SDL/12-388A

SPACE DYNAMICS LABORATORY

RASAR

REAL-TIME, AUTONOMOUS, SYNTHETIC APERTURE RADAR

Real-time, Autonomous, Synthetic Aperture Radar (RASAR) is a quad-polarization, dual-band SAR designed to be SWAP compatible with deployment on the Shadow-200 or STUAS Integrator UAS. RASAR has been developed as one component of a suite of cooperative sensors designed to enable real-time, cross-modal data fusion.

RASAR is a self-contained system that can be flown in an external pod mounted under the wing of the Shadow or other UAS, minimizing any impact on current ISR payloads. A single-band podded system weighs less than 25 lbs and requires less than 150 W of total power. To maximize the system flexibility to the fleet, RASAR has adapted the Naval Research Laboratory's (NRL's) Software Reconfigurable Payload (SRP) open architecture design concept, and has been developed as a set of card swappable modules that can be directly inserted into a standard SRP chassis. SRP is a USMC Program of Record and supports RF communications and operations across the full spectrum of RF frequencies.

RASAR is part of a continuing research program developing compact, autonomous-sensing systems compatible with UAS operations and deployments. The sensor development was led by NRL, in conjunction with the Space Dynamics Laboratory (SDL) and SRC, Inc. This research was conducted under the Office of Naval Research (ONR) sponsored FEATHAR (Fusion, Exploitation, Algorithms, and Targeting for High-Altitude Reconnaissance) program and is continuing under the ONR-sponsored Tactical EO/IR/SAR/SIGINT Integrated for Targeting (TEISIT) program.

SPECIFICATIONS

OPERATING BAND (L-BAND)	1215 – 1390 MHz *(0.9 m resolution)*
OPERATING BAND (X-BAND)	Range: 9.5 – 10.5 GHz *(400 MHz)*
PEAK TRANSMIT POWER	25 – 44 W
SYSTEM POWER	150 W
WEIGHT	25 lbs (L-Band)
MAX ALTITUDE	≤ 8000 ft, AGL
STANDOFF	500 – 4000 m
MAX SWATH WIDTH	4 km
EFFECTIVE PRF	≤ 1kHz
BEAMWIDTH	80° (L-Band), 7° (X-Band)
NAVIGATION SOLUTION	DGPS/MEMS
POLARIZATION	HH, VV, VH, HV
PROCESSING MODES	Real-time onboard back-projection, GMTI, full-swath ground-assist back projection

APPLICATIONS

- Day-night **all-weather** imaging
- Direct, single pass, **thin target detection** capability
- Demonstrated performance in **counter IED** mission
- Provides moderate **foliage & snow penetration** capability
- Arbitrary waveform generation provides interference mitigation & **spectrum agility**
- **Wide Azimuth Beam** (WAB) capability
- Multi-aperture image enhancement
- Persistent surveillance & area survey operational modes
- Simultaneous HH/VV polarization, **quad-polarization**
- Change-detection (CD)
- **Rapid add-on capability** for existing theater assets
- High power, 25,000 ft altitude available with a modest SWAP increase
- Ground Moving Target Indicator (GMTI)

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RASAR

DATA FLOW & PROCESS

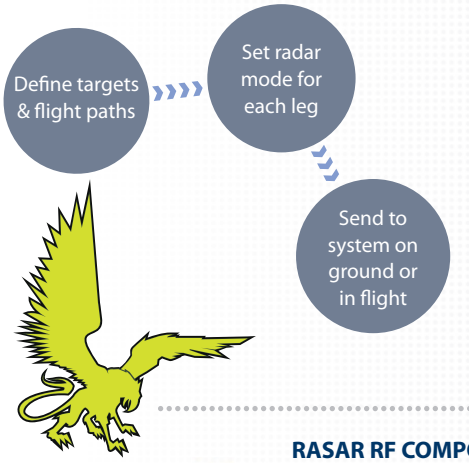
MISSION OPERATION

Planning

A collection of targets and flight paths is defined prior to take-off and composes a mission. For each leg, the radar mode of operation (HH/VV, quad polarization, interferometric) is set.

Operation

During a flight, the radar automatically turns on and off as it passes the targets defined in the mission. The data is automatically processed and stored or downlinked. The sensor can be dynamically tasked in flight by operators or cross-cued by other sensors.



ONBOARD PROCESSING

Pre-processing

Data is captured at 1.6 GHz with 12 bit samples. The raw samples are digitally demodulated into raw baseband IQ (In-phase Quadrature) data. Normal operational pulse repetition frequency is between 10-20 kHz. Pulses are filtered and aggregrated to knock out returns from outside the antenna beam and provide a boost to the SNR.

Geometry Compression

Given RASAR's wide beam, the data is further filtered so that only the samples needed to reconstruct the target are kept. Specifically, the data is filtered and decimated so that only the target/beam intersection is kept. Range compression and clipping of unneeded range samples is also performed. Data compression rates of 20x are achieved, which enable transmission of the data down a 8 Mbps datalink.

Onboard Image Formation

Onboard FPGA runs backprojection algorithm to produce basic images.

Data Storage & Downlink

The raw data, geometry compressed data, and formed complex images are stored in the sensor's solid state disk. All can be downlinked to a ground user.

GROUND DISPLAY

Database Cataloging

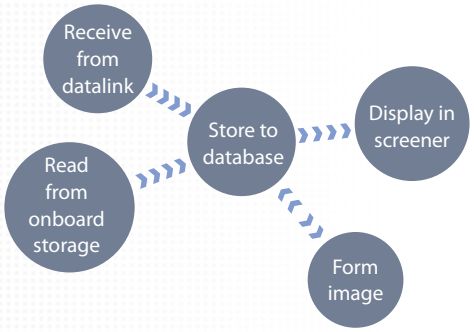
Data is received from the datalink or read from the onboard storage and stored into a database.

Image Formation

Backprojection is used on the ground to form full images. The algorithm has been optimized to use a GPU to enable near real-time processing of the data as it is downlinked.

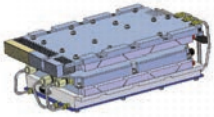
Screener Display

Images are displayed to the end user. Change detection, HH/VV subtraction, and various other post processing are performed at this stage.



SYSTEM HARDWARE

RASAR RF COMPONENTS



Receiver / Exciter Unit

- 12-bit 1600 MHz DAC & ADC drive direct signal synthesis & recording

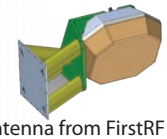
LNA/PA Unit

- 25 W peak power amplifier
- Low-noise amplifier design optimizes to available SWAP

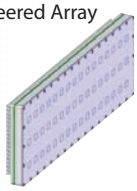
RASAR POD

- Adapted from a prior NRL program
- Proven pod system with 100+ flight hours

RASAR ANTENNA

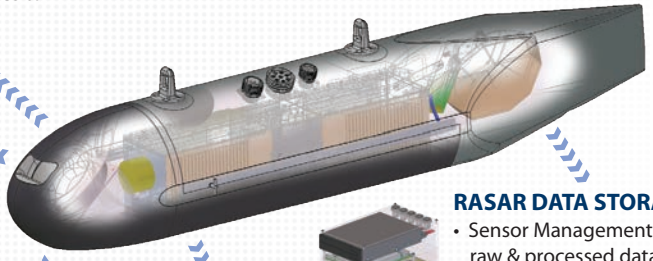


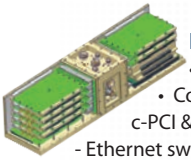
- Compact L-band antenna from FirstRF
- Active Electronically Steered Array (AESA) X-Band



X-BAND TRANSCEIVER

- Dual channel



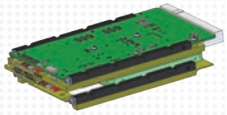


RASAR CHASSIS

- Use existing SRP chassis
- Compact-PCI backplane provides for c-PCI & Ethernet connectivity
  - Ethernet switch resident on backplane
- 100 MHz system clock & interlocked GPS receiver are resident on chassis backplane
- Clock & 1-PPS signals routed to all c-PCI slots
- SRP chassis entered flight testing in April 2011

RASAR DATA STORAGE

- Sensor Management System (SMS) provides raw & processed data storage & datalink management functions
- All connectivity is via Ethernet
- SMS is mounted centerline or in a second wing-pod

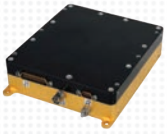


RASAR PROCESSING & CONTROL CARD

- Combined i7/FPGA card stack
- Performs system command & control, digital spotlighting, navigation processing, & image formation processing
- Additional processing cards enable expanded airborne image formation processing

RASAR NAVIGATION

- Differential GPS combined with high-accuracy INS provides high-quality navigation solution
- RASAR testbed uses Novatel CPT system (DGPS/FOG)
- RASAR UAS system will use Novatel DPGS receiver combined with Honeywell HG1900 IMU



RASAR DATALINK

- Any Ethernet-enabled datalink structure can be used
- Has been successfully demonstrated with a Mini-CDL datalink
- Datalink is mounted centerline or in a second wing-pod

IN COOPERATION WITH

NAVAL RESEARCH LABORATORY

ISR & IRCM SYSTEMS · APPLIED OPTICS BRANCH