Abstract—Currently there are quite works investigate the Inertial Measurement Unit (IMU) and the Global Position System (GPS) fusion. The majority are implemented on personal computers, due to the high computational cost. However, nowadays there are System On Chip (SOC) platforms with a lot of resources capable of the integration with GPS/IMS, providing a high performance, variety of peripherals, ease communication with different devices and possibility to add more modules into the development prototyped, also this kinds of platform can be the primary step of an ASIC. The propose in the current project is to integrated Inertial Navigation System (INS) based on SOC platform, insuring a good precision in the velocity and position information, and high performance and rapid response ability for the navigation system.

Index Terms—Inertial Measurement Unit (IMU), IMS, INS, GPS, SOC, Kalman Filter, Velocity/Position Estimation.

I. INTRODUCTION

The precision of the GPS has increased considerable during the time and the errors that range from meters to centimetres, depending on the environment in which they are used. A great importance has to be given to the satellites that provide the information for the GPS, taking into consideration that in some adverse conditions the tracking of the satellites can be compromised and therefore some errors in the navigation system can appear.

On the other hand, the Inertial Measurement Unit (IMU) is an autonomous instrument that is used to measure acceleration and angular velocity with a certain frame of reference. These instruments contain Microelectromechanic Systems (MEMS) such as accelerometers and gyroscopes that provide information about changes in orientation of the object and then transform the data into the desired frame of reference and obtaining the speed and the position of the object. The downside of the IMU is that the sensors have inaccuracies; therefore another source to provide regular updates of navigation is needed in order to limit the error and prevent damage to the inertial positioning.

The inertial data integration with the IMU and GPS observations provide an excellent choice, because both systems can be supplemented to overcome the disadvantages comparing to acting as an individual. To unite these two systems, another problem appears that is the complex calculations due to the different frequencies and different reference frames of each system. Also, applications nowadays require not only high accuracy but also a response in real time. The solution proposed in this work is to integrate INS and GPS through a SOC, using the Power PC processor as a processing unit.

Comparing the development platform with conventional methods made in several documents [3][9][11]; In this case we propose a SOC platform designed using EDA tools that provide a description level layout giving a support to the full custom designed in the development of a ASIC to integrated both instruments INS/GPS.

This paper is divided into five parts: theoretical framework, description of the system, implementation, conclusions and future work. In section II describes the GPS and INS, highlighting their main advantages and disadvantages when acting independently. The section III describes the basic components for the GPS / INS integration in the platform, taking into consideration the algorithms for the inertial navigation, Kalman filtering and the data acquisition from the GPS. In section IV, the PowerPC hardware system is presented along with adding the custom IP. In the next section, we present the performance graphic of the Kalman Filter for integrating GPS / INS, and resources occupied by the modules that were implemented into the platform. In the final section, the conclusions and the future work that can be performed with the platform.

II. THEORETICAL FRAME

A. The Global Positioning System (GPS)

The Global Positioning System (GPS) is a tracking system, which was created by the Department of Defence of the U.S.A. with military purposes to provide estimates of speed, position and time. Operating since 1995, it uses a network of computers together and a constellation of 24 satellites to determine by triangulation latitude, longitude and altitude of any object on the Earth surface [8]. The working principle of the GPS consists in calculating the distances from the point where the GPS (receiver) is located to a minimum of three satellites whose location is known. To determine each of these distances it is measured the time it takes to reach the receiver of the user, and this time is multiplied by the speed of light and in this way to get the satellite-receiver distance.
The GPS measurements are affected by different error sources; among the main error sources can be found: the ionosphere disturbance, meteorological phenomena. Clock imprecision, multipath error. The interference “Selective Availability S / A” and the topology receiver - satellites. As said before, the integration with the Inertial Measurement Unit overcomes some of these problems by increasing the availability and the precision in the navigation systems. The following item describes the concept of inertial navigation in which the IMU is framed.

B. Inertial Navigation System

The inertial navigation is based on the relative positioning using the information provided by the accelerometers and the gyroscopes, such as the acceleration and angular velocity coming from the sensors is used to determine the speed and the direction of the movement. The inertial sensor set is known as the IMU that along with the mechanization equations, form an Inertial Navigation System (INS)[10]. The more comun inertial systems are classified as:

1. Gimbals. These are the ones that maintain the axes of the sensors and they are identical to the interest frame, which can be an inertial frame (space-stabilized system) or a local frame (local-level system). The advantage of such systems is that they do not require the transformation of the coordinates; it is relatively easy to calculate the navigation solution[10]. But has several detractors due to the need high quality motors, they are not perfect and consumes high power to keep the platform aligned.

2. Strap down. In these systems there is measured the angular velocity and the specific forces along the axis of the frame. To obtain the solution of the vehicle navigation it is necessary to transform the specific forces on the desired navigation frame[10].

The IMU is a strap down system, the groups of the sensors are fixed to the coordinates system of the vehicle. So it requires a software solution to keep track of the orientation of the IMU and rotate the measurement from the body frame to the navigation frame. This method reduces the size, cost, power consumption and complexity of the system compared with the gimbals.

Another important element of the INS is the reference frames and the rotations. Although there are different coordinate systems in this work is handled primarily NWU, which uses the cartesian coordinate system that is presented in Figure 1, taking the North, West, Up (NWU) as axes. This is formed basically from a tangent plan, fixed to the earth's surface.

The rotation of the vehicle is observed with respect to the angles \( \psi, \theta, \phi \) as shown in Figure 2. One should keep in mind that the body frame must be aligned with the axes of the IMU.

III. Description of the System

The system is basically divided into 3 main stages that are: The IMU (Inertial Measurement Unit), the GPS (Global Position System) and a block of digital processing that is done on the XUP.

The description of each of these blocks is shown as follows:

A. The IMU Block

The Inertial Measurement Unit is to detect the 6 motions of Degrees Of Freedom (DOF). According to the three axes, each one accelerometer and gyroscope is set to measuring one axe. Since the function of IMU will use six sensors to sense along all three axes.

The physical design of the IMU is half of a cube, composed by three planes. Each axis will have an accelerometer and a gyroscope to calculate the acceleration and angular velocity at least one time [1]. One side of the cube contains an ADC to control the signal from the gyroscopes and the connector interface that is used to connect with the FPGA. The accelerometers have a measurement range of \( \pm 2g \). They have digitals output whose duty cycles (the ratio of pulse width to period) are proportional to the acceleration like we can see as it follows.

\[
a = \left( \frac{T_1}{T_2} - 0.5 \right) \cdot g / 12.5\%
\]

Where \( g \) is the gravity. This way the duty cycle of the output can be directly measured by a counter without using A/D converter. Also the IC contains a signal conditioning circuitry to implement open loop acceleration measurement architecture.

The three output signals from the gyroscopes have a angular velocity range of 300 deg/s. They have a good measurement precision, the effect of temperature drift must be eliminated by removing the DC output component, and it connects with a

---

**Fig. 1. NWU The local navigational frame**

**Fig. 2. Body Frame aligned with the axes of the IMU**

**Fig. 3. Signal accelerometer**
high-pass filter with low cut-off frequency to the sensor’s output. Also a low pass filter was necessary to block out high frequency component to suppress the noise component in the sensor element. After the signal conditioning circuitry each one of the gyroscopes access to the ADC serial multichannel that is capable of throughput rates of 125KSPS when provided with a 2 MHz clock. The 16-bit serial output goes into the FPGA, which generates the necessary control signal to the ADC and read the data coming with the 200 Hz sample frequency. Finally the data is converted from the serial frame into a parallel frame and translate the raw data into the angular velocity.

B. The GPS Block

The Block of the GPS has a receiver module LS-40MM sensitivity 12 channel, fast acquisition <10 second hot start and <45 second cold start, it has an onboard patch antenna, providing good signal reception when the antenna is exposed to the sky, the rate update is 1 Hz. The serial interface protocol is based on the National Marine Electronics Association’s NMEA 0183 ASCII interface specifications [6]. The NMEA messages have different formats like GPGGA, GPGSA, GPGSV, GPZDA. The purpose of this work was to choose the GPRMC format. The GPS reading is done via IP and it has the role to handle the serial port, the data is read through the RS232 of the board interface XUP where there is an algorithm to detect and subdivide the GPRMC format. With the purpose to obtain the necessary information for further processing, this task is implemented in the PowerPC processor where the data from the GPS are updated every second.

C. SOC Platform

The next module is the SOC Platform, this in turn contains several blocks as shown in figure 4.

1) IMU Acquisition

The module that performs the acquisition of data coming from the IMU (Acel), In the case of the accelerometers consists of state machines that are used to manage the counter that determines the pulse width, the calculation of the acceleration and the data that after that is stored in a dual port memory. It is worth to mention that the sampling frequency used to read the accelerometer was 200 Hz. The module Gyros in the figure 4 is to send the necessary control signals to the ADC and once the data is obtained in a serial form, the module changes it into a parallel format with the purpose to be stored into a dual port memory.

2) Mechanization

The values of acceleration and angular velocity that senses the IMU are relative to the reference frame of the vehicle (body frame $X_b Y_b Z_b$) [4]. Because it must have a common framework for all measures that will be processed, the equations that relate the reference system (body frame) with the navigation system have to be known. To finish it one must use a matrix of transformation to change the acceleration of the body system to the inertial system, then a double integration is performed in order to obtain the velocity and the position respectively. It should also be considered the orientation of the vehicle for which the Euler angles or the quaternions are used. The first step in the process of mechanization is the initial alignment of the INS, which consists in the determination of the initial values of the transformation which changes the coordinates of the sensor system (body frame) coordinates to inertial navigation system (land system)[4]. To set the inertial navigation systems it is considered when the vehicle with the IMU is at rest and has not yet begun its trajectory, when both coordinate systems coincide (Navigation frame and body frame). Thus, all measures derived from the IMU will be referred as this imaginary inertial reference frame that is defined just in the original position of the vehicle[4]. Since initially coordinate systems coincide (Inertial frame and body frame), must be the initial values in the three axes of position, speed and angle that determines the orientation (roll, pitch and Yaw) are zero, as is shown in the equations below[4]:

$$P(0) = [x(0), y(0), z(0)] = [0, 0, 0]$$

$$V(0) = [v_x(0), v_y(0), v_z(0)] = [0, 0, 0]$$

$$[\psi(0), \phi(0), \theta(0)] = [0, 0, 0]$$

Taking the initial conditions and the inertial reference frame, in continuation it is obtained the matrix of transformation of coordinates fixed to the body (body frame) coordinates for the coordinates of navigation. Having $a_b$, the acceleration vector measured by the IMU and $a_n$ the acceleration vector of the vehicle in the frame of reference of the navigation, it must[4]:

$$a_n = R_n^b a_b$$

(2)

Where $R_n^b$ is the rotation matrix.

Although there are various methods for obtaining the rotation matrix in this work the use of quaternion was chosen because the literature reported this as having a low computational cost and has no singularities like in the Euler angles [3]. In this way, the transformation matrix $R_n^b$ using quaternions is:

$$R_n^b = \begin{bmatrix}
        e_0^2 + e_2^2 - e_3^2 & 2e_1e_2 - 2e_0e_3 & 2e_1e_3 + 2e_0e_2 \\
        2(e_1e_2 + e_0e_3) & e_0^2 - e_2^2 + e_3^2 & 2(e_2e_3 - e_1e_0) \\
        2(e_1e_3 - e_0e_2) & 2(e_2e_0 + e_1e_3) & e_0^2 - e_3^2 + e_1^2
    \end{bmatrix}$$

(3)

Since the vehicle is in motion it is necessary to keep updating the matrix $R_n^b$. In order to get the value of each of its components the value of quaternions at each instant, must
known. Using the expression that relates the derivative of a vector in a body reference frame with its derivative in an inertial reference frame, it is reached [4]:

\[ E = \frac{1}{2} \mathbf{\omega} E \]  

(4)

Where \( E \) is the quaternion and \( \mathbf{\omega} = [\omega_x, \omega_y, \omega_z] \) is the angular velocity from the IMU. Making a Taylor development in order to obtain a recursive form that can be implemented, we get to the following equation [4].

\[
\begin{bmatrix}
    e_i(t+\Delta t) \\
    e_j(t+\Delta t) \\
    e_k(t+\Delta t) \\
    e_l(t+\Delta t)
\end{bmatrix} = \begin{bmatrix}
    e_i(t) \\
    e_j(t) \\
    e_k(t) \\
    e_l(t)
\end{bmatrix} + \frac{1}{2} \begin{bmatrix}
    -e_i -e_j -e_k \\
    e_i -e_j e_k \\
    -e_k e_j \\
    e_k e_j -e_i
\end{bmatrix} \mathbf{\omega} \Delta t
\]  

(5)

Where \( \Delta t \) is the sampling period.

To implement the above equations, the initial values of each quaternion have to be known. It is \( e_i(0) \) for \( i = 0, 1, 2, 3 \).

Since we known the initial positions \( (X, Y, Z) \) and orientation \( (\text{roll} (\psi), \text{yaw} (\phi), \text{pitch} (\theta)) \) we can use the equation which relates the Euler angles with the quaternions, thus determining the initial conditions of the quaternions [4].

\[
\begin{align*}
    e_0 &= \cos(\phi/2) \cos(\theta/2) \cos(\psi/2) + \sin(\phi/2) \sin(\theta/2) \sin(\psi/2) \\
    e_1 &= \cos(\phi/2) \cos(\theta/2) \sin(\psi/2) - \sin(\phi/2) \sin(\theta/2) \cos(\psi/2) \\
    e_2 &= \cos(\phi/2) \sin(\theta/2) \cos(\psi/2) + \sin(\phi/2) \cos(\theta/2) \sin(\psi/2) \\
    e_3 &= -\cos(\phi/2) \sin(\theta/2) \sin(\psi/2) + \sin(\phi/2) \cos(\theta/2) \cos(\psi/2)
\end{align*}
\]

Having the initial values of each quaternion, can be calculated the quaternion for \( t+\Delta t \). Thus, using the equation (5) in a recursive way, the elements of the matrix of rotation \( R_b^i \) for each instant are obtained and hence the acceleration in the inertial reference frame \((a_n)\) is determined. Taking the \( a_n \), the speed and position of the vehicle in the inertial reference frame is determined.

\[
\begin{align*}
\dot{v}(t) &= \int_{t_0}^{t} a_n(t) \, dt \quad \Rightarrow \quad \ddot{p}(t) &= \int_{t_0}^{t} \ddot{v}(t) \, dt
\end{align*}
\]

To realize the implementation it is expressed in the form of difference equations:

Velocity

\[ v_f[k] = v_f[k-1] + \frac{\Delta t}{2} (a_{n}[k-1] + a_{n}[k]) \]  

(6)

Position

\[ p_f[k] = p_f[k-1] + \frac{\Delta t}{2} (v_f[k-1] + v_f[k]) \]  

(7)

Where \( a_{n} \) is the acceleration in the inertial reference frame and \( f = x, y, z \)

Having calculated the velocity and the position of the vehicle, it is needed to determine the orientation of this with respect to the inertial reference frame. To complete it, the three Euler angles (Figure 2) \( \psi, \phi, \theta \) are needed, each of these angles is related to the angular velocity that is provided by the gyroscopes that are mounted on the IMU. In the following equation (8) it is shown how they are related [9]:

\[
\begin{bmatrix}
    \dot{\phi} \\
    \dot{\theta} \\
    \dot{\psi}
\end{bmatrix} =
\begin{bmatrix}
    1 & \sin \phi \tan \theta & \cos \phi \tan \theta \\
    0 & \cos \phi & -\sin \phi \\
    0 & \sin \phi \sec \theta & \cos \phi \sec \theta
\end{bmatrix}
\begin{bmatrix}
    \omega_x \\
    \omega_y \\
    \omega_z
\end{bmatrix}
\]  

(8)

Integrating the result of the above equations and taking into account the initial conditions, the Euler angles are derived. The drawback is that for the \( \pm 90^\circ \) pitch angles, the function \( \tan \theta \) becomes infinite. In order to solve this problem the quaternions are used. Taking advantage of the calculation of the quaternions, which was done to determine the transformation matrix of coordinates of the body frame to the inertial reference frame. This information is used to determine the Euler angles. This is presented in the following equations [9]:

\[
\begin{align*}
    \theta &= \sin^{-1} \left[ -2(e_3 e_0 - e_2 e_1) \right] \\
    \phi &= \cos^{-1} \left[ \frac{e_0^2 - e_2^2 - e_3^2 + e_1^2}{\sqrt{1 - 4(e_3^2 - e_0^2)^2}} \right] \\
    \psi &= \cos^{-1} \left[ \frac{e_0^2 + e_2^2 - e_3^2 - e_1^2}{\sqrt{1 - 4(e_3^2 - e_0^2)^2}} \right]
\end{align*}
\]

(9)\( \quad \) (10)\( \quad \) (11)

This way we will count on the speed, position and orientation of the vehicle. The next step is to use the Kalman filter in order to reduce system noise.

3) The Kalman filter

Kalman filter is widely used in the modern navigation systems, due to its ability to integrate various sensors with different bandwidths and also considers variables of interest with good precision. This filter combines a set of mathematical equations that form an optimal algorithm of recursive data processing that provides a stochastic estimate of the state of a variable of interest. In this case is applied to the measured data of the GPS and IMU, in order to obtain a solution with minimal noise. The data coming from the mechanization process are used in the equations of Kalman filter to minimize his error.

The Kalman Filter combined with the information from INS/GPS in order to optimize the system accuracy and get the tradeoffs between the accuracy and the cost. It should be noted that the data from the INS have a sampling period of 5ms, while the GPS is updated every second. For the development of the KF one begins by storing in the memory of the FPGA a distributed set of coefficients matrices and once loaded the matrix the output of the Kalman filter is calculated.
4) Acquisition GPS

The acquisition of GPS is realized by the serial RS232 port on XUP. The information supplied by gps is refreshed every 1s.

And deliver a string of data with all the above formats, it should make a pre-selection of this frame. In this case the format of GPRMC which provides information that will be used in the Kalman filter. The routine makes the detection is to compare each of the data string with the ASCII value of 'M', which defines the beginning of the plot, because it contains no other form this term. Once detected format of interest is observed if the data is valid, it will extract the necessary parameters. Thus, this information is in WGS-84 Geodetic coordinates must be transformed to the coordinate system inertial reference, which requires conversion to the WGS-84 coordinate frame of reference for navigation.

IV. IMPLEMENTACION

To implement the system on the XUP development board was used the development environment 9.1 ISE (Integrated Software Environment) and also the EDK (Embedded Development Kit) from Xilinx. The tests and measures of some hardware components were performed using the ChipScope 9.1. The initial configuration of the system architecture consists of 2 PowerPC 405 processors, one for the management of the JTAG and the other one dedicated to the data-processing that performs the GPS / INS integration. Of the peripherals that provide the BSB (Base System Builder) tool, it was only necessary to use: BRAM of 128KB and RS232_UART. The other components necessary for the system are added as custom IP, which provides versatility and extendibility to the platform.

The architecture implemented (Figure 5) of each of modules of the platform consisted basically of three steps:

1. Acquisition of data coming from the IMU: In this part it was necessary to use 4 DCM (Digital Clock Manager) of the 8 available to the FPGA to reduce the reference clock frequency of the system. In this case a reference frequency of 100MHz was selected and then it was lowered to 2MHz for the management of the ADC of the gyroscopes and the reading of the acceleration. A high frequency was chosen as a reference with the purpose of having enough time for the data processing and thus obtains an estimate of the speed and the position of the vehicle in real time.

2. The data read from the mechanization stage are processed to implement the system on the XUP development board was used the development environment 9.1 ISE (Integrated Software Environment) and also the EDK (Embedded Development Kit) from Xilinx. The tests and measures of some hardware components were performed using the ChipScope 9.1. The initial configuration of the system architecture consists of 2 PowerPC 405 processors, one for the management of the JTAG and the other one dedicated to the data-processing that performs the GPS / INS integration. Of the peripherals that provide the BSB (Base System Builder) tool, it was only necessary to use: BRAM of 128KB and RS232_UART. The other components necessary for the system are added as custom IP, which provides versatility and extendibility to the platform.

3. The system is defined by the following equation

\[ a_{IMU} = a_{real} + a_{bias} + noise \]  

(12)

Where \( a_{IMU} \) is the acceleration measured by the IMU, \( a_{real} \) is the real acceleration and \( a_{bias} \) represents the offset of the measurement of acceleration[5].

Subsequently the system of equations is generated for each of the axes and once we have the continuous-time system, the Matlab is used to change a discrete-time each of the expressions. Since the Kalman filter receives a GPS data every 200 samples of the IMU (per sensor), it is necessary to change a term in the Kalman algorithm to define the moments in which the GPS data are involved and in this way, the reading from the UART it is realized using the libraries generated using the tool EDK. The data read from the mechanization stage are processed using the inertial navigation equations that due to the matrix operations and the math calculation with trigonometric functions present a high computational cost. To solve this problem the Cordic algorithm is used, which is traditionally used for the calculation of transcendental and trigonometric functions, based on the polynomial expansions, such as Taylor polynomials, Min-Max or Chebichev [7]. It also permits the calculation of such functions in a simple, fast and accurate way, without requiring costly hardware for the multiplying, what makes this algorithm suitable for the development of this platform. After the mechanization process the data are passed to the Kalman filter. The creation of each of the matrices used in the filter is implemented in such a way that to the sensors of the IMU a white noise with Gaussian distribution is added. These data are measured when the IMU is still immobile; Matlab is used to determine the mean and variance of each sensor.

The Matlab program is used for the system output. Once the data was obtained the Matlab program
was used to graph the results and observe the system performance. The Figures 6 and 7 show the measurement of the IMU and the output of the platform, where it is estimated the value of the position and velocity respectively.

![Fig. 6. Performance Filter Kalman (Position)](image)

It is noted that the system output has small variations from the true value, in the figure 7 we can see the dates of the velocity.

![Fig. 7. Performance Filter Kalman (Velocity)](image)

In each case for the configuration of the matrices of Kalman’s filter, was considered that the data from the IMU had a white noise with the mean -0.32 (V) and a standard deviation 0.49 (V) equal to each axe. The reports of the resources consumed for each of the modules implemented in the XUP development board, are presented below:

<table>
<thead>
<tr>
<th>Table I. Acquisition (IMU)</th>
<th>Logic Utilization</th>
<th>Used</th>
<th>Available</th>
<th>Utilization</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of Slices</td>
<td>280</td>
<td>13696</td>
<td></td>
<td>2%</td>
</tr>
<tr>
<td>Number of Slice Flip Flops</td>
<td>267</td>
<td>27392</td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Number of 4 input LUTs</td>
<td>301</td>
<td>27392</td>
<td></td>
<td>1%</td>
</tr>
<tr>
<td>Number used as BRAMs</td>
<td>12</td>
<td>136</td>
<td></td>
<td>8%</td>
</tr>
<tr>
<td>Number of PPC405s</td>
<td>2</td>
<td>2</td>
<td></td>
<td>100%</td>
</tr>
<tr>
<td>Number of DCMs</td>
<td>2</td>
<td>8</td>
<td></td>
<td>25%</td>
</tr>
</tbody>
</table>

This report is the consumption of resources for the acquisition of the IMU, which can be seen in the Table I. We are also including the 4 dual port memories with 1KB of size.

<table>
<thead>
<tr>
<th>Table II. Kalman Filter</th>
<th>Logic Utilization</th>
<th>Used</th>
<th>Available</th>
<th>Utilization</th>
</tr>
</thead>
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<td>Number of Slices</td>
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<td>Number of Slice Flip Flops</td>
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<td>27392</td>
<td></td>
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<td>Number of 4 input LUTs</td>
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<td>27392</td>
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</tr>
<tr>
<td>Number used as BRAMs</td>
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<td></td>
<td>11%</td>
</tr>
<tr>
<td>Number of PPC405s</td>
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<td></td>
<td>100%</td>
</tr>
<tr>
<td>Number of DCMs</td>
<td>2</td>
<td>8</td>
<td></td>
<td>25%</td>
</tr>
</tbody>
</table>

VI. CONCLUSIONS

The inertial sensors are widely used in land navigation, its biggest disadvantage is the growth of errors when they do not have a control system, in addition, the price of an IMU with good accuracy in the market is expensive. This platform has shown a very low-cost IMU, which is useful for the cases where a high precision is not required. Even though the GPS is of great utility in the navigation due to its complementary technology with the INS, it is necessary to improve the modelation of the errors of the sensors to obtain a good performance of the Kalman’s filter and thus have a high, precise position. On the other hand, the platform proposed in this paper shows great flexibility for the development of various applications, thanks to its availability of peripherals. It also has the ability to create custom IP which facilitates the implementations taking into account the modular philosophy not only in terms of hardware but also software.

VII. FUTURE WORK

The future work is aim to renew the Inertial Measurement Unit (IMU), decreasing his size and using accelerometers and gyroscopes with better accuracy, remain its low cost. Also it is aimed to adapt other modules of sensors, for example pressure, stress, humidity, light and temperature etc. With the propose of developing a demonstrator that could keep the information temporally and transmit them into the remote base station , based in MPSOC design. The power consumption of this platform is an important aspect that has not yet been calculated, it will be taken into account in the future prototypes.

VIII. REFERENCES


[9] V. Kumar N. Integration of Inertial Navigation System and Global Position System Using Kalman Filtering
