To generate a Realm class, go to Xcode and create a new file. In the right sidebar, choose Realm (Fig. 3):

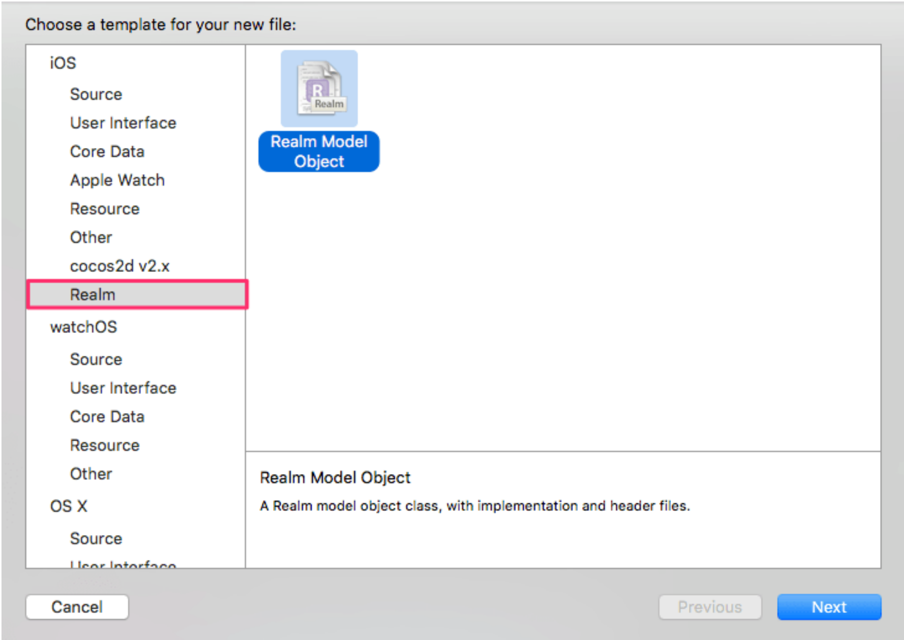



Fig. 3. Realm Class Generation

With the help of the instructions given above, Realm can be used in various projects.

REFERENCES

1. Realm [Электронный ресурс]. / Realm Swift. – 2015. – Режим доступа: https://realm.io/docs/swift/latest/. – Дата доступа: 14.12.2015.

**UDC 004.414.23**

## PROGRAMMING MODEL OF SIDE-VIEW SYNTHETIC APERTURE RADAR

***ALIAKSANDR PRONIN, MIKHAIL IVANOU***
**Polotsk State University, Belarus**

*The article considers the principle of operating a side-view Synthetic Aperture Radar on an unmanned aircraft, its mathematical model and software model algorithm, the results of the synthesis of radar images obtained by probing the Earth's surface relief area.*

**Introduction:** currently, monitoring the state of the earth's surface, mapping and obtaining information about certain earthly objects are implemented by radio-wave systems. As such, synthetic aperture radar (SAR) systems are used, which are installed on board of space and ground-based aircrafts. The result is high resolution, and the information obtained is characterized by high detail [1].

When using a synthetic aperture method, a high resolution synthetic aperture formation is achieved as a result of the translational movement of the aircraft carrying the antenna, which radiates probe signals in a direction perpendicular to the track. The spatial resolution of the SAR can be made sufficiently high, regardless of the altitude of the aircraft.

Nowadays the SAR uses digital signal processing techniques. This makes it possible to realize the synthetic aperture antenna algorithms in real time and in terms of an arbitrary maneuvering aircraft. The challenge of digital processing of radar image (RI) is solved by programmable logic integrated circuits (PLIC) of FPGA type, due to their high performance and concurrency work. Also, FPGA is ideal for multiplication operation [2], which is an integral part of radar data processing.

**The goal:** to develop a program SAR model, which will be the basis for synthesis algorithms development and radar images correction.

**Objectives:** to synthesize the mathematical SAR model to calculate its basic parameters, to develop SAR software model algorithm.

The block diagram in Fig. 1. explains the principle of the SAR work

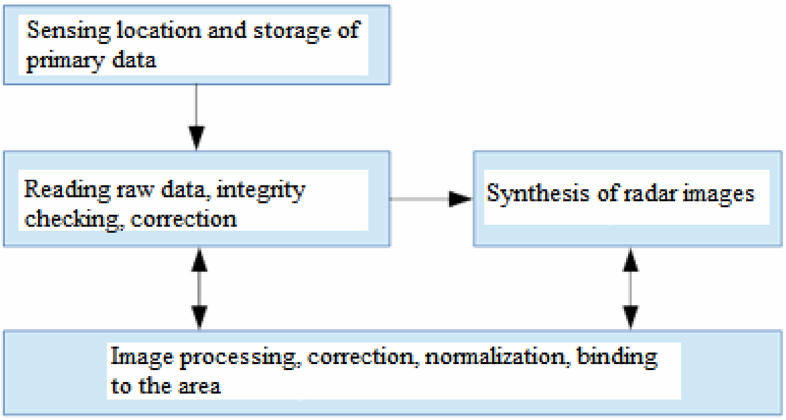



Fig. 1. Block diagram of the SAR algorithm

The geometrical model of the SAR is shown in Fig. 2. Supposing there is a point A (X, Y, Z) in some relief area. The antenna aircraft, which moves in the Y direction, is shown with C. The azimuth scan image (X-axis) is formed through the antenna pattern (OE-line segment), and in the elevation angle (Y-axis) it is formed as the result of the aircraft movement. Ideally, the aircraft altitude is not changed and is a known quantity. The change of the probed surface height with respect to the aircraft antenna results in a change of the time delay or the phase of the received reflected signal relative to the reference signal. Accordingly, knowing the parameters of the phase of the received signal it is possible to extract information about the probed surface relief.

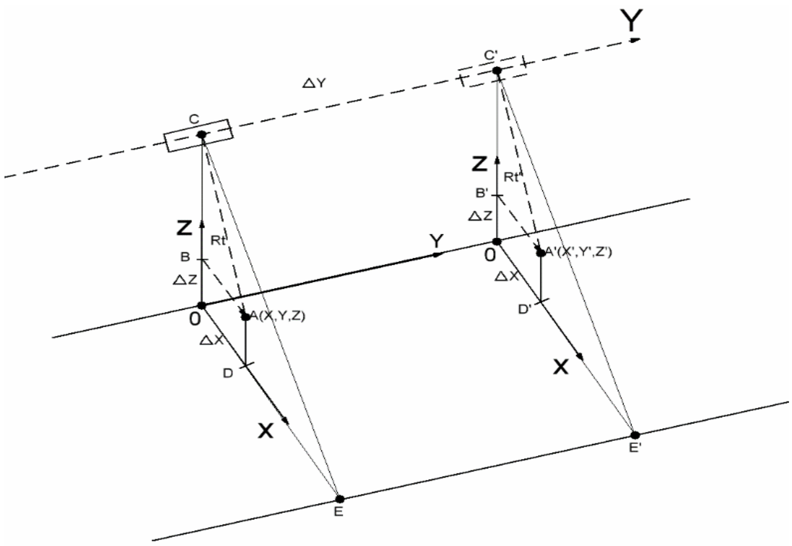



Fig. 2. The SAR geometric model

Considering that the received signal travels from the antenna to point A and is reflected back from point A to the antenna, the delay value is determined according to the expression (1):

$$\tau = 2 * Rt / c, \tag{1}$$

where C is light velocity, Rt - the distance between the antenna (point C) and the relief point (point A).

The value of Rt can be determined from the right triangle ABC, where Rt is the hypotenuse. The value of AB leg defines the coordinates of A (X), the value of BC leg is determined from expression (2):

$$\Delta h = BC = H - \Delta Z \tag{2}$$

where H is the height of the flight of the aircraft, $\Delta Z$ is A (Z) coordinate, $\Delta h$ is the height of the aircraft with respect to point A.

Accordingly, Rt is determined by expression (3):

$$Rt = \sqrt{\Delta h^2 + X^2} = \sqrt{(H - \Delta Z)^2 + X^2}\,. \tag{3}$$

Taking into account expressions (3) and (1) the amount of delay of the received signal is determined by expression (4):

$$\tau = \frac{2 * \sqrt{(H - \Delta Z)^2 + X^2}}{c}\,. \tag{4}$$

Modern SAR uses sophisticated probing signals, mainly with chirp modulation. It is also possible to use the phase modulation (PM) probing signals, which require simpler equipment. However, the appearance of phase distortion in the probe pulse caused by the Doppler frequency shift of the received signal, limits the use of PM signals in the high-resolution SAR diffraction. And the use of short pulses leads to interference caused by the "irregular" pulse in neighboring soundings [3]. Therefore, the developed software model uses chirp signal modulation, which is described by expression (5):

$$U_{лчм}(t) = \begin{cases} 0, t < -\tau_u / 2, \\ U_m \cos(\omega_0 t + \mu t^2 / 2), -\tau_u / 2 \le t \le \tau_u / 2, \\ 0, t > \tau_u / 2, \end{cases} \tag{5}$$

where μ is the rate of chirp signal frequency change, which is determined from expression (6):

$$\mu = \frac{f_{\max} - f_{\min}}{\tau_u}\,. \tag{6}$$

The reflected signal with a time delay $\tau_з$ is determined by expression (7):

$$U_{лчм}(t + \tau_з) = \begin{cases} 0, t + \tau_з < -\tau_u / 2, \\ U_m \cos(\omega_0 (t + \tau_з) + \mu (t + \tau_з)^2 / 2), -\tau_u / 2 \le t + \tau_з \le \tau_u / 2, \\ 0, t + \tau_з > \tau_u / 2, \end{cases} \tag{7}$$

The azimuth resolution is determined by multiplying the width of the radiation pattern of the antenna at a distance to the target [4] and is determined according to expression (8):

$$\Delta X = \lambda R / L, \tag{8}$$

where R is aircraft flight altitude, $\lambda$ is the wavelength of the probing frequency signal, L is the length of the aperture in the azimuth direction.

The results of the calculations of the SAR model basic parameters are shown in Table.

SAR Model Characteristics

| Parameters | Characteristics |
|---|---|
| Azimuth discrimination | 0.5m |
| Range resolution | 0.08m |
| Flightspeed | 25 m / s |
| Flight altitude | 1000m |
| Probing pulses frequency | 300 Hz |
| Wavelength | 5 cm |
| Pulse duration | 10mcs |
| Speed chirp | $4.1{*}10^{11}c^{-2}$ |
| Sampling frequency | 1MHz |
| Aperture size | 100m |
| The number of PAR elements | 250 |

The echo signals are stored in the form of a matrix, whose number of lines is determined by the number of phased array L elements, and the number of columns is determined by the number of M samples. And the overall size of the matrix will depend on the flight time, i. e. a set number of increments of range (N-1) and will be be LxM * N (Fig. 3).

The SAR simulation software uses «Matlab» applications package.

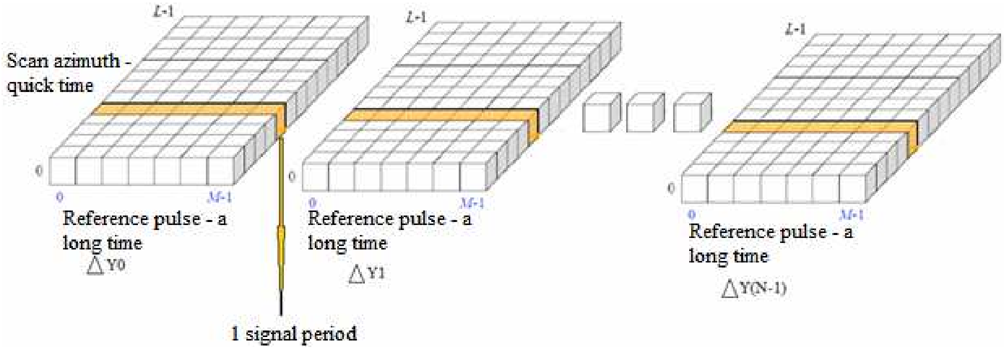



Fig. 3. The formation of the radar data matrix

The algorithm that simulates the above SAR parameters is worked out. It generates echoes reflected from the relief surface, and stores them in an array of radar data. The structure of the algorithm is shown in Fig. 4.

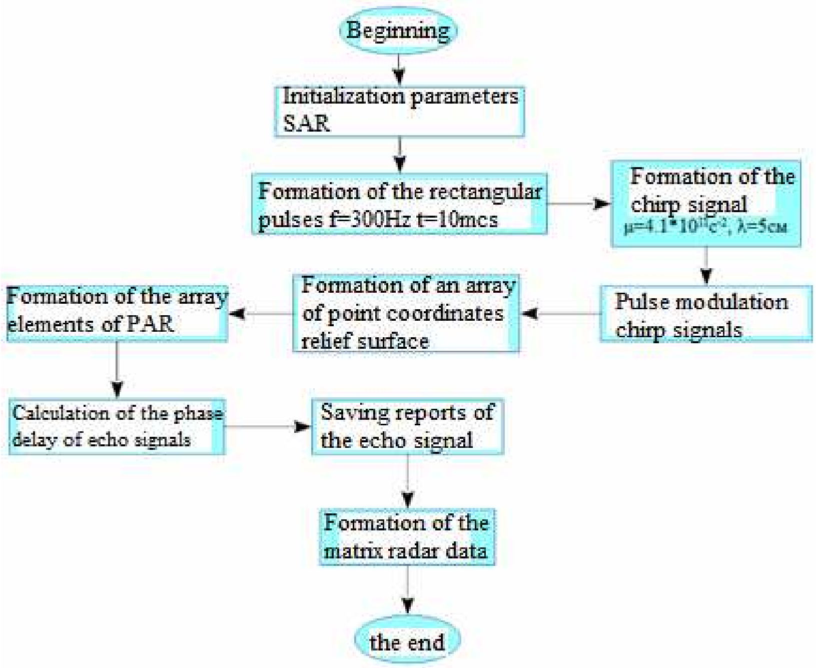
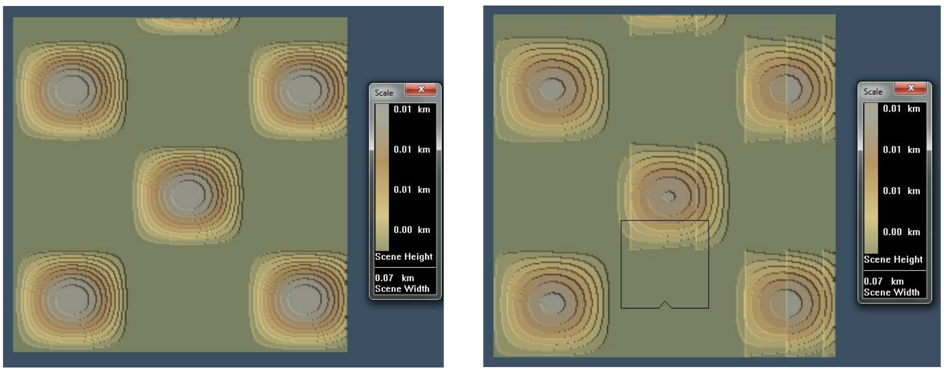



Fig. 4. SAR Software model algorithm

The simulation results are shown in Fig. 5. The probed surface modeled in MATLAB and visualized with 3DEM program, is shown in Fig.5 (a). The synthesis of the radar data is carried out with the help of the correlation processing (Fig.5 (b)).




(a) (b)

Fig. 5. Simulated surface (a) obtained in radar data (b)

**Conclusion.** Fig.5 (b) shows that the radar data matrix has some irrelevant distortions related to the sampling frequency of echoes and the viewing angle change.

SAR programming model allows to simulate the formation of radar images in rectilinear uniform motion of the aircraft over the site of the relief area. The model is the basis for the development of fast algorithms for the synthesis of radar images, for radar data correction algorithms in the drift trajectory of the aircraft, as well as for filtering algorithms. It helps to assess the technical requirements for the SAR functional blocks at its implementation.

REFERENCES

1. Кондратенков, Г.С. Радиолокационные системы дистанционного зондирования Земли : учеб. пособие для вузов / Г.С. Кондратенков ; под ред. Г.С. Кондратенкова. – М. : Радиотехника, 2005. – 368 с.
2. Беляев, А. Современные устройства цифровой обработки сигналов. Вместе или врозь? / А. Беляев, Т. Солохина, В. Юдинцев // Электроника: Наука, Технология, Бизнес. – 2009. – № 1. – С. 28–35.
3. Радиолокационные системы землеобзора космического обзора / В.С. Верба [и др.] ; под ред. В.С. Вербы. – М. : Радиотехника, 2010. – 680 с.
4. Применение цифровой обработки сигналов [Электронный ресурс]. – Режим доступа: http://lib.alnam.ru/book_acos.php?id=86. – Дата доступа: 13.12.2015.

**UDC 621.372.037.372**

## THE ANALYSIS OF METHODS OF SIGNALS RECEPTION IN TECHNICAL CHANNELS OF INFORMATION LEAKAGE

***DZIANIS RABENKA, VLADIMIR ZHELEZNYAK***
**Polotsk State University, Belarus**

*According to a digital signal definition an actual problem is to establish numerical values of criterion of speech signal security. The criterion of speech signal security should correspond sufficiently to the criterion of a speech signal in a digital form.The criterion sets limit, which value is a border between presence and absence of a speech signal in a leakage channel.*

The transfer of **digital information** has obvious advantages if compare it to transfer of analogue information. Methods of protection from information leakage became more complicated thanks to obtaining of high quality and high level of reliability of **digital information** transfer.

The primary analog speech signal is biological. Thereupon its transformation to the digital form provides naturalness of the restored speech for qualitative perception. Transfer of speech signals in the digital form through communication channels (data transmission) is caused by a number of transformations because digital signals should be transferred through analog channels (tone frequency channel), i.e. correspond to spectral efficiency.

The purpose of the present research is to substantiate the possibility of application of binary signals for security estimation of digital signals with various structural characteristics and parameters in channels of information leakage.

Thereto it is necessary to take the analysis of structural characteristics and parameters of signals in information leakage channels.

General structure of communication system is a complex of message source, transmission channel and addressee (receiver). At this point the channel is a part of transmission system, kind and characteristics of which are specified and their change is complicated or simply impossible. The problem solved by transmission system is to transfer a message *m* from an originator to an addressee. As a rule, the source message is presented in such form in which its effective channeling is impossible. Therefore transfer and reception devices are usually included in the system. Given devices transform a message *m* into a signal *s* and transform an accepted signal *r* into an accepted message *m*!.

Thus transformation $m \to s$ carried out by the transmitter is biunique and determined; transformation $s \to r$ defined by the channel is casual; transformation $r \to m!$ carried out by the transmitter is determined but not biunique.

If a source generates messages from final set it is called a source of discrete messages, otherwise a source is called a source of continuous messages.

Process of transformation of a signal by message is called modulation. Change of parameters of a signal according to the message which is subject to transfer is carried out during modulation. If a set of signals formed during modulation is final modulation, it is called discrete or digital.