

**An Embedded Linux Platform to collect,
analyze and store critical data for navigation
of an autonomous vehicle**

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Autonomous Underwater Vehicle (AUV)

- Gather oceanographic data and strategic military data
- AUV community major concerns underwater navigation for autonomous vehicle
- Implement a Global Positioning System (GPS) unit



A Hydroid Remus AUV

Global Positioning System (GPS)

- **What could GPS unit do?**

Provide very precise and inexpensive measurements of geodetic coordinates

- **Disadvantage of GPS unit**

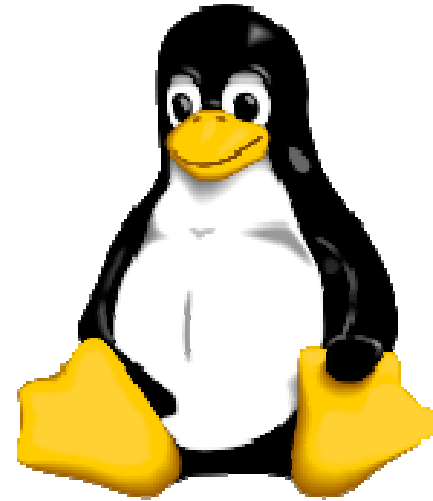
Radio signals cannot penetrate beneath the ocean's surface

- **AUV community found a solution**

Use inertial measurement unit integrated with GPS to produce navigation information

What is Linux?

- **Developed by Linus Torvalds, University of Helsinki, in 1991**
- **Multi-tasking, multi-user, multi-processor operating system**
- **Unix-like**
- **Support ARM, X86, Alpha, SuperH, PowerPC and SPARC**



Linux Kernel

- **Process management**

 - The kernel creates and destroy process

 - Handle input and output connection

 - The scheduler controls how process share the CPU

- **Memory management**

 - Build up a virtual addressing space

- **File systems**

 - The kernel builds a structured file system on hardware

- **Device control**

- **Networking**

Time to implement our hardware system...

System resources:

- A single board computer
- External ADC
- GPS Receiver
- RS-232 Interfacing
- Accelerometer
- Analog Compass
- Thermistor

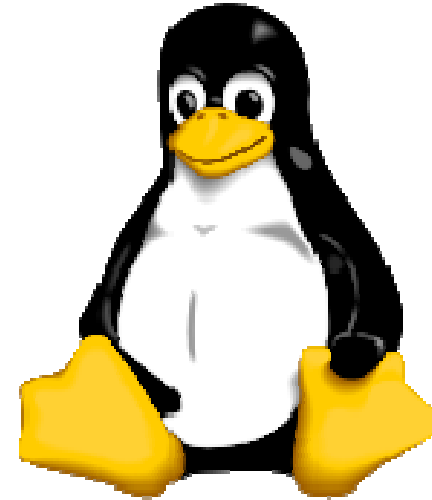


TS-7200 Single board computer

- **Runs on a 200Mhz ARM9 processor**
 - **ARM9 Architecture**
Based on 32-bit RISC architecture
Supports Linux operating system
 - **Support a compact Flash card (CF Card)**
 - **Support USB and Ethernet ports**
-

Max197 External ADC

- **Integrated in TS-7200**
- **An optional 8 channel ADC**
- **Convert an analog signal to 12-bit digital output**
- **Each channel is independently software programmable**



SiRF star III based EM402 GPS Receiver

- **To provide the absolute positioning of any object**
 - **Self-contained GPS unit with a passive antenna**
 - **4800 baud serial data bus**
-

RS-232 Interfacing

- **Single-ended serial communication protocol**
 - **Support efficient data communication at low baud rates <20kps**
 - **Exchanging data by reading from or writing to a file**
-

ADXL311EB Accelerometer board

- Dual axis accelerometer
- Measure the linear acceleration of a rigid body along a single axis
- Used along with gyroscopes, which measure the angular acceleration of a rigid body
- By integrating the output of the accelerometer, the velocity of the system is obtained

$$Dis\ tan\ ce = velocity_0 * time + \frac{1}{2} acceleration * time^2$$

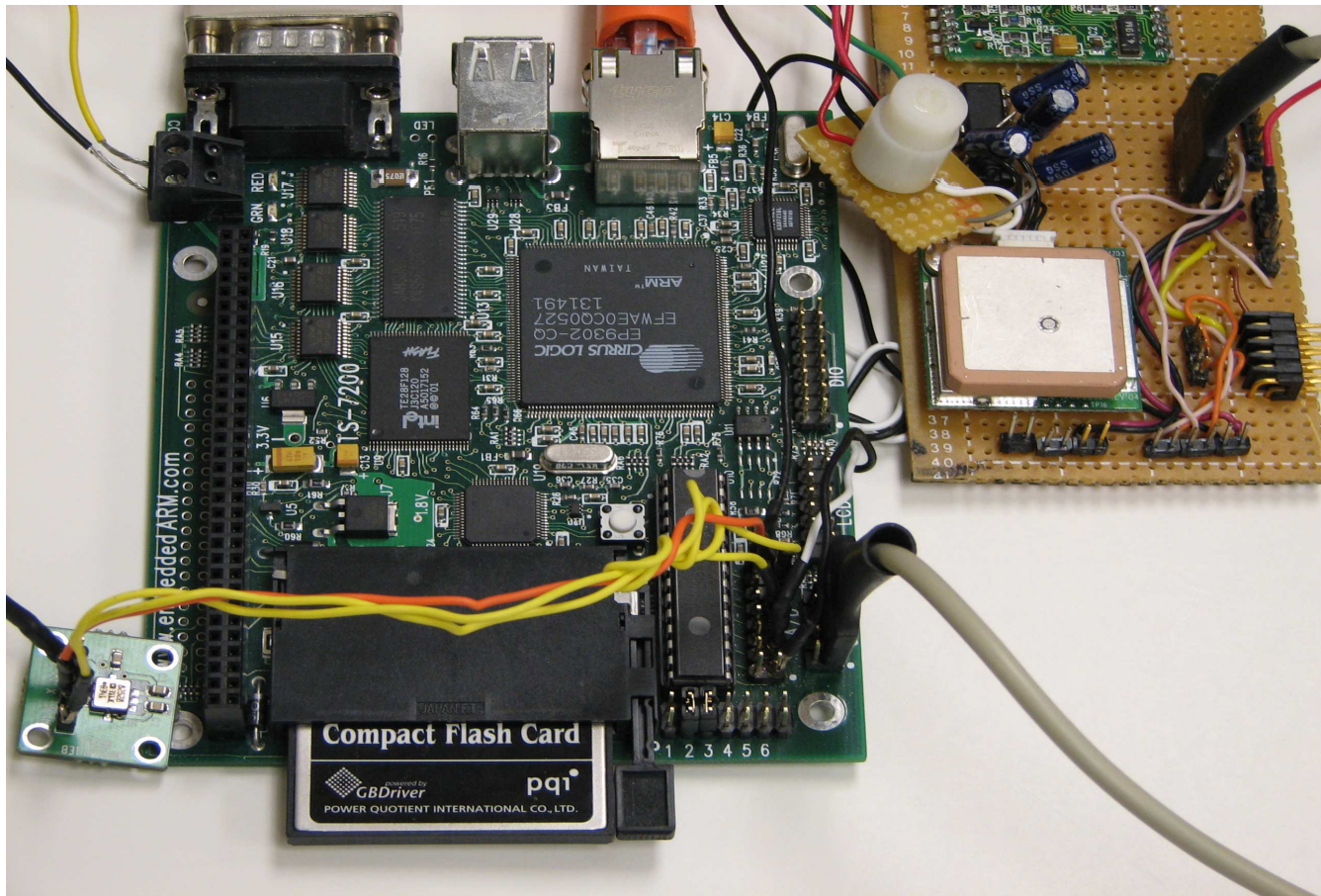
R1655 Analog Compass

- **Measure the direction of the horizontal component**
 - **Compass output resemble a sine-cosine set of curves**
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LM35 Thermistor

- **A negative temperature coefficient**
 - **Nominal output voltage is from 250mV to 1.000V**
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The complete system setup



Now we start to develop software...

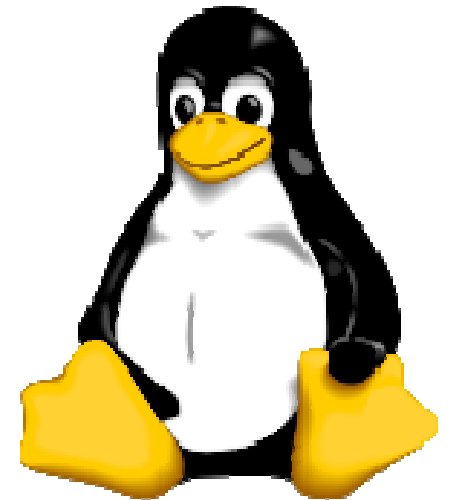
- **Linux Environment**

TS-Linux embedded distribution is installed on the on board Flash memory

(Download it at <http://www.embeddedarm.com>)

- **Compiler**

GNU C compiler provides all the software for the development of an Embedded Linux system



Description of main program

- **MAX 197 external ADC**
 - **Header file for the external ADC**
 - **RS232 configuration code**
 - **GPS Receiver**
 - Linux distinguished devices into three fundamental device types: a char module, a block module, a network module
 - Char devices are accessed by means of file system nodes, such as `/dev/tty1` and `/dev/lp0`
-

Output from the ADC and the GPS Receiver

```
Terminal
File Edit View Terminal Tabs Help
The ADC measured value is: 0.00
  the direction is 987
the direction is 1210
the compass reading is: NE
GPRMC,0000014.044,,,,,0,
Waiting for ADC to respond on channel 0....ok
Waiting for ADC to respond on channel 1....ok
Waiting for ADC to respond on channel 2....ok
The Accelerometer X Axis is: 1.30
Waiting for ADC to respond on channel 3....ok
The Accelerometer Y Axis is: 1.27
Waiting for ADC to respond on channel 4....ok
The Temperature measured is: 0.75
Waiting for ADC to respond on channel 5....ok
The Second Accelerometer X Axis is: 1.27
Waiting for ADC to respond on channel 6....ok
The Second Accelerometer Y Axis is: 1.20
Waiting for ADC to respond on channel 7....ok
The ADC measured value is: 0.00
  the direction is 986
the direction is 1210
the compass reading is: NE
GPRMC,0000014.044,,,,,0,
```

System features

- **Use an Embedded Linux supporting a single board computer**
- **Most of the work has been done in kernel development**
- **the code is written as generic as possible, so that it could be ported to other Linux-based SBC**
- **Interface Ethernet and USB**
- **Various sensor measurement for Marine research**

Thank you!
