

# .NET GADGETEER

A PLATFORM FOR CUSTOM DEVICES

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**Microsoft Research**

**Based on paper presented at Pervasive 2012 by  
Nicolas Villar, James Scott, Steve Hodges, Kerry  
Hammil, Colin Miller**

# What is .NET Gadgeteer?

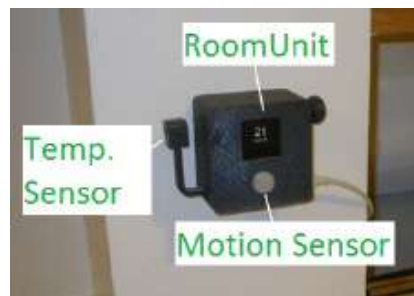
- A rapid prototyping platform for small electronic devices

## Characteristics:

- Low threshold
- High ceiling



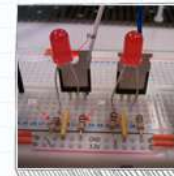
Gadgeteer school projects



Lancaster



Syma S107 Remote Control with .NET Gadgeteer



.NET Gadgeteer Binary Clock



Camera Picture Puzzle



Text to Speech for Applications



.NET Gadgeteer Thermometer with LCD



.NET Gadgeteer Servo Camera & Windows Phone Client



Flipbook Maker



.NET Gadgeteer-Powered Robot



Pulse Oximeter Web Service



Arcade Console

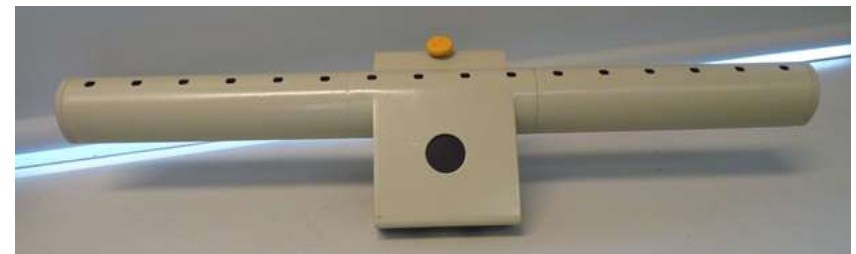


Module Tutorial: Buttons



Module Tutorial: Seed Studio GPS

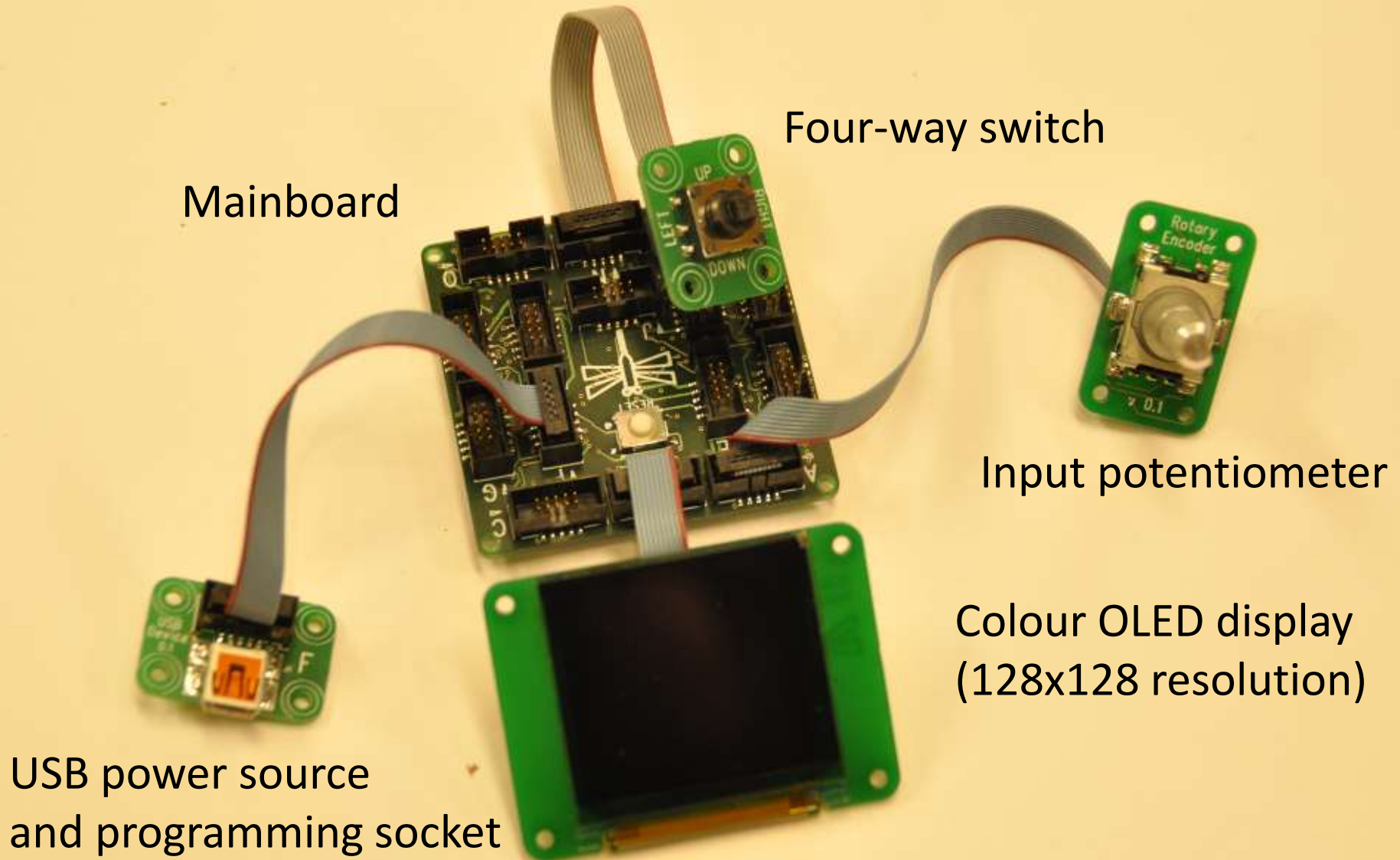
Gadgeteer hobbyist projects



Open University

# Making a custom hand-held videogame device in 24 hours

# Connect hardware modules (5 minutes)



Mainboard

Four-way switch

Input potentiometer

Colour OLED display  
(128x128 resolution)

USB power source  
and programming socket

# Game development in C# (5 hours)

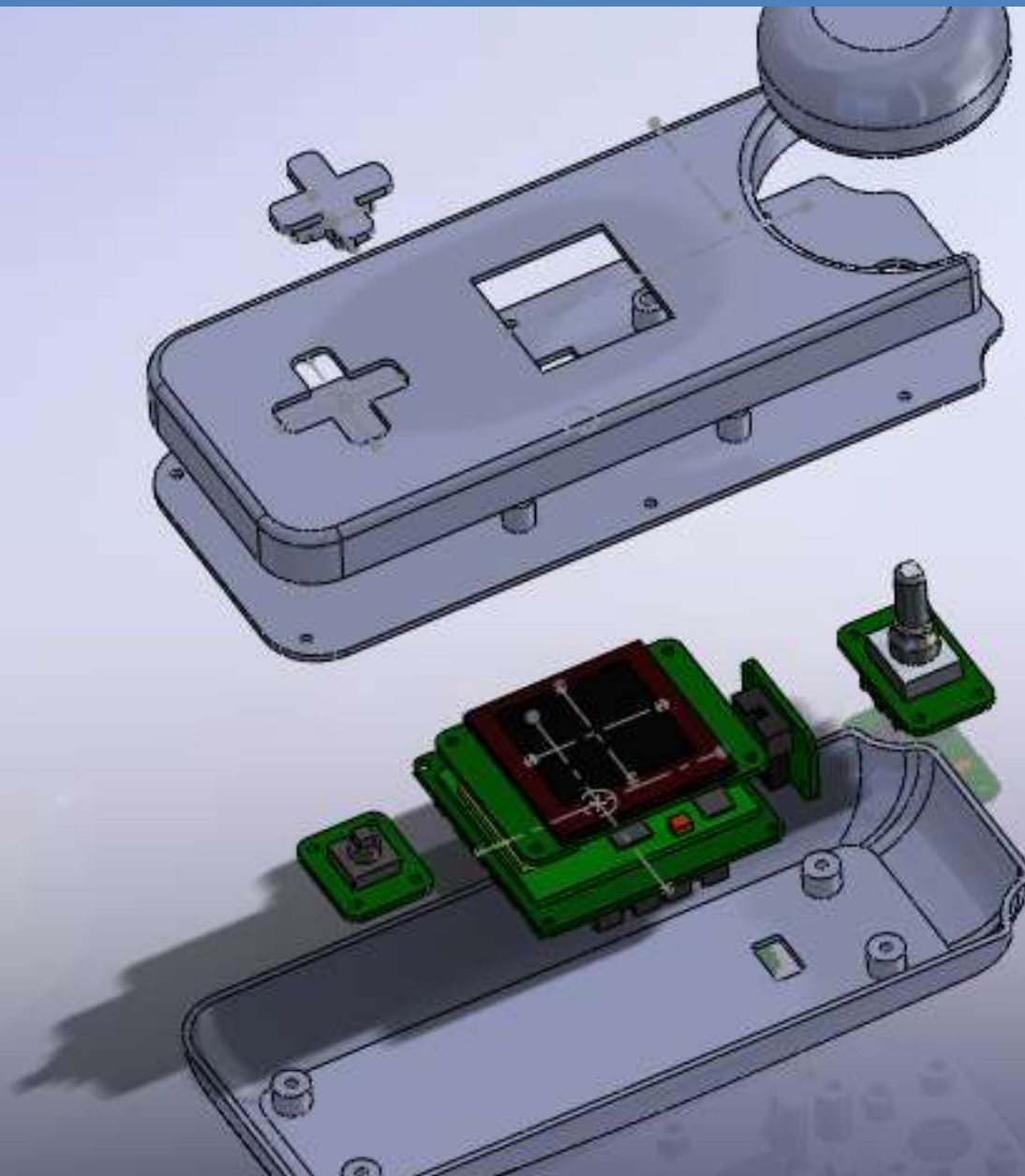
```
public Point[] positions;
public Point displacement;
public Color color;

public Piece(Point[] positions, Point displacement, Color color)
{
    this.positions = positions;
    this.displacement = displacement;
    this.color = color;
}

public void Rotate(bool clockwise)
{
    for (int i = 0; i < positions.Length; i++)
    {
        Point oldpos = positions[i];
        positions[i].x = clockwise ? -oldpos.y : oldpos.y;
        positions[i].y = clockwise ? oldpos.x : -oldpos.x;
    }
}

public Piece Clone()
{
    Piece clone = new Piece((Point[])positions.Clone(), new Point(displacement.
    return clone;
}
```

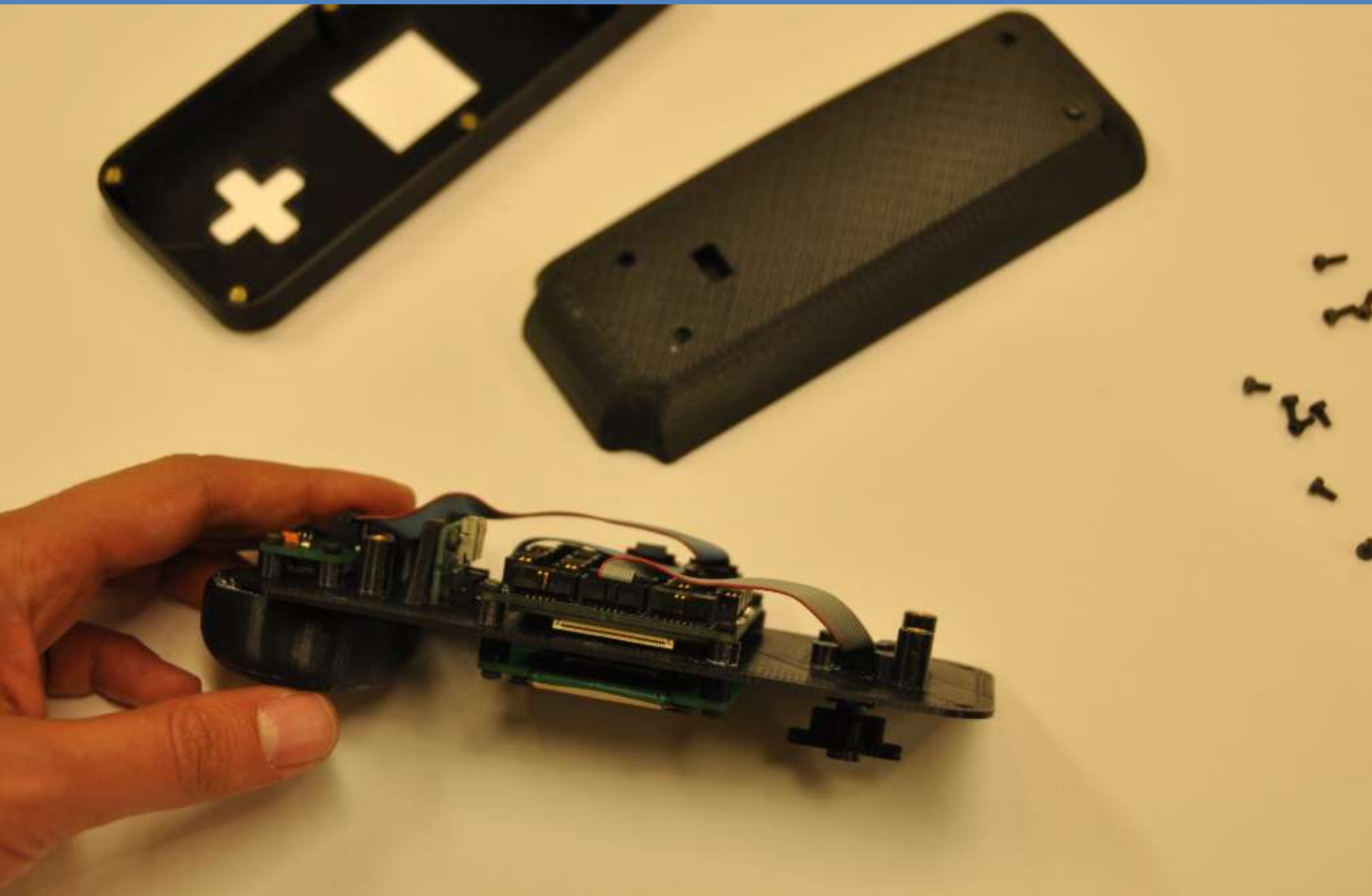
# Enclosure design (3 hours)



3D printing (6 hours)



# Assembly (20 minutes)







# The .NET Gadgeteer Platform

Modular  
Hardware



Software  
Tools

```
void ProgramStarted()  
{  
    // Initialize GTM.Modules and  
    myButton = new GTM.Button(GTM)  
    myLed = new GTM.MulticolorLE  
  
    myButton.  
  
    // Do one  
    Debug.Pri  
}
```

⚡	ButtonPressed
⚡	ButtonReleased
📁	DebugPrintEnabled
⚡	Equals
⚡	GetHashCode
⚡	GetType
📁	IsPressed
⚡	ToString

Physical  
Design



Gadgeteer

# The .NET Gadgeteer Platform

Modular  
Hardware

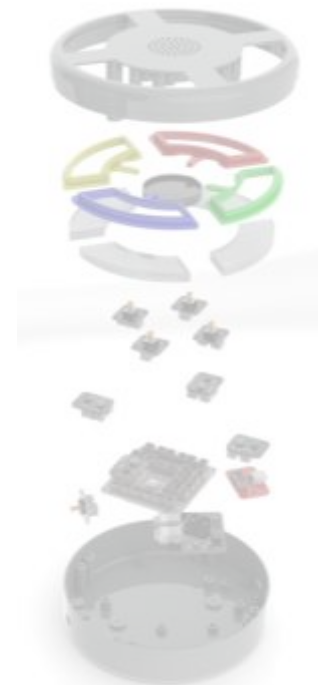


Software  
Tools

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Physical  
Design



Gadgeteer

# Modular hardware: mainboards

At the heart of every Gadgeteer project is a **mainboard**. A mainboard is made up of a programmable processor (ARM7 / ARM9 / Cortex M4), memory, and a number of sockets that Gadgeteer **modules** can plug into.



# Modules: sensors



Seed Studio Compass



Seed Studio Accelerometer



Seed Studio Soil Moisture Sensor



Seed Studio GPS



Seed Studio Temperature and Humidity Sensor



Seed Studio Gyroscope



Seed Studio Barometer



Sytech 3-Axis Accelerometer



Seed Studio Pulse Oxymeter



GHI PIR Sensor



Seed Studio Current Sensor



GHI Light Sensor

# Modules: communication



GHI RS232



Seeed Cellular Radio



GHI Serial-USB



Sytech Ethernet and SD



GHI CAN (Dual-Wire)



GHI XBee Adapter



GHI Bluetooth



GHI Ethernet J11D



GHI Ethernet ERC28



GHI WiFi RS21

# Modules: display and user input



Seed OLED Display



GHI Display T35



GHI I FD7R



GHI Video Out



GHI Multicolor LED (DaisyLink)



Sytech LCD Touch Panel 4.3



GHI Camera



Sytech Serial Camera



GHI Potentiometer



GHI Button



Sytech Button LED



GHI Joystick

# Modules: power and actuation



Sytech USB Device



GHI USB Client SP



GHI USB Client DP (Dual-Power)



SolderMonkey LittleStep



Seed Relays



GHI Motor Driver L298



# Modules: storage and audio



GHI Micro SD Card



GHI USB Host



GHI SD Card



Sytech Ethernet and SD

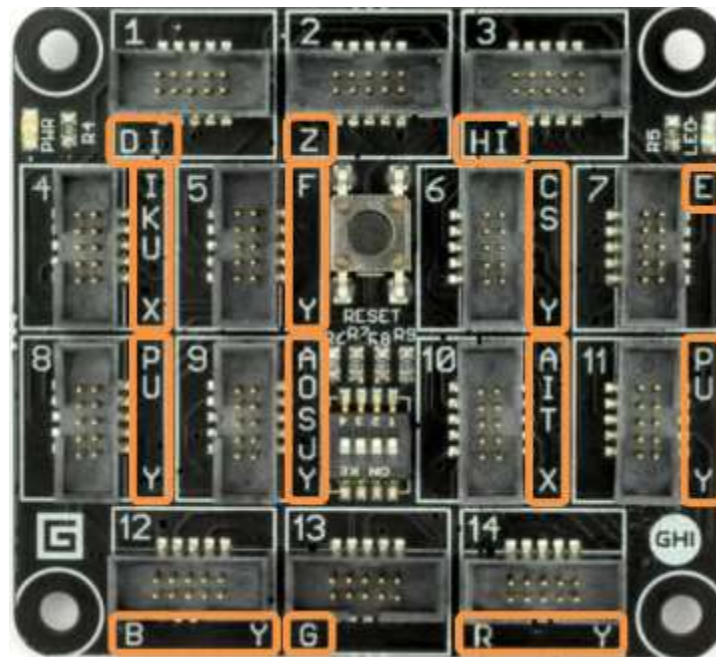


GHI Music

# Modules: extensibility



Sockets have types, which specify their electronic interface capabilities

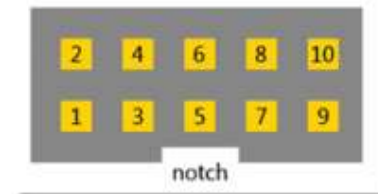


# Socket Type A

Pin 1	Pin 2	Pin 3	Pin 4	Pin 5	Pin 6	Pin 7	Pin 8	Pin 9	Pin 10
+3.3V	+5V	AIN (G!)	AIN (G)	AIN	GPIO	[UN]	[UN]	[UN]	GND

*Pinout specified by the socket type A definition.*

<b>AIN</b>	Analog input pin.
<b>GPIO</b>	A general-purpose digital input/output pin, operating at 3.3 Volts.
<b>(G)</b>	In addition to another functionality, a pin that is also usable as a GPIO.
<b>[UN]</b>	Modules must not connect to this pin if using this socket type. Mainboards can support multiple socket types on one socket, as long as individual pin functionalities overlap in a compatible manner, so that a pin from one socket type can overlap with a [UN] pin of another.
<b>!</b>	Interrupt-capable and software pull-up capable GPIO (the pull-up is switchable and in the range of 10,000 to 100,000 ohms).
<b>+3.3V</b>	Connection to the +3.3V power net.
<b>+5V</b>	Connection to the +5V power net.
<b>GND</b>	Connection the power ground net.



# Socket types definition table

TYPE	LETTER	PIN 1	PIN 2	PIN 3	PIN 4	PIN 5	PIN 6	PIN 7	PIN 8	PIN 9	PIN 10
3 GPIO	X	+3.3V	+5V	GPIO!	GPIO	GPIO	[UN]	[UN]	[UN]	[UN]	GND
7 GPIO	Y	+3.3V	+5V	GPIO!	GPIO	GPIO	GPIO	GPIO	GPIO	GPIO	GND
Analog In	A	+3.3V	+5V	AIN (G!)	AIN (G)	AIN	GPIO	[UN]	[UN]	[UN]	GND
CAN	C	+3.3V	+5V	GPIO!	TD (G)	RD (G)	GPIO	[UN]	[UN]	[UN]	GND
USB Device	D	+3.3V	+5V	GPIO!	D-	D+	GPIO	GPIO	[UN]	[UN]	GND
Ethernet	E	+3.3V	+5V	[UN]	LED1 (OPT)	LED2 (OPT)	TX D-	TX D+	RX D-	RX D+	GND
SD Card	F	+3.3V	+5V	GPIO!	DAT0	DAT1	CMD	DAT2	DAT3	CLK	GND
USB Host	H	+3.3V	+5V	GPIO!	D-	D+	[UN]	[UN]	[UN]	[UN]	GND
I2C	I	+3.3V	+5V	GPIO!	[UN]	[UN]	GPIO	[UN]	SDA	SCL	GND
UART+Handshaking	K	+3.3V	+5V	GPIO!	TX (G)	RX (G)	RTS	CTS	[UN]	[UN]	GND
Analog Out	O	+3.3V	+5V	GPIO!	GPIO	AOUT	[UN]	[UN]	[UN]	[UN]	GND
PWM	P	+3.3V	+5V	GPIO!	[UN]	[UN]	GPIO	PWM (G)	PWM (G)	PWM	GND
SPI	S	+3.3V	+5V	GPIO!	GPIO	GPIO	CS	MOSI	MISO	SCK	GND
Touch	T	+3.3V	+5V	[UN]	YU	XL	YD	XR	[UN]	[UN]	GND
UART	U	+3.3V	+5V	GPIO!	TX (G)	RX (G)	GPIO	[UN]	[UN]	[UN]	GND
LCD 1	R	+3.3V	+5V	LCD R0	LCD R1	LCD R2	LCD R3	LCD R4	LCD VSYNC	LCD HSYNC	GND
LCD 2	G	+3.3V	+5V	LCD G0	LCD G1	LCD G2	LCD G3	LCD G4	LCD G5	BACKLIGHT	GND
LCD 3	B	+3.3V	+5V	LCD B0	LCD B1	LCD B2	LCD B3	LCD B4	LCD EN	LCD CLK	GND
Manufacturer Specific	Z	+3.3V	+5V	[MS]	[MS]	[MS]	[MS]	[MS]	[MS]	[MS]	GND
DaisyLink Downstream*	*	+3.3V	+5V	GPIO!	GPIO	GPIO	[MS]	[MS]	[MS]	[MS]	GND

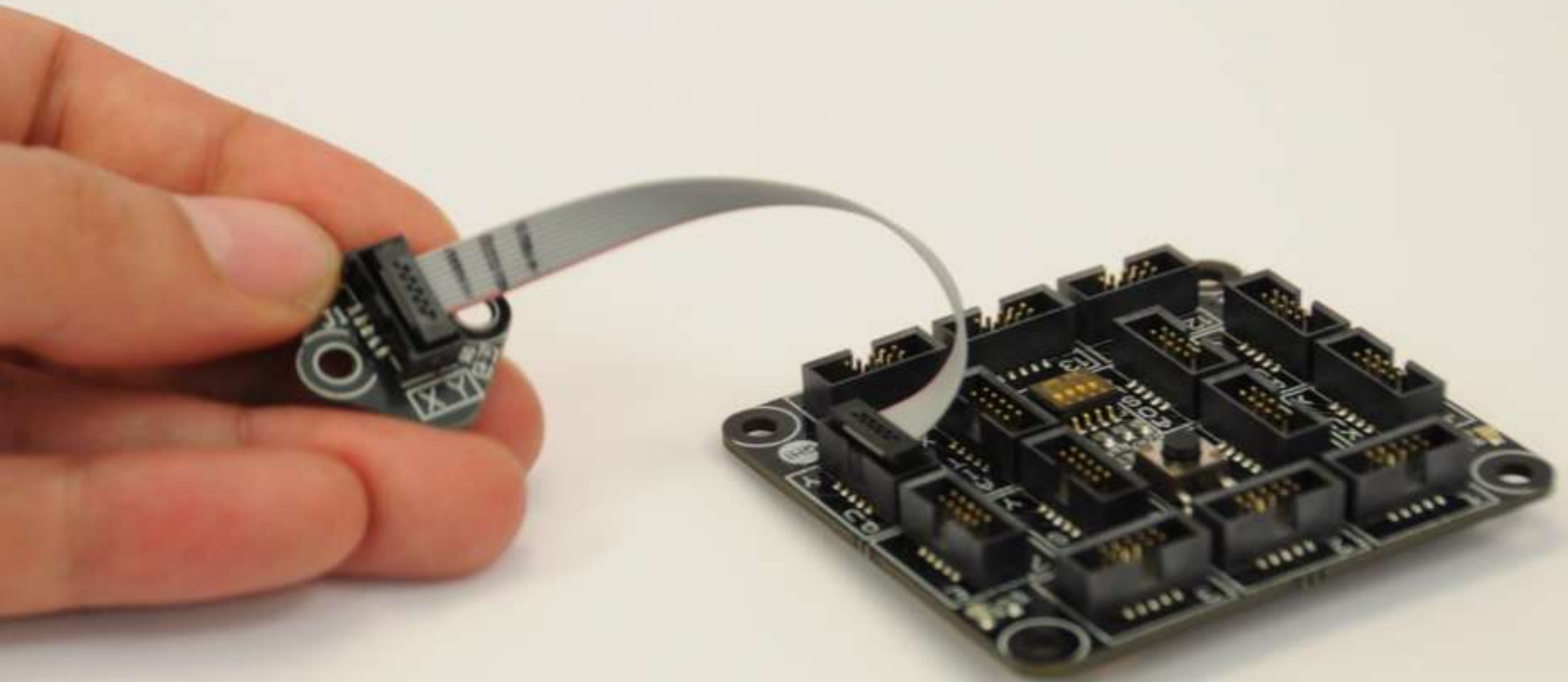
**GPIO** A general-purpose digital input/output pin, operating at 3.3 Volts.

**[UN]** Modules must not connect to this pin if using this socket type. Mainboards can support multiple socket types on one socket, as long as individual pin functionalities overlap in a compatible manner. A pin from one socket type can overlap with a [UN] pin of another.

! Interrupt-capable and software pull-up capable GPIO (the pull-up is switchable and in the range of 10,000 to 100,000 ohms).

\* Socket type \* should not appear on a mainboard, only on DaisyLink modules. The [MS] pins on this socket type can optionally support reflashing the firmware on the module.

# Connecting a module to a mainboard



# The .NET Gadgeteer Platform

Modular  
Hardware

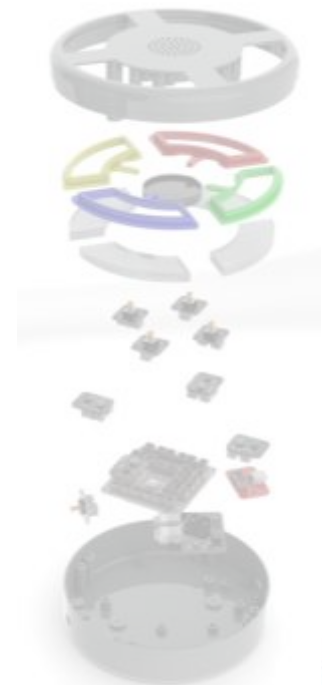


Software  
Tools

```
void ProgramStarted()  
{  
    // Initialize GTM.Modules and  
    myButton = new GTM.Button(GTM.  
    myLed = new GTM.MulticolorLE  
  
    myButton.  
  
    // Do one  
    Debug.Pri  
}
```

- ButtonPressed
- ButtonReleased
- DebugPrintEnabled
- Equals
- GetHashCode
- GetType
- IsPressed
- ToString

Physical  
Design



# Software tools

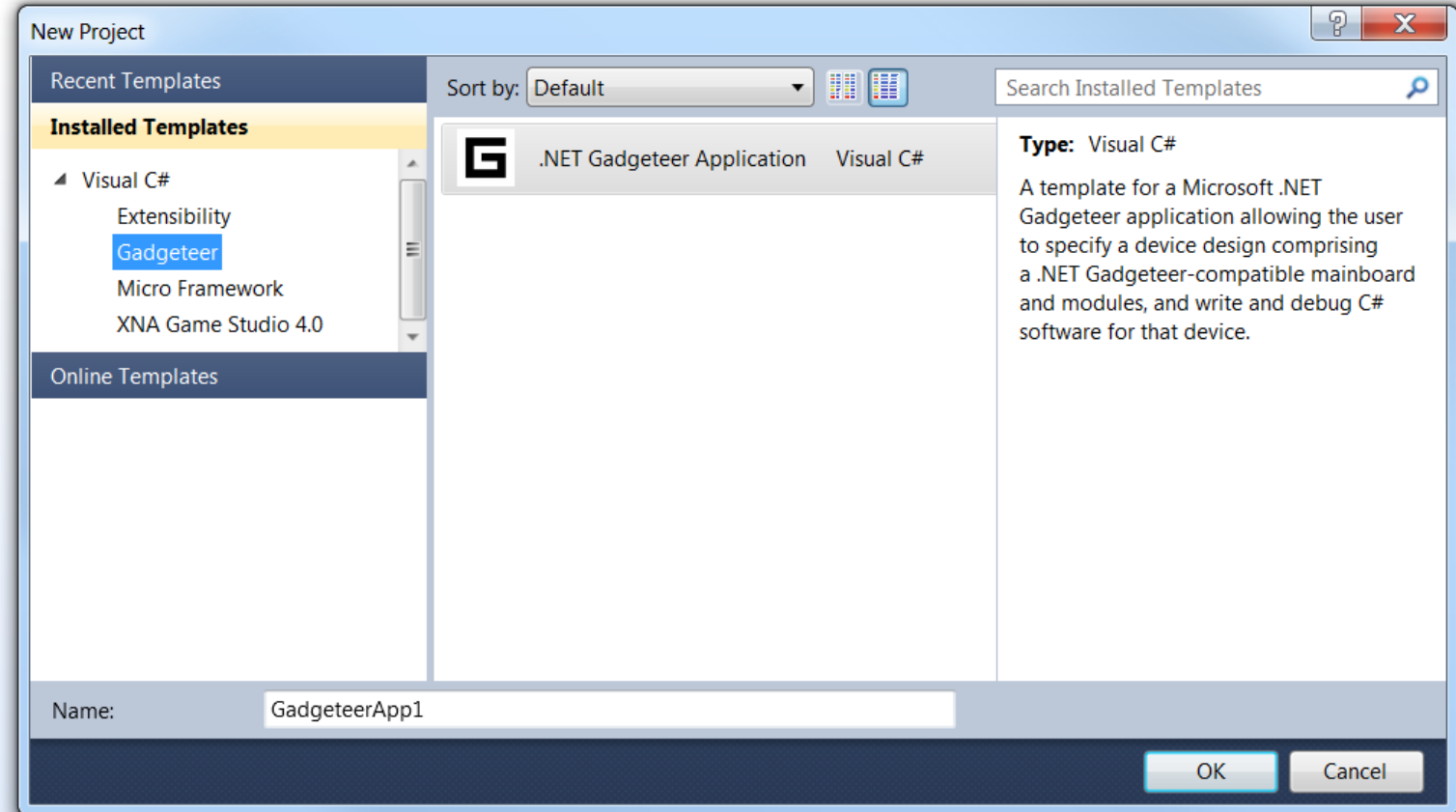
## Based on the .NET **Micro** Framework:

- Subset of .NET
- Programming in C# and Visual Basic
- Interactive debugging

## .NET Gadgeteer adds:

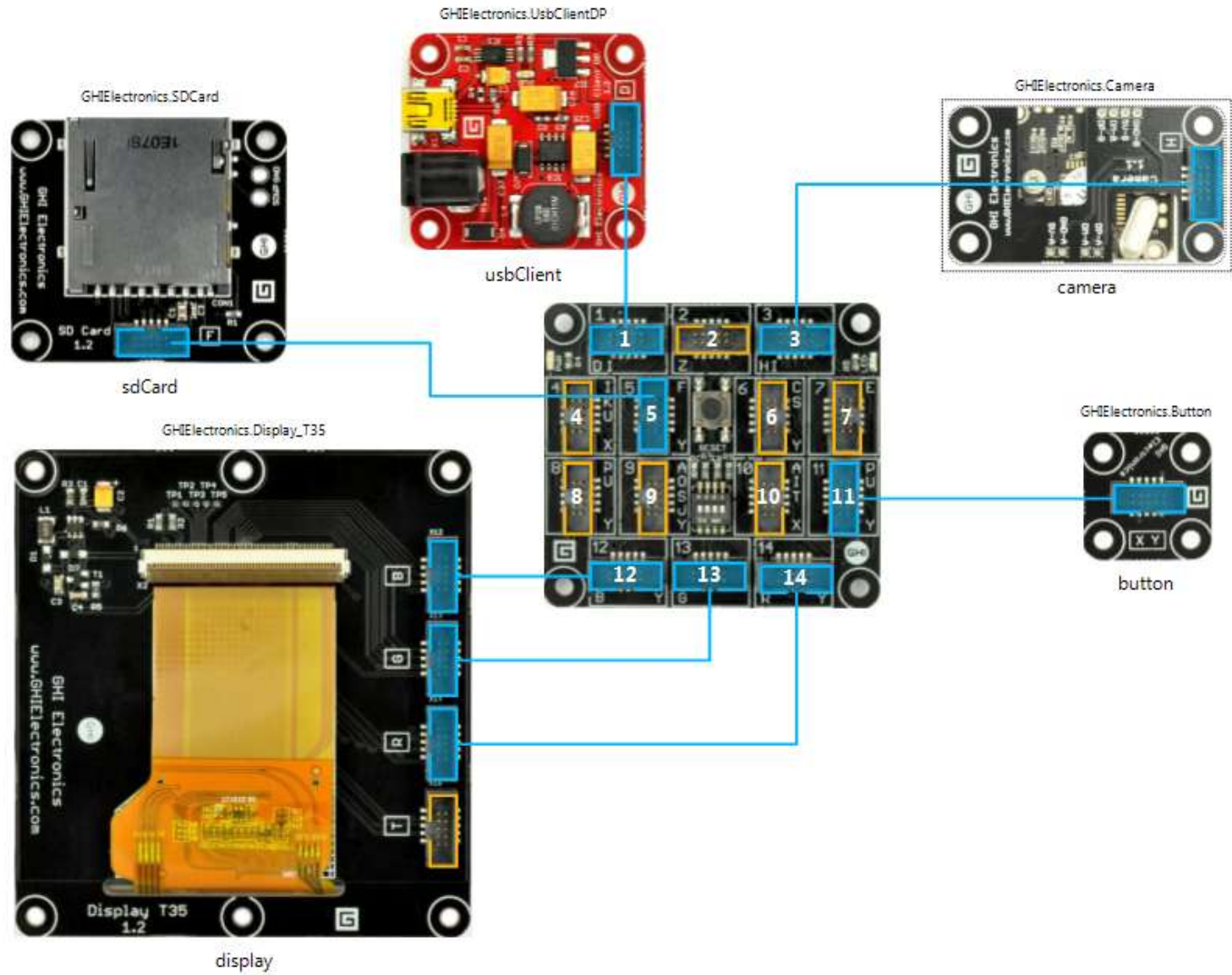
- Gadgeteer Core Libraries
- Visual Studio Graphical Designer
- Framework for mainboard and module drivers





Toolbox

- Gadgets
  - Seed
    - Pointer
    - Accelerometer
    - Barometer
    - CellularRadio
    - Compass
    - GPS
    - Gyro
    - MoistureSensor
    - OLED\_Display
    - Relays
    - TemperatureHumidity
  - Microsoft Research
    - Pointer
    - Accelerometer
    - Button
    - Dmx
    - Midi
    - MulticolorLed
    - Osc
    - UsbDevice
  - Sytech Designs Ltd
    - Pointer
    - Button
    - EthernetSD
    - LCDTouch
    - Serial2USB
    - USBDevice
  - GHI Electronics
    - Pointer
    - Button
    - Camera
    - Display\_T35
    - EBlockExpansion
    - Ethernet\_J11D
    - Extender
    - Joystick
    - MulticolorLed
    - Potentiometer
    - SDCard
    - UsbClientDP
    - UsbHost
    - UsbSerial
    - WiFi\_RS21
  - Gadgets Mainboards
    - Pointer
    - FEZ Spider
    - Nano



```
void ProgramStarted()
{
    // Associate events with event-handling methods
    button.ButtonPressed += new Button.ButtonEventHandler(button_ButtonPressed);
    camera.PictureCaptured += new Camera.PictureCapturedEventHandler(camera_PictureCaptured);
}

void button_ButtonPressed(Button sender, Button.ButtonState state)
{
    camera.TakePicture();
}

void camera_PictureCaptured(Camera sender, GT.Picture picture)
{
    // Show the picture on the display
    display.SimpleGraphics.DisplayImage(picture, 0, 0);

    // Save the picture to the SD card
    sdCard.GetStorageDevice().WriteFile("picture.bmp", picture.PictureData);
}
```

# The .NET Gadgeteer Platform

Modular  
Hardware



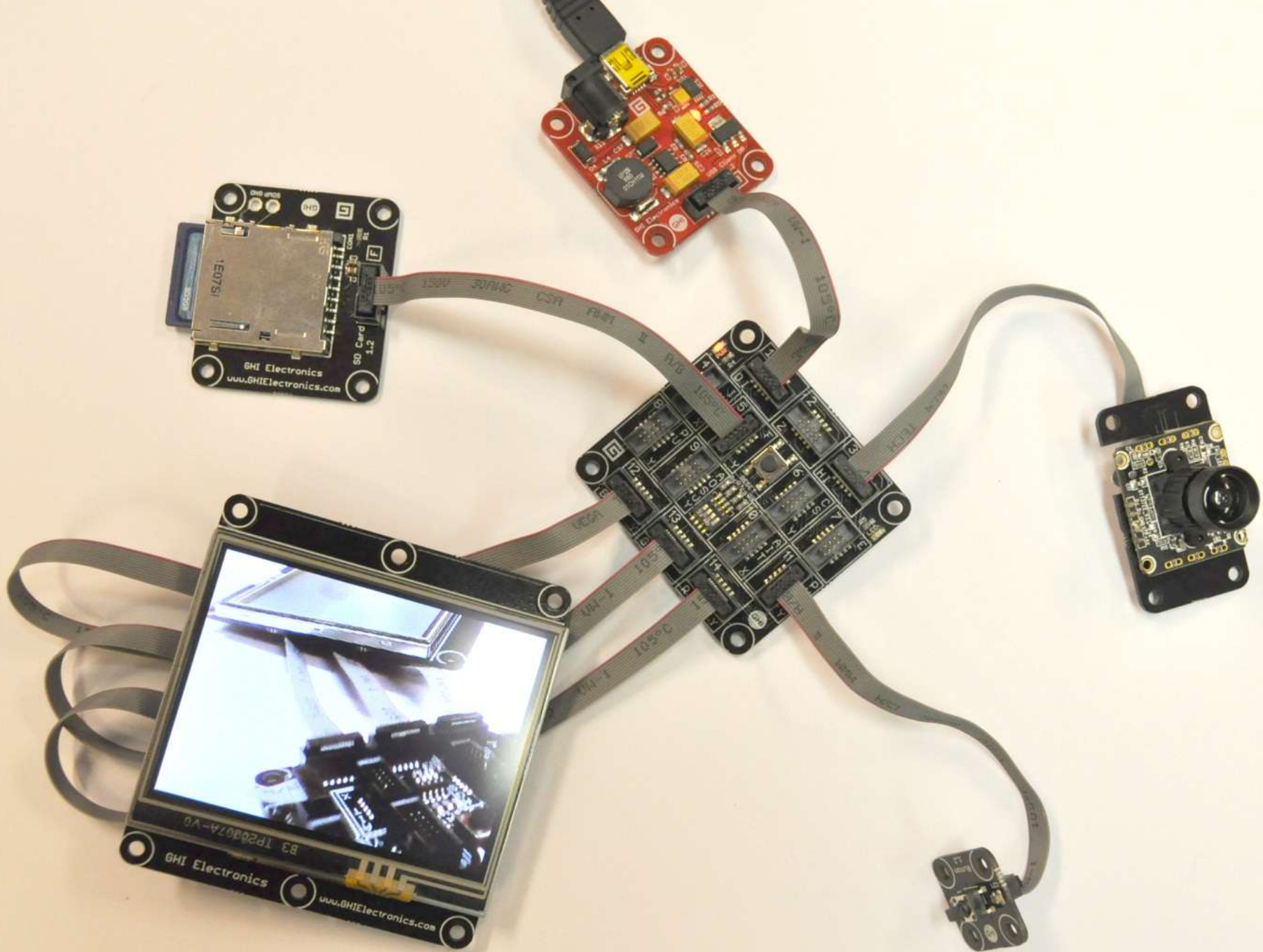
Software  
Tools

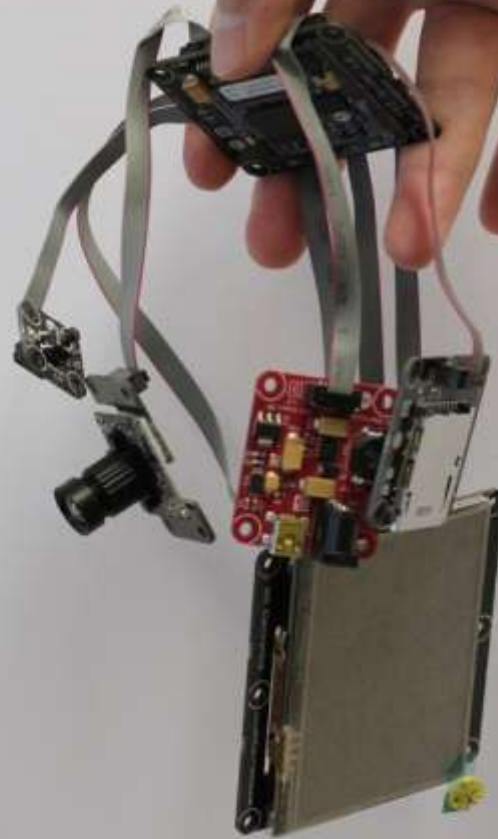
```
void ProgramStarted()  
{  
    // Initialize GTM.Modules and  
    myButton = new GTM.Button(GTM)  
    myLed = new GTM.MulticolorLE  
  
    myButton.  
  
    // Do one  
    Debug.Pri  
}
```

- ButtonPressed
- ButtonReleased
- DebugPrintEnabled
- Equals
- GetHashCode
- GetType
- IsPressed
- ToString

Physical  
Design







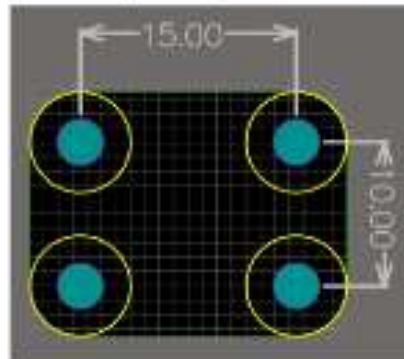


# Hardware design guidelines

The keep-out area should be clearly delimited in the silkscreen on both sides of the PCB, as shown in the following illustration. For small modules, where space is tight, it is possible to interrupt the keep-out delimiter silkscreen to make space for other labeling or silkscreen elements. Under no circumstances should you place components inside the keep-out area.



All mounting holes should be placed on a 5-mm grid, that is, the distance between adjacent holes should be a multiple of 5 mm, as shown in the following illustration.



## Corners

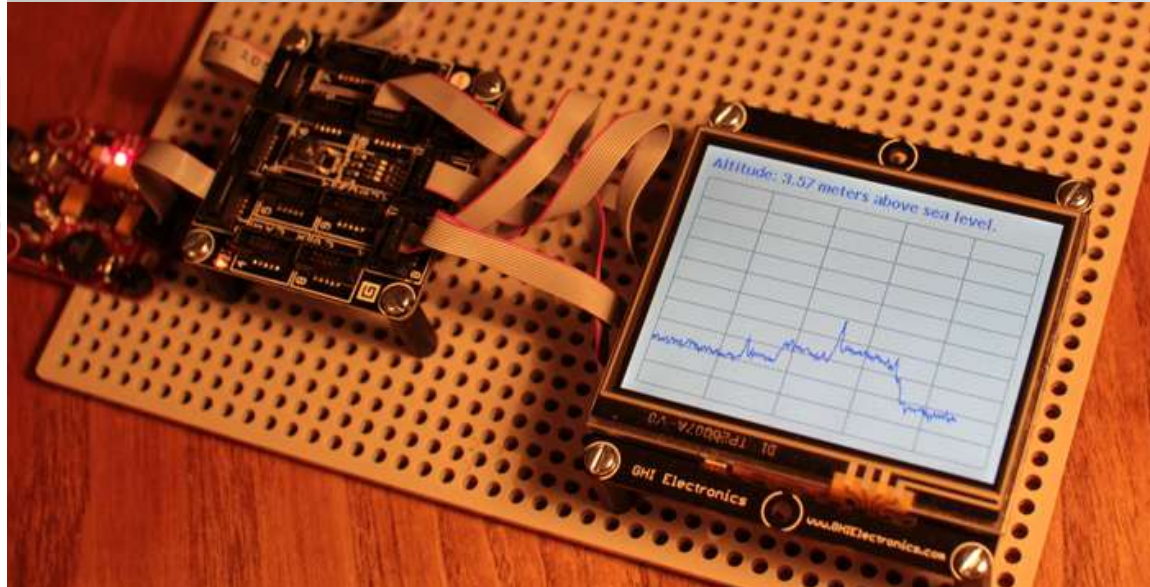
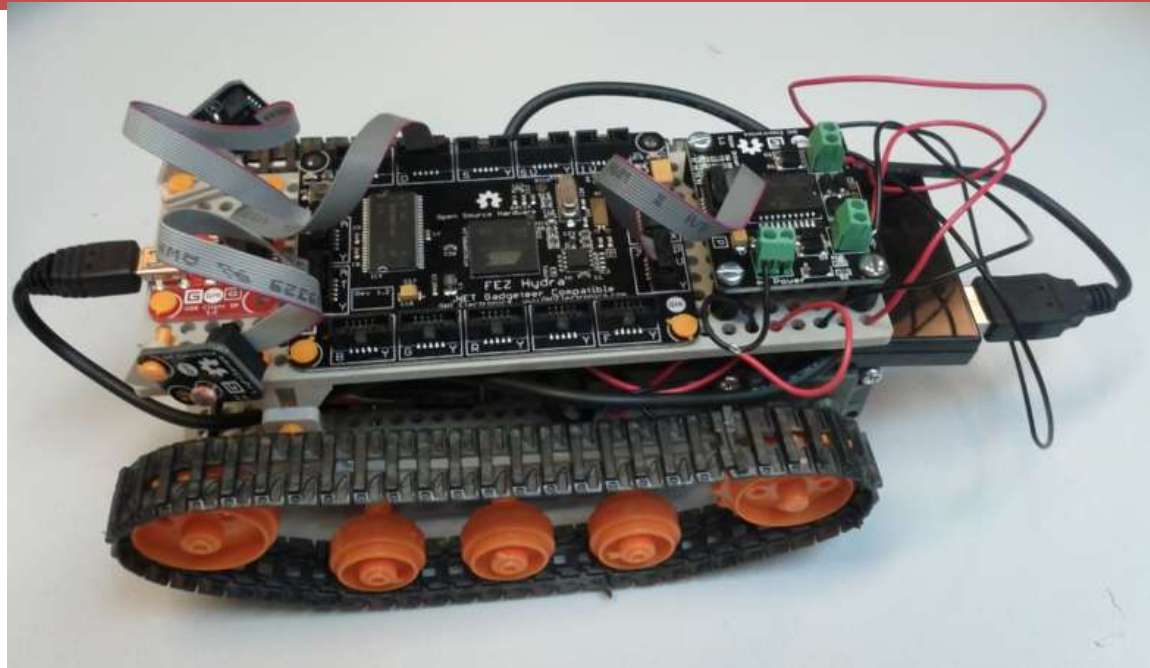
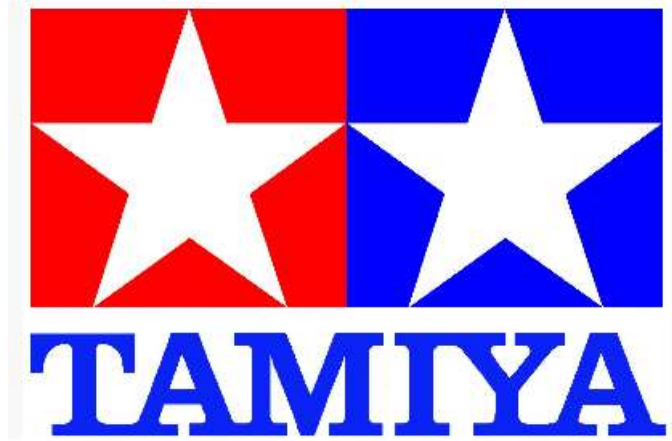
Corners should be rounded, with a 7-mm-diameter curve that is concentric with a mounting hole's keep out area, as shown in the following illustration.



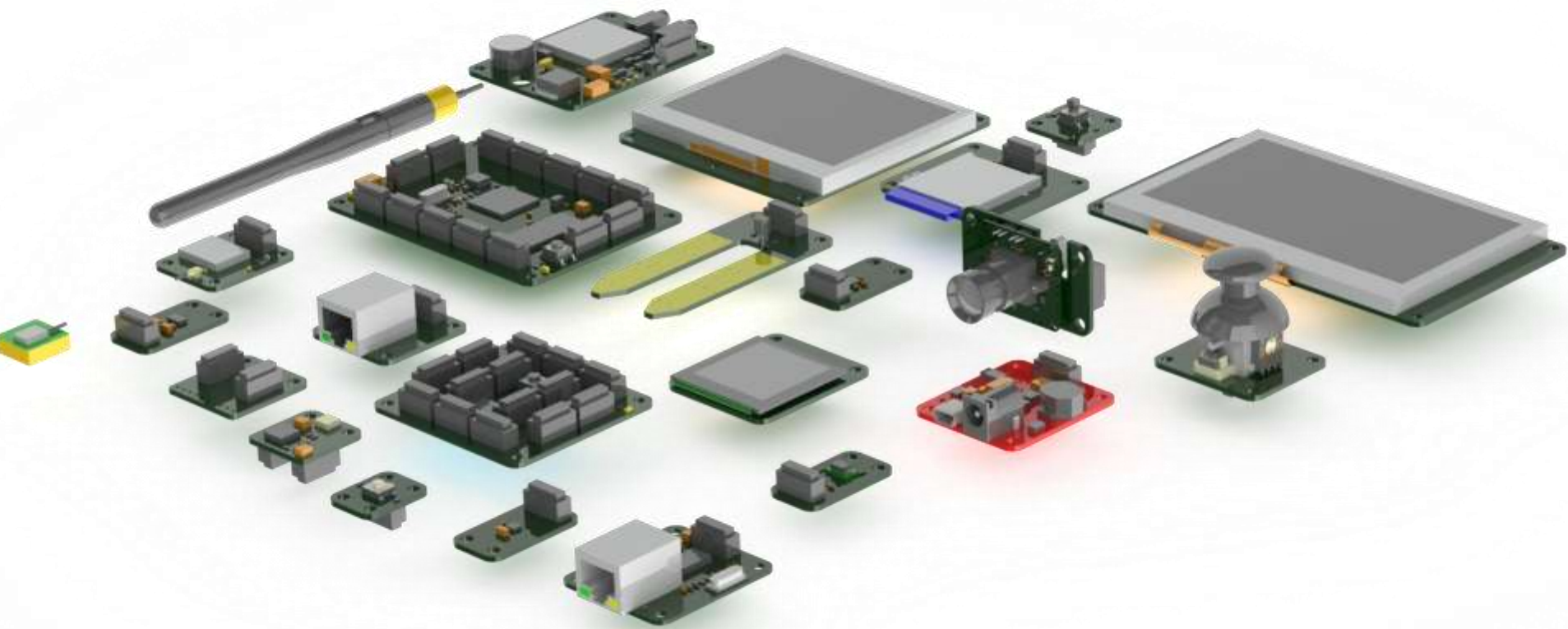
If a corner does not include a mounting hole, the corner does not need to be rounded. However, we recommend that you maintain the same 7-mm rounding diameter for consistency.



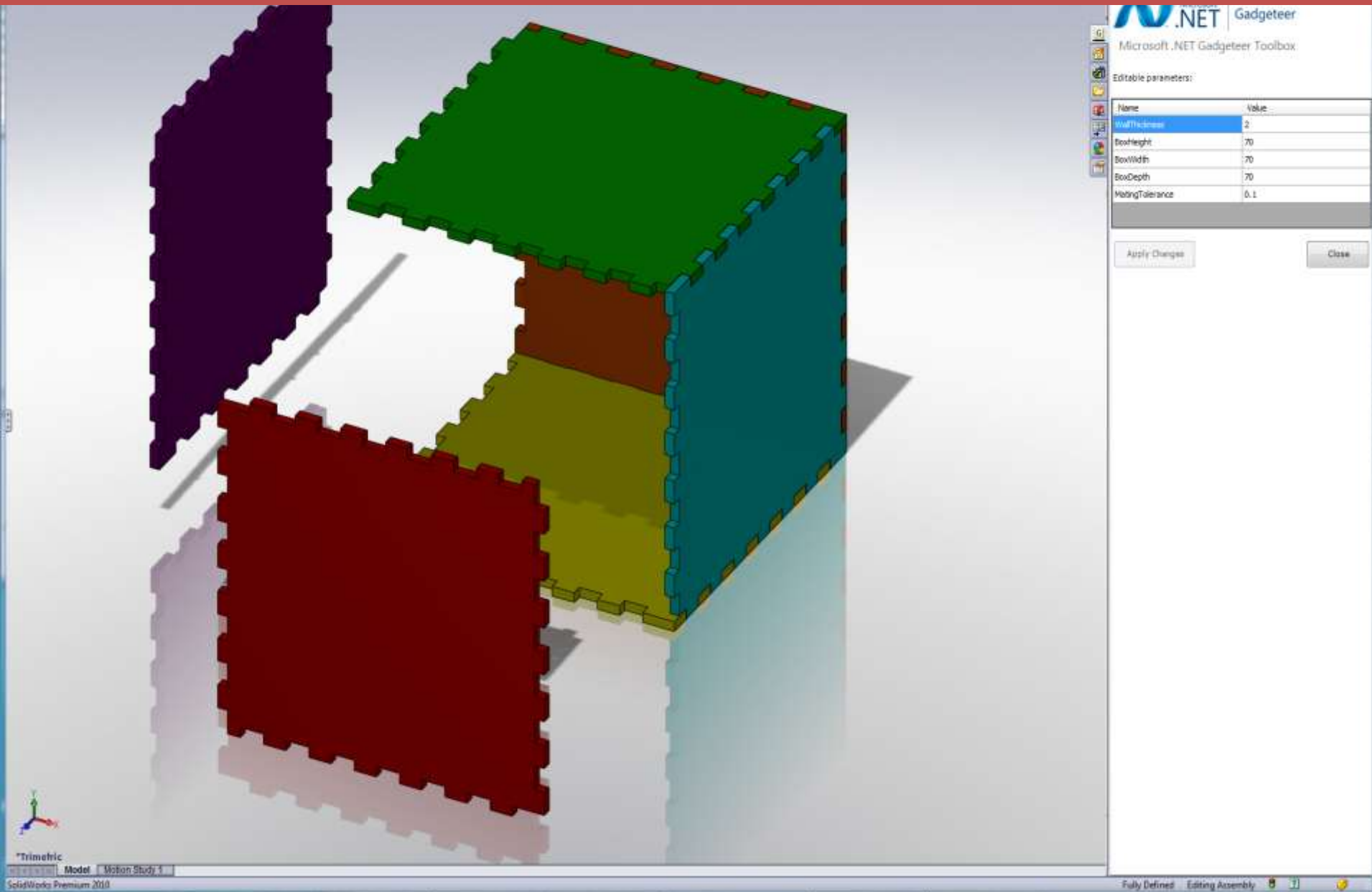
# Standardized mounting holes



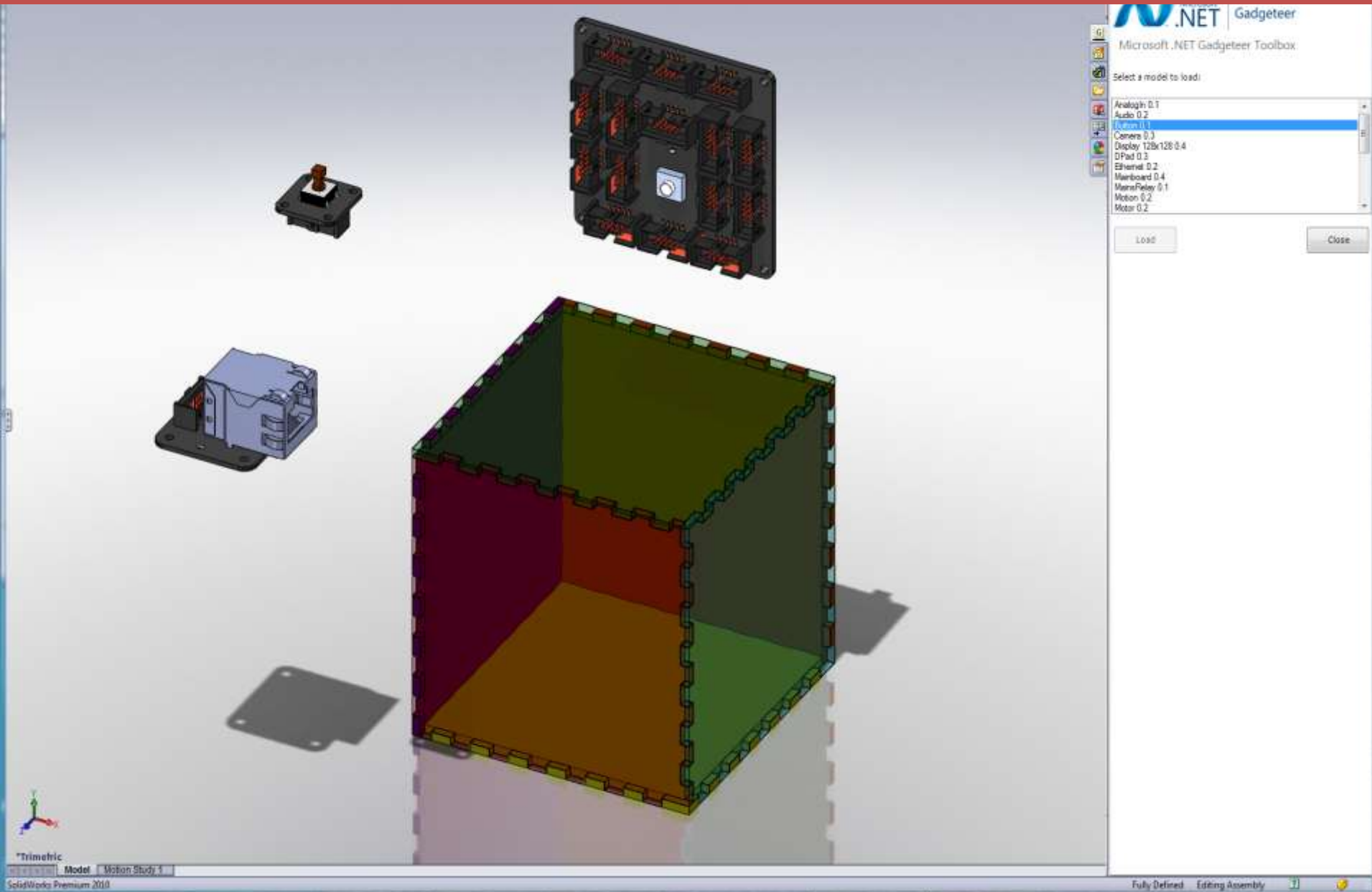
# 3D models of hardware modules



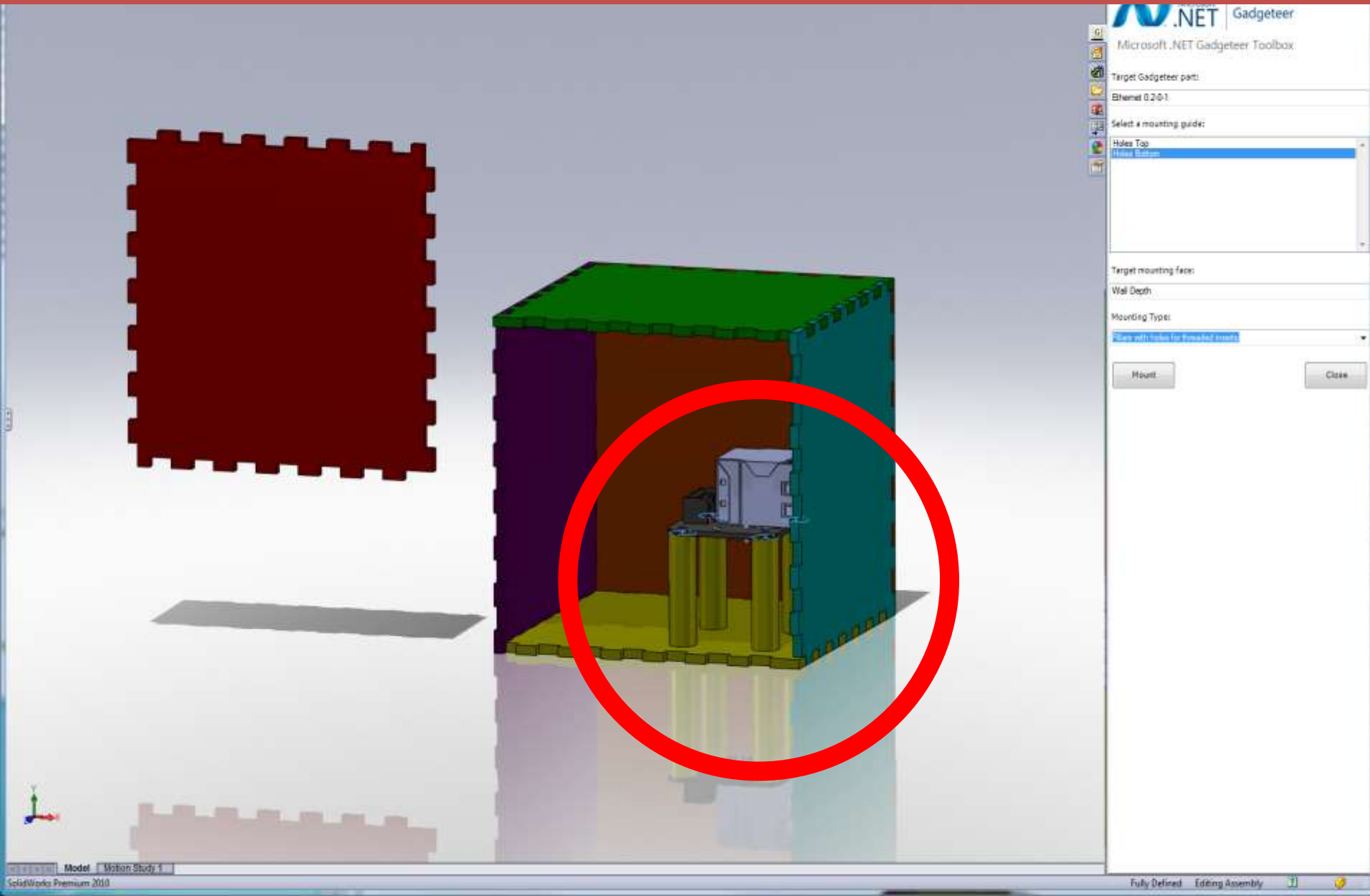
# Integration with 3D CAD (SolidWorks)



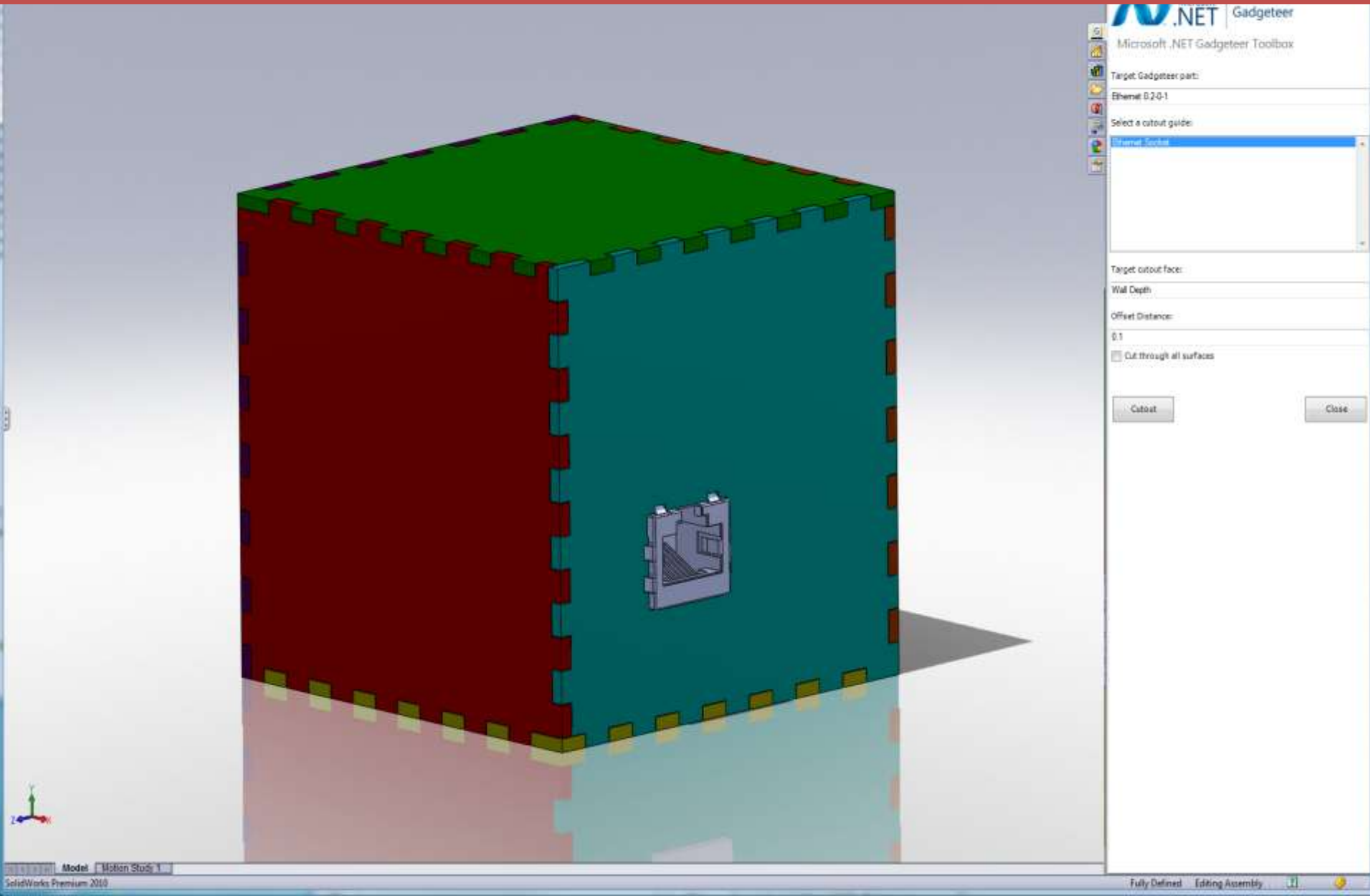
# Adding and positioning 3D models



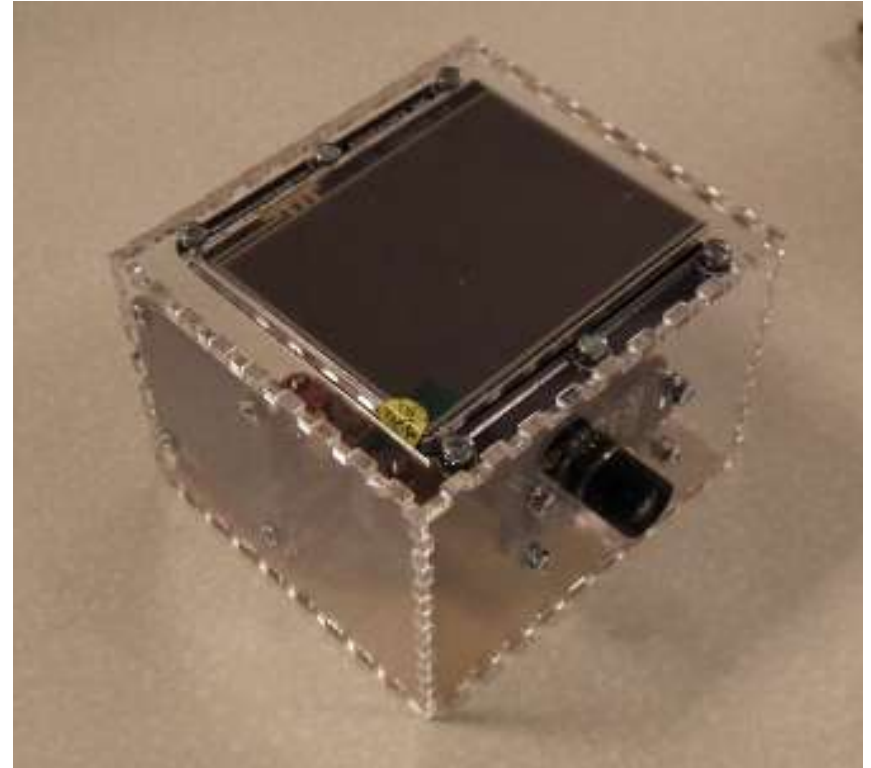
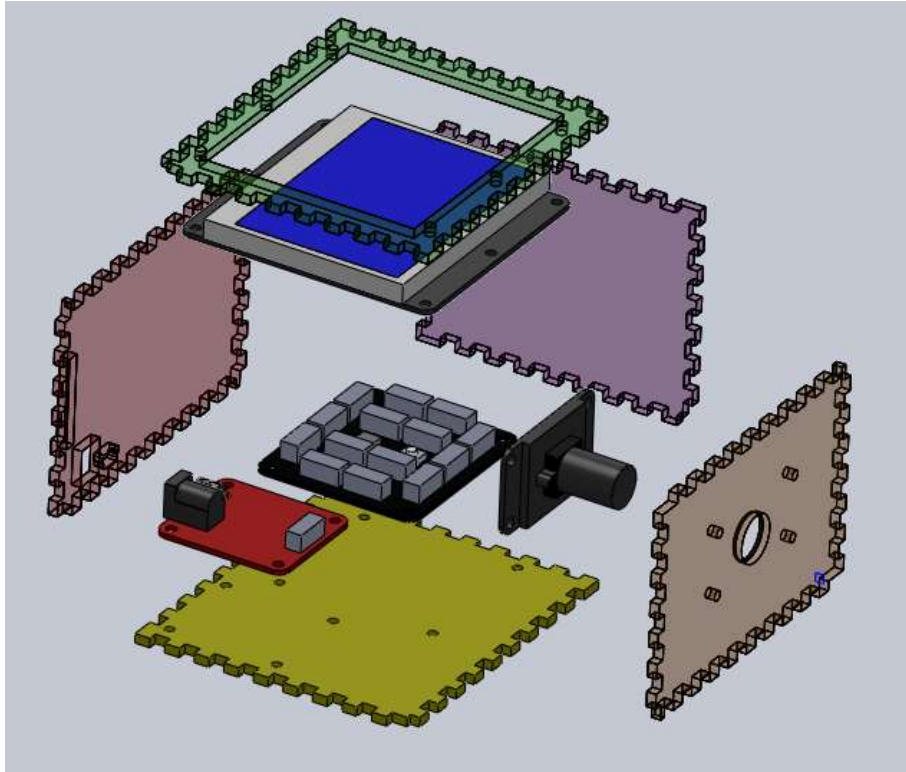
# Automatic mounting feature generation



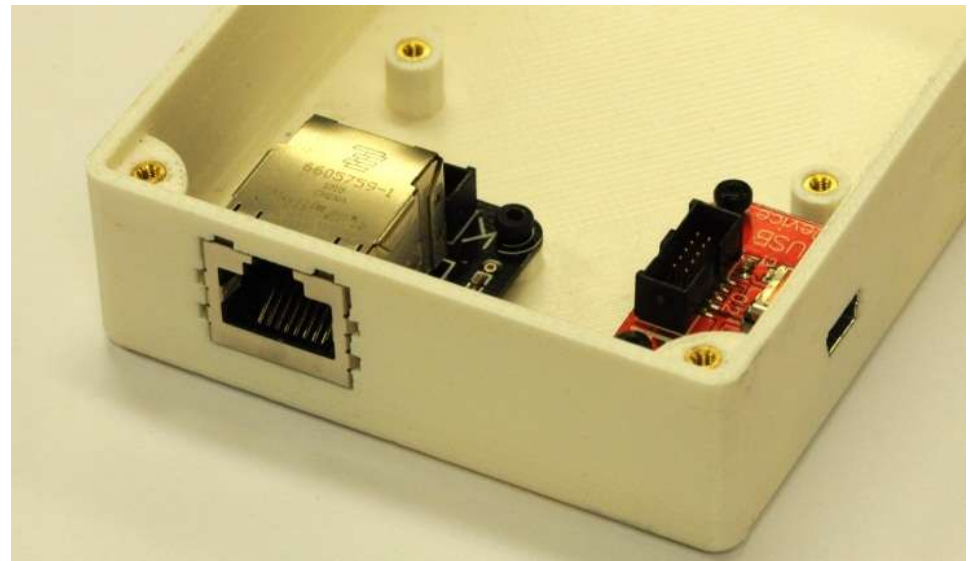
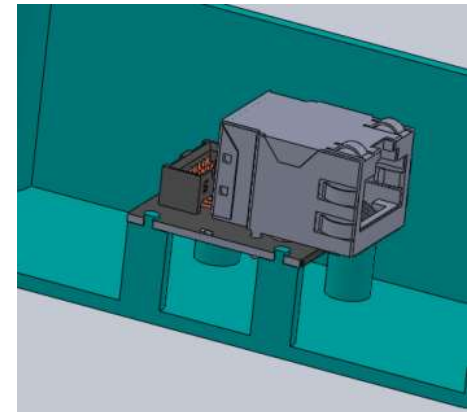
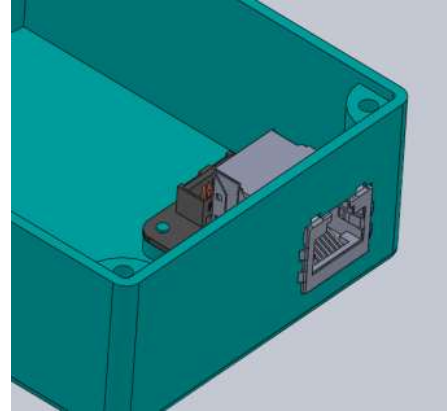
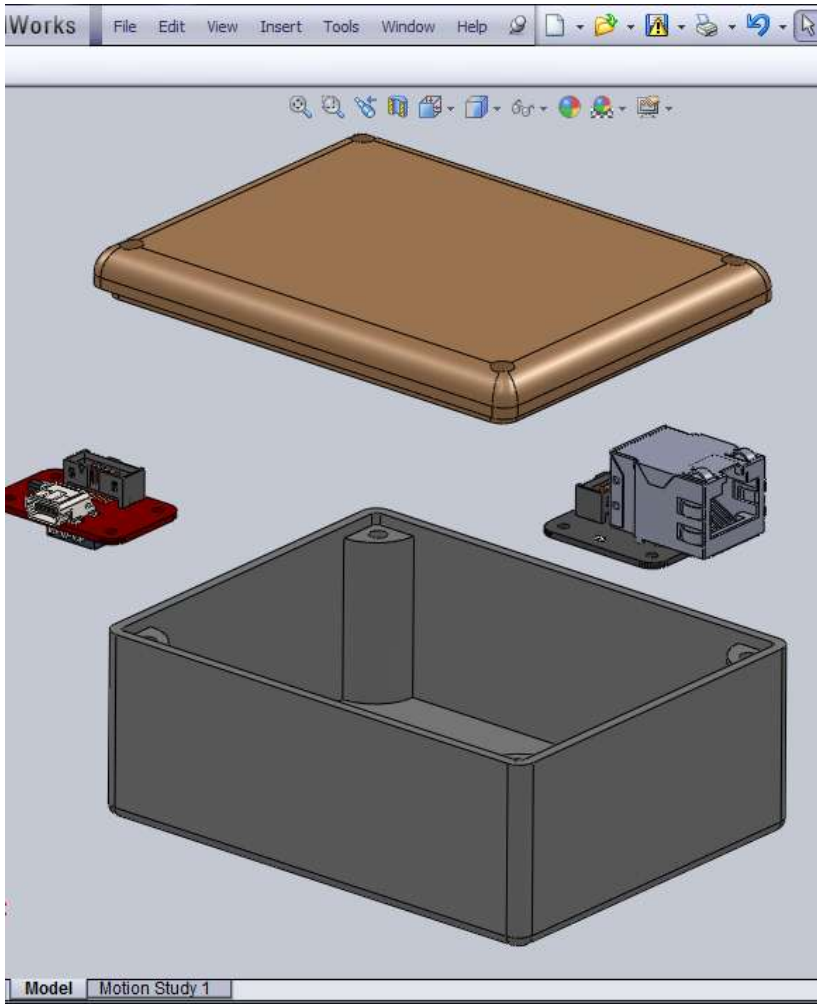
# Automatic cut-out generation



# Laser-cut enclosure based on the *Jigsaw Box* template



# 3D-printed enclosure based on the *Project Box* template





1x 3D printed  
"Base"

1x GHI\_USB\_Client\_DP\_1.2

1x Seeed\_Moisture\_Sensor\_1.0

1x Seeed\_OLED\_Display\_1.0

1x Sytech\_Button\_1.0



2 inch  
x1



2 inch  
x2



2 inch  
x2



1x 3D printed  
"Sensorholder"



1x 3D printed  
"Frontlid"



1x Seeed\_Cellular\_Radio\_1.0

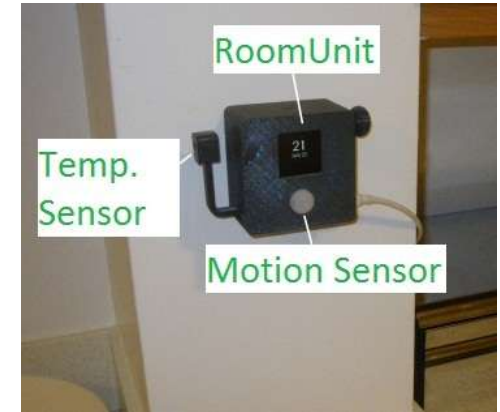
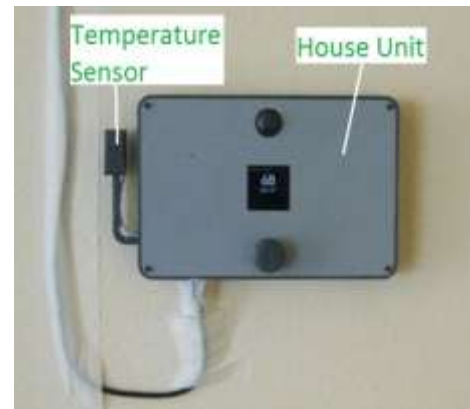
1x 3D printed  
"Sensorholder  
lid"

1x GHI\_PEZE\_SPIDER\_1.0



# PreHeat (Scott et al, UbiComp 2011)

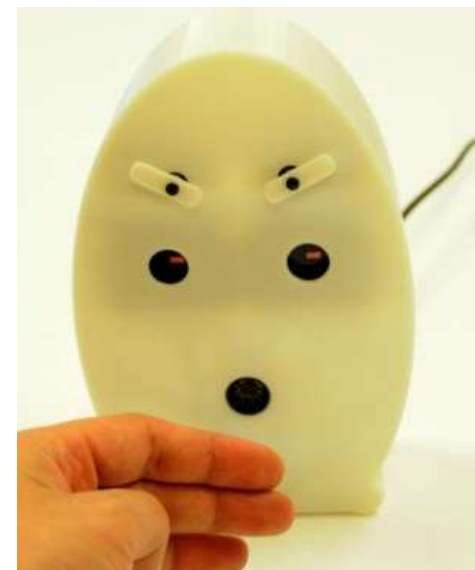
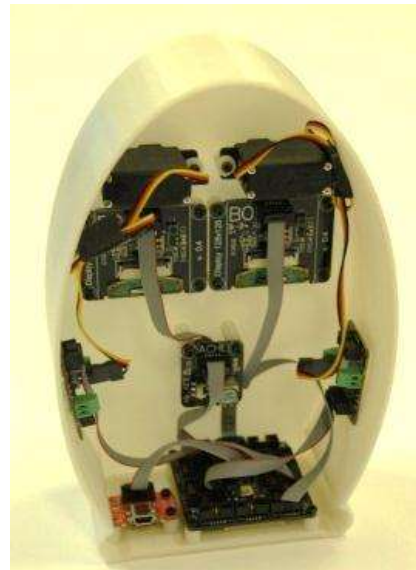
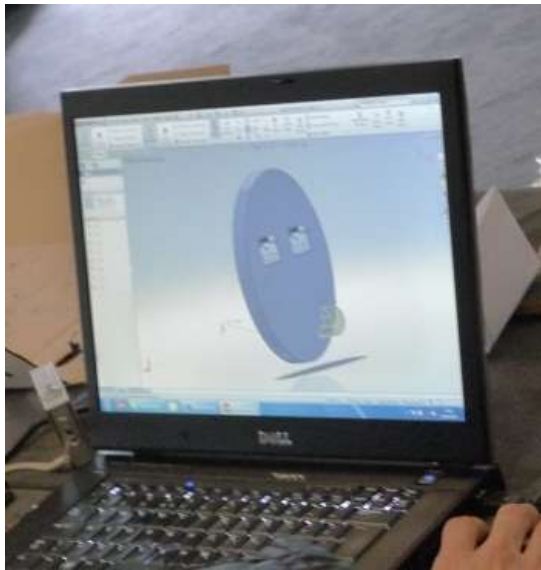
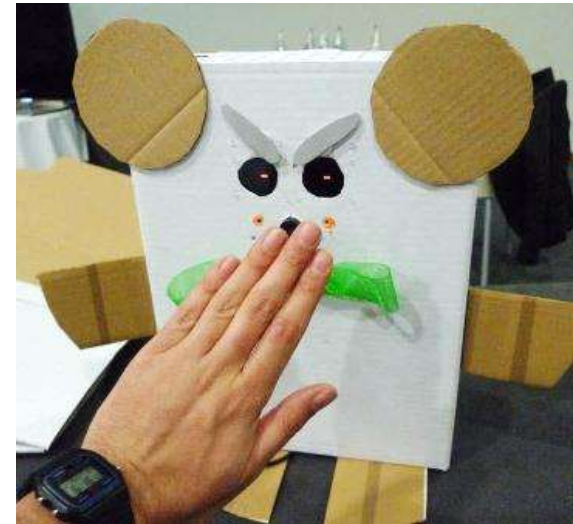
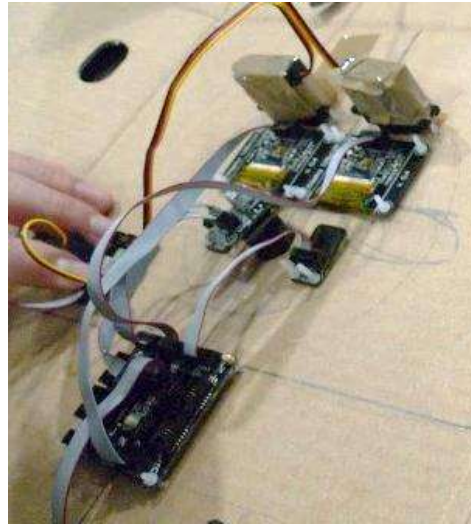
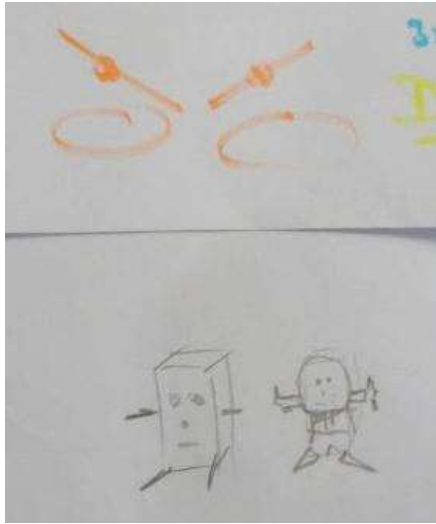
Home heating  
using occupancy  
sensing &  
prediction



# Form-factor iteration



# TEI'11 Studio: from sketch to 3d-printed demo



# Getting .NET Gadgeteer out of the lab

http://gadgeteer.codeplex.com/

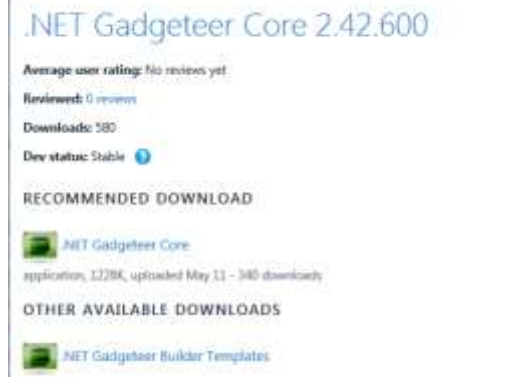
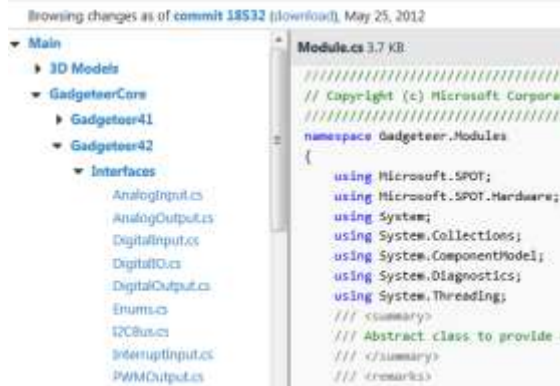
# Open source repository for project documentation, software and hardware designs



## Introducing .NET Gadgeteer!

Microsoft .NET Gadgeteer is an open-source toolkit for building small electronic Framework and Visual Studio or Visual C# Express. .NET Gadgeteer combines the programming, solderless assembly of electronics with a kit of peripherals, and its construction using computer-aided design. This powerful combination allows it to be iteratively designed, built and programmed in a matter of hours rather than a description of the platform - <http://channel9.msdn.com/Blogs/Clint/.NET-Gadg>

The .NET Gadgeteer project is an open collaboration between Microsoft, hardware. This website is targeted at those interested in developing .NET Gadgeteer-comp you are interested in buying and using .NET Gadgeteer compatible hardware, have <http://netmf.com/gadgeteer/>. If you already have hardware and are looking for a visit the hardware vendor's website.



# http://netmf.com/gadgeteer/

Hardware index,  
example projects,  
forums



## SHOWCASE: PRODUCT SHOWCASE

Welcome to the Product Showcase. Here you will be able to see some of the modules and mainboards that are available just browse through and see what there is. It may inspire your next big idea.

This showcase is provided as a place for the people who make the parts and pieces to talk to you directly. The information is verified by us. If you have questions about what you see here, the company that posted it is the best place to get an answer.

Enter Search Terms

Sort By

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Mouser Part No: 958-GHI-4  
 Manufacturer Part No: CRBRS-BK-354  
 Manufacturer: GHI Electronics  
 Description: Development BASIC KIT  
 Lifecycle: 

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Specifications	My Notes
Manufacturer:	GHI Electronics
RoHS:	 <a href="#">Details</a>
Tool Type:	Mainboard
Processor To Be Evaluated:	STM32F4
Core:	ARM Cortex M4
Interface Type:	CAN, I2C, SPI, UART, US
Part # Aliases:	GHI-CRBRS-BK-354



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- BearExtender (1)
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-  & Up (1)
-  & Up (7)
-  & Up (7)


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# Acknowledgements

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Gadgeteer

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