# GSI's Synthetic Aperture Radar (SAR) Application Brief

## Introduction

GSI's Synthetic Aperture Radar (SAR) application brings new promise to the field of synthetic aperture image construction.

Running on GSI's Gemini® APU chip, the SAR application uses a backprojection algorithm to construct the synthetic-aperture images from the input array of pulses.

## GSI APU advantages

Backprojection is widely considered to be the optimal algorithm for synthetic-aperture image processing. It's best suited for data transmitted from various space and airborne platforms, permitting submeter ground resolution and various frequencies. However, its usage remains prohibitive, due to the computational cost of running it on a CPU or GPU.

## GSI's APU Chip Changes All That

The processing speed of the GSI APU is significantly faster than CPU and GPU—tens to hundreds time faster. Optimized to take advantage of the GSI chip's parallel computing power, the GSI SAR application allows:

1. Using the backprojection algorithm for best image construction results.
2. Near Real Time (NRT) processing capabilities that significantly shorten the time to customer images/data delivery.
3. On-board processing capabilities, when required, for example, on a manned intelligence mission aircraft.
4. Significant computing cost reduction.

## How it works

Satellites, manned mission planes, and drones use SAR radars to send out pulses continuously, day and night, under all weather conditions. The information received back from the pulses is then used to construct an image of the area.

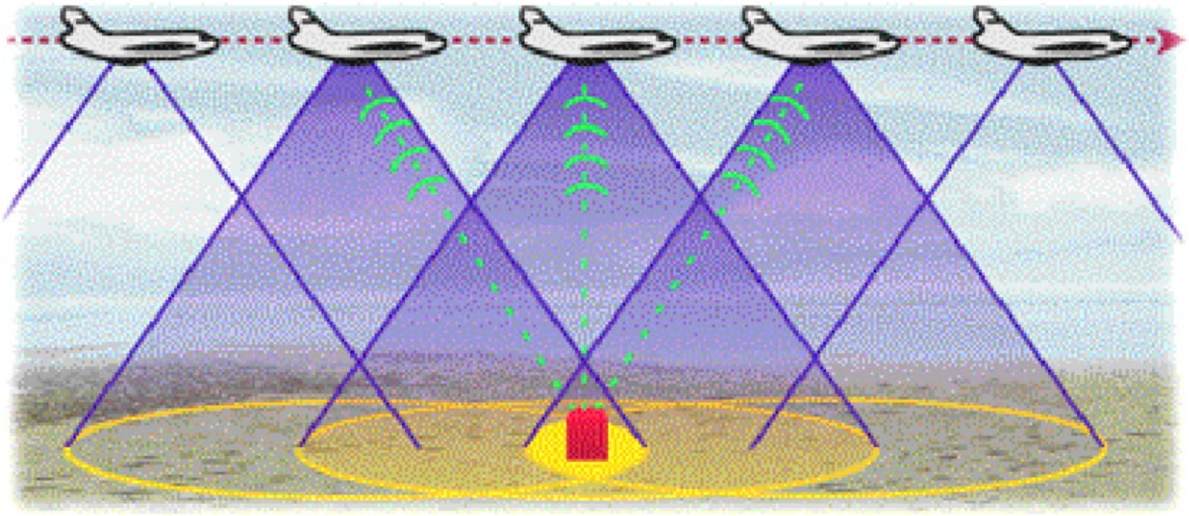

**Figure 1: Multiple Radar Beams**[1]

The GSI SAR API receives these pulses as a 2D numpy array of 32-bit floating point values. Using backprojection on the input array, the API is able to analyze the intensity of the pulses projected back from the ground to the platform and to construct an image of the area.


**Figure 2: SAR Image vs. Histogram Image**

[1] Image source: https://www.semanticscholar.org/

## Specifications

| Specification | Category | Supported range |
|---|---|---|
| Platform speed | Manned mission aircrafts | ~900 Km/hour |
| | Medium class UAVs | ~170 Km/hour |
| | High-altitude drones * | ~450 Km/hour |
| | LEO satellites* | 28,100 Km/hour |
| Supported transmission altitudes | Mission aircraft, drones | Up to 20 Km |
| | Satellites | ~500-1000 Km |
| Pulse input array | Capacity | Typically: 1000–10,000 pulses (No limitations for higher needs) |
| File input format | NPY extension file of 32-bit floating point values | MATLAB format |
| Surface topography Z-tolerance | All | Support all |
| Image ground resolution | Area of ground covered by digital individual pixel | Between 0.1 and 100 meters |
| Precision mode | Variable fixed point | High precision mode using 16 bits fixed points<br>Low precision mode using 8 bits fixed points |

*Not implemented yet

| GSI APU SAR Benchmark vs. GPU & CPU<br>April 21, 2021 - Image: Output - 10K X 10K Pixels, Input pulses # -10K | | | | | |
|---|---|---|---|---|---|
| **Parameters** | **Value/ Unit** | **APU Leda-S @ 350 MHz** | **APU Leda-E @ 500 MHz** | **Intel CPU** | **Nvidia GPU** |
| Floating point definition | — | Variable size fixed point | Variable size fixed point | FP 32-bit | FP 32-bit |
| Score - total time | Minutes | **4.7 min** | **3.3 min** | 60.0 min | 6.3 min |
| Time per one pulse | Milliseconds | **28 ms** | **19.8 ms** | 360.0 ms | 38.0 ms |
| Power | Watts | **39 W** | **57 W** | 113 W | 160 W |
| HW used | — | 1 APU card | 1 APU card | 1 CPU Intel Xeon 5115 Gold 20 core | 1 Nvidia V-100 16 Gbyte |

| SAR benchmark—Single server comparison<br>April 21, 2021 - (APU vs. Nvidia V-100 GPU and Intel Xeon Gold) | | | |
|---|---|---|---|
| **Single server solution** | **Size** | **Total server power** | **Performance, Normalized to one image** |
| APU server: Supermicro 1029P:<br>16 Leda-S cards | 1 U | 1.2 KW | 0.29 min |
| APU server Advanced Sky 6200:<br>8 Leda-E cards | 2 U | 1.0 KW | 0.41 min |
| Nvidia Tesla V-100 server:<br>8 V-100 cards<br>16 Gbyte | 4 U | 3.6 KW | 0.79 min |
| Intel Xeon Gold server<br>8 cards | 2 U | 2.1 KW | 7.50 min |

**Note:** Using 8-bit IFFT improves APU speed by 18%, causing slight degradation in quality (1-2%).

## 5 Km x 5 Km SAR Image, 0.5 resolution Image in 1 Second Scenario

Intel Xeon Gold Based
~ 23 cabinets

NVIDIA V-100 based
~ 5 cabinets

GSI APU based
0.4 cabinet (Leda-S 350)
Portable

| | | CPU | GPU | APU |
|---|---|---|---|---|
| **5 Years** | **Total Power** | 84.0 M KW | 15.0 M KW | 1.9 M KW |
| | **Power Cost** | $10.9M | $1.9M | $0.2M* |
| **Infrastructure** | | 23X | 5X | 0.4X |

*Price/kwh is $0.10.

**GSI delivers the most cost-effective solution.**

For more information, contact us at: aerospace@gsitechnology.com.