**Product: Technical Directions Inc. (TDI) Embedded Turbine Controller Version 3**

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1. **Situation Appraisal**

TDI is developing the third generation of their Embedded Turbine Controller which they would like to be developed using industry best practices for microcontroller based embedded systems. The controller design would be based on the TDI\_TEEC3\_Environments\_Block\_Diagram\_v1a.docx from 2018/11/26.There are several areas that they are looking for assistance in:

* Scalable architecture design that can form the base code for future versions
* Modular software implementation using industry best practices such as MISRA-C
* Basic security consideration such as locking down the flash segments in the microcontroller
* Integrating test capabilities and diagnostics that can easily be read and modified in the field

This second phase development effort will focus on defining the CAN/Ethernet interface specification and developing demonstration code that tests the interface using an off-the-shelf development board.

The Wi-Fi module used is ESP-WROOM-02

It’s possible to jus use the ESP8266 for audio playback. Here is an example:

<https://github.com/earlephilhower/ESP8266Audio>

important lnks

<https://github.com/nailbuster/esp8266FTPServer>

<https://tttapa.github.io/ESP8266/Chap01%20-%20ESP8266.html>

<https://diyprojects.io/esp8266-ftp-server-spiffs-file-exchange-rapid-development-web-server/#.XXF_4ZNKh26>

https://www.st.com/en/embedded-software/x-cube-audio.html

<https://wunderkis.de/cube-lwip-yaffs/index.html>

1. **Audio Playback**
   1. **MP3 Decoding**

T

<https://learn.adafruit.com/native-mp3-decoding-on-arduino>

* 1. **I2S Interface**

I2S is an electrical interface used to connect serial audio data. It transmits PCM audio data to a receiver that is then able to generate stereo audio from the data stream.

I2S has at least the following signals:

A clock in the dark

Description automatically generated

The bit clock frequency is the product of the sample rate, the number of bits per channel and the number of channels. So, for example, CD Audio with a sample frequency of 44.1 kHz, with 16 bits of precision and two channels (stereo) has a bit clock frequency of:

44.1 kHz × 16 × 2 = 1.4112 MHz

Additional details about the bus can be found at:

* <https://en.wikipedia.org/wiki/I%C2%B2S>
* [https://web.archive.org/web/20140223115501/http://www.eng.auburn.edu/~nelson/courses/elec5260\_6260/Inter-IC%20Sound%20%28I2S%29%20Bus2.pdf](https://web.archive.org/web/20140223115501/http:/www.eng.auburn.edu/~nelson/courses/elec5260_6260/Inter-IC%20Sound%20%28I2S%29%20Bus2.pdf)
* [https://web.archive.org/web/20070102004400/http://www.nxp.com/acrobat\_download/various/I2SBUS.pdf](https://web.archive.org/web/20070102004400/http:/www.nxp.com/acrobat_download/various/I2SBUS.pdf)

1. **Measures of Success**

Progress toward the objectives will be measured by:

* Deliver CAN/Ethernet communication document
* Define the “bus master” behavior
* Deliver development board prototype that can transmit dummy messages, receive commands to control LED’s and store configuration information.

1. **Value to Client**

The value of the project appears to be multifold, including:

* Leveraging Jacob’s experience developing flight software and real-time software systems
* Bringing to bear world-class techniques for robust embedded software design
* Utilizing the past experiences of Jacob Beningo, a Certified Software Development Professional, for implementing the software
* Increasing the effectiveness of the embedded software design and implementation.
* The design and development of embedded software that is modular and reusable for future projects
* Fully documented software that will be easy to maintain and upgrade
* Minimization of software complexity through analysis and reporting techniques
* Avoidance of productivity loss by employees by focusing on software rather than the system.
* Implementing knowledge on debugging techniques and application tracing that can decrease time on future project spent debugging.

1. **Timing**

Phase 2 is expected to take approximately 2 – 3 months barring any unforeseen events or complications.

1. **Methodology and Options**

The available options for this project can be found below:

1. **Phase 2 Development -** In this capacity, I would work as your back-stage resource to develop the software and documentation to complete the phase 2 objectives. During this phase, I would be accessible by phone, email and up to 2 on-site meetings at TDI.
2. **Joint Accountabilities**

Client would be responsible for internal scheduling, reasonable access to key personnel, on-site administrative support and reasonable access to past and current documentation and hardware that would aid the project. Client would also be responsible for providing the following materials:

* Providing the source code and any related documentation to previous versions
* Signing the boiler plate Beningo Embedded Group consulting agreement

I would sign all required nondisclosure and confidentiality agreements and would provide all administrative support off-site. We agree to immediately appraise each other of any intelligence or findings that would impact the success of the project so that rapid action could be considered.

1. **Terms and Conditions**

I rarely assess an hourly or daily fee, since you should not have to make an investment decision every time my assistance may be needed, nor should your people have to seek permission to spend money if they need my help. This is a unique feature of my consulting practice. Unfortunately, this is not always possible if there are considerable unknowns. In this instance, option 2 cannot be quantified until the software architecture is completed. For this reason, option 2 is currently an estimate based on existing knowns and will be refined into a full quote once the software architecture is completed. Every effort will be made to leverage existing software, API’s and HAL’s in order to speed up development.

Fees for options are:

**Option 1** - $25,000 USD

These fees are inclusive of expenses so long as all work required is conducted at Beningo Embedded Group offices. On-Site activities at Client Offices are possible at their expense for travel. Any travel expenses such as flights, hotels, taxi fare, etc shall be prepaid.

Payment terms for any of the options are:

50% due on proposal acceptance.

50% due 30 days from proposal acceptance.

A 10% discount is provided if payment is received in full upon proposal acceptance.

This project, once approved, is non-cancelable for any reason, although it may be delayed, rescheduled, and otherwise postponed without any penalty whatsoever.

1. **Acceptance**

Your signature below indicates acceptance of this proposal and the terms and conditions herein. Alternatively, your initial payment per the terms above will also represent acceptance of this proposal.

Please check the option(s) you prefer: \_\_\_ #1

**Beningo Embedded Group, LLC**

P.O.Box 400,

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Tel. 248-719-6850

,

Jacob Beningo, Consultant Date

**Technical Directions Inc. (TDI)**

,

Signature Date

,

Name Position

1. **Appendix A – Additional Phases Estimation**

Phase 3 Development is expected to cover the following software development activies:

* Remaining Microcontroller Drivers:
  + Analog to Digital Converter
  + Pulse Width Modulation
  + Comparator
  + Watchdog Timer
  + Flash
  + Real-time Clock
  + MAX31856

These items are expected to take 1 – 2 months development effort and $15,000.

Phase 4 Development is expected to cover the following items:

* Application Development
  + Control Law
  + Testing and Debugging on actual hardware
  + Application Component integration

These items are expected to require 2 – 3 months development and ~$30,000.

1. **Appendix B – Jacob Beningo Short Bio**



Jacob Beningo is a Certified Software Development Professional (CSDP), chair of the IEEE South Eastern Michigan Consultants Affinity Group, an independent consultant and lecturer who specializes in the design of embedded software for resource constrained and low energy mobile devices. He has successfully completed projects across a number of industries including automotive, defense, medical and space. He enjoys developing and teaching real-time and reusable software development techniques using the latest methods and tools. He blogs for EDN.com about embedded system design techniques and challenges. Jacob holds Bachelor’s degrees in Electrical Engineering, Physics and Mathematics from Central Michigan University and a Master’s degree in Space Systems Engineering from the University of Michigan.

1. **Appendix C – Client Testimonials**

Jacob supported our nanosatellite project, as an embedded software consultant. He developed the detailed software specifications, based on our ‘napkin’ sketch, and delivered fully tested, working software, supported by the complete and accurate documentation, on the schedule that we agreed with. The embedded code was solid and well received during the code reviews. That software has been operating flawlessly on orbit for the past two years.  In this world of late deliveries of unreliable ill-documented products, this is amazing and stand-out achievement. I am eager to work with Jacob on our next satellite project.

Tomas Svitek, CEO

In addition to having an extremely high level of expertise with regard to architecting and implementing embedded software and real-time embedded systems, Jacob has a rare talent for communication. His cheerful disposition, enthusiasm, and depth of knowledge make Jacob one of the most popular presenters at the [Embedded Systems Conference (ESC)](http://www.embeddedconf.com/). Jacob's sessions are always well-attended (often standing room only) and well-received by the attendees.

Clive "Max" Maxfield, Editorial Director, Embedded.com, and Technical Content Director, ESC

"Jacob was everything we could hope for in an embedded systems consultant. His understanding of the entire design process from requirements gathering, system architecting, implementation to testing and production was of great value to us. Jacob's layered software architecture design allowed us to quickly adapt to changing customer requirements saving both time and cost. He is easy to work with and has a knack for taking a complex technical topic and explaining it in easy to understand terms. I would recommend him and look forward to working with him on my next project."

Larry Roy

Vice President, Development

Embedded Logix

"Designing a robust and functional system starts with a good architecture design. Jacob worked with us to improve our embedded software architecture designs and helped us to implement a layered software architecture with clear and defined API's. His method for documenting software and adhering to software standards was phenomenal. We recommend and look forward to working with Jacob on future embedded software projects."

Ron Shelby

C&S Engineering