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27<sup>th</sup> November 2021

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- Be aware of others
- Be welcoming and respectful
- Be friendly and patient
- Be open to all questions and viewpoints
- Be understanding of differences
- Be kind and considerate to others

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# Meadow - A Modern Development Ecosystem for Internet of Things

Mark Stevens  
Wilderness Labs



# About

## Mark Stevens

- Currently a Firmware Engineer, Wilderness Labs
- Software Engineer, Project Manager and Operations Manager
- Tinkering with hardware and software since the late 1970s



@nevynuk

# Agenda

- Embedded Development Today
- Meadow Hardware
- Meadow OS
- Development Environments
- Meadow.Foundation
- Demonstrations
- The Future for Meadow

A wide-angle photograph of a serene landscape. In the foreground, there's a calm lake reflecting the surrounding environment. The middle ground consists of rolling green hills dotted with small buildings and trees. The background features majestic, rugged mountains with patches of snow or ice clinging to their peaks. The overall scene is peaceful and natural.

# Embedded Development Today

# Embedded / IoT is Everywhere

Compute has moved through several phases:

- Mainframe -> Mini
- Mini -> Desktop
- Desktop -> Mobile

Embedded devices are all around us

IoT uptake is gaining velocity and appearing in a wide variety of industries

# Embedded Development

Traditionally Embedded C or Assembly

IDEs and techniques have not really moved on from 1990s

Often register level debugging

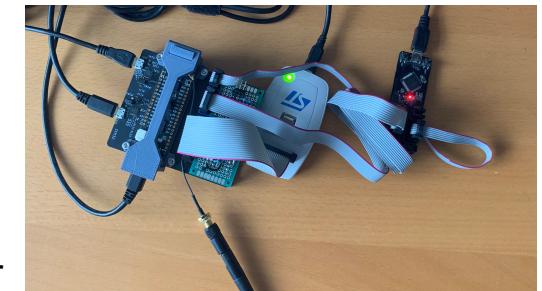
Additional hardware required to debug the target processor

Some alternative languages available:

- MicroPython and CircuitPython
- Rust
- Ada

Limited driver support for many language and chip combinations

*Often complex to debug*



# .NET Alternatives

## NanoFramework

- Evolved from MicroFramework (NETMF)
- Low power microcontrollers
- Not full .NET
- C#

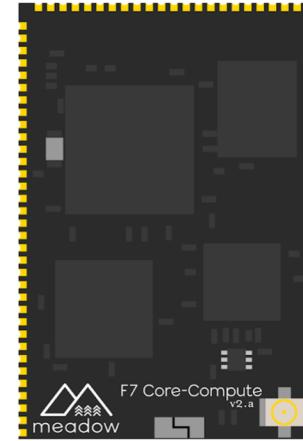
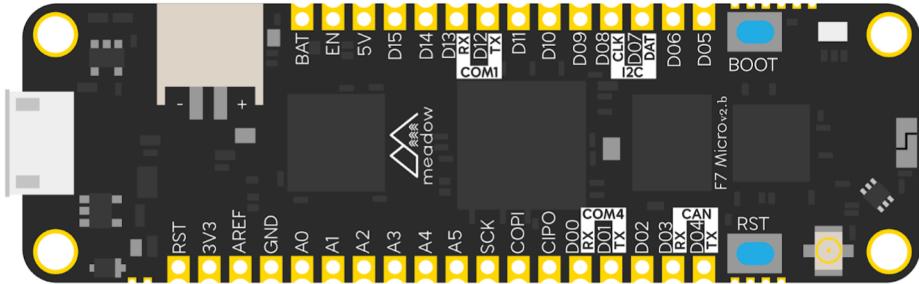
## Raspberry Pi

- Full .NET
- Raspberry Pi is relatively power-hungry compared with Microcontrollers

A wide-angle photograph of a mountainous landscape. In the foreground, there's a body of water with some small, rocky islands. The middle ground shows a valley with green fields and scattered trees. In the background, there are majestic, rugged mountains. The sky is clear and blue.

# Meadow Hardware

# Meadow Hardware



Low-energy, microcontroller-based Modules.

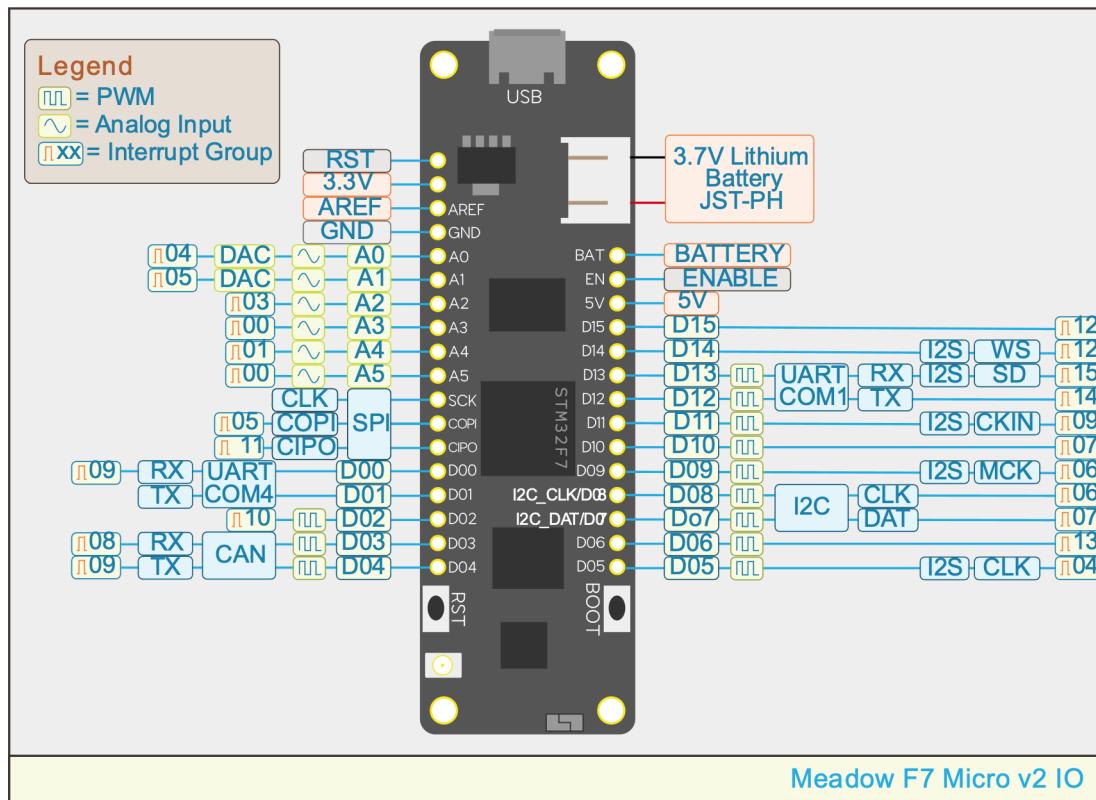
BLE, WiFi, Ethernet, LiPo Charging.

Prototype to production using the same hardware and code

# Meadow F7 Features

Item	Meadow F7 V1	Meadow F7 V2
CPU	STM32F777	STM32F777
Internal RAM	412 KBytes	412 KBytes
Coprocessor	ESP32	ESP32
External RAM	32 MBytes	32 MBytes
External Flash	32 MBytes	64 MBytes
GPIO	25	25
SMT	N	Y

# Meadow F7 Peripherals

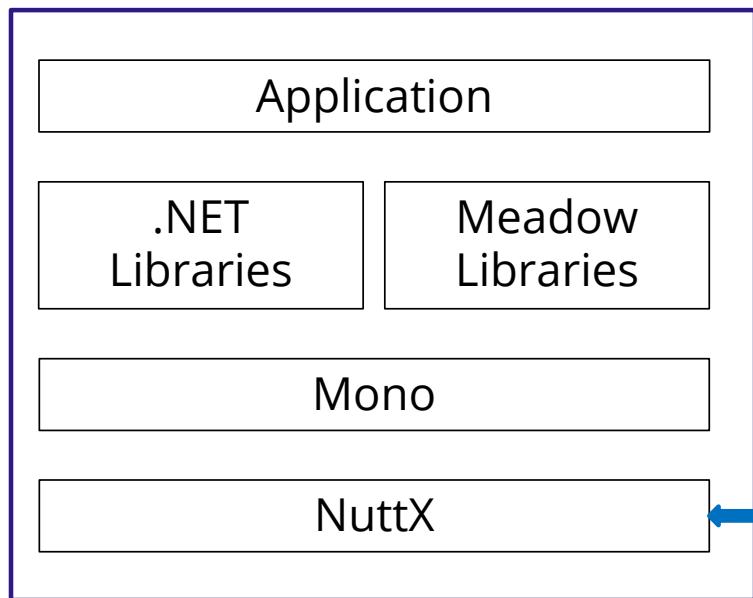


A wide-angle photograph of a mountainous landscape. In the foreground, there's a calm lake reflecting the surrounding environment. The middle ground shows a valley with green pastures and small clusters of trees. In the background, majestic mountains rise, their peaks partially obscured by clouds. The overall scene is peaceful and natural.

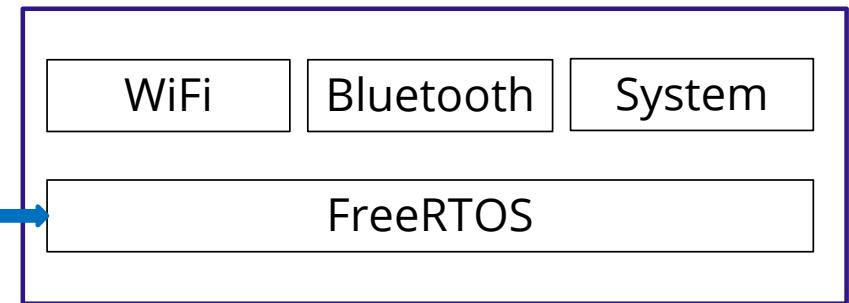
Meadow OS

# OS Stack

## STM32



## ESP32



# Meadow.OS Features

Networking (WiFi + Ethernet) with full SSL

BLE Server

SQLite

Watchdog Timer

Persistent File System

A wide-angle photograph of a mountainous landscape. In the foreground, there's a body of water with small, rocky islands. The middle ground shows rolling green hills and pastures with a few small buildings. The background is dominated by towering, rugged mountains with patches of snow and green vegetation. The sky is clear and blue.

# Development Environments

# Development Environments

Development environments:

- Windows, VS Code and Visual Studio 2019 (VS2022 in flight)
- Mac, VS Code and Visual Studio for Mac 2019
- Linux, VS Code

Meadow is supported through:

- Visual Studio extensions
- Command line tool

Languages:

- C#
- F#
- VB.NET

# Debugging

Debugging is fully integrated with Visual Studio

Visual Studio Code can be used with the aid of the command line tool

Applications can also be debugged using the Mono command line debugger

A wide-angle photograph of a mountainous landscape. In the foreground, there's a calm lake reflecting the surrounding environment. Beyond the lake, the terrain rises into green pastures and meadows dotted with small buildings and trees. The background is dominated by towering, rugged mountains with rocky peaks and patches of snow or ice. The overall scene is one of natural beauty and tranquility.

# Meadow Foundation

# Meadow.Foundation

Open-source peripheral driver library:

<https://github.com/WildernessLabs/Meadow.Foundation>

Sample applications for each driver

Consistent, curated, quality

Documentation:

<http://developer.wildernesslabs.co/>

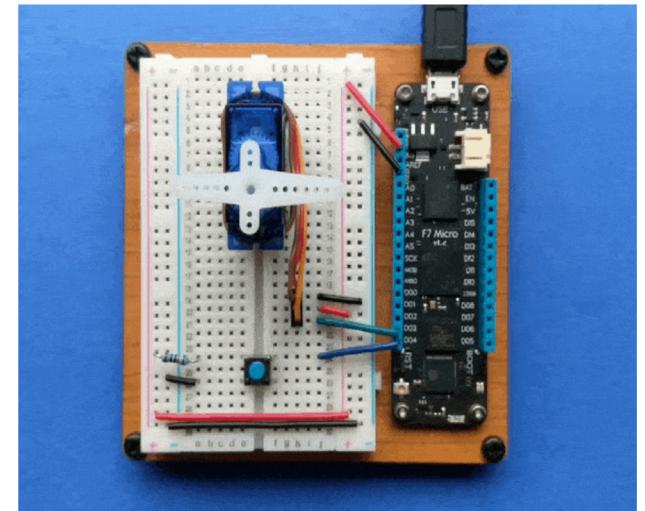
# Drivers and Libraries

Driver Type	Number	Driver Type	Number
Core (LEDs, switches etc.)	23	Audio	2
Displays	25	Motor drivers	4
Real-time clocks	2	Atmospheric sensors	17
Cameras	3 (in progress)	Distance	1 (5 in progress)
GPS & GNSS	2	Mass (Load cells)	2
Moisture	2	Power (current)	1
Light	9 (1 in progress)	Motion	11 (2 in progress)
Sound	1	Radio (FM)	1 (1 in progress)
Weather	2	Servos	1
Transceivers	2		
Miscellaneous (EEPROMS, IO Expanders etc.)	15	Temperature	3 (1 in progress)

# Sample Projects

- developer.wildernesslabs.co
- Github
- Hackster

```
var servo = new Servo(  
    Device.CreatePwmPort(  
        Device.Pins.D03), NamedServoConfigs.SG90);  
  
var button = new PushButton(Device, Device.Pins.D04);  
  
button.Clicked += (s, e) => {  
    servo.RotateTo(75);  
    Thread.Sleep(1000);  
    servo.RotateTo(0);  
};
```



A wide-angle photograph of a mountainous landscape. In the foreground, there's a calm lake reflecting the surrounding green hills and rocky peaks. The hills are covered with patches of green grass and small clusters of evergreen trees. In the background, tall, rugged mountains rise against a clear sky. A few small buildings, possibly chalets or farmhouses, are scattered across the hillsides.

# Meadow in Action

# Meadow in Action

Demo 1 - Getting Started

Demo 2 - How Bright is it?

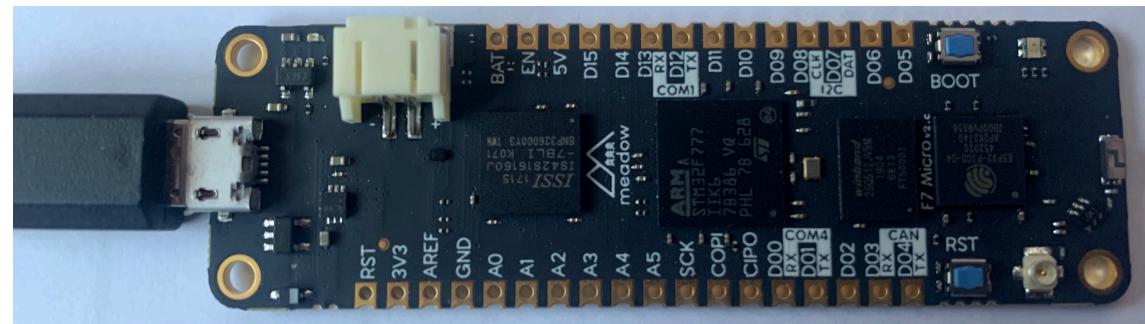
Demo 3 - Meadow on the Move

*Here be  
Dragons*

# Demo 1 - Getting Started

Blinky (Hello, World for IoT)

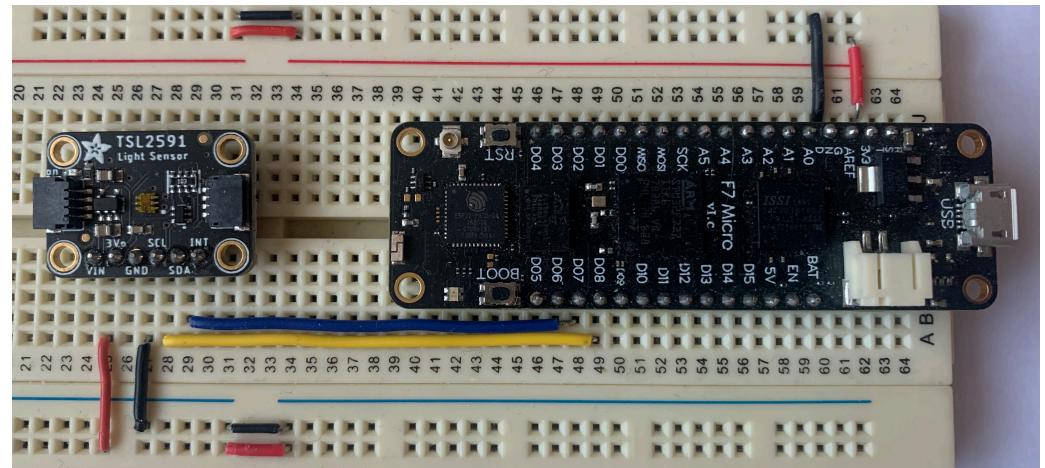
- F#



# Demo 2 – How Bright is it?

Connect to light sensor

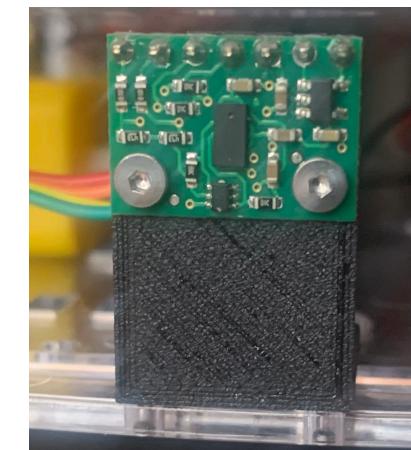
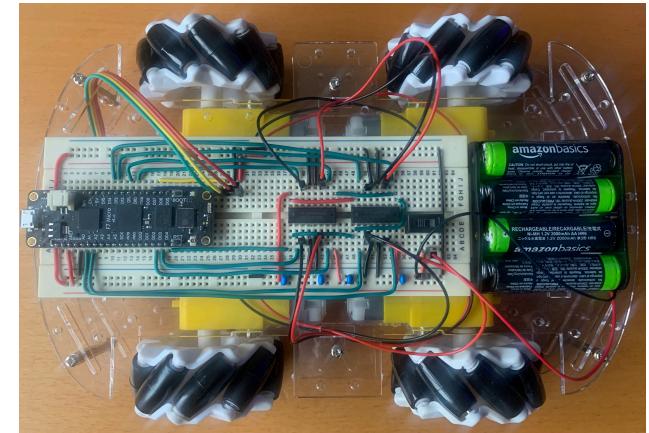
- C#
- Take light level readings
- Debugging
- Send readings to Adafruit.io



# Demo 3 – Meadow on the Move

Buggy with single distance sensor

- C#
- Take distance readings from sensor
- Control four motors
- Bluetooth remote control
- Combine directional control with distance measurement for collision avoidance



A wide-angle photograph of a mountainous landscape. In the foreground, there's a body of water with some small, rocky islands. The middle ground shows a valley with green fields, scattered trees, and a few small buildings. The background is dominated by towering, rugged mountains covered in green vegetation. The sky is clear and blue.

The Future

# Roadmap

OtA Updates

Meadow.OS Security Stack

Meadow.Linux

.NET 6

AoT Compilation

Tree-shaking (linking to reduce application and library sizes)

Power and sleep APIs

CAN bus

Roadmap: [http://developer.wildernesslabs.co/Meadow/Release\\_Notes/Roadmap/](http://developer.wildernesslabs.co/Meadow/Release_Notes/Roadmap/)

# Conclusion

- Meadow represents a new way to build IoT devices
  - Innovative hardware
  - Full .NET and nuget support
  - Use your favourite language
- Choice of operating system
- Choice of IDE
- Full debugging support on all operating systems
- Comprehensive library of drivers (Meadow.Foundation)

A wide-angle photograph of a serene landscape. In the foreground, there's a calm lake reflecting the surrounding environment. Beyond the lake, rolling green hills covered with small clusters of trees and houses. In the background, a range of majestic mountains with rugged peaks rises against a clear, light blue sky.

# Q & A

# Further Information & Social Media

Presentation, sample code and additional links:

[https://github.com/WildernessLabs/Meadow\\_Project\\_Samples/  
source/DeveloperDay2021](https://github.com/WildernessLabs/Meadow_Project_Samples/source/DeveloperDay2021)

## Wilderness Labs

-  [developer.wildernesslabs.co](http://developer.wildernesslabs.co)
-  [@wildernesslabs](https://@wildernesslabs)
-  <https://github.com/Wildernesslabs>
-  <https://www.hackster.io/WildernessLabs>
-  <https://www.youtube.com/c/WildernessLabs>

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# Thank You

