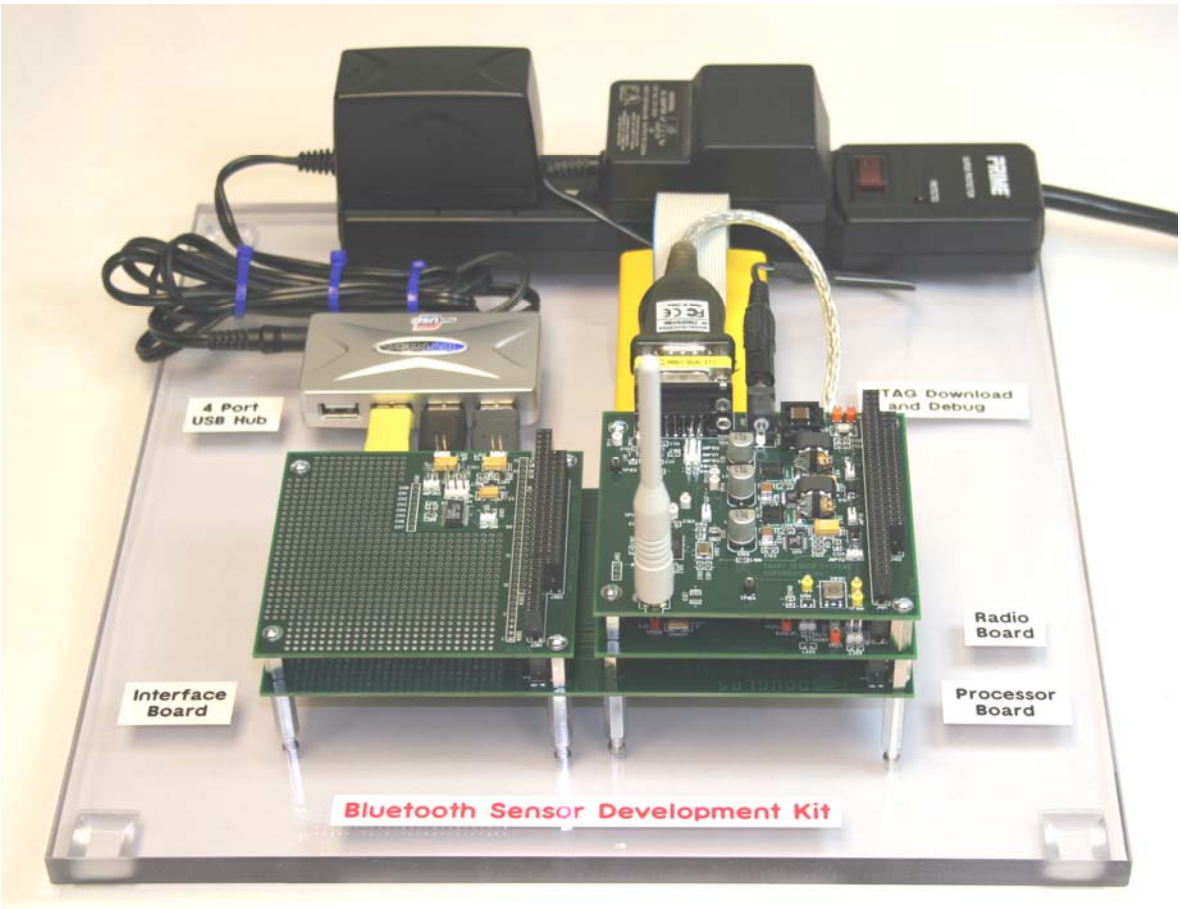

Figure 6: The TIM Components of the Bluetooth Sensor Development Kit

Note that, rather than have the three TIM boards stacked vertically, a PC/104 extender board is used to allow the Interface Board (on the left) to be installed separately from the Radio Board and the Processor Board on the right. This is very convenient during development as it provides ready access to any sensor or actuator components on the breadboarding area of the Interface Board. Note also the Bluetooth antenna attached to the Radio Board.

The Bluetooth Sensor Development Kit contains two wall transformers, one to power the USB Hub and the other to power the three TIM boards.

Bluetooth Sensor Development Kit Software

The table below shows the software that is provided with the Development Kit as well as the software that is acquired by the customer.

Software Provided with the Development Kit	Software Acquired by the Customer (with our recommendations)
• **NCAP** o Subsets of the IEEE 1451.0, 1451.5 and 1451.5→Bluetooth libraries. These will be provided as Windows XP-compiled libraries. o A simple NCAP GUI to exercise the TIM. • **TIM** o The IEEE 1451.0, 1451.5 and 1451.5→Bluetooth libraries compiled for the STMicroelectronics microprocessor. o The microprocessor OS and subroutines to interface to the Interface Board's A/D converter. • Windows-based diagnostic software to query the status of the TIM microprocessor on the Processor Board. • A TEDS Editor -- TEDS stands for "Transducer Electronic Data Sheet" and contains transducer-specific information.	• Development Tools: A compiler, linker and debugger to develop driver software to interface to sensor/actuator circuitry on the Interface Board. **NOTE: Smart Sensor Systems is using IAR Systems' Integrated Development Environment (IDE) and recommends that our customers use this same tool.** **As noted previously, the Development PC is also provided by the customer.**

Smart Sensor Systems Product Offerings

The products offered by Smart Sensor Systems are listed below.

PRODUCT	COMPONENTS	PRICE
Bluetooth Sensor Development Kit	One TIM as shown in Figure 6 One NCAP Bluetooth Radio Board & USB cable NCAP Software TIM Software Diagnostic Software TEDS Editor Includes one software License to Use (LTU) for a single computer.	See NOTE below
TIM Can be used for low volume TIM deployments.	One Bluetooth Radio Board One Processor Board (STMicroelectronics STR710FZ2) One Interface Board	See NOTE below
NCAP Bluetooth Radio Board	One NCAP Bluetooth Radio Board One USB cable NCAP software	See NOTE below
TIM Bluetooth Radio Board	One TIM Bluetooth Radio Board	See NOTE below
Processor Board	One Processor Board (STMicroelectronics STR710FZ2)	See NOTE below
Interface Board	One Interface Board with 20 bit A/D converter	See NOTE below
TIM 1451 Source Code	1451.0 source 1451.5 source 1451.5 → Bluetooth source	Contact Smart Sensor Systems for source licensing terms
Multi-TIM License to Use (LTU)	License to use Smart Sensor Systems pre-compiled 1451 object libraries with multiple TIMs in a production environment	Quantity discount schedule is to-be-determined

NOTE: Please contact Smart Sensor Systems for prices.

TIM Development Methodologies

Smart Sensor Systems will support a range of development methodologies based on the customer's wants and needs. These methodologies can range as follows:

1. Customer develops the complete TIM using the Bluetooth Sensor Development Kit.
2. Smart Sensor Systems develops the complete TIM based on the customer's specification.
3. A collaborative development model is used where the customer and Smart Sensor Systems jointly develop the TIM based on the customer's desired division of labor.

Please contact Smart Sensor Systems to further discuss any of these development methodologies.

Options to Produce Your TIM

Upon completion of TIM development using the Bluetooth Sensor Development Kit, customers will have a number of options to produce their standalone TIM, including:

1. For low volume production runs or for small-scale testing of the TIM in the customer's environment, the standalone TIM can be deployed directly. Additional TIMs can be purchased directly from Smart Sensor Systems. Depending on the volume, it may make sense to do a custom layout of the TIM-specific circuitry on the Interface Board in lieu of manually assembling circuitry on multiple Interface Boards.
2. Customers may choose to use the infrastructure provided by the modular TIM but insert, for example, their own custom Processor Board. Smart Sensor Systems will document all PC/104 connector pinouts in support of this activity.
3. A completely custom TIM can be designed to integrate those components of the TIM that are needed in the customer's final product. This provides the most compact size and the most economical price for the TIM at the expense of additional development effort. Smart Sensor Systems would be pleased to quote this design service upon request.