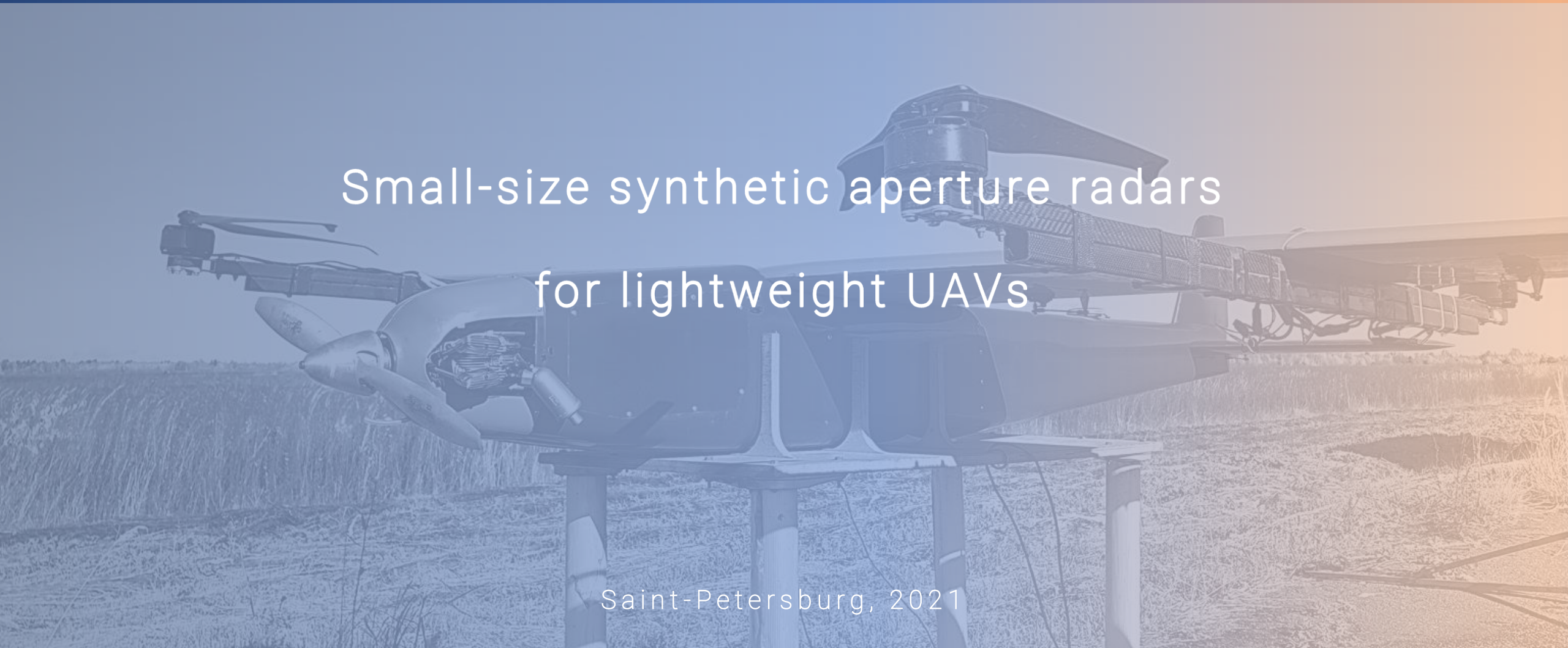
Scientific Center of Applied Electrodynamics JSC



Small-size synthetic aperture radars for lightweight UAVs

Saint-Petersburg, 2021

Synthetic aperture radar. Options

The synthetic aperture radar (SAR) for small UAVs is an in-house development of SCAE JSC. It is produced in several modifications:

- small-sized X-band SAR;
- small-sized L-band SAR;
- small-sized L and X-bands SAR;

X-band SAR

- frequency range – from 9.3 up to 9.8 GHz;
- hardware unit weight – 1.6 kg;
- antenna weight – 0.18 kg;
- antenna dimensions – 200 x 100 x 20 mm;

L-band SAR

- frequency range – from 1200 up to 1350 MHz;
- hardware unit weight – 1.6 kg;
- antenna weight – 0.7 kg;
- antenna dimensions – 800 x 200 x 40 mm;

LX-band SAR

Dual-frequency radar.

- hardware unit weight – 2.5 kg;
- antennas weight – 1 kg.

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Advantages of radar monitoring

Radar monitoring allows to get images in low cloudiness, smoke and at night. It makes possible to bind image objects in distance to the trajectory of the carrier.

Features of L-band radar monitoring:

- observation of objects in optically opaque environments: under the foliage of trees, in dense vegetation, under snow and ice, under a thin layer of soil, under radio transparent domes;
- revealing the heterogeneity of the structure of optically opaque media: snow, ice, soil.

Features of X-band radar monitoring:

- high resolution images;
- smaller (in comparison with the L-band) dimensions of the radar antenna.

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X-band SAR

An X-band antenna is represented as a 32-element in-phase bipolarizing array.

- Frequency range is from 9.3 up to 9.8 GHz.
- VSWR – no more than 1.6.
- Polarization isolation coefficient – not less than 21 dB.
- Dimensions – 200 x 100 x 20 mm.
- Gain is 19 dB.

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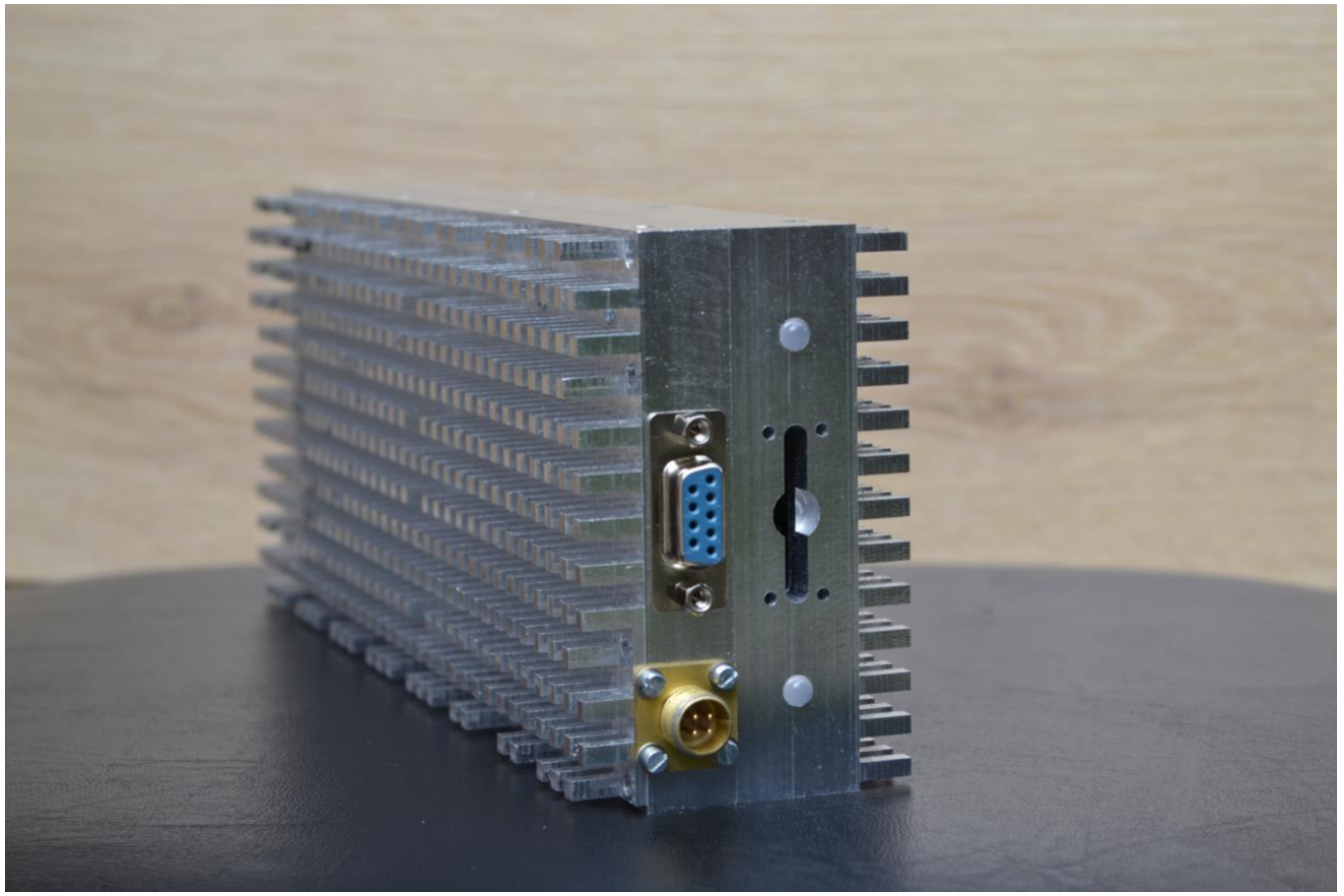
X-band SAR

Photo and overall dimensions of the SAR hardware unit in a single-frequency design.



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SAR hardware

Hardware is built on the principle of software-transformable radio electronic means – frequency, spectrum width, signal type, polarization can be changed only by software.

Digital signal processing unit

(ADC of the receiving part, DAC of the chirp signal shaper, control and signal processing FPGA)

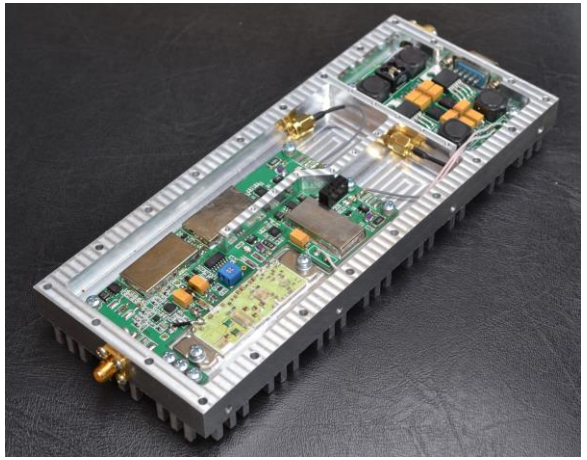
ADC sampling frequency – 1100 MHz

DAC frequency – 2200 MHz

The DSP unit includes:

- analog-to-digital converter (ADC),
- digital-to-analog converter (DAC),
- amplifiers of synchronization signals,
- system on a chip (SoC),
- random access memory SDRAM DDR3,
- reference generator with an operating frequency of 50 MHz,
- USB 3.0 interface controller,
- converter of TTL to LVDS levels.

An analog part of the transceiver unit with an output pulse power of the transmitter equal to 40 W.



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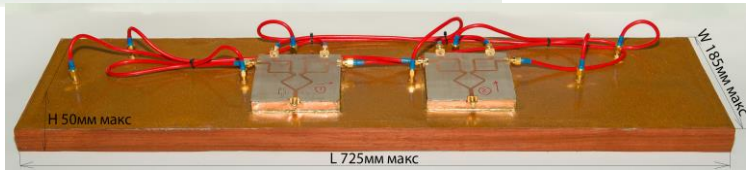
L-band SAR

Photos and overall dimensions of an L-band antenna represented as a 4-element in-phase bipolarized antenna array.

- Frequency range is from 1200 up to 1350 MHz
- VSWR – no more than 1.4.
- Polarization isolation coefficient – not less than 16 dB.
- Dimensions – 800 x 200 x 40 mm.
- Gain is 14 dB.



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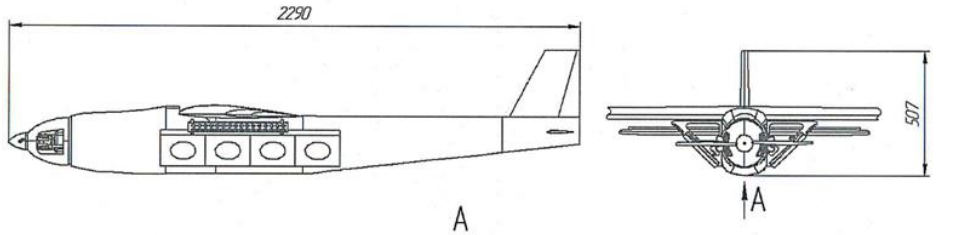
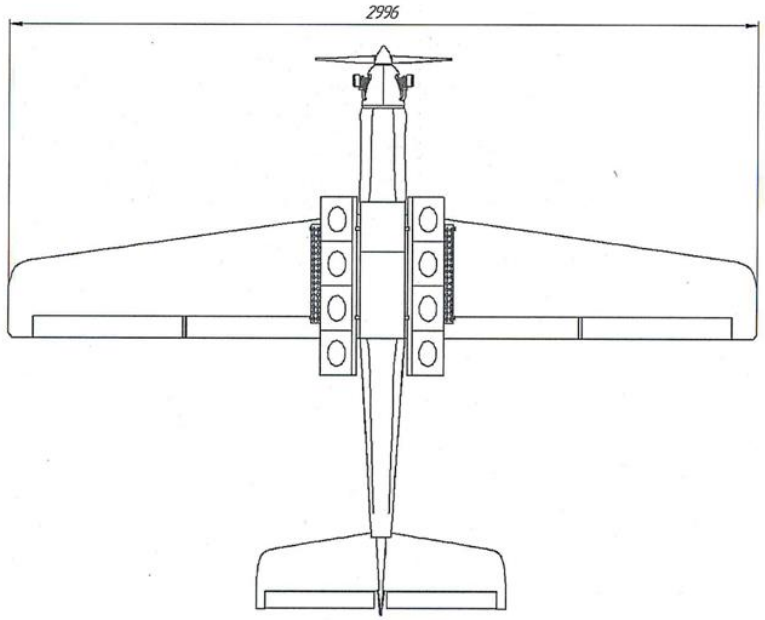
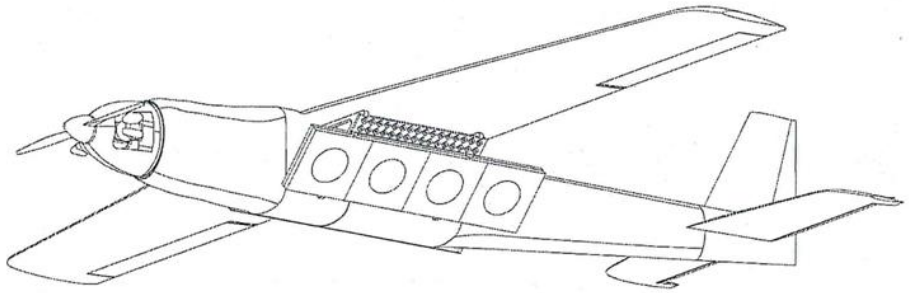
LX-bands SAR

Placement of X- and L-band antennas on the UAV for dual-frequency SAR option.







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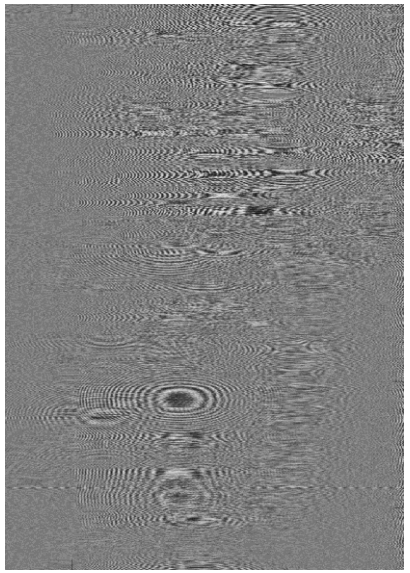
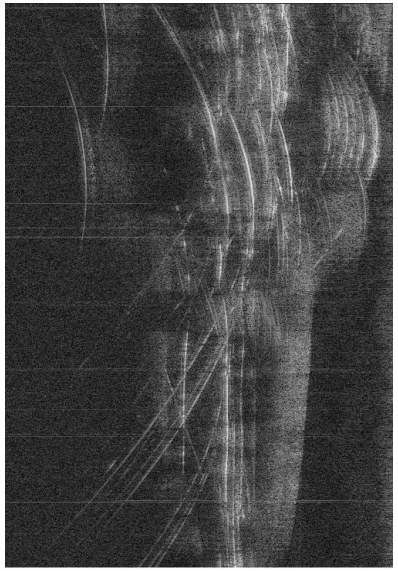
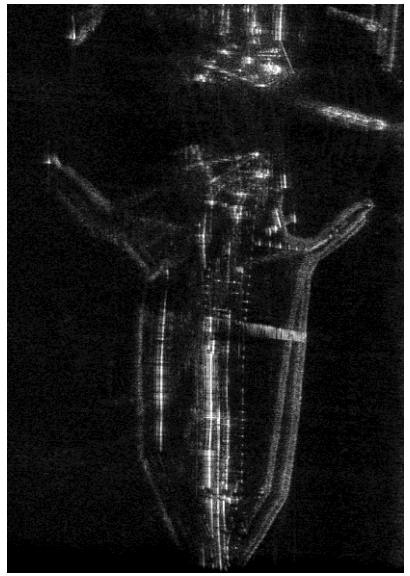
Results



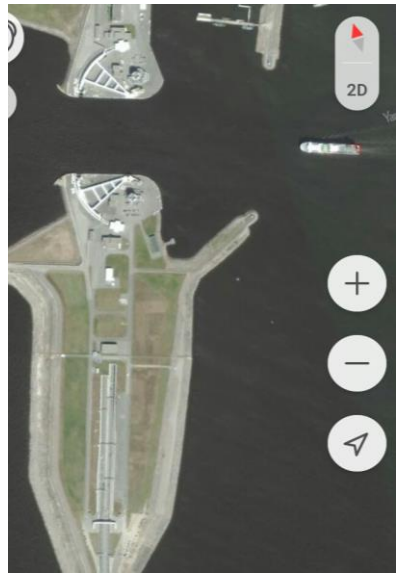
Radio hologram – raw data



Radio hologram after range compression



Radar image



Visible image

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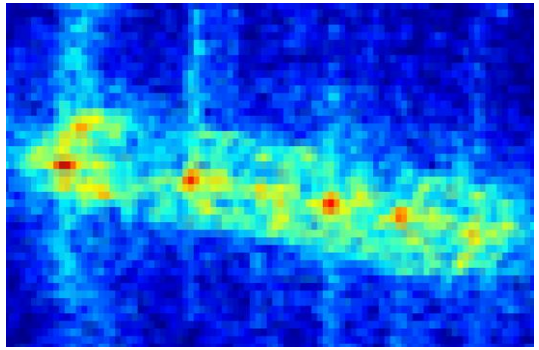
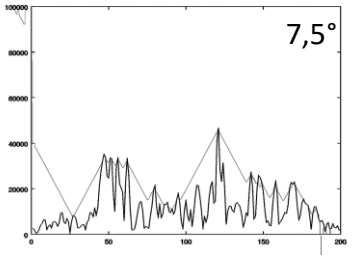
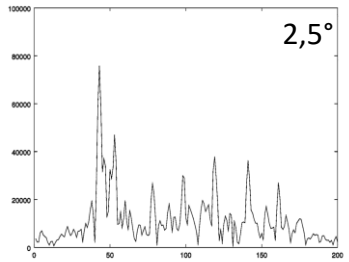
Results

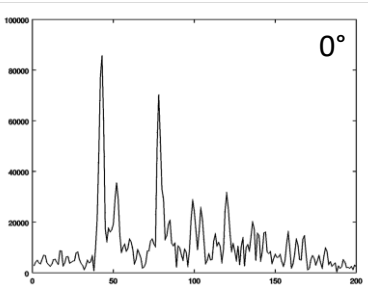
Visible image



2-dimensional radar image





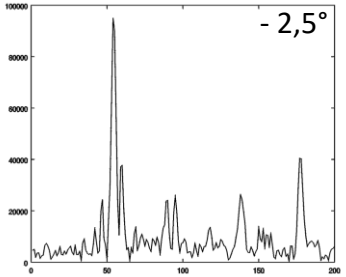


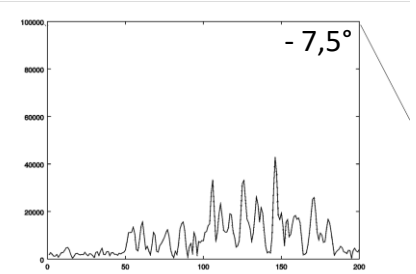
Experimentally obtained long-range portraits of the vessel in the L-band at azimuth angles from -7.5 ° up to + 7.5 °.

Flight altitude – 400 m

Speed – 120 km / h

Range to the vessel – 1100 m





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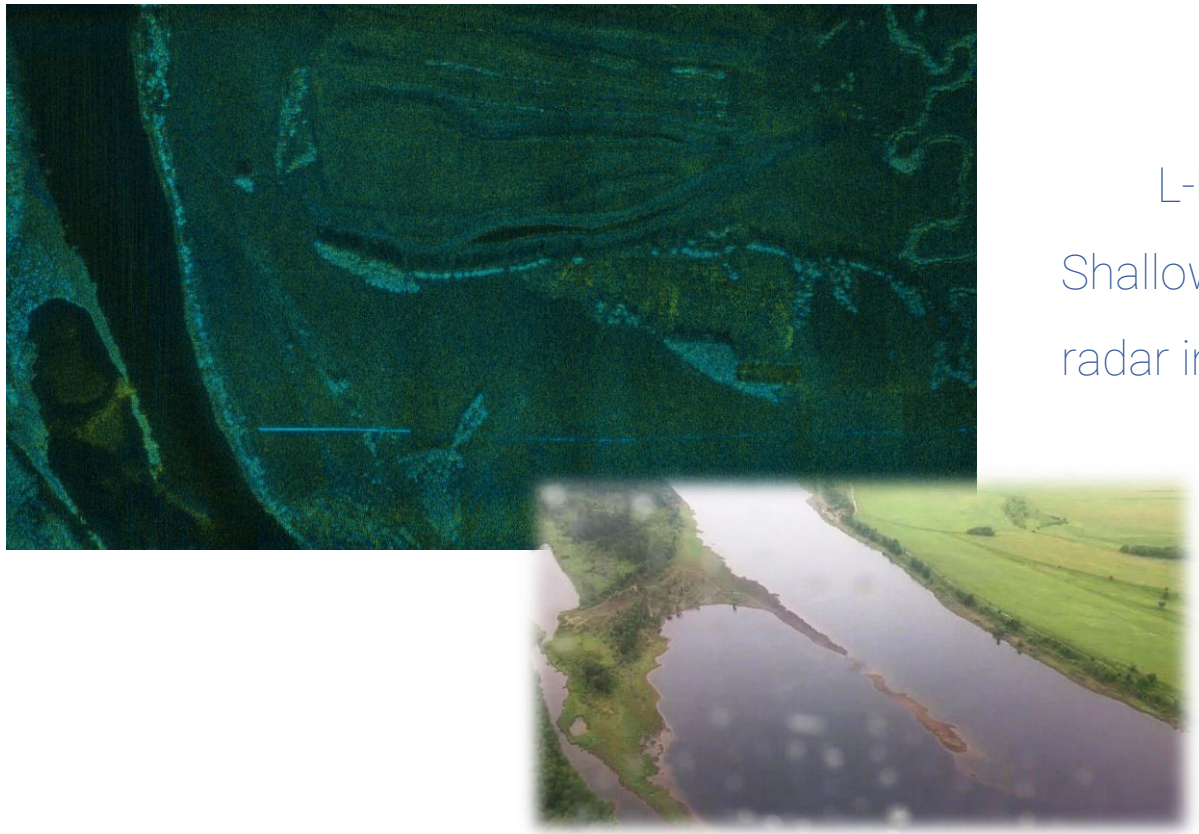
Results



L-band bipolarized image. On the left – the river. Shallows are visible in the horizontally polarized radar image (yellow color)

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Results

Photo and radar images of treatment facilities

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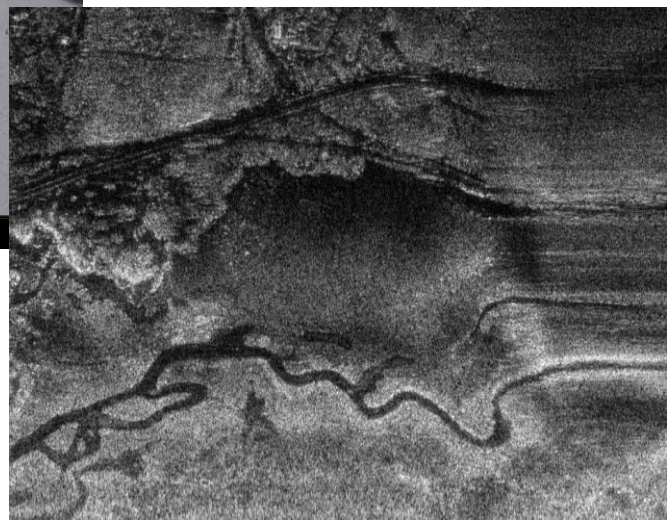
Results

A frozen river under snow is not notable in the visible range but is remarkable on L-band radar images as a dark strip corresponding to a lower intensity of the radar signal reflection.



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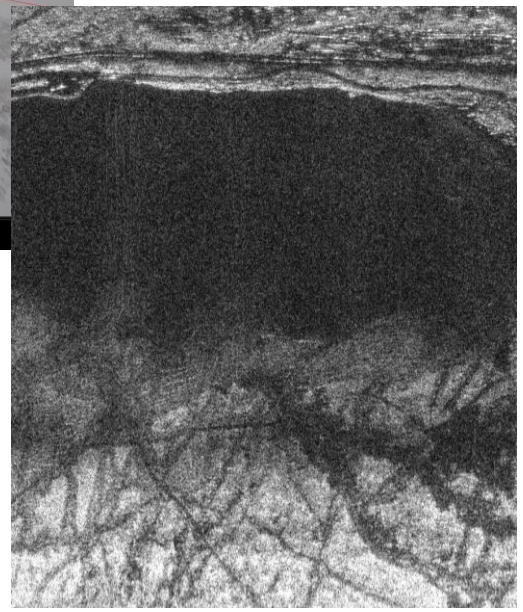
Results

L-band radar images can reveal the inhomogeneous structure of the ice cover. Cracks in the ice are not visible in the optical image and are visible in the L-band radar images. Inhomogeneities are most pronounced at large angles of irradiation of ice.



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