KA-BAND RADAR DEVELOPMENT AND EXPERIMENT RESULTS AT NTU

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ABSTRACT

The Ka-band consists of frequencies in the range 27 GHz to 40 GHz and a wavelength between 1.1 to 0.75 centimeters. The Ka-band frequency showcases high potential in supporting military forces, radars, aircraft, radio communications, and satellite communications. After successfully developing the Ku-band drone SAR systems during the past few years, the Satellite Research Centre (SaRC) at Nanyang Technological University (NTU) is working on Ka-band radar including the wideband FMCW SAR system and Ka-band pulse radar prototype for space-borne precipitation observation.

1. Ka-band FMCW SAR

The drone SAR is a highly miniaturized SAR sensor system based on a Ka-band FMCW radar frontend. The characteristics of the sensor system are given in TABLE I.

System Parameters	
Imaging Mode	Boresight Stripmap
Waveform	LFMCW
Carrier Frequency	35 GHz
Bandwidth	2 GHz
Polarization	VV
PRF	2 kHz
Antenna Gain	18 dBi
Transmit Power	20dBm
System payload	5 kg
Platform	Octal rotor

TABLE I. MULIT-ROTOR FMCW SAR CHARACTERISTICS

A pair of standard horn antennas is used for radar signal transmission and receiving. The 3 dB beam width is around 20 degrees in azimuth. The overall SAR system payload is 5 kg including the SAR transmitter, receiver, antennas, a mini-PC for control and data streaming and batteries to power up the whole system. The integrated SAR system without GPS is demonstrated in Fig. 1. Fig. 2 & 3 show a trial ground truth and the corresponding SAR image.

Fig. 1 Integrated Drone SAR System

Fig. 2 Ground truth of NTU Arts School

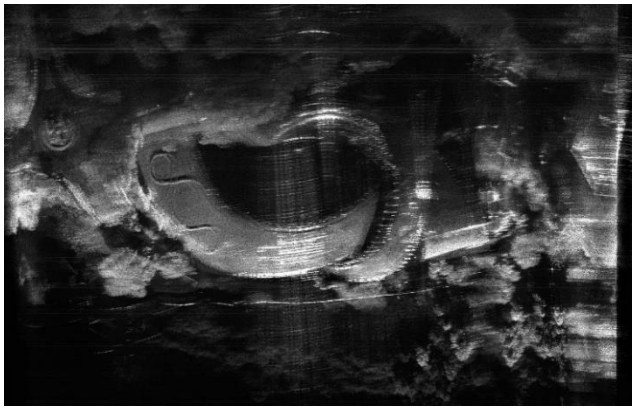

Fig. 3 SAR Image of NTU Arts School

2. SYSTEM DESIGN

After demonstrating the technology for mapping tropical storms (convective mass flux, CMF) with a 6U satellite radar (RainCube), Jet Propulsion Laboratory (JPL) and California Institute of Technology (Caltech) are investigating the next generation RainCube with a three small satellite mission concept in low Earth orbit to do global equatorial region mapping of the frequency and dynamics of these CMFs. The Satellite Research Centre (SaRC) at Nanyang Technological University (NTU), Singapore is studying the possibility of adding one or two satellites to that mission to allow more frequent spatial and temporal coverage.

Before developing the next generation RainCube satellite, we decide to build up a ground-based Ka-band radar prototype since there is no weather radar payload relevant study at SaRC before. The main characteristics of the Ka-band radar prototype system are given in TABLE II.

System Parameters	
Radar Mode	Pulse Doppler
Waveform	Chirp / Arbitrary waveform
Carrier Frequency	35.75 GHz
Bandwidth	≤ 50 MHz
Polarization	VV
Antenna	Offset parabolic reflector (5 feeds)
Antenna Gain	44 dBi
Beam width	1 degree
HPA Power	20 Watts
Pulse width	2 ~ 200 μs
Duty Cycle	10%
Noise Figure	< 5 dB (receiver)
Data recorder	16-bit ADC with DDC

TABLE II. KA-BAND PULSE RADAR PROTYPE CHARACTERISTICS

Typhoon "Rai" (known as “Odette”) rapidly intensified on December 16, 2021, becoming a Category 5 Super Typhoon before making landfall over the Philippines. Rai is the 22nd named storm of the 2021 Pacific typhoon season and the 9th typhoon. At 03:00 UTC on December 16, the center of Typhoon "Rai" (Odette) was located about 891 km (554 miles) southeast of Manila, Philippines. In Fig. 4, we can see Singapore is also affected and precipitation can be observed. Thus, NTU radar team decided to take this opportunity to conduct radar field trial.

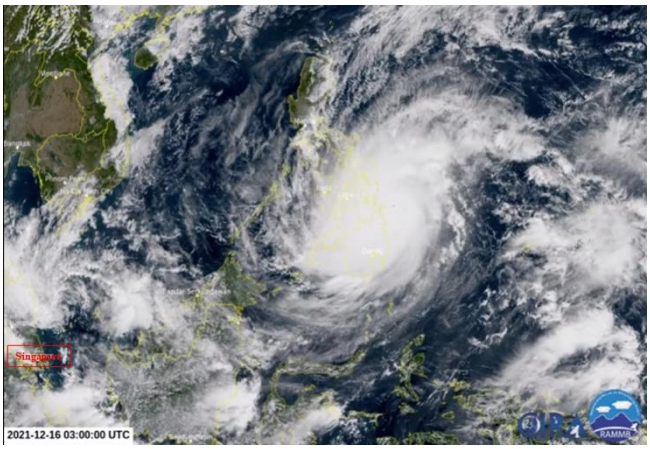

Fig. 4 Typhoon "Rai" (Odette) on December 16, 2021

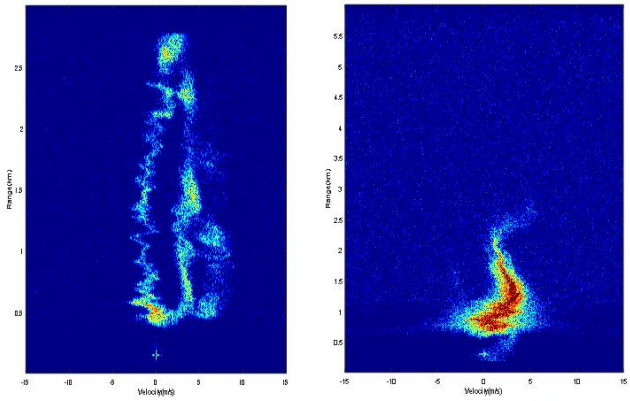

Fig. 5 RD-map of precipitation with short pulse

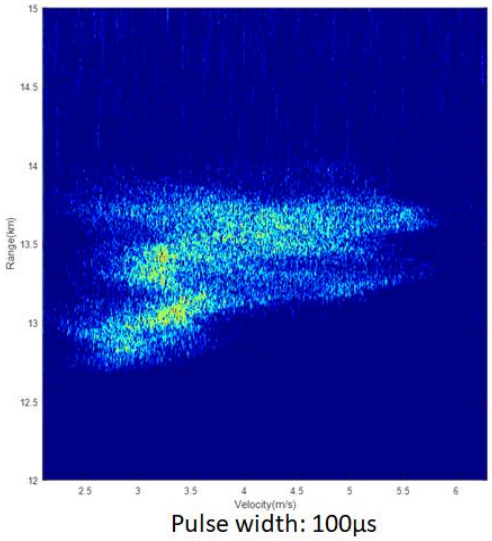

Fig. 6 RD-map of precipitation with long pulse