EMBENTION

Embention and DDX Solutions, Innovation, and Business Partnership

OFFER FOR CUSTOMERS:

Conversion of an Aircraft into a Fully Autonomous Platform

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CONTENT

INTRODUCTION

Scope

This proposal is developed according to DDX Solutions & Embention for the collaboration of Veronte ecosystem avionics.

Within the scope of the project, Embention proposes a series of activities required to finalize the conversion of an aircraft into a total autonomous platform.

A certification datapack with detailed DO178C and DO254 compliance is included within the scope of the proposal. Support during the certification and customization of the certification documentation may need a separate agreement.

Embention Background

Founded in 2007 and based in Spain, Embention has become a reference in the UAV and UAM industry with the development of the Veronte Autopilot, a professional control system for autonomous vehicles that has been successfully installed in more than 500 aircraft distributed in 70 countries.

DDX Solutions Background

DDX Solutions is an USA based software development company in the heart of the Washington DC - Maryland - Virginia area, which builds turnkey enterprise software solutions, databases and web applications, provides full lifecycle systems development support including expert database solutions, legacy system migration, system integration, operations and maintenance services.

We also take part in innovation projects in partnership with companies in the UAS, UAM domain, anticipating and responding to customers' cutting edge tasks and autonomy necessities, based on our project team's exotic car CE certification experience.

DDX Solutions Integration

To achieve the objectives defined in the project and the requirement compliance matrix, Embention suggests using the latest version of Veronte Autopilot 4x (v1.8)

Configuration activities and testing will be performed to ensure the fulfillment of the agreed compliance matrix. Firmware and Software team assistance will also be provided in case it is required to meet any of the requirements.

A verification team will support the activities related to testing, verification of requirements, environmental qualification, and similar activities.

Support activities are defined to be completed in 9 months. During this time, the Embention engineering team will work side by side with the team at DDX Solutions to complete all the activities defined within the project and collaborate on any other subjects that arise from the collaboration. All this is managed by a program manager at Embention in close coordination with the DDX Solutions project manager.

EQUIPMENT

Veronte Autopilot 4x

The Veronte Autopilot 4x is designed for the control of any autonomous vehicle doing critical missions. With only 650g, it includes **three complete autopilot cores plus an arbiter board** managing the redundancy.

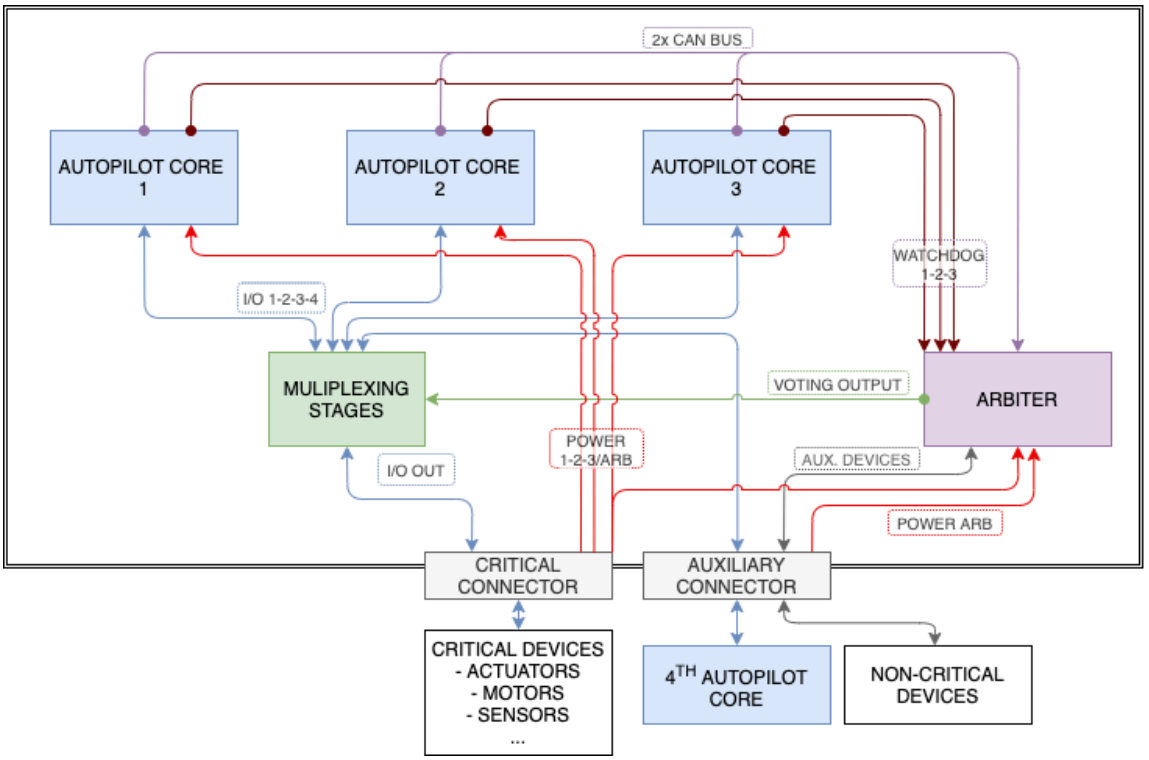
Veronte Autopilot follows the most demanding safety standards in the aviation industry being **DO254, DO178 and DO160** compliant and designed so there is **no single point of failure.**

Veronte Autopilot can be easily programmed using **Model Based Design**. Thanks to the use of the Programs Module, it allows the control of any aircraft setup without needing to modify the source code in the autopilot and **maintaining the DO178C compliance**.

Redundancy

Veronte Autopilot 4x embeds **three complete autopilot cores** plus an arbiter board managing the redundancy. An **external 4th autopilot** core can also be used, this unit can be configured as the main flight controller or as a backup unit.

During the operation, all autopilot units will “think” that they are in control of the aircraft but the multiplexing stages will only allow one of these units to output the control signals to the actuators and devices. These logics can be defined through the **customizable voting algorithms** in the arbiter. The right logics will be configured as per the SSA (System Safety Analysis) results.



This hardware has been designed so there is **no single point of failure**. Even in the event of an arbiter failure, the system will automatically assign control to one of the autopilot cores. Redundant configuration includes redundant power input so multiple batteries can be used for powering the system.

Veronte Autopilot 1.8 Upgrade

One of our fundamentals at Embention is the continuous evolution of our products. Since the start of the collaboration with DDX Solutions, Embention has released a new version of Veronte Autopilot hardware, with the following features:

- **Improved RTK and GNSS heading:** new GNSS sensors in Veronte Autopilot are significantly better in various aspects (supported constellations, accuracy, number of concurrent constellations, frequency). The positioning accuracy has improved from 0.025m+1ppm to 0.01m+ppm CEP, it also improves RTK and GNSS heading estimation.
- **Enhanced high-temperature hardware design and production materials**: in order to offer best performances in extreme scenarios and to pass more demanding quality and environmental tests. New materials are used in the PCB manufacturing, these new fibers have better performance on heat conditions, extending the lifetime of the product.
- **Additional failure detection means:** development of failure detection algorithms and redundant hardware. The new PCB design includes additional signals for failure detection that can communicate each one of the autopilot cores with the arbiter. Also the internal CAN Bus network has been modified to enhance robustness.
- **Short-range 2.4GHz LOS included in all units:** short range communications module included, in order to facilitate system integration. This module is based in Digi

Xbee and permits to have an independent link for telemetry download and configuration.

- **4G BLOS module with extended coverage:** BLOS communications and UTM capabilities through the embedded eSIM card.
- **Extended navigation capabilities:** new sensors in Veronte Autopilot are significantly more accurate than previous ones. These enhanced sensors permits to improve the navigation estimation. Also the navigation algorithms have been enhanced in order to offer a higher level of customization in the Kalman Filter and to easily interface with new sensors.
- **Internal Remote ID or ADS-B with IN/OUT:** extended collaborative sense and avoid capabilities, allowing the compliance of new FAA unmanned operation requirements. WIFI and Bluetooth modules have been integrated to enable Remote ID communications, this module can be replaced by a 1W ADS-B IN & OUT module if preferred.
- **Embedded Global DEM, geoid, magnetic and gravity fields:** worldwide terrain altitude and magnetic field is included in the Veronte Autopilot so the aircraft can easily move from one location to the other. AGL estimation is available worldwide with no need to update the files of the area.
- **Internal enclosure pressure port**: A new pressure port has been included for measuring the pressure inside the autopilot.

Veronte MEX

Veronte MEX is a three-axis magnetometer, which detects the direction and strength of a magnetic field. This allows obtaining orientation references with outstanding stable performance over time and temperature.

Thanks to the I/O expansion capabilities, this powerful peripheral also permits to ease the reduction of wire in autonomous vehicles at the time it allows an increase in the number of devices in the system. It makes it possible to relocate and to group sensors, actuators, payloads, and motor controllers… enhancing the I/O connectivity in the Veronte Autopilot.

Veronte CEX

CEX stands as a powerful peripheral to ease the reduction of wire in autonomous vehicles at the time it permits to increase in the number of devices in the system. It makes it possible to relocate and to group sensors, actuators, payloads, and motor controllers… enhancing the I/O connectivity in the Veronte Autopilot. With its easy integration, CEX becomes a quick solution for increasing connectivity capacity and allowing wiring optimization, especially in large systems.

This device will be used in the STOL for adding ports to the system and to ensure robust communications with areas of the aircraft distant from the main avionics bay.

The I/O available in Veronte CEX include:

- 2x Isolated CAN buses
- 1x ARINC 429 output
- 5x ARINC 429 inputs
- 1x RS485 port
- 2X RS232 ports
- 1x I2C port
- 8x 5V PWM
- 9x 3.3V GPIO convertible to PWM
- 4x 3.3V and 5V ECAPs
- 2x 0V to 3.3V analog inputs
- 2x 0V to 5V analog inputs
- 2x 0V to 12V analog inputs
- 2x 0V to 36V analog inputs
- Redundant power supply input

Ground Station Hardware

Veronte PCS is a rugged control station hardware designed for outdoors use. The aluminium enclosure with IP54 protection allows the operation of the system in all weather conditions by protecting the electronics from rain and harsh environments.

The foldable mast included can be extended up to 3 m, raising the radio modules and antennas for maximizing the datalink LOS. Furthermore, the embedded Veronte Autopilot 1x includes all sensors needed for professional drone operations, enabling RTK, differential barometer, operations from moving vehicles, relative missions…

The whole system is delivered with a rugged plastic storage case for easy transportation.

This setup allows installing the Veronte PCS init (installing datalink and sensors) on open fields, maximizing the performance of GNSS receivers and datalinks, while operator can operate from a safe location.

Veronte PCS is ready to be used with a ground configuration, all sensors and devices integrated and the required wires to connect it to any other Veronte device (like T28 Tracker or LCS).

Veronte T28 is a high-performance tracking antenna specifically designed for most demanding applications. The T28 includes directional and omnidirectional antennas in the tracking antenna system. Both antennas are used to obtain the best operational performance. The omnidirectional antenna is used for short-range operations and the directional one for tracking the vehicle when it operates at high distances, so the T28 points to the aircraft in real-time movement, operating at long range and not moving at short range.

The system can install any directional antenna to maximize system operation capabilities. Embedded control actuators and installed encoders permits to automatically point the antenna with unique precision. Height and orientation given to the antenna makes the device perfect for long range operations.

Suitable for: UAVs, UASs, RPASs, UGVs, USVs and any other moving systems.

The platform is prepared to install different kind of antennas for video and data-link communications. Patch, yagi and parabolic grid antennas can be used within the system for best operational performance. Tripod is also interchangeable and custom tripods can be adapted.

With Veronte PCS and T28 using Silvus Datalinks, the distance LOS is up to 200km. With the option of activating the eSIM card embedded into the autopilot or connecting a Satcom module to the autopilot, BLOS distance can be increased.

The choice of the datalink, range of operation & geographical terrain are important determinants of the overall performance. Embention recommendation is to work with Silvus Datalink for the highest performance levels to ensure the control from 1 ground control station of 3-5 aircraft.

Simulation Environment

HIL Simulator

Hardware In The Loop simulator permits to perform real-time simulations using the **real autopilot hardware** and software that is used during the operation.

Real aircraft movement is possible by connecting the aircraft to the simulator. Plane Maker tool permits to customize aircraft layout and components (engine, fuel tanks, propeller…). In case that a custom simulation software is preferred, it is possible to interface it with Veronte Autopilot by emulating the X-Plane protocol.

Safety & Certification

Veronte Autopilot is developed in compliance with the **DO178C (Software Considerations in Airborne Systems and Equipment Certification) and the DO254 (Design Assurance Guidance for Airborne Electronic Hardware)** standards.

Veronte Autopilot's compliance level with the standard is DAL B. Low-level software testing is now being performed to achieve compliance with the DAL A requirements in 2024.

DO178C + DO254 Certification Datapack is included within the scope of the proposal so DDX Solutions can have access to all documentation required to start a certification program.. Content of the Veronte Autopilot Certification Datapack is

Data Item	DO / ED Reference	Internal ID	Data Format
Plan for Software Aspects of Certification	11.1 OO.11.1	PSAC	PDF Document
Software Development Plan	11.2	SDP	PDF Document
PDI Development Plan	11.2	PDIDP	PDF Document
Software Verification Plan	11.3	SVP	PDF Document
PDI Verification Plan	11.3	PDIVP	PDF Document
Software Configuration Management Plan	11.4	SCMP	PDF Document
PDI Configuration Management Plan	11.4	PDICMP	PDF Document
Software Quality Assurance Plan	11.5	SQAP	PDF Document
Software Requirements Standards	11.6	SRS	PDF Document
Software Design Standards	11.7 OO.11.7	SDS	PDF Document
Software Code Standards	11.8 OO.11.8	SCS	PDF Document
Software Requirements Data	11.9	SRD	PDF Document
Software Design Description	11.10	SDD	PDF Document
Source Code	11.11	SC	ZIP File
Executable Object Code	11.12	EOC	Binary File
Software Verification Cases and Procedures	11.13	SVCP	PDF Document
Software Verification Results	11.14 OO.11.14	SVR	GitHub Database

PDI Verification Results	11.14 OO.11.14	PDIVR	GitHub Database
Software Environment Life Cycle Configuration	11.15	SECI	PDF Document
PDI Environment Life Cycle Configuration Index	11.15	PDIECI	PDF Document
Software Configuration Index	11.16	SCI	PDF Document
PDI Configuration Index	11.16	PDICI	PDF Document
Problem Reports	11.17	PR	GitHub Issues
Software Configuration Management Records	11.18	SCMR	GitHub Database
PDI Configuration Management Records	11.18	PDICMR	GitHub Database
Software Quality Assurance Records	11.19	SQAR	GitHub Issues
Software Accomplishment Summary	11.20 OO.11.20	SAS	PDF Document
Trace Data	11.21 OO.11.21	TD	PDF Document
Parameter Data Item Files	11.22	PDIF	XML Files in GitHub Database

DO-254 / ED-80 Datapack (Airborne Electronic Hardware)

Data Item	DO / ED Reference	Internal ID	Data Format
Plan for Hardware Aspects of Certification	10.1.1	PHAC	PDF Document
Hardware Design Plan	10.1.2	HDP	PDF Document
Hardware Validation and Verification Plan	10.1.3 10.1.4	HVVP	PDF Document
Hardware Configuration Management Plan	10.1.5	HCMP	PDF Document
Hardware Process Assurance Plan	10.1.6	HPAP	PDF Document
Hardware Requirements Standards	10.2.1	HRS	PDF Document
Hardware Design Standards	10.2.2 10.2.3 10.2.4	HDS	PDF Document
Hardware Requirements Data	10.3.1	HRD	PDF Document
Hardware Design Data	10.3.2.1 10.3.2.2 10.3.2.2.4	HDD	PDF Document
Hardware Configuration Index	10.3.2.2.1	HCI	PDF Document
Assembly Drawings	10.3.2.2.2 10.3.2.2.3	MD	GitHub Database
Hardware Trace Data	10.4.1	HTD	PDF Document
Hardware Test Procedures	10.4.2 10.4.4 10.5	HTP	PDF Document
Hardware Validation and Verification Results	10.4.3 10.4.5	HVVR	GitHub Database
Problem Reports	10.6	PR	GitHub Issues
Hardware Configuration Management Records	10.7	HCMR	GitHub Database
Hardware Process Assurance Records	10.8	HPAR	GitHub Database
Hardware Accomplishment Summary	10.9	HAS	PDF Document

*Support for custom documentation drafting or dedicated assistance during the certification process is excluded from the scope of the proposal. It can be discussed separately by the time it is needed.

INTEGRATION SUPPORT

Embention will dedicate a team with a full-time dedication to the project to achieve the required objectives. This team will be multidisciplinary so the different tasks can be completed timely. Also, a project manager will be assigned to the project, being the main PoC for any aspects related to the program.

The duration of this close support for industrialization is planned to last 9 months. Duration can be extended or reduced as per project requirements and evolution, dedicated support engineering will be invoiced according to the total duration in which the engineering team is available.

Required dedication from the Embention team may vary depending on the implication of DDX Solutions engineers in the different tasks. It is expected that the teams from Embention and DDX Solutions work side by side sharing experiences and tasks. According to the activities described, it is expected that 2 full-time engineers will be dedicated to the project during the duration of the contract. These engineers will change during the program as per the needs arising from different stages of the project.

Project Management

The project manager at Embention will be responsible for closely following the project activities. Bi-weekly meetings will be scheduled between the DDX Solutions team, the project manager at Embention and other engineers involved in the different stages of the project. Punctual meetings will also be possible if the project requires it.

The project manager will be responsible for analyzing the requirements and defining the appropriate tasks to be performed. He will assign the engineering team to be dedicated to the project balancing the dedication to the project as per the number of full-time engineers hired and the program schedule.

Embention's Joint Collaboration Framework will be used as the main tool for communications and file / configuration traceability. This framework is based in GitHub permitting to perform the following functions:

- Task management and assignment
- Issue report
- Task/Isssue communications and traceability
- File exchange
- PDI (Configuration) exchange and traceability
- Documentation configuration management

The project manager will lead the PDR and CDR activities at Embention to ensure that the objectives defined on the SoW are met.

System Support

To support the activities related to the autopilot integration and configuration, a team including PDI, avionics, software, and firmware engineers will be involved in the project.

System Engineering

The Embention team will collaborate with the DDX Solutions team on the review and detailed definition of the system architecture and wiring diagrams. Also mechanical installation of the avionics (position, dampening…) will be jointly defined. Together with this, detailed data (weight, manuals, datasheets…) will be provided for each part.

PDI Configuration

To meet the requirements described, the existing Veronte Autopilot configuration used in the STOL needs to be updated to include specific functionalities not integrated into the date. For this, a PDI engineer from Embention will collaborate with DDX Solutions to update these files.

The PDI engineer will also assist with the migration of the Veronte Autopilot configuration to the latest firmware version and the installation of this software into the autopilot units. As part of the autopilot configuration, the engineer will assist with the definition of the appropriate control laws for the aircraft and the fine-tuning process.

Also, the PDI engineer will collaborate in drafting the documentation related to the autopilot performance and the specific parameters or interfaces defined for the STOL project.

Software Assistance

In case it is required, the software and firmware teams will participate in the project for the execution of punctual tasks requiring the modification of the firmware inside the Veronte products or associated software.

Onsite Integration

Integration engineers will travel to customer facilities assisting with the different tasks that may require it (iron bird setup, ground testing, inflight testing…).

This engineer will travel for periods of two weeks on each trip. Timing for the trips will be agreed upon among Embention's and DDX Solutions project managers according to the program schedule.

A total number of 5 trips is expected to be required. This amount can be adjusted as per project needs.

Testing Support

The Certification and Verification teams at Embention will support the project to collaborate with the activities related to test plan definition, verification of the configuration, requirement verification and environmental testing.

Software/ Configuration Tests

The Verification team will use the STOL setup integrated with the Embentions's EDE to execute the software test required to ensure the compliance with the system requirements defined in the SoW (some tests may require from real flight verification - TBD).

In the first stage, the Verification team will execute the set of existing tests at Embention, for the DDX Solutions configuration (PDIs). Once this phase is finalized, a new test will be generated and passed according to the requirement list received.

These tests can be used in later stages of the project to prove the performance of the autopilot and the compliance with the system requirements within the scope of a certification process with the aviation authorities.

Environmental Test

Embention will provide support on the definition of the test plans and to identify the LRUs to be tested and the possible interfaces among them. As some of these tests may include other components from the aircraft, these should be executed by the DDX Solutions team with the collaboration of Embention.

DDX Solutions & Embention partnership

DDX Solutions will complete if/as necessary the capabilities of Embention and the beneficiary with its own people and/or recruit additional resources on a consensual contractual basis (with all the implied parts)

The quotations are merely as an informative and as a reference of the equipment that implies per our experience in past projects. Any other "particular situation" will require analysis and reconsideration and an updated quote based on the particularities of the application.