Industry and University Cooperation in Innovation on Remote Sensing Technology between Indonesia and Japan

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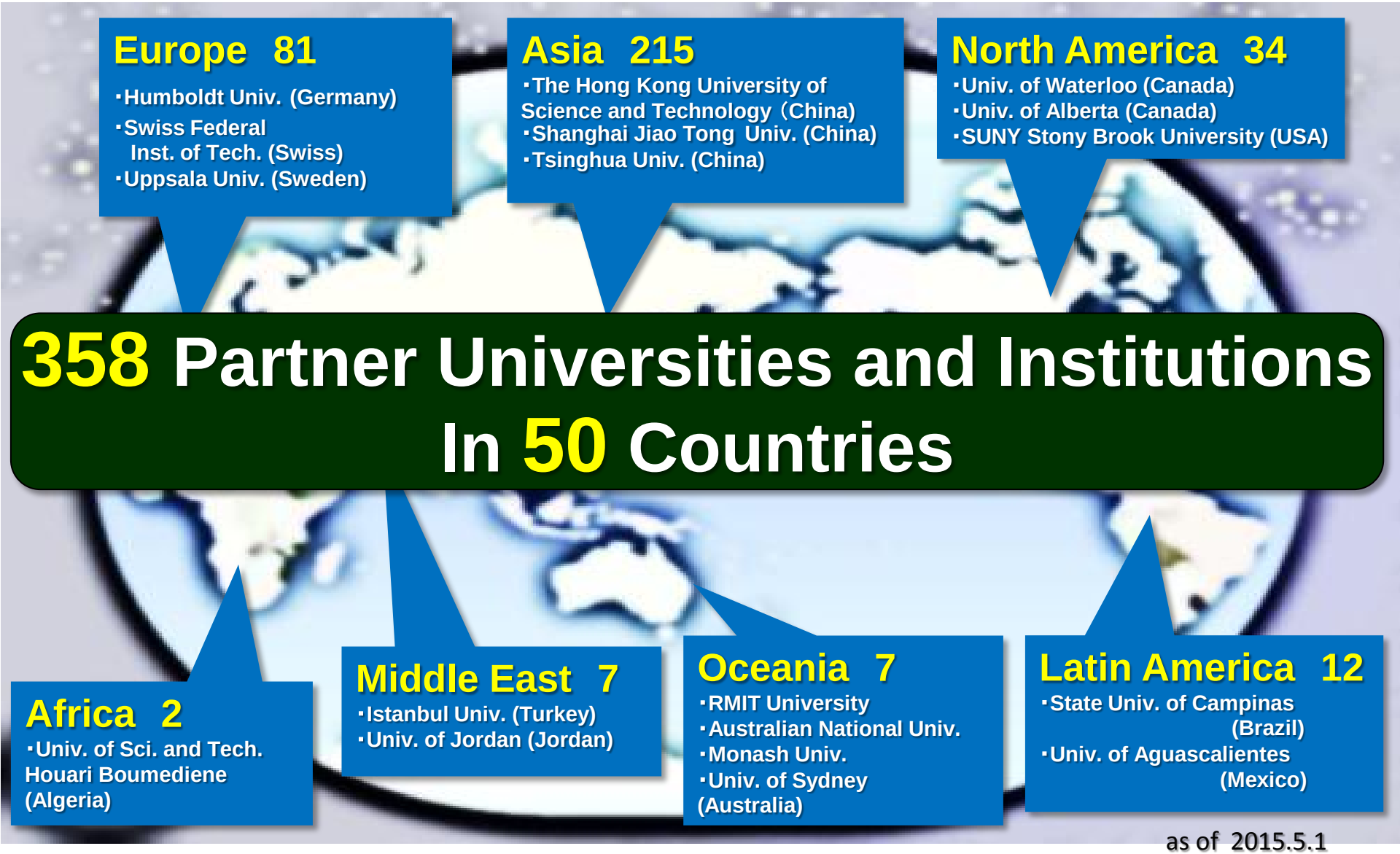
Location

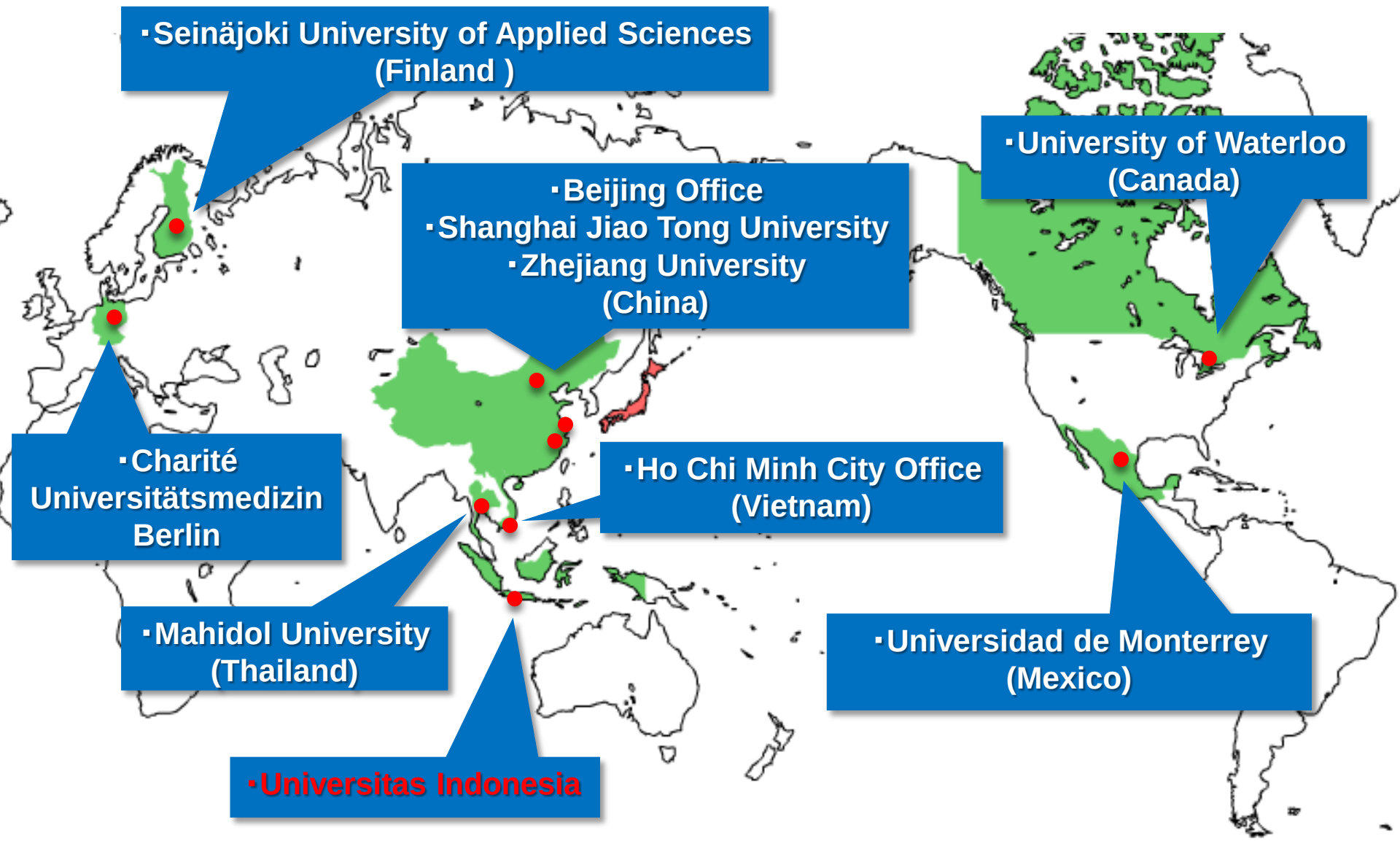
40 minutes by train to Tokyo and to Narita airport ✈

Partner Universities & Institutions



as of 2015.5.1

10 International Offices



Exchange agreements between universities in Indonesia and Chiba University

Conclusion of university-level agreement with Chiba university

Oct. 4th, 1990	Universitas Gadjah Mada
Dec. 29th, 1997	Universitas Indonesia
Mar. 16th, 2006	Institut Teknologi Bandung
Jul. 16th, 2007	Universitas Udayana
Sep. 12th, 2007	Universitas Hasanuddin
Mar. 19th, 2010	Institut Pertanian Bogor
Jan. 28th,2011	Universitas Padjadjaran
Jul. 4th, 2012	Institut Teknologi Sepuluh Nopember
Aug. 3rd, 2012	Universitas Diponegoro
Nov. 10th, 2014	Indonesian Agency for Meteorology, Climatology and Geophysics (BMKG)

Conclusion of double-degree agreement with Chiba university

Mar. 19th, 2010	Institut Pertanian Bogor
Jul. 5th, 2012	Universitas Hasanuddin
Jul. 18th, 2012	Universitas Udayana
Jul. 31th, 2012	Universitas Indonesia
Aug. 7th, 2012	Universitas Gadjah Mada
Oct. 9th, 2012	Institut Teknologi Bandung
Oct. 25th, 2012	Universitas Padjadjaran

Double Degree Programs

China

- Shanghai Jiao Tong University - Design MS, Bioengineering PhD, Horticulture MS/PhD
- Tsinghua University - Horticulture MS
- Zhejiang University - Design MS
- University of Electronic Science and Technology of China - Electronic Engineering PhD

Indonesia

- University of Indonesia - Medical Engineering, Environmental Remote Sensing MS/PhD
- University of Udayana - Environmental Remote Sensing MS/PhD
- University of Gadjah Mada - Environmental Remote Sensing MS/PhD
- University of Hasanuddin - Environmental Remote Sensing MS/PhD
- Institut Teknologi Bandung - Environmental Remote Sensing MS/PhD
- University of Padjadjaran - Environmental Remote Sensing, Horticulture MS/PhD
- Bogor Agricultural University - Horticulture MS

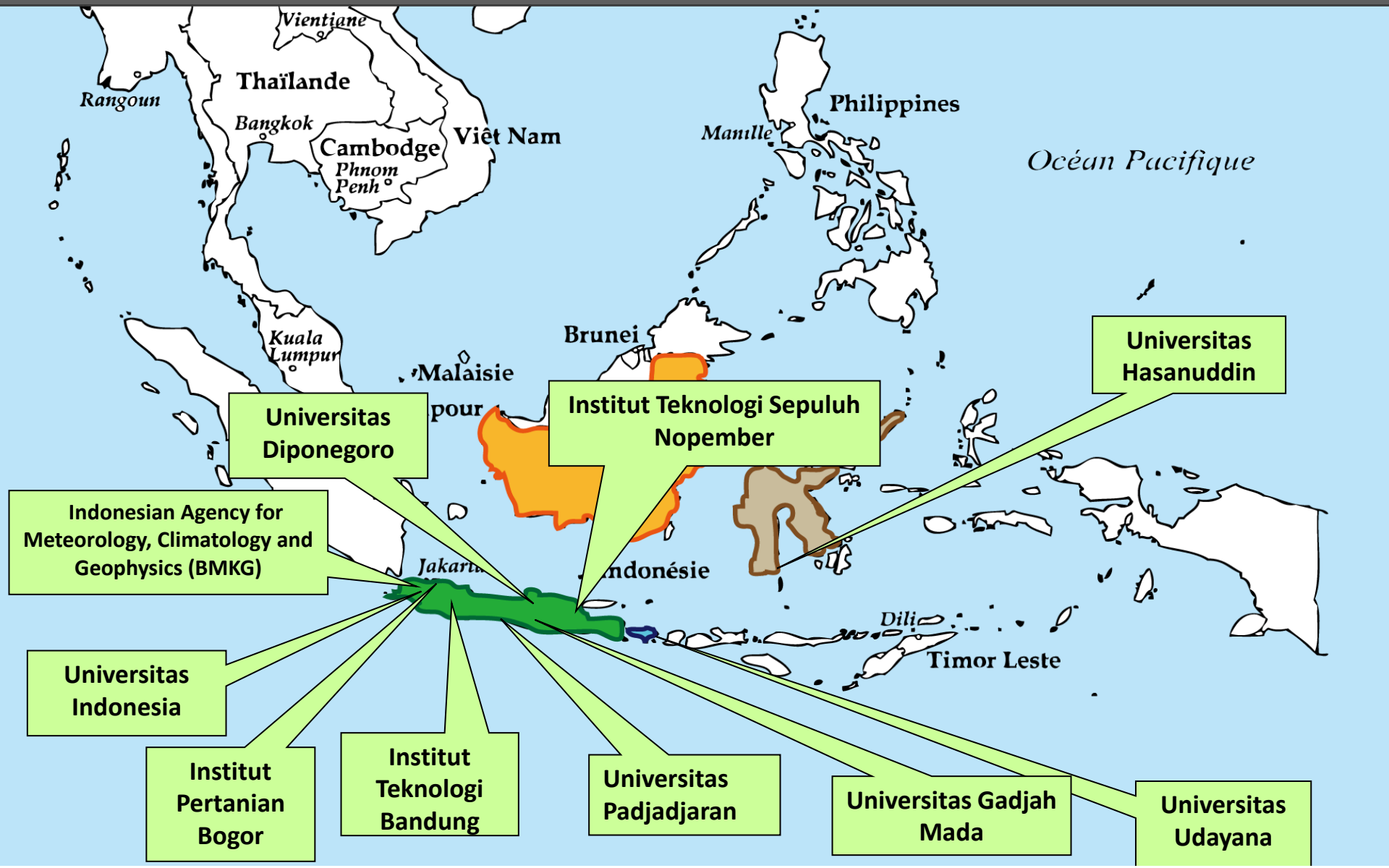
Thailand

- Mahidol University - Horticulture, Pharmaceutical Sciences PhD
- Silpakorn University - Pharmaceutical Sciences PhD
- King Mongkut's Institute of Technology - Horticulture PhD

Italy

- Università degli Studi di Firenze - History of Italian art PhD

Sister Universities in Indonesia



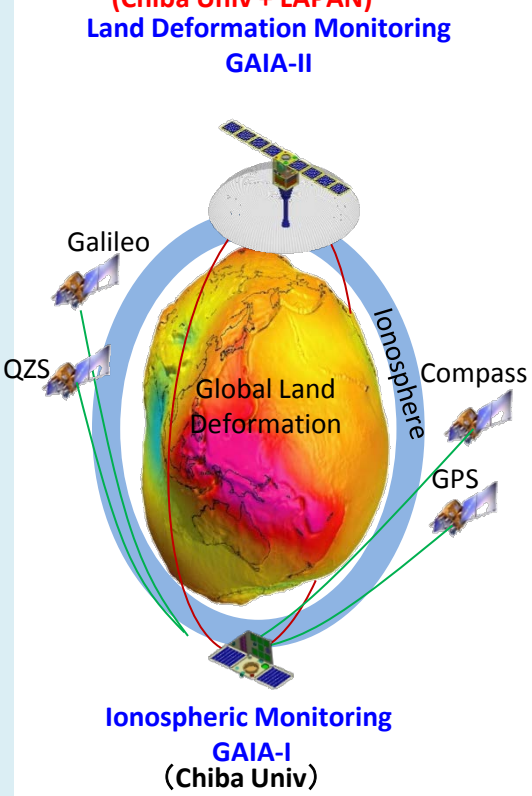
Roadmap of Chiba University Microsatellites Mission

Integrated Earth Environmental Diagnosis Research Program – Observation of Continental Land Deformation using Microsatellites Constellation

- ☐ Project Period : **FY 2013 – FY 2022**
- ☐ Principal Investigator : **Prof. Josaphat Tetuko Sri Sumantyo**
- ☐ Funding : **Japan Ministry of Education and Technology (MEXT)**

Project abstract

- Center for Environmental Remote Sensing (CEReS) of Chiba University is developing GNSS-RO sensor onboard microsatellite (GAIA-I : 50 kg class) to observe the relationship of ionospheric phenomenon and land deformation (Wide area and low resolution).
- CEReS collaborates with Indonesian Aerospace Agency (LAPAN) to develop circularly polarized synthetic aperture radar (CP-SAR) onboard microsatellite (GAIA-II : 100 kg class) to observe land deformation (local and high resolution).



Expected impact

- Scientific impact

1) **GNSS-RO onboard microsatellite（GAIA-I）:**
   - Observation of global land deformation and change of total electron contents
   - Observation of atmospheric temperature, water vapor, sea surface height, gravity etc
   - Observation of earthquake precursor and the mechanism in global area
   - **Visualization of Ionospheric Physical Information**

2) **CP-SAR onboard microsatellite（GAIA-II）:**
   - Observation using circular polarization and its study for new applications
   - Local observation of land deformation
   - **Visualization of top land surface and land deformation**

- Community impact
  - Reduction of disaster impact by microsatellite constellation
  - Widthspread collected satellite data for international community
  - Reduction of disaster impact and realization of safe and reliable community
- Improvement impact
  - Promoting advanced research and education on remote sensing field
  - Gathering academic and research institutions to collaborate on high technology on microsatellite, unmanned aerial vehicle and microwave sensors for remote sensing

Advance Microwave Remote Sensing Research Center 2015-2022

センター事務支援
事務支援

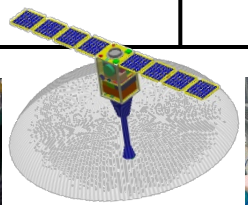
資料整理者
事務支援

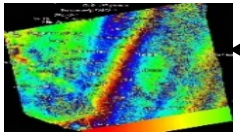
特任助教
小型衛星SARの開発

推進責任者
拠点事業の総合統括

中核推進者1
無人航空機・航空機・小型衛星SAR・その応用の開発

中核推進者2
FPGA回路、SAR画像処理等の開発





SAR画像
（JAXA, DLR,等）
SAR画像の提供

地上管制局
（エルム社、九州大学等）
小型衛星SARのコマンド、テレメトリ、ミッションデータの送受信の管理、**インタフェース**、ソフトウエア等

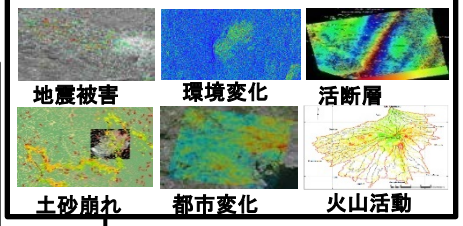
バスシステム
（LAPAN、NSPO、九州大学等）
小型衛星SARのバスシステム（電力系、姿勢制御系、中央制御計算機、通信系、**インタフェース**等）の開発

宇宙用アンテナ
（QPS社、英国ケント大学等）
軽量・安価・宇宙用メッシュパラボラアンテナ、展開系、給電系、インターフェース、送受信制御系

SARシステム
（日本無線、マイクロラボ社等）
無人航空機、航空機、小型衛星搭載用のSARセンサの開発、チャープ発生器、RFシステム、アンテナ等の開発

SAR応用開発
（東京大学、パドュー大学等）
InSAR、DInSAR、PS-InSAR等によるグローバル地殻変動と環境変化の観測用の各種手法の開発

画像解析・応用



データベース
（マルチスープ社、モナッシュ大学等）
データベース、表示・発信用のソフトウエアの開発等

ロケット※（JAXA、LAPAN、ISRO等）
打ち上げ用のロケットの調整、小型衛星・ロケットのインタフェース等の開発

航空機実証実験
（インドネシアLAPAN、インドネシア大学等）
Boeing 737-200航空機による飛行実証実験、SARセンサ補正・検証実験、SAR画像処理等

無人航空機
（コンクック大学、バンドン工科大学等）
SAR飛行実証実験用の大型無人航空機、自律飛行システム、通信系、UAV用材料の開発

全国共同利用共同研究施設の協力研究員

一般社会
行政機関

国内・国際産業

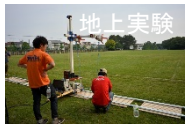
大学院リモートセンシングコース

大学間協定校部局間協定校

※平成26年9月5日千葉大学の小型衛星がJAXA相乗り公募小型副衛星候補リストに登録された。小型衛星SARは米国打ち上げ用ロケット(台湾・NSPOと調整中)・日本のイプシロン・ロケット(IHI確認中)・インドのPSLV(LAPANと調整中、予算が決定済み)などでも打ち上げ可能である。

Advance Microwave Remote Sensing Research Center

2015-2022



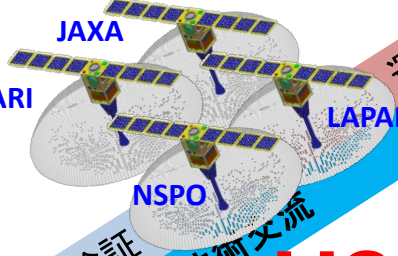
宇宙環境用へ

人工衛星の開発

先端マイクロ波リモートセンシング拠点：国内外の研究者との技術交流

小型衛星の校正・検証

運用



H34～

小型衛星SAR
コンステレーション
グローバル
地殻変動観測

H33

小型衛星SAR
コンステレーション

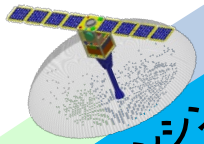
H32

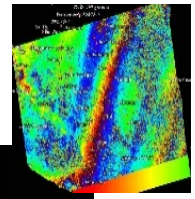
小型衛星SAR
応用開発

H31

小型衛星SAR
校正・検証

H30





微分干渉SAR等
による1mm精度
の技術開発

H29

小型衛星SAR
ミッション系開発：
概算要求orインドネシア
116,899千円
バスシステム系：
インドネシア
宇宙航空局
3,000千米ドル

打ち上げ
※1

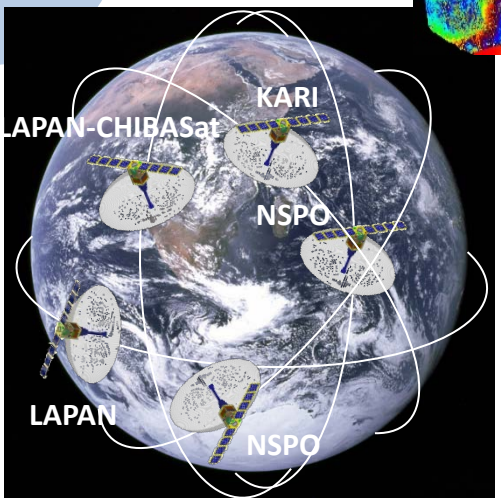
H28

小型衛星SAR
ミッション系開発：
概算要求orインドネシア
103,000千円
バスシステム系：
インドネシア
宇宙航空局
3,500千米ドル

～H27

航空機搭載用
SARセンサ開発
地上局整備
無人航空機・
航空機搭載
実証実験
等

無人機・航空機に
よる校正・検証



小型衛星SARコンステレーション

打ち上げ費：
インドネシア
宇宙航空局
1,500千米ドル

※1　平成26年9月5日千葉大学の小型衛星がJAXA相乗り公募小型副衛星候補リストに登録された。小型衛星SARは米国打ち上げ用ロケット(台湾・NSPOと調整中)・日本のイプシロン・ロケット(IHI確認中)・インドのPSLV(LAPANと調整中、予算が決定済み)などでも打ち上げ可能である。

Roadmap of Chiba University Microsatellite Missions

Basic Research | Advanced Research | Operation / Missions

2013-2017 LAPAN-Chibasat (360 Millions Yen＋LAPAN 400 Millions Yen)

Chiba University - LAPAN - Chibasat (LAPAN-A5 / GAIA-II) L Band SR; Polar, 100 Kg

Chiba University COE Start-up Program, MEXT Special Project etc.

BHIMASENA Research & Development

(EP-SAR & CP-SAR : Patent Pending : 2014-214905)

NSPO, KARI, BHIMASENA Research & Development

GAIA-II

Chiba University – Ajou University, Korea
NSPO, Taiwan, Polar, 100 Kg

Chiba University - LAPAN
Equatorial, 100 Kg

GAIA-II

Chiba University – Seoul University, Korea
Planetary, 100 Kg

Chiba University – Lapan, Malaysia
Equatorial, 100 Kg

Chiba University Charter : Always Aim Higher

(Chiba University + LAPAN)
Land Deformation Monitoring
GAIA-II

Galileo

QZS

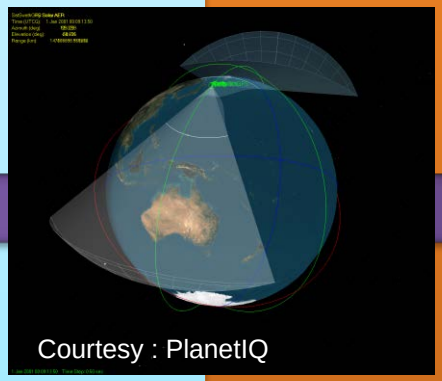
Land deformation etc

大気

NSPO, iQPS

Chiba Univ., Kyoto Univ., JAXA, Taiwan - NCU, Polar, 50 Kg
GPS-RO onboard Microsatellite

GAIA-I



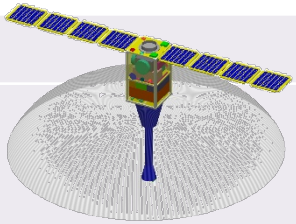
Land Deformation Monitoring
GAIA-I
（Chiba University）

Josaphat Laboratory Ground Experimental Synthetic Aperture Radar onboard Unmanned Aerial Vehicle (JX Series)

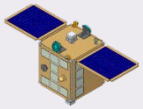
L Band SAR | C/X Band SAR | mmW Band SAR | Multiband SAR Mission

2010-2015 | 2016-2020 | 2021-2025 | 2026-2030 | 2031-2035

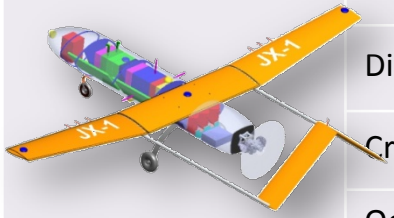
GAIA-II : Target of CP-SAR onboard Microsatellite Mission



Basic experiment

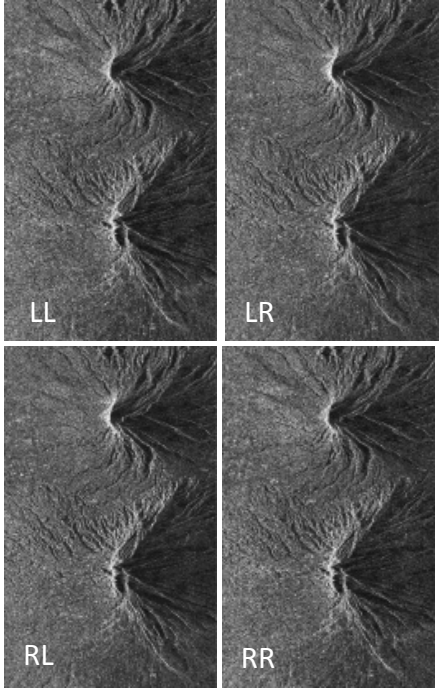


Applications

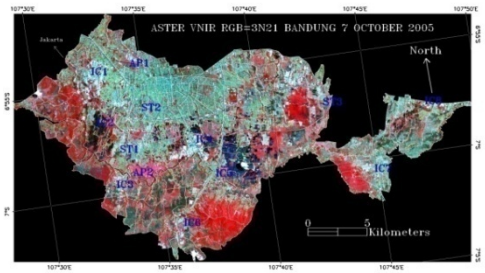


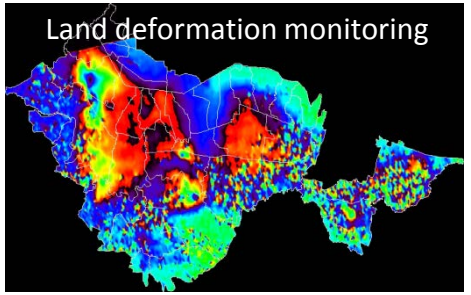
Items	Details
Scattering mechanism of circularly polarized microwave	Scattering mechanism from vegetations, cryosphere, soil and rocks, desert etc
Interferometry	• Linear vs Circular Polarization Interferometry SAR • DEM extraction by CP wave
Axial ratio image (ARI)	Vegetation, geologic, cryosphere etc mapping by using ARI
Landcover mapping	• Forest – non forest area classification • Tree height estimation • Paddy field extraction • Wetland extraction • Mangrove area mapping • Snow – ice berg detection
Disaster monitoring	Earthquake, volcano eruption, flood, forest fire etc
Cryosphere monitoring	Ice berg, glacier, artic route etc
Ocean monitoring	Oil spill, ocean wave etc

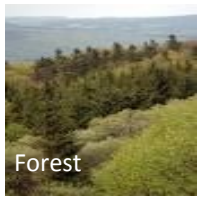
Source : Josaphat Tetuko Sri Sumantyo et al. IEEE TGRS Vol. 50, No. 1, pp. 259 – 270, January 2012

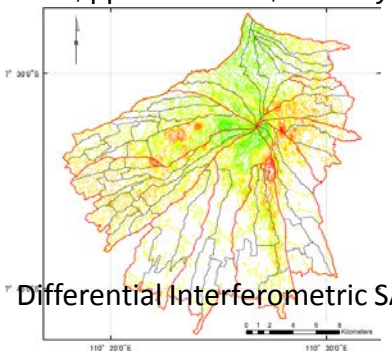


Circular Polarimetric SAR



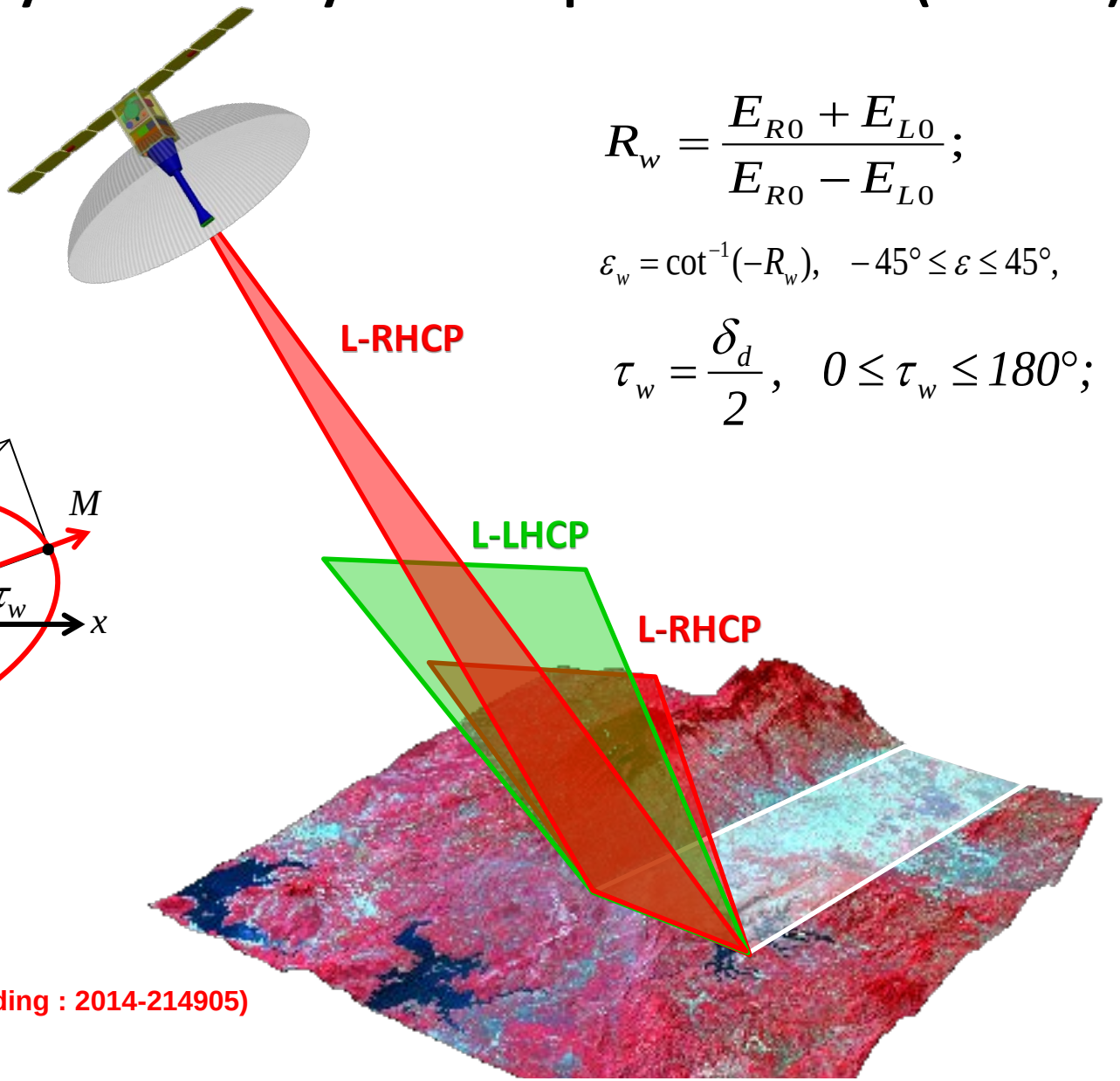






Differential Interferometric SAR

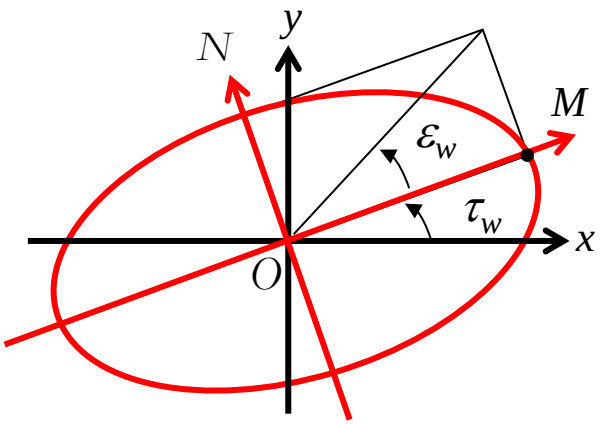
Principle of Circularly Polarized Synthetic Aperture Radar (CP-SAR)



$$R_w = \frac{E_{R0} + E_{L0}}{E_{R0} - E_{L0}};$$

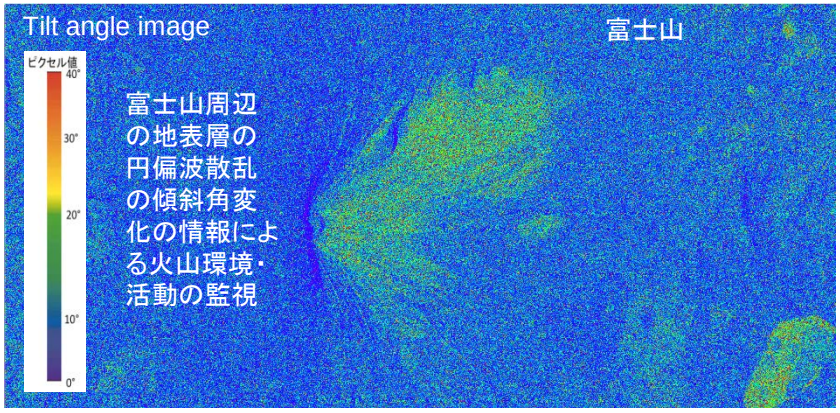
$$\varepsilon_w = \cot^{-1}(-R_w), \quad -45° \le \varepsilon \le 45°,$$

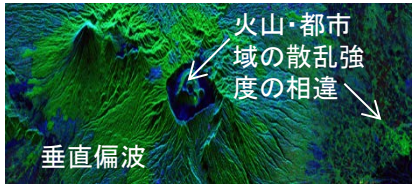
$$\tau_w = \frac{\delta_d}{2}, \quad 0 \le \tau_w \le 180°;$$

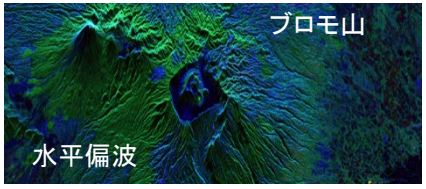


(EP-SAR & CP-SAR : Patent Pending : 2014-214905)

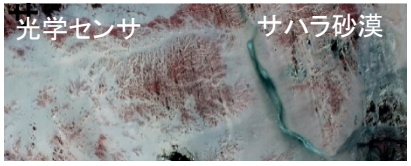
CP-SAR Imaging

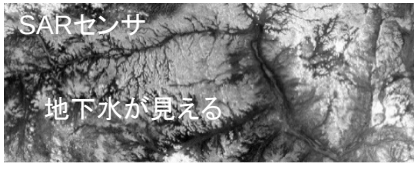






光学センサ VS 合成開口レーダ(SAR)セン





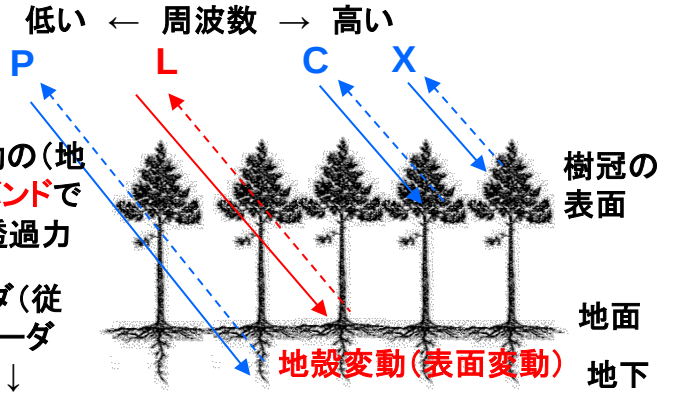
用語	解説
合成開口レーダ(SAR)	Synthetic aperture radar(合成開口レーダ、ごうせいかいこうれーだ)の略。全天候型センサで、昼夜を問わず運用できる多目的センサである。レーダの一種で、航空機や人工衛星に搭載し、移動させることによって仮想的に大きな開口面(レーダの直径)として働くレーダである。
CP-SAR	Circularly polarized synthetic aperture radar(円偏波合成開口レーダ、えんへんぱごうせいかいこうれーだ)の略。千葉大学が提案したセンサである。従来の合成開口レーダは直線偏波を使用したので、電離層におけるファラデー回転などの影響で、画像解析に影響を与えた。これに対して、CP-SARはこの影響が小さく、円偏波の特性も活用でき、地殻変動の観測をはじめ、様々な新しい使用方法がある。

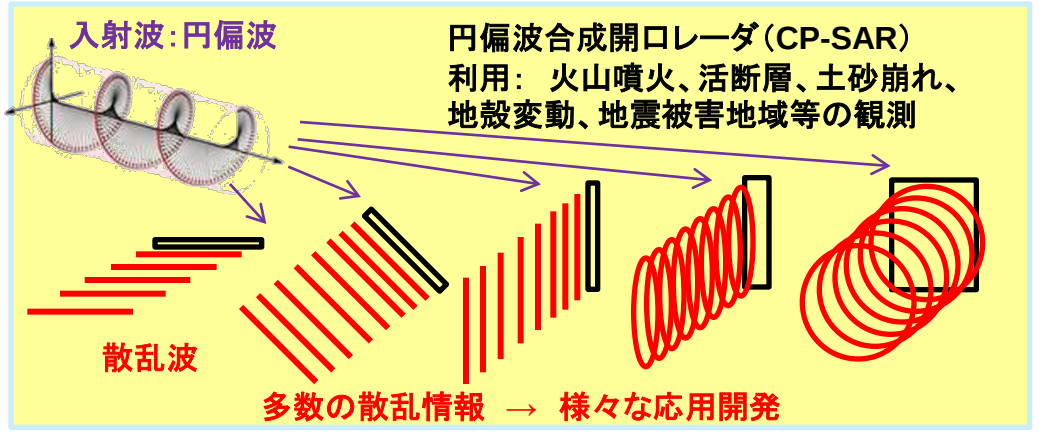
用語解説

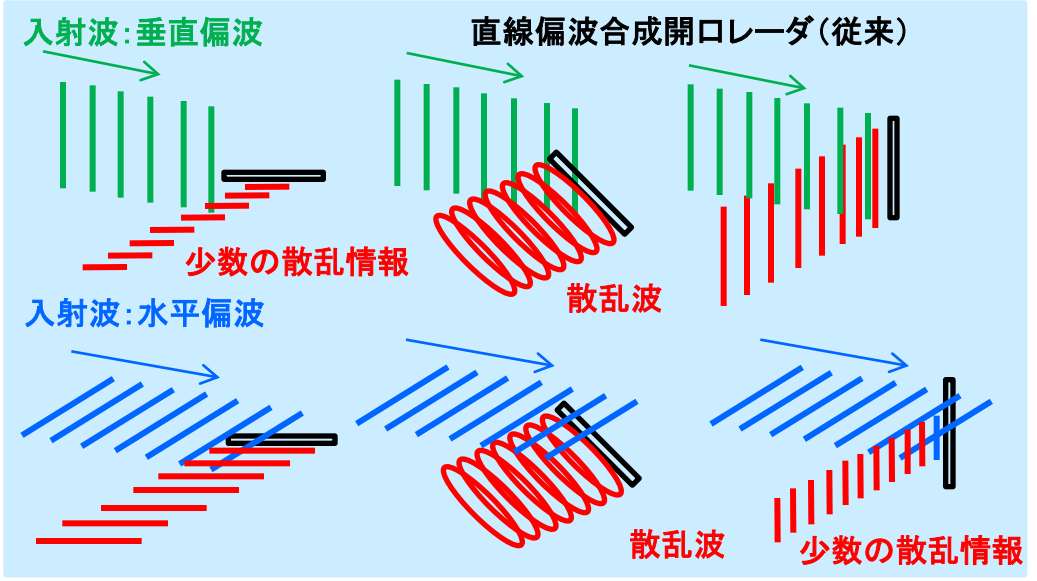
小型衛星SARが地殻変動の(地球表面)観測のためにLバンドで運用する。 各周波数の透過力

→

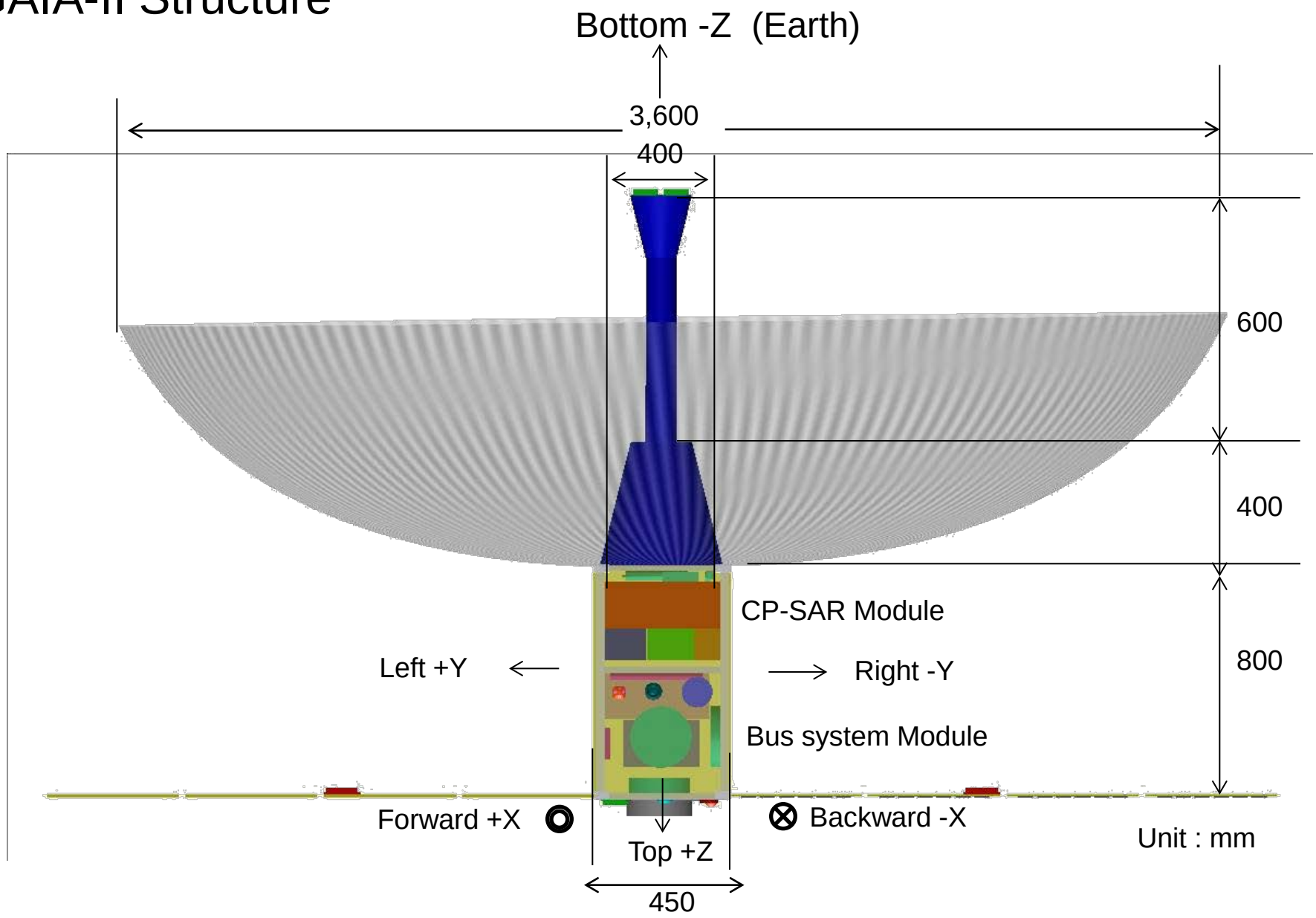
直線偏波合成開口レーダ(従来)と円偏波合成開口レーダ(CP-SAR)の比較 ↓







GAIA-II Structure

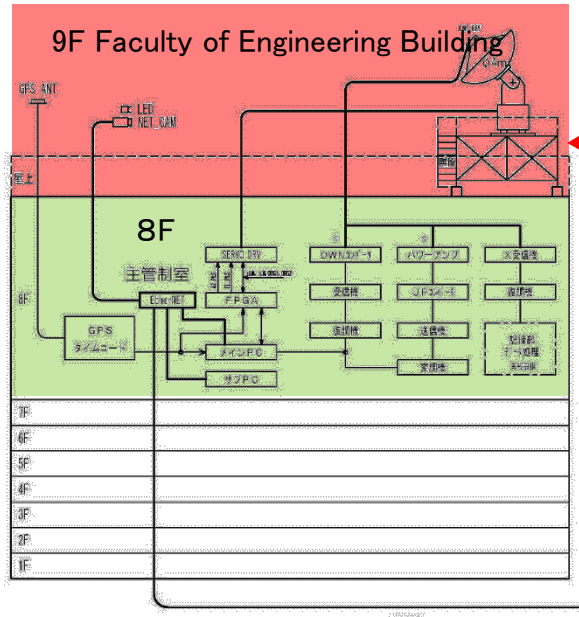


(EP-SAR & CP-SAR : Patent Pending 2014-214905)

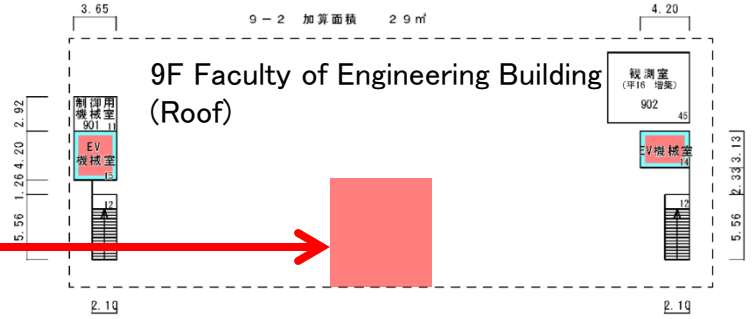
Josaphat Laboratory (JMRSL) Satellite Ground Station (JG1):

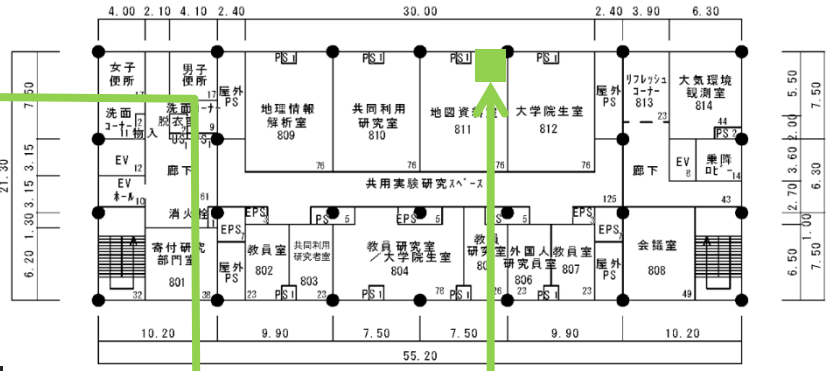
S Band : Command TX & Telemetry RX

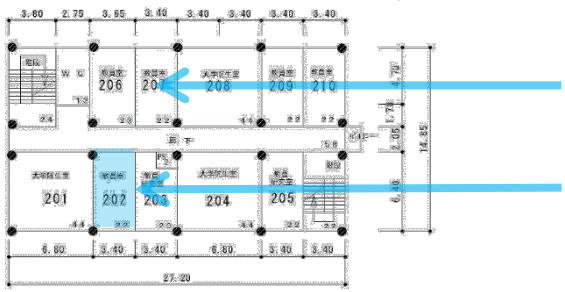
X Band : Mission Data RX



Antenna & Controller







2F Center For Environmental Remote Sensing Building (Josaphat Laboratory)

Sub Ground Control Room

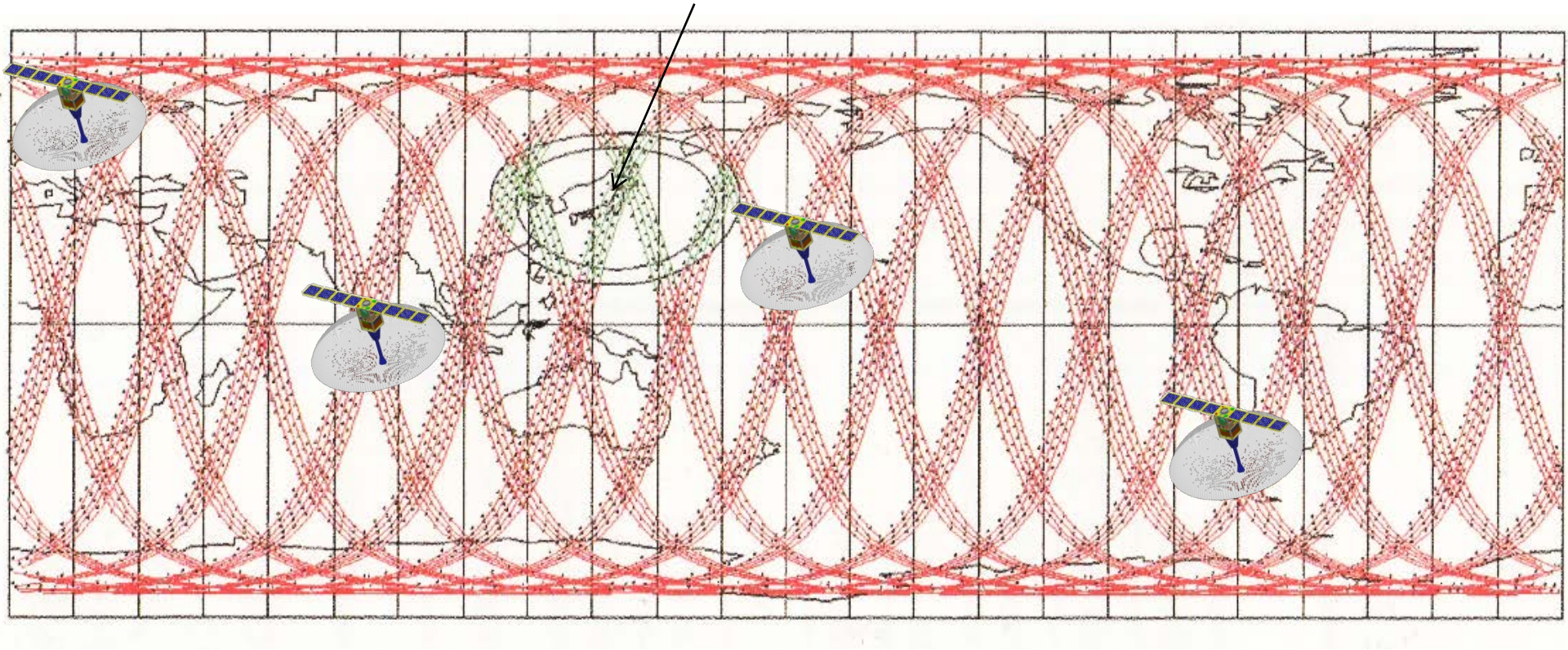
Main Ground Control Room

Josaphat Microwave Remote Sensing Laboratory

Center for Environmental Remote Sensing, Chiba University

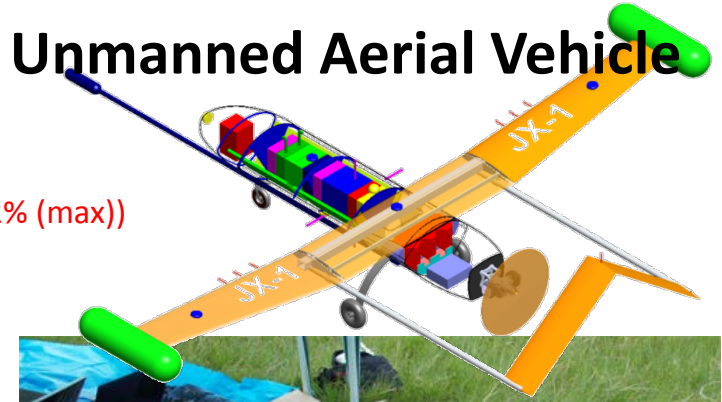
Orbit

Josaphat Laboratory (JMRSL)
Center for Environmental Remote Sensing (CEReS)
Chiba University (JG-1)



CP-SAR RF System Module : Specification for Unmanned Aerial Vehicle

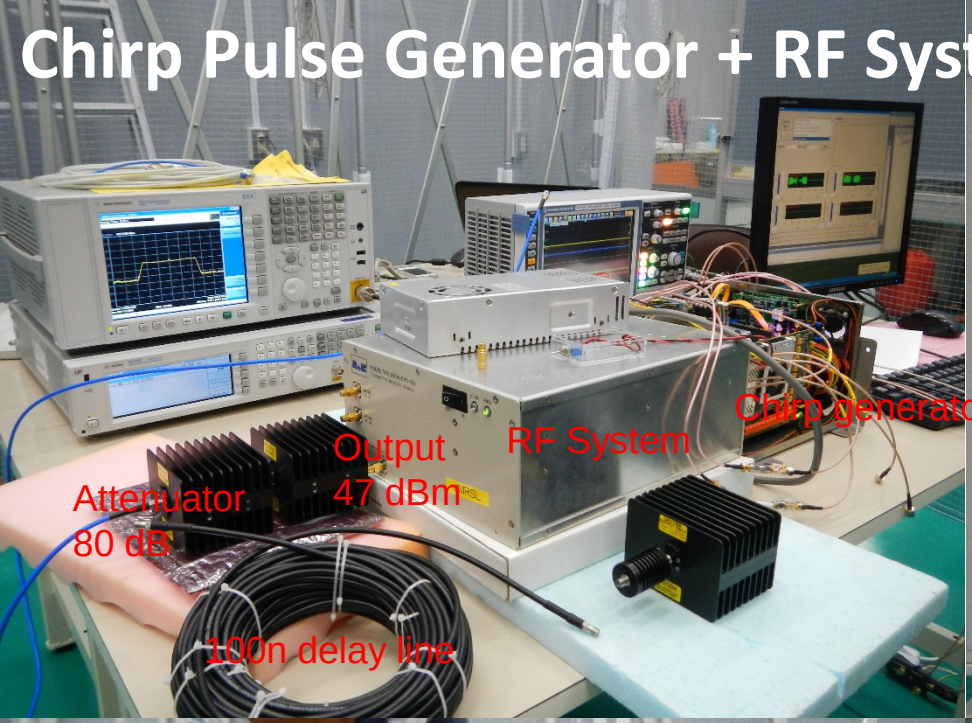
- Transmission frequency range : 1270 MHz ± 25 MHz (max 150 MHz)
- Baseband range : DC to 50 MHz (max 150 MHz)
- Pulse transmission output power : 50 W (Pulse width 10 ms (max), Duty circle 2% (max))
- Transmission system gain : + 47 dB (min)
- Receiver system gain : + 60 dB (min)
- Gain flatness : ± 1.5 dB (max)
- Receiver noise ratio : 3.5 dB (max) @+25°C
- Modulator : (RX and TX) QPSK
- Output higher harmonic wave : -30 dBc (max)
- Output spurious : -60 dBc (max)
- Transmission system gain tuning function : 1/2/3/8/16 dB (0 to -31 dB)
- Receiver system gain tuning function : 1/2/3/8/16 dB x 2 (0 to -62 dB)
- Impedance : 50 W
- Transmission system output VSWR : 1.5 : 1 (typ.)
- Receiver system input VSWR : 1.5 : 1 (typ)
- Transmission system antenna switching speed : 1μs (typ.) / 2 ms (max)
- Receiver system antenna switching speed : 1μs (typ.) / 2 μs (max)
- Transmission system On/Off speed : 100 ns (max)
- Receiver system On/Off speed : 100 ns (max)
- Power voltage : DC +28 V (DC +25 to + 35 V switchable)
- Current consumption : 5A (max)
- Temperature : +0°C to 45°C
- Saving temperature : -20°C to 80°C
- RF connector : SMA-Female
- Power connector : N/MS3102A10SL-3P
- Control connector : D-Sub-37P
- Weight : 10 kg (max)
- Size : W 250mm x H 100mm x D 300mm

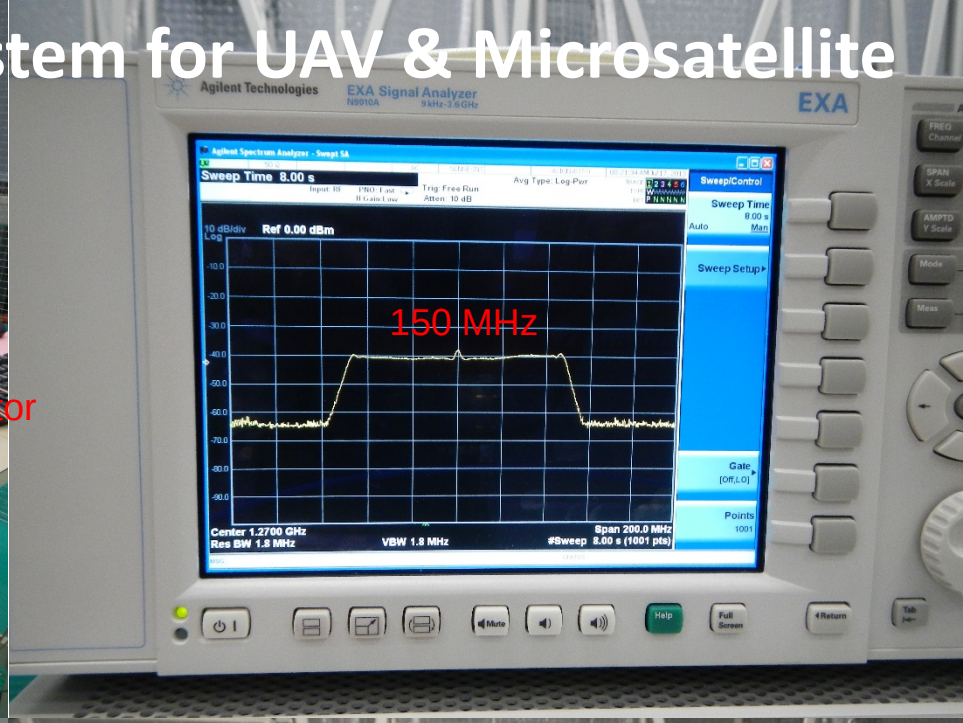


L Band CP-SAR System developed by Josaphat Laboratory for UAV

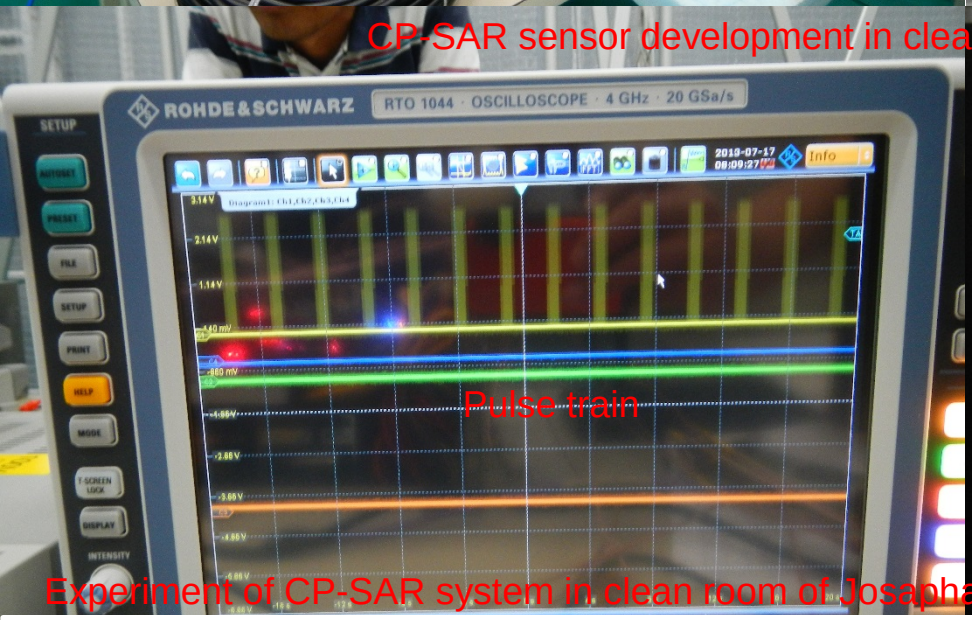
Measurement of patch array antenna for CP-SAR UAV system in Josaphat Laboratory anechoic chamber

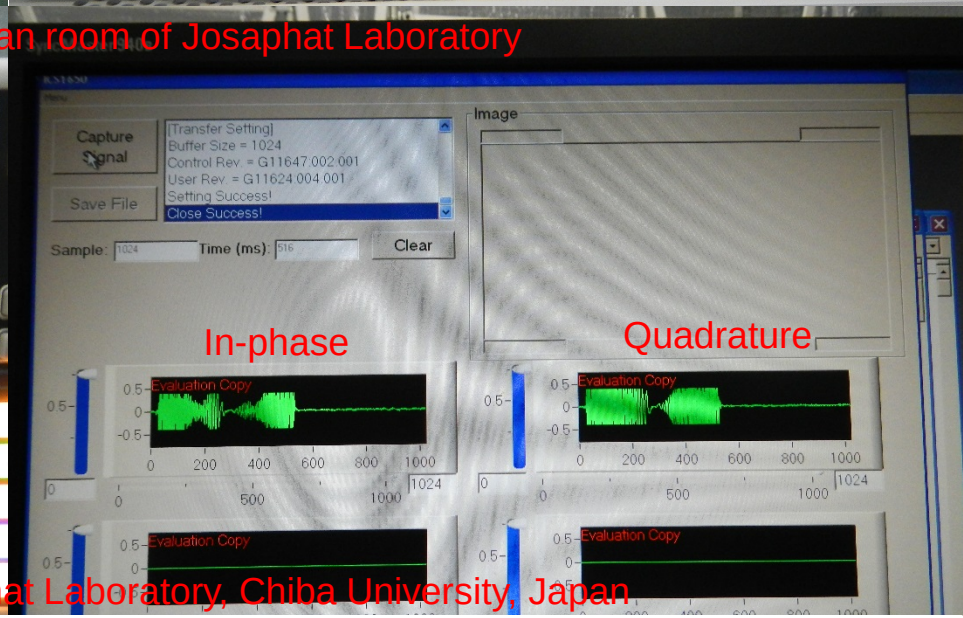
Chirp Pulse Generator + RF System for UAV & Microsatellite





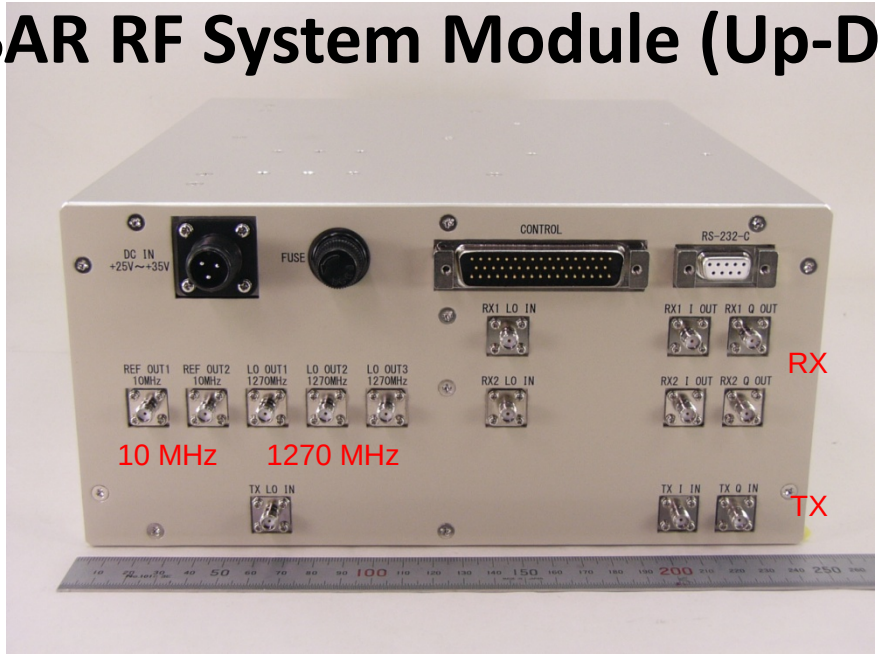
CP-SAR sensor development in clean room of Josaphat Laboratory

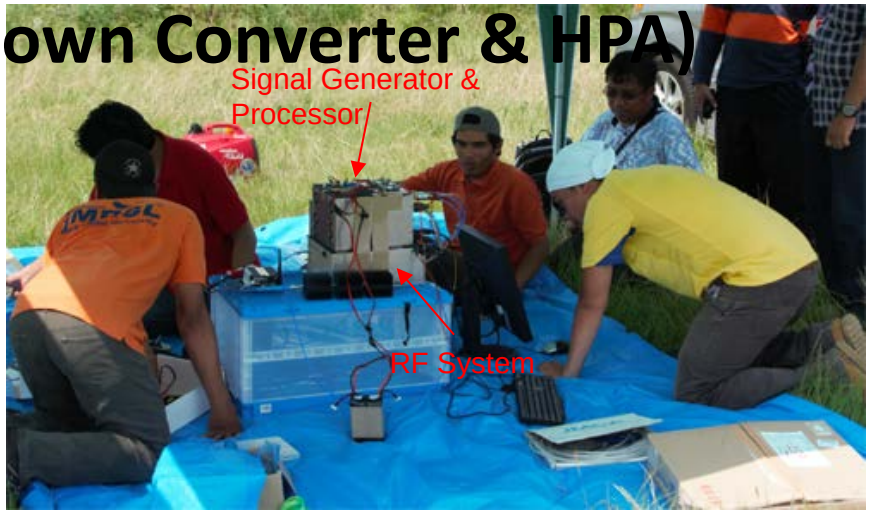




Experiment of CP-SAR system in clean room of Josaphat Laboratory, Chiba University, Japan

CP-SAR RF System Module (Up-Down Converter & HPA)





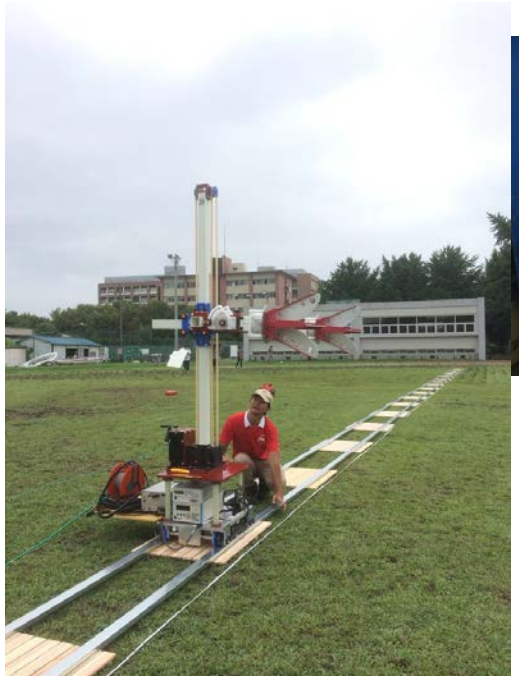
Josaphat Laboratory's researchers and students preparing CP-SAR sensor for UAV, Fujikawa Airfield, 29 August 2013 (above)

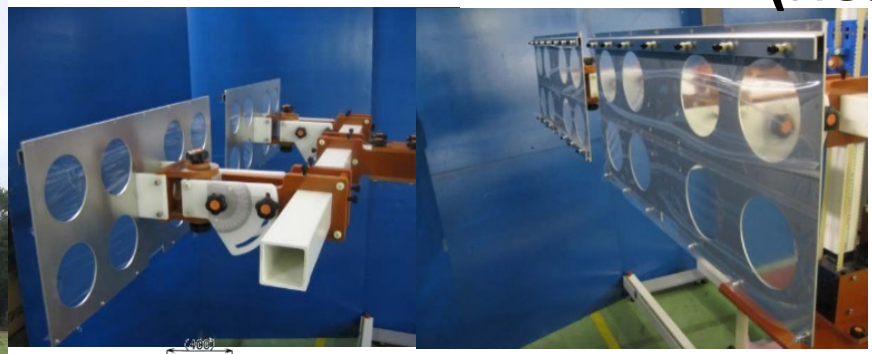
Installed CP-SAR sensor inside UAV JX-1 (below).

Collaborators :

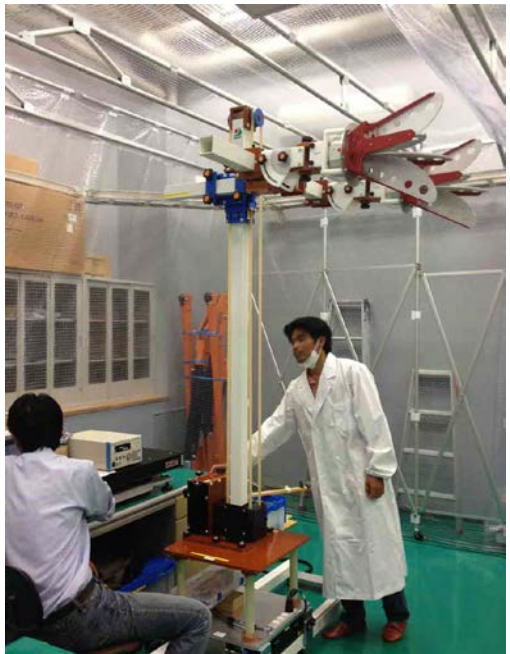
Indonesian Aerospace Agency (LAPAN)
University of Indonesia (UI)
Universitas Negeri Padang (UNP)
Institute of Technology Bandung (ITB)
University of Gadjahmada (UGM)
Bhimasena
etc

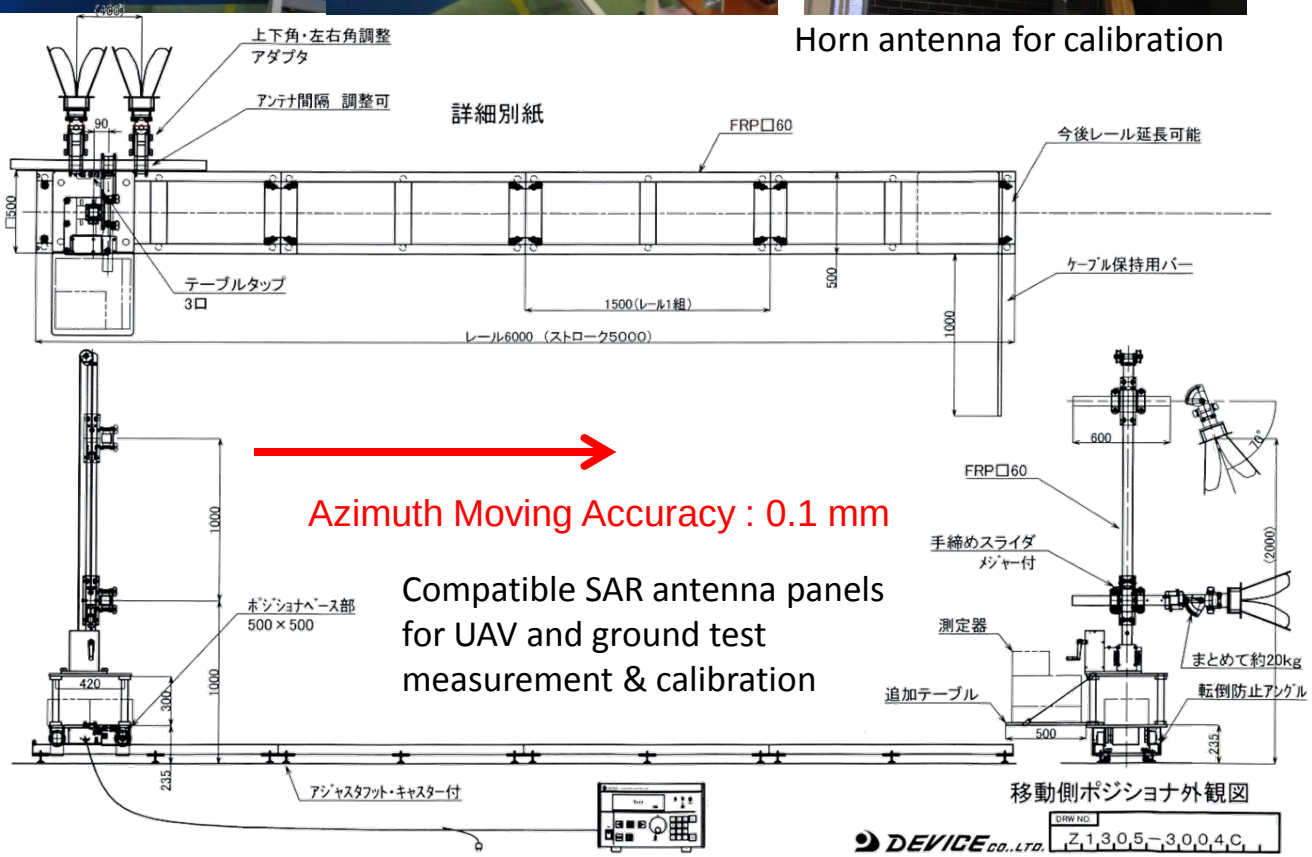
Calibration System : Ground Test / Point Target / Spaceborne Antenna (Near Field to Far Field)



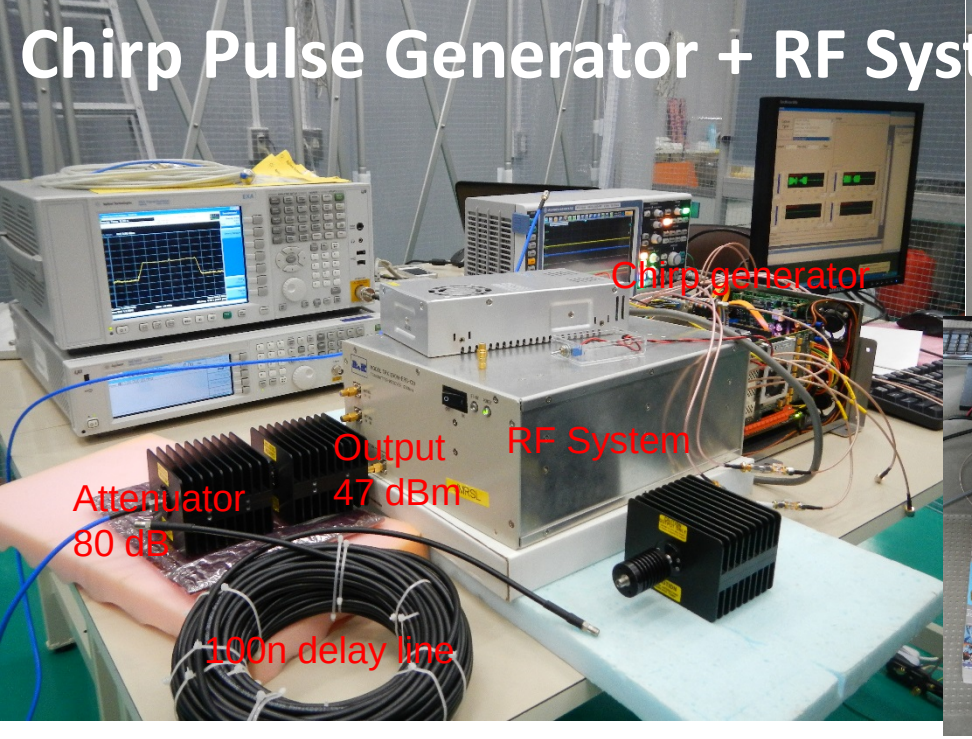


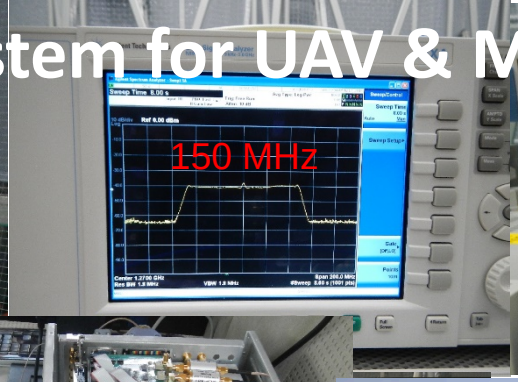
Horn antenna for calibration

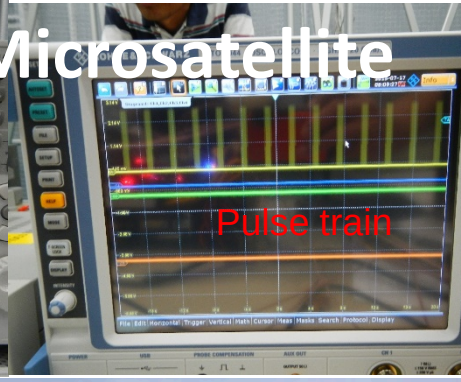




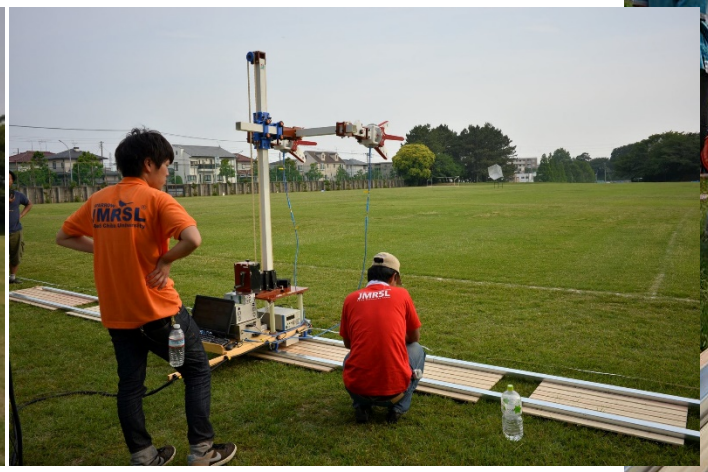
Chirp Pulse Generator + RF System for UAV & Microsatellite







CP-SAR sensor development in clean room of Josaphat Laboratory



Point target test

Josaphat Microwave Remote Sensing Laboratory
Center for Environmental Remote Sensing, Chiba University
CHIBA UNIVERSITY

Car onboard SAR System

Car onboard SAR System

Get directions | My places

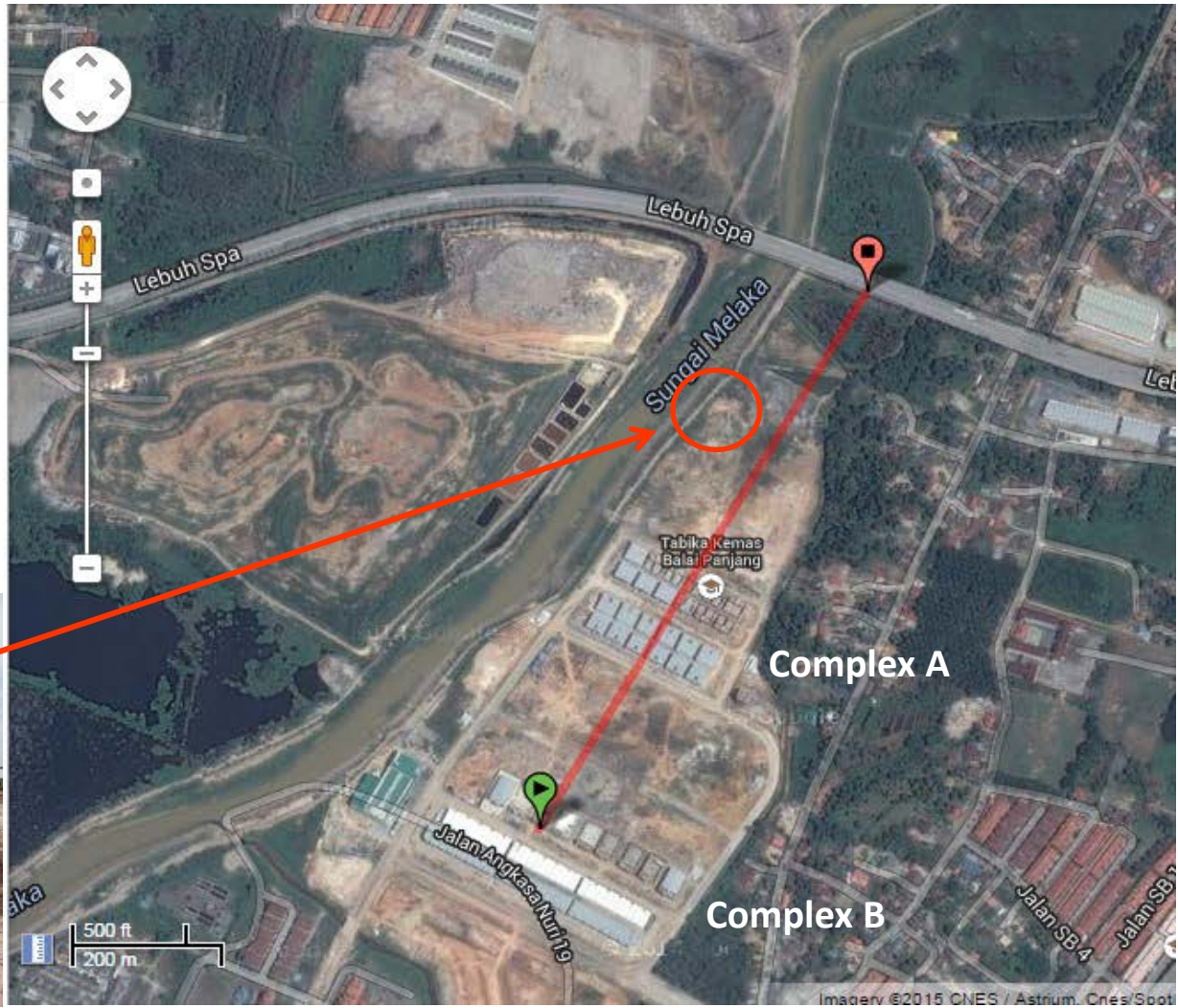
Distance Measurement Tool

Click on the map to trace a path you want to measure.

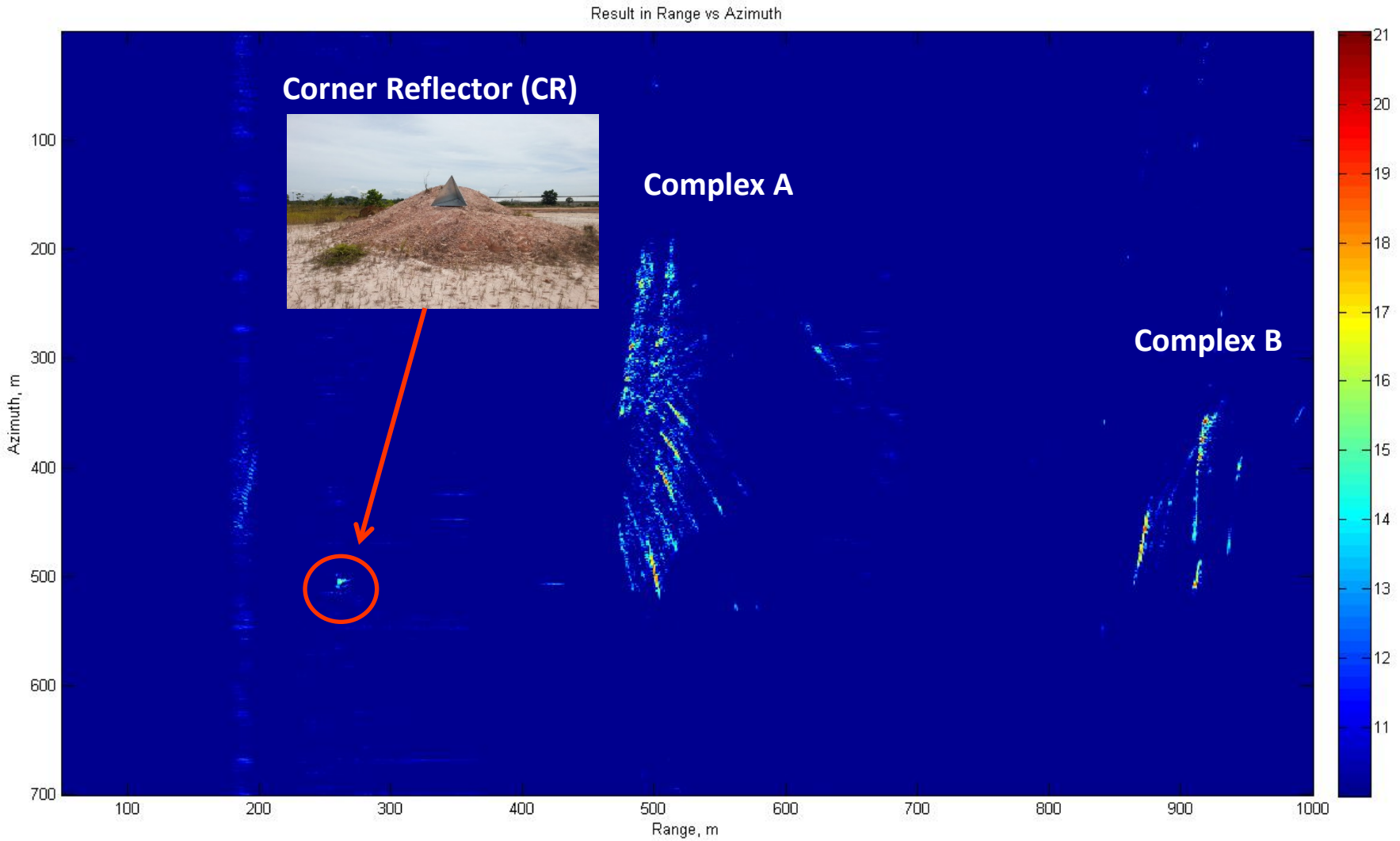
Units:
Metric English I'm feeling geeky

Total distance:
872.931 m

Delete last point | Reset



Car onboard SAR System



Roadmap of Chiba University Unmanned Aerial Vehicle (UAV)

Research and Human Resources Development on Fixed Wing Large Scale Unmanned Aerial Vehicle (UAV)

Large UAV JX-1
Long range & wide coverage

Payload : 25 kg
Multimedia University, Malaysia(MMU)
Indonesian Aerospace Agency (LAPAN) etc

Large UAV JX-2
Long range & wide coverage

Payload : 25 kg
Multimedia University, Malaysia(MMU)
Indonesian Aerospace Agency (LAPAN) etc

Development of Josaphat Laboratory
Ground Experimental Large Scale
Unmanned Aerial Vehicle (UAV) JX Series

Mini UAV JX-3
Medium range & coverage

Payload : 10 kg
Multimedia University, Malaysia(MMU)
Indonesian Aerospace Agency (LAPAN) etc

Development of L band UAV-SAR

Small UAV JX-4
Short range & small coverage

Payload : 5 kg
Multimedia University, Malaysia(MMU)
Indonesian Aerospace Agency (LAPAN) etc

Low Resolution	Medium Resolution	High Resolution	Multi Resolution
L Band SAR	C/X Band SAR	mmW Band SAR	Multiband SAR Mission

2010-2015	2016-2020	2021-2025	2026-2030	2031-2035

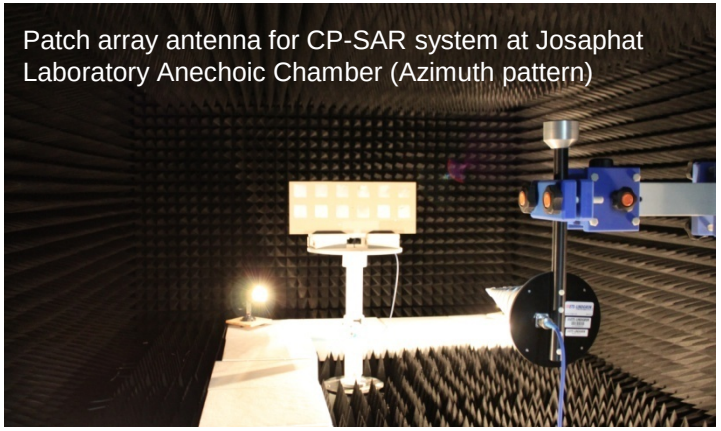
Josaphat Laboratory Experimental Unmanned Aerial Vehicle (JX-1)

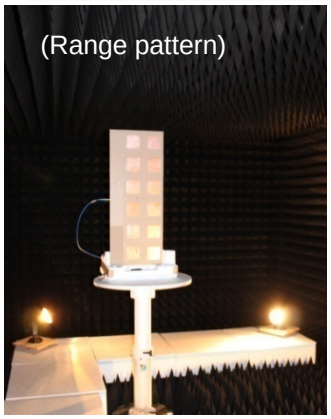
Weight of JX-1 Parts

Items	Weight
Main body (including battery, tank etc)	48.0
Centre / main wing 1 unit	16.0
Wing (2 unit x @ 10 kg)	20.0
Ladder (2 unit x @ 7 kg)	14.0
Other instrument (bow etc)	7.5
Gasoline (20 liters)	16.0
Payload (CP-SAR, camera etc)	25.0
Total	146.5

IMU : IMU440 76 x 95 x 64 mm 540 gr

Parameters	Specification
Altitude	1 ～ 4 km
Central frequency (CP-SAR sensor)	1.27 GHz
Pulse width	3.9 ～ 23.87 μs
Pulse bandwidth	50 MHz (16 ～ 245.89 MHz)
Polarizations	RHCP+LHCP
Off nadir angle	40° ～ 60°
Resolution	1 ～ 10 m
Observation width	10 km
Antenna size	0.75 m x 0.4 m x 4 panels
Azimuth beamwidth	7.94°
Range beamwidth	29.78°
Antenna efficiency	80%
PRF	1,000 Hz
Peak power	5.27 ～ 17.46 W
Average power	20.59 ～ 416.62 mW
Observation time	2.81 ～31.70 minutes
Payload	25 kg


Patch array antenna for CP-SAR system at Josaphat Laboratory Anechoic Chamber (Azimuth pattern)

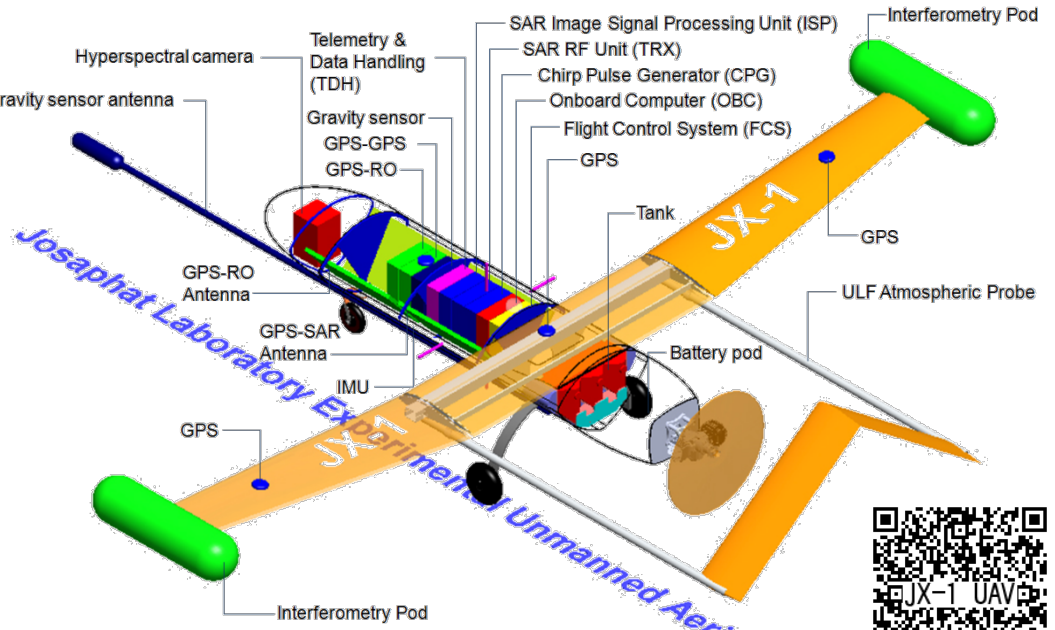

(Range pattern)


JX-1 Taxing Test at Otone Airport

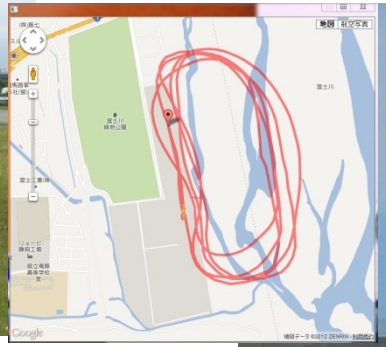
Josaphat Laboratory Experimental Unmanned Aerial Vehicle (JX-1)

Detail Parts

Preparation of flight test at Fujikawa Airfield, 29 August 2013



Youtube : Josaphat UAV (Insert keywords)



First Flight, Fujikawa Airfield, 7 June 2012

After successful First Flight of Josaphat Laboratory Unmanned Aerial Vehicle (JX-1) at Fujikawa Airport on 7 June 2012

Josaphat Microwave Remote Sensing Laboratory
Center for Environmental Remote Sensing, Chiba University
CHIBA UNIVERSITY

Josaphat Laboratory Experimental Unmanned Aerial Vehicle (JX-1)

Josaphat Laboratory Experimental Unmanned Aerial Vehicle (JX-2)

KERJA DAN KARYA

Mereka yang Melampaui Bangsanya

Namanya Josaphat Tetuko Sri Sumantyo (45). Ia lahir di Bandung dan menjadi ahli penginderaan jarak jauh menggunakan gelombang mikro.

INDONESIA TANGGUH
70 TAHUN MERDEKA

Namanya dipakai untuk sebuah laboratorium di Universitas Chiba, kota Chiba, Jepang, yakni Josaphat Microwave Remote Sensing Laboratory (JMRSL). Jaraknya sekitar 5.000 kilometer dari kampung halamannya.

Prestasi Josaphat bukan tentang penyematan namanya di laboratorium itu. Kemampuannya membuat JMRSL sebagai laboratorium terbesar di dunia untuk penginderaan jarak jauh berbasis gelombang mikro melejitkan namanya.

Ditemui saat sedang berada di Kalibata, Jakarta, Kamis (13/8), Josaphat menjelaskan, JMRSL mendunia karena gigih dan gencarnya penelitian dan promosi ke sejumlah negara. Produk risetnya memperhalki produk serupa di dunia. Salah satunya, sensor pemantau muka bumi bernama Circularly Polarized-Synthetic Aperture Radar (CP-SAR).

CP-SAR bisa memetakan penurunan muka tanah. Radarnya bisa mendeteksi setiap milimeter penurunan dan mendeteksi kandungan air bawah tanah, termasuk di gurun. Dengan hasil penelitiannya itu, penduduk daerah kering di Afrika, misalnya, bisa mengetahui lokasi potensial sumber air. Paten CP-SAR baru

(Bersambung ke hal 15 kol 4-7)

Pesawat nirawak JX-1 dalam uji coba penerbangan dengan membawa serta radar CP-SAR, 29 Agustus 2013, di Fujikawa Airfield, Shizuoka, Jepang. JX-1 dan CP-SAR yang dirancang untuk kegiatan penginderaan jarak jauh merupakan karya Josaphat Tetuko Sri Sumantyo, warga negara Indonesia pengelola Josaphat Microwave Remote Sensing Laboratory di Universitas Chiba, Jepang.

Kompas Newspaper, 15 August 2015

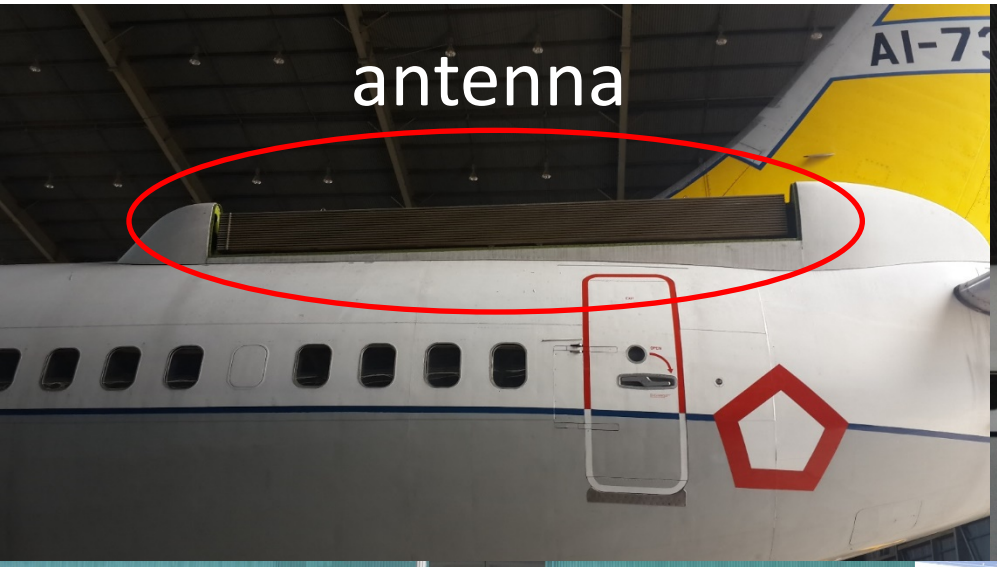
JMRSL

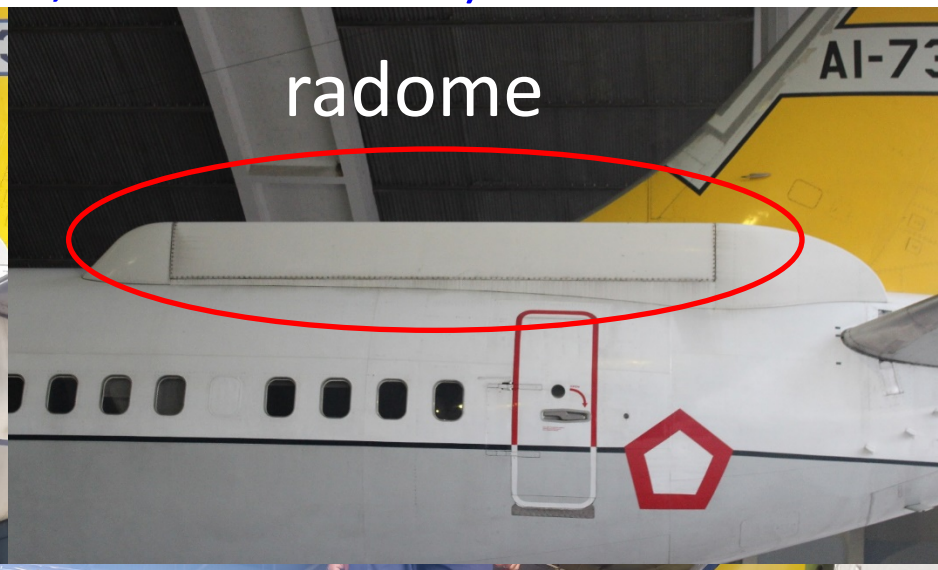
Josaphat Microwave Remote Sensing Laboratory
Center for Environmental Remote Sensing, Chiba University

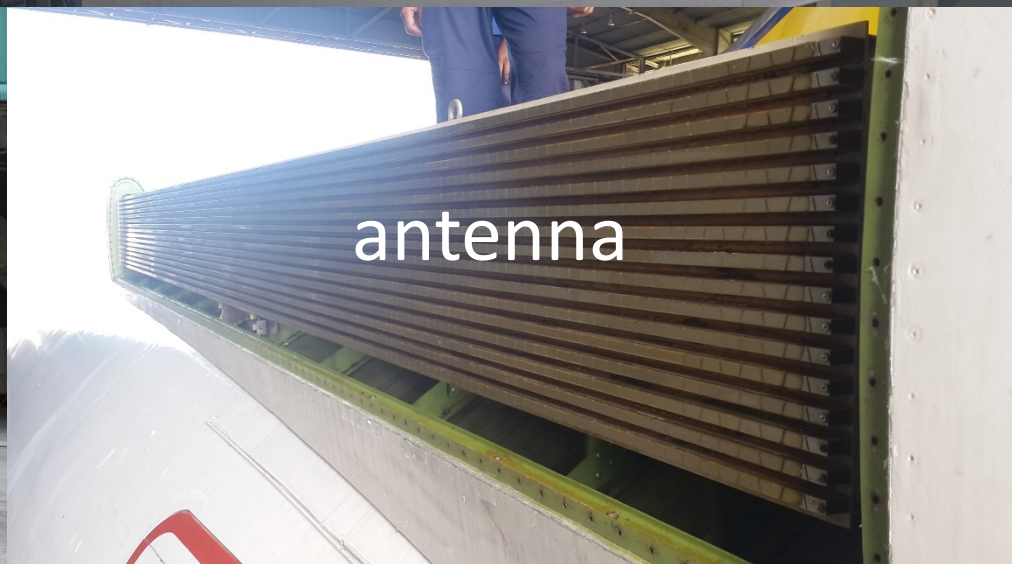
CHIBA UNIVERSITY

Boeing 737-200 Airborne SAR Flight Test : January – March 2016

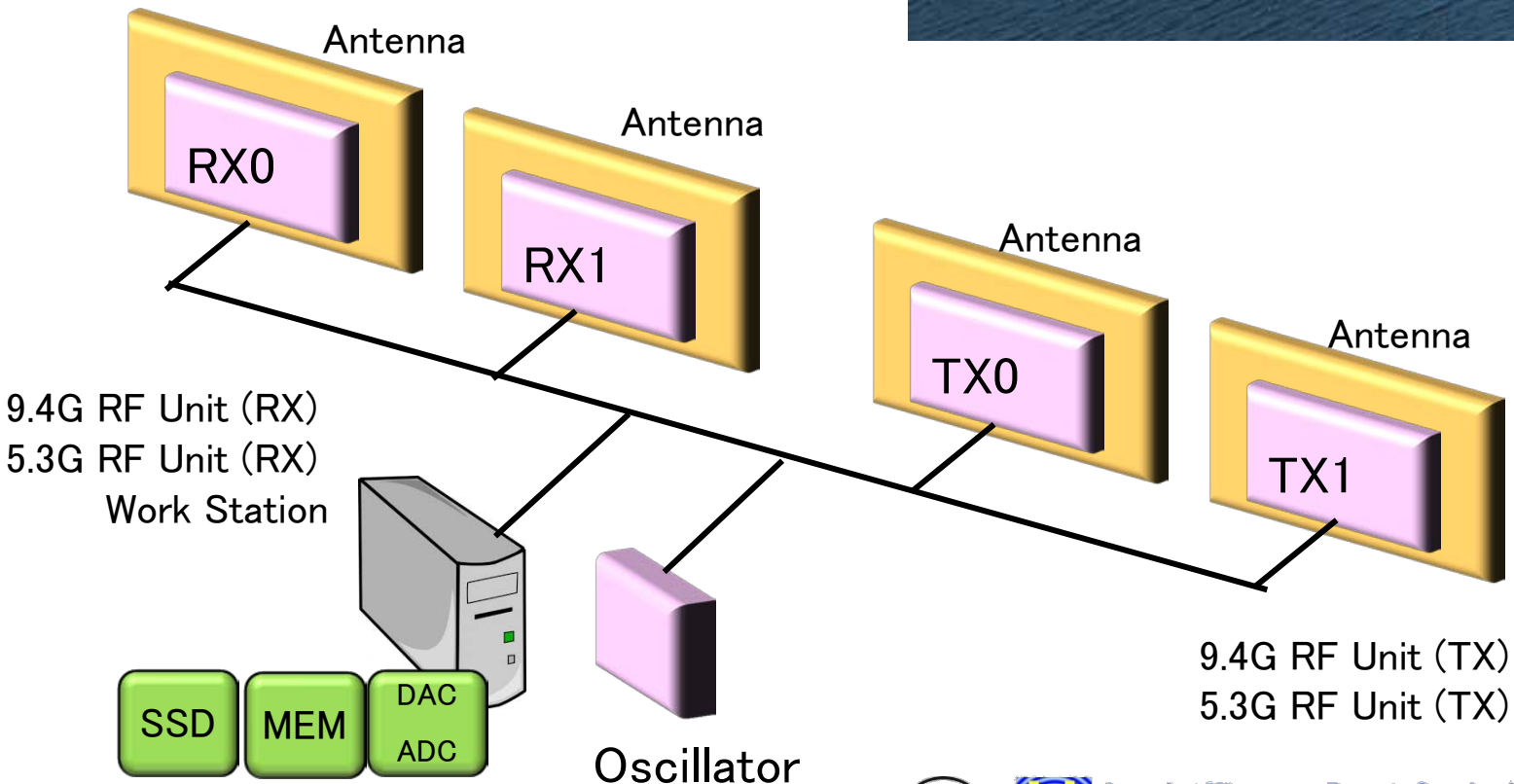
C and X Band CP-SAR System (Chiba University, JRC, Lapan, UI, Ubara, TNI-AU, Bhimasena etc)







C and X Band CP-SAR System for Aircraft



Josaphat Microwave Remote Sensing Laboratory
Center for Environmental Remote Sensing, Chiba University

C & X Band CP-SAR System for Aircraft : Flight Test (January – March 2016)
Plan : 2016 – 2020 Twice Flight Test / year

Illegal fishing, oceanic surveillance, earthquake, volcano, forest fire, subsidence, active fault, sedimentation etc

Applications of SAR Images

29 July 1997 SPOT HRV

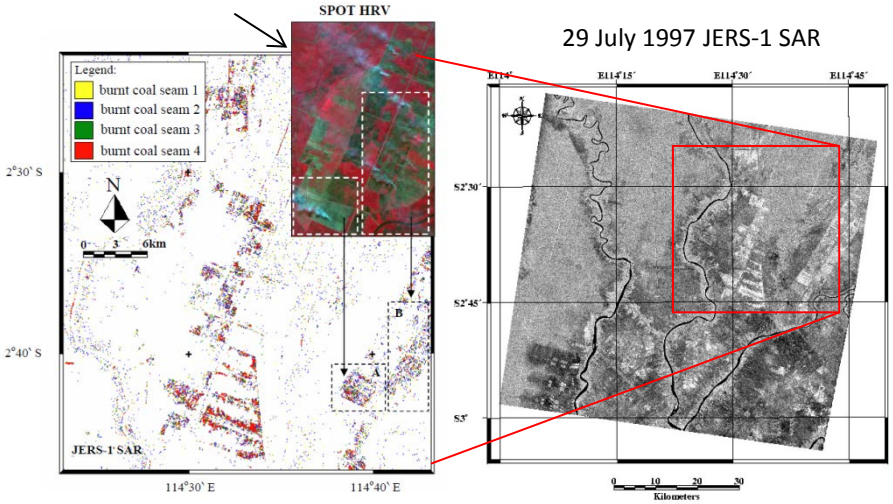
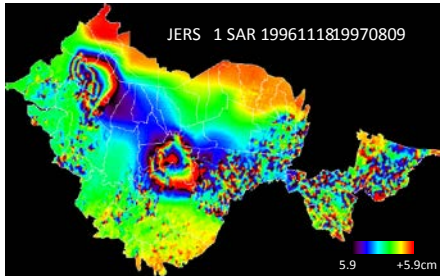
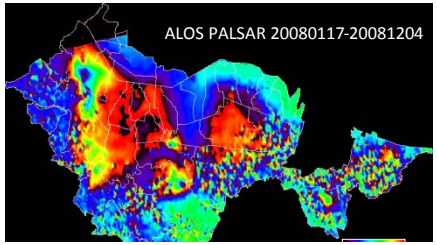


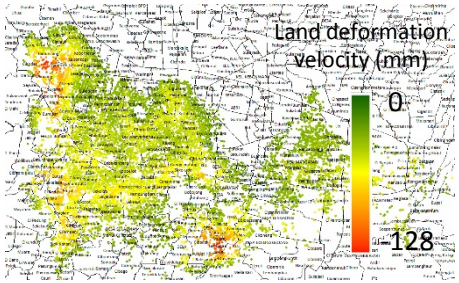
Fig. 1. Estimation of burnt coal seam

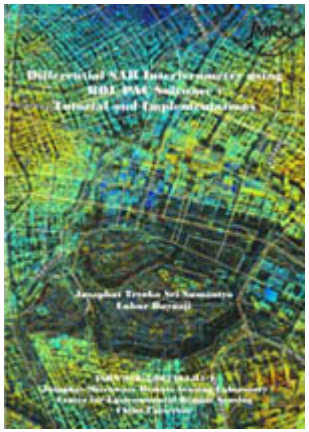
J.T. Sri Sumantyo, Ryutaro Tateishi, and N. Takeuchi, "Estimation of burnt coal seam thickness in central Borneo using a JERS-1 SAR image," International Journal of Remote Sensing, Vol. 24, No. 4, pp. 879 - 884, February 2003





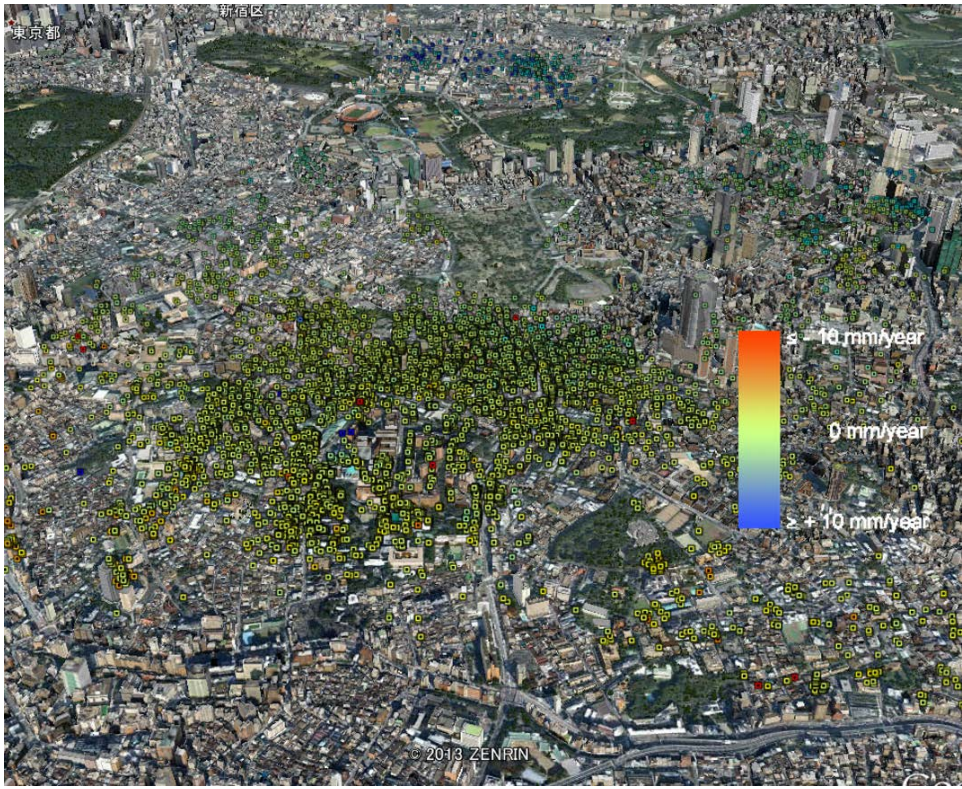
J.T. Sri Sumantyo, Masanobu Shimada, Pierre Phillipe Mathieu, and Hasanuddin Zainal Abidin, "Long term continuously DInSAR technique for volume change estimation of subsidence," IEEE Trans. Geoscience and Remote Sensing, Vol. 50, No. 1, pp. 259 – 270, January 2012 (SICE award)





Book Publications (SAR, UAV, Antennas, Propagation etc)

Workshop & Tutorial on SAR Image Processing including Basic SAR Image processing, InSAR, DInSAR, PS-InSAR etc.



Josaphat Microwave Remote Sensing Laboratory
Center for Environmental Remote Sensing, Chiba University
CHIBA UNIVERSITY

ANALYSIS OF LAND DEFORMATION VELOCITY USING PSI ALOS PALSAR : IMPACT OF COASTAL SEDIMENTATION TO FUTURE JAKARTA GIANT SEA WALL AND WATERFRONT CITY

Josaphat Tetuko Sri Sumantyo[1], Bambang Setiadi[1], Daniele Perissin[2], Shimada Masanobu[3], Pierre-Philippe Mathieu[4] and Minoru Urai[5]

[1] Center for Environmental Remote Sensing, Chiba University, Japan, [2] School of Civil Engineering, Purdue University, United States, [3] Earth Observation Research Center, Japan Aerospace Exploration Agency, Japan, [4] Earth Observation Science & Applications, European Space Agency, Italy, [5] Advanced Industrial Science and Technology, Japan

Picture source : http://www.kuiper.nl

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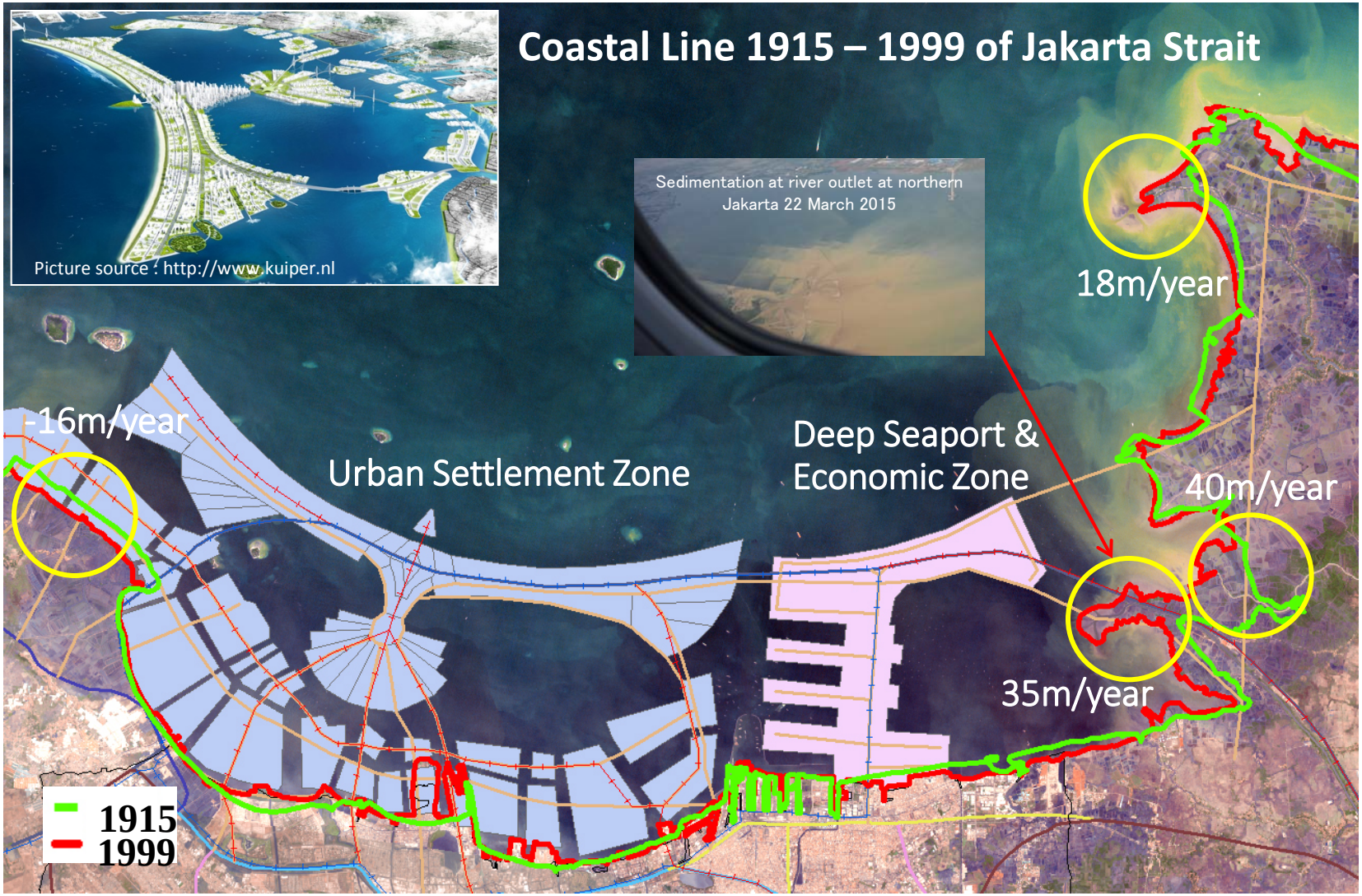
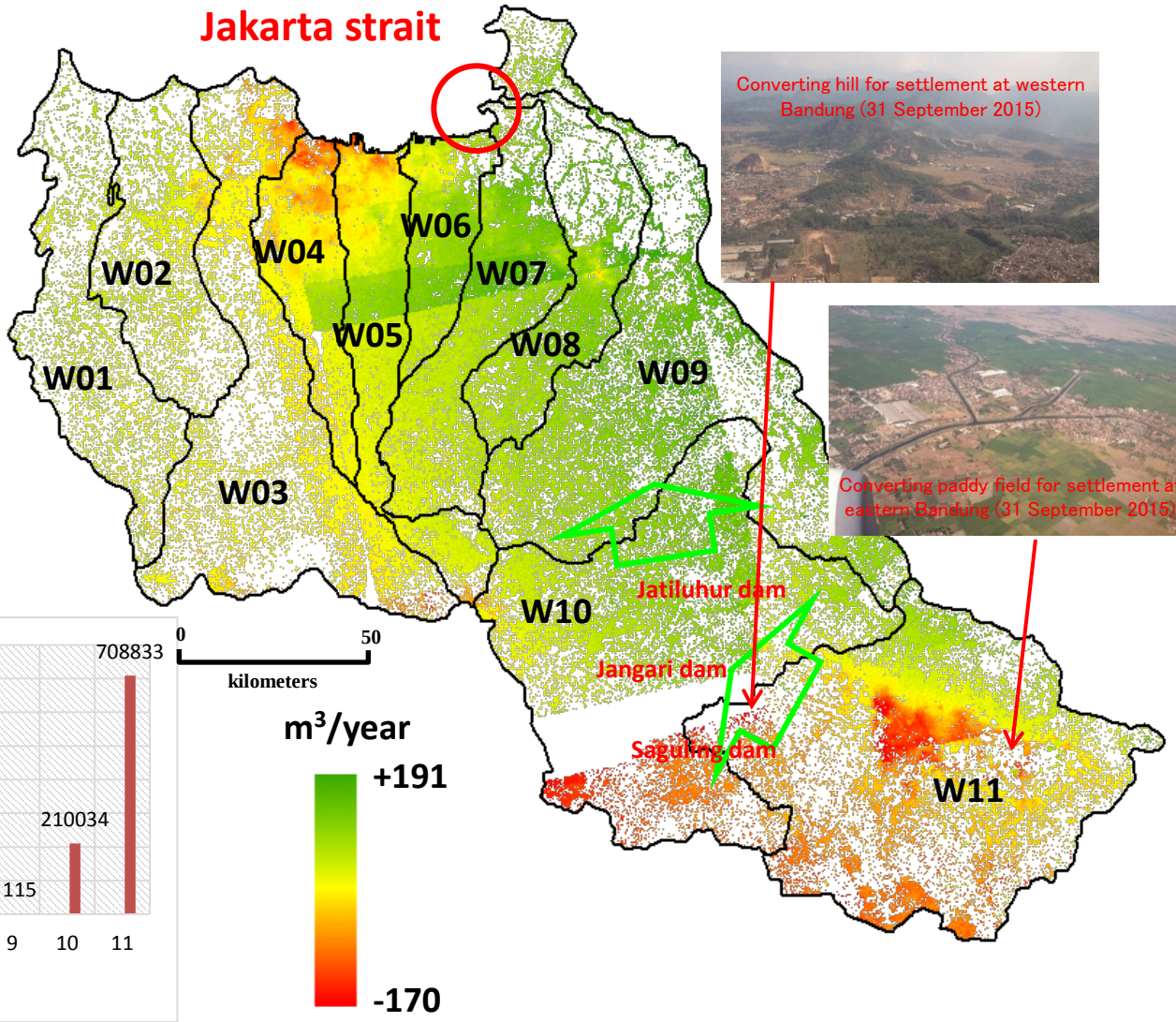

Coastal Line 1915 – 1999 of Jakarta Strait
Picture source : http://www.kuiper.nl
Sedimentation at river outlet at northern Jakarta 22 March 2015
18m/year
-16m/year
Urban Settlement Zone
Deep Seaport & Economic Zone
40m/year
35m/year
1915
1999

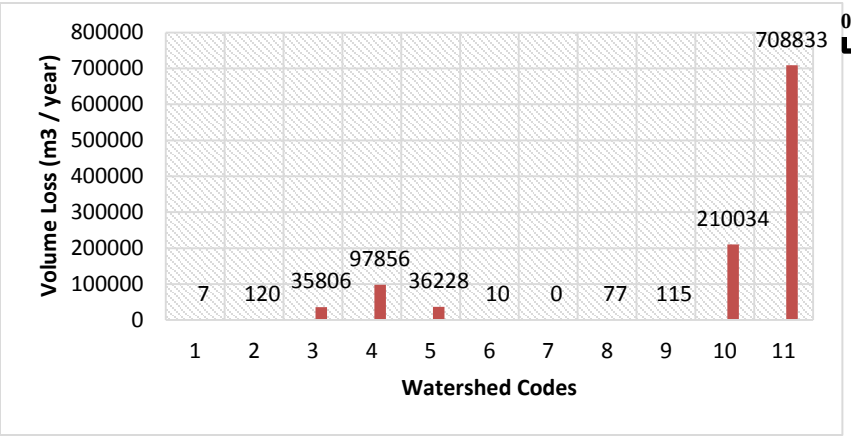
Analysis Result : Volume Loss (m^3/year)

Volume loss in each watershed using ALOS PALSAR images

Volume loss in watersheds of W03, W04, W05, W10, and W11

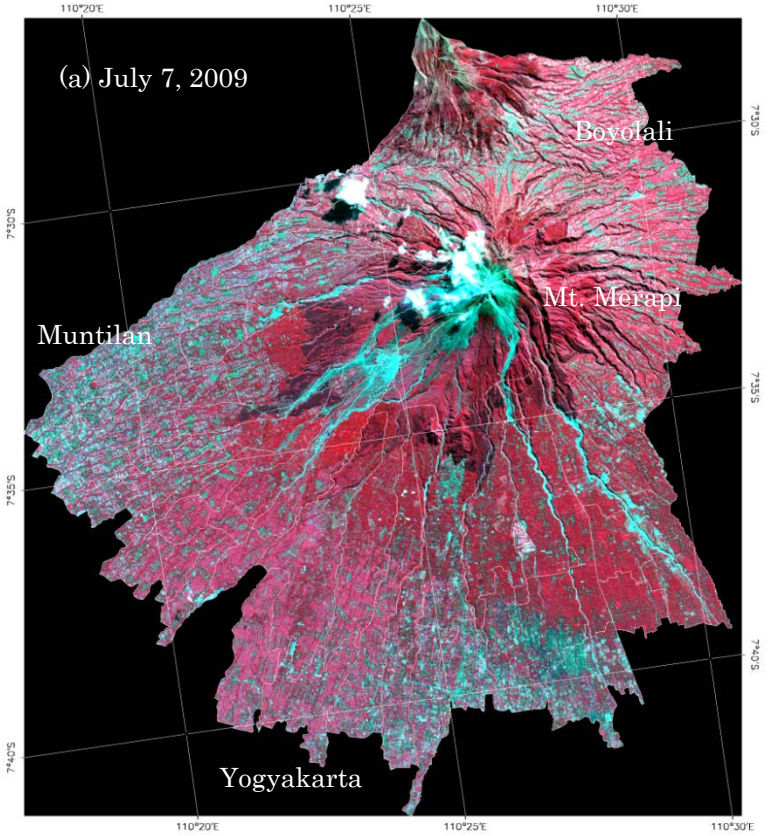
Volume loss of sedimentation material does not occurred in W07-W09, therefore the land deformation in these watersheds does not influence to Jakarta Giant Sea Wall.

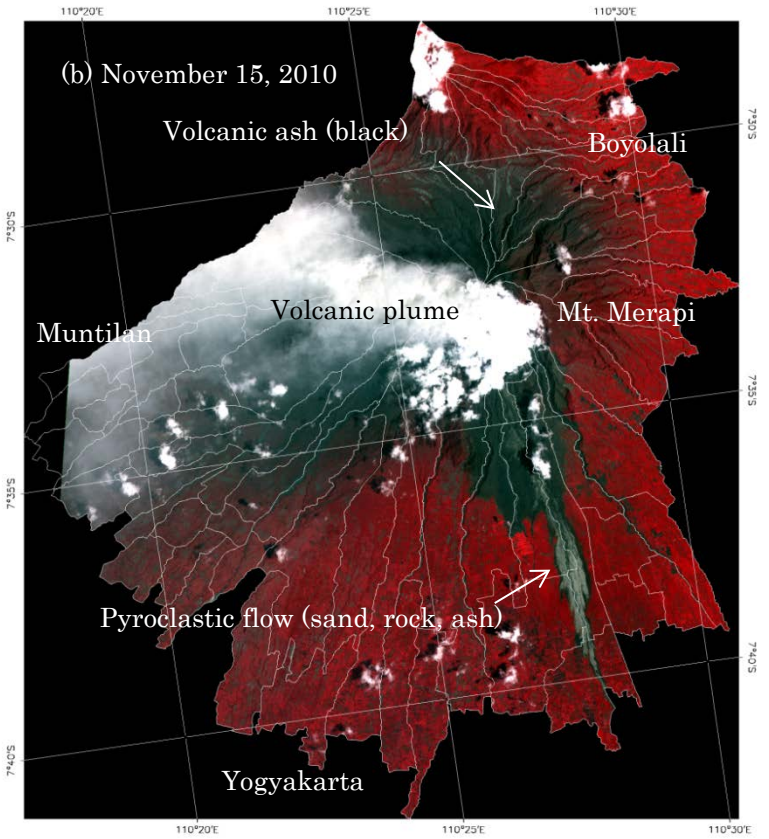




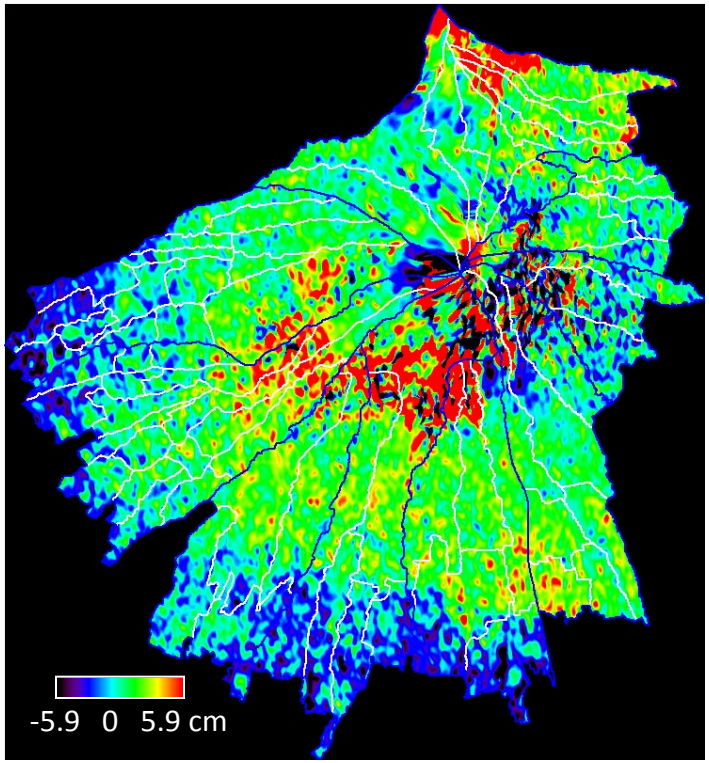
Application (1) : Monitoring of Mount Merapi Eruption

Terra ASTER images of Mount Merapi eruption (November 15, 2010) and before (July 7, 2009)

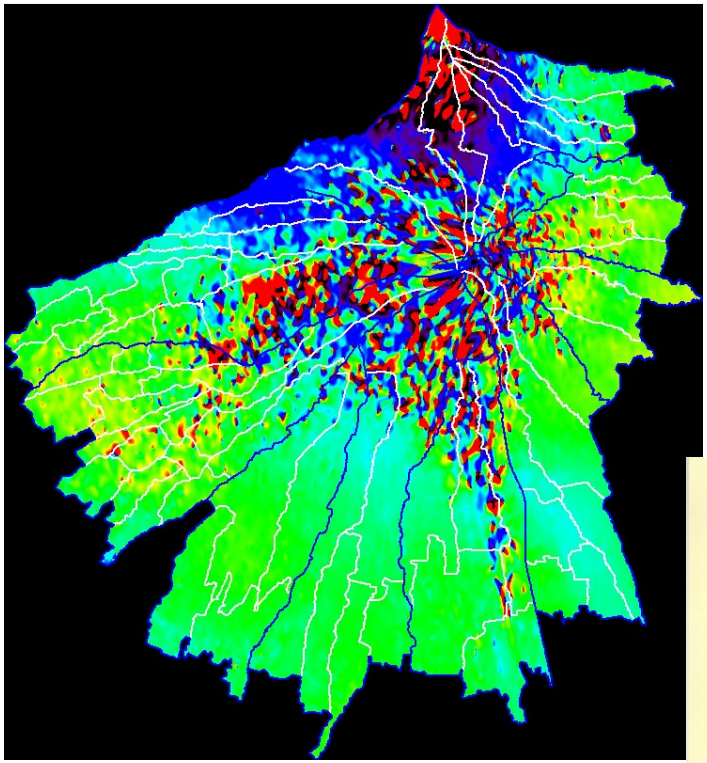




Interferogram of ALOS PALSAR pairs



(a) A1 pair : Slave September 16, 2010 – Master November 1, 2010



(b) A2 pair : Slave March 16, 2010 – Master December 17, 2010

This is to certify that
the Technical Program Committee has awarded the

2011
Best Paper Award

to

Josaphat Tetuko Sri Sumantyo

for the paper entitled
"DInSAR Technique for Retrieving Volume Change of Volcanic Materials on Slope Area"

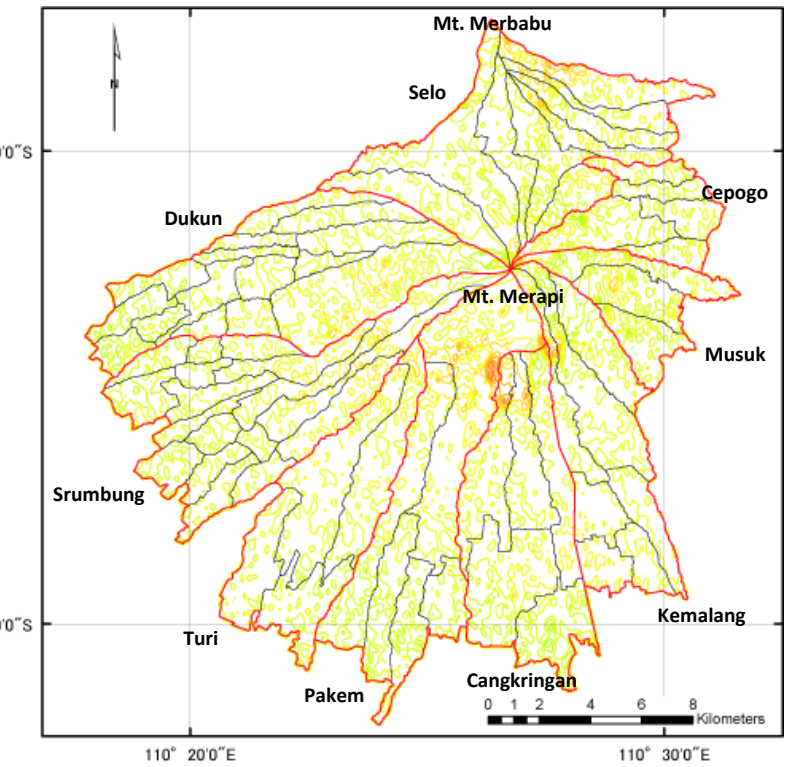
given at the International Conference on Space, Aeronautical and Navigational Electronics 2011 (ICSANE2011)
held in Bali

The Institute of Electronics, Information and Communication Engineers (IEICE)

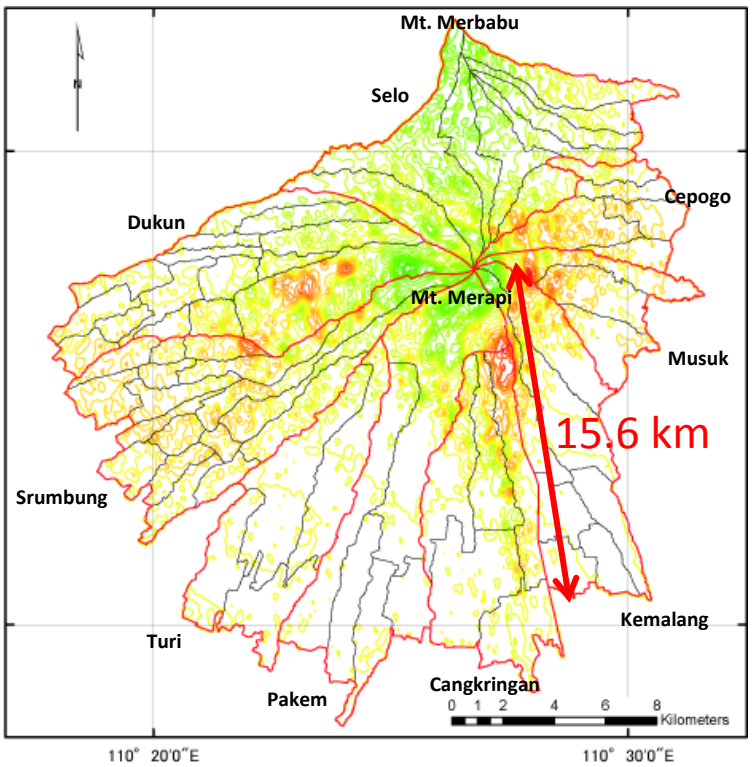
前田 惟裕
Technical Program Committee Chair
October 19th, 2011

Thickness distribution of volcanic ash of Mount Merapi derived by DInSAR technique

(a) Slave 16 September 2010 – Master 1 November 2010 (FBD)



(b) Slave 16 March 2010 – Master 17 December 2010 (FBS)



Legend

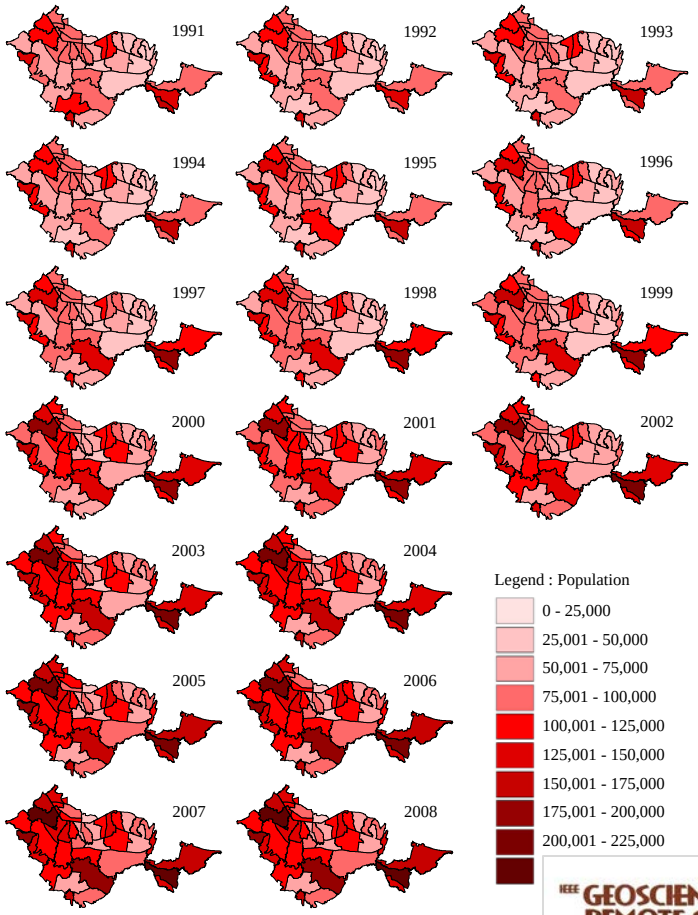
De mation (cm)

-15 15
-14 14
-13 13
-12 12
-11 11
-10 10
-9 -9
-8 -8
-7 -7
-6 -6
-5 -5
-4 -4
-3 -3
-2 -2
-1 -1
0 0
1 1
2 2
3 3
4 4
5 5
6 6
7 7
8 8
9 9
10 10
11 11
12 12
13 13
14 14
15

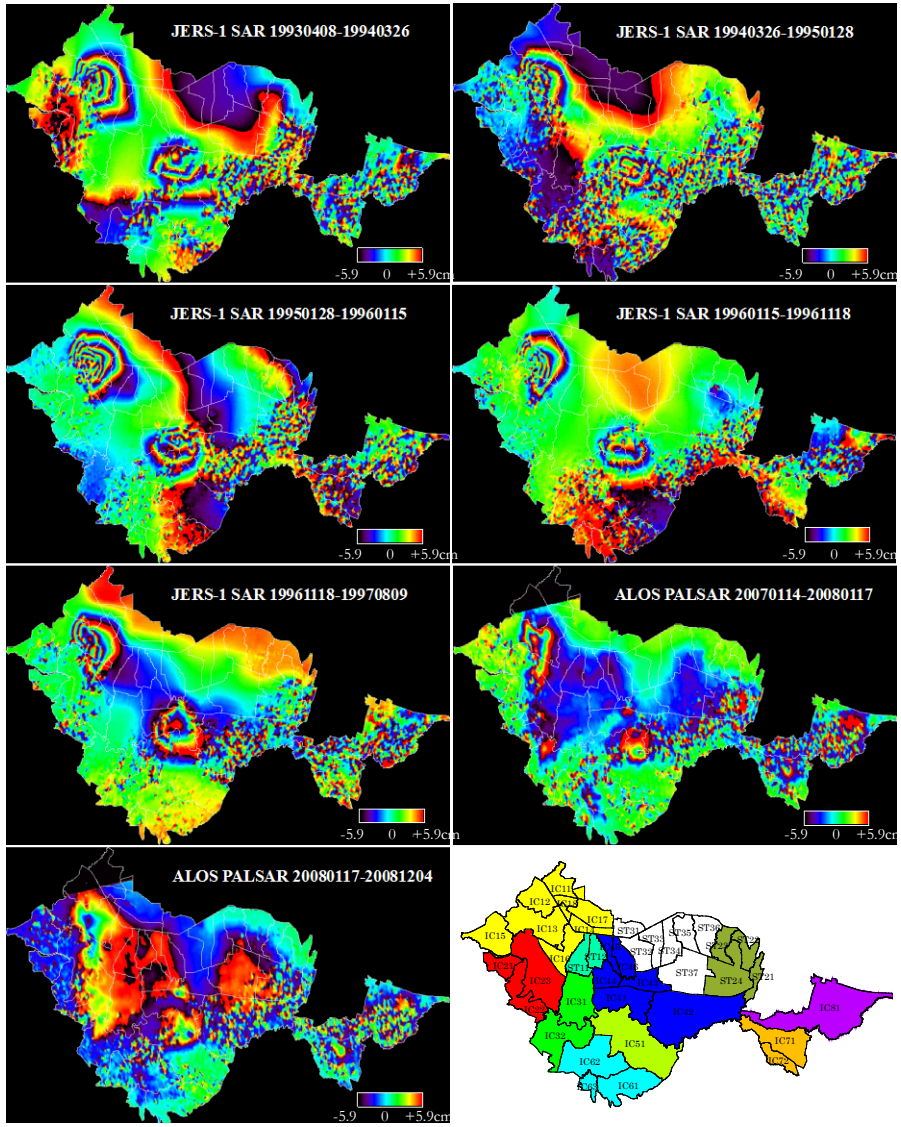
District boundary

Village boundary

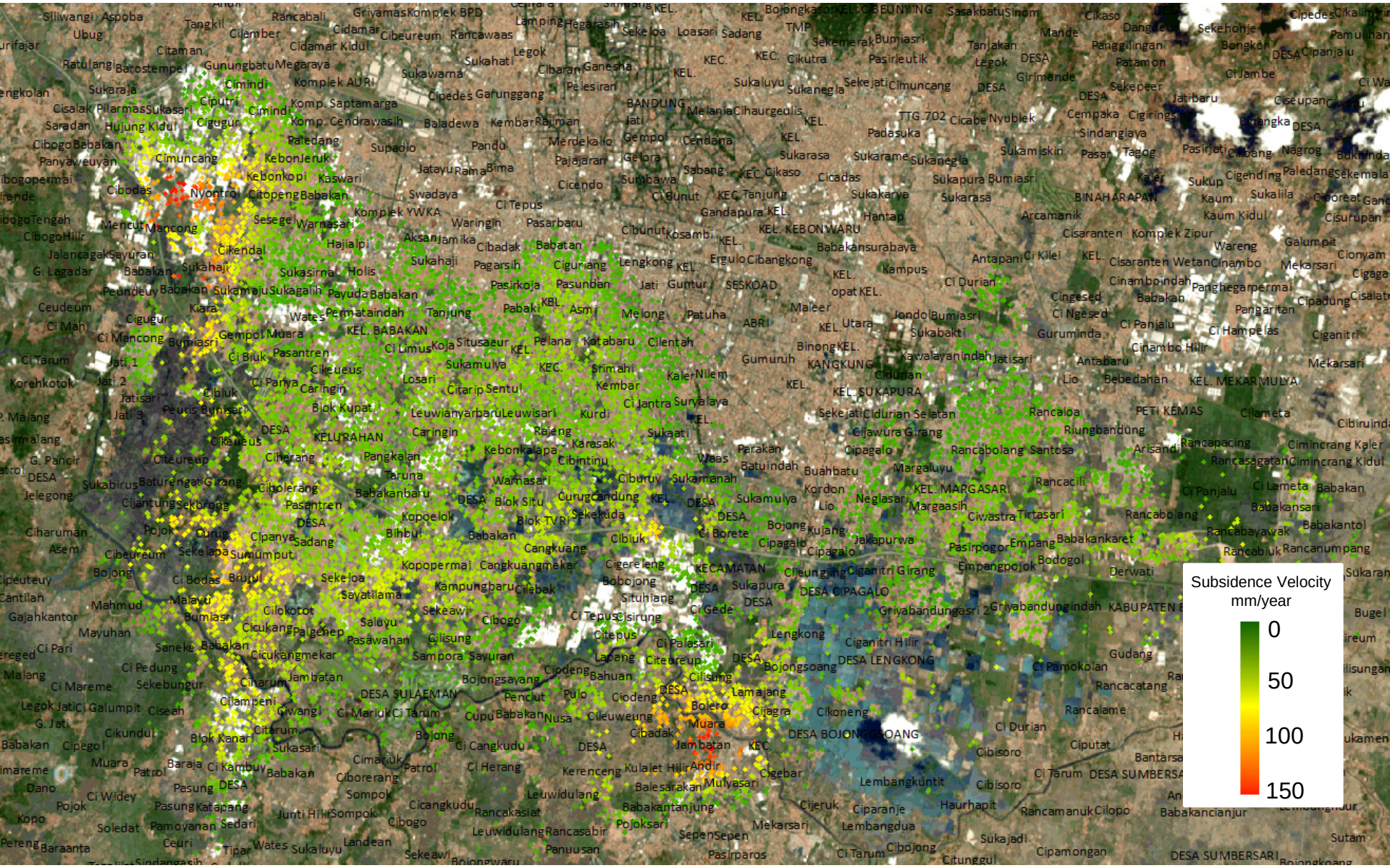
Application (3) : Monitoring of Subsidence of Bandung City



Josaphat Tetuko Sri Sumantyo, Masanobu Shimada, Pierre Peter Mathieu, and Hasanuddin Zainal Abidin , "Long-term Consecutive DInSAR for Volume Change Estimation of Land Deformation," IEEE Transactions on Geoscience and Remote Sensing, Vol. 50, No. 1, pp. 259 – 270, January 2012 (New Jersey : IEEE) ISSN 0196-2892



PS-InSAR : Subsidence of Bandung City



ALOS PALSAR 2007 - 2011

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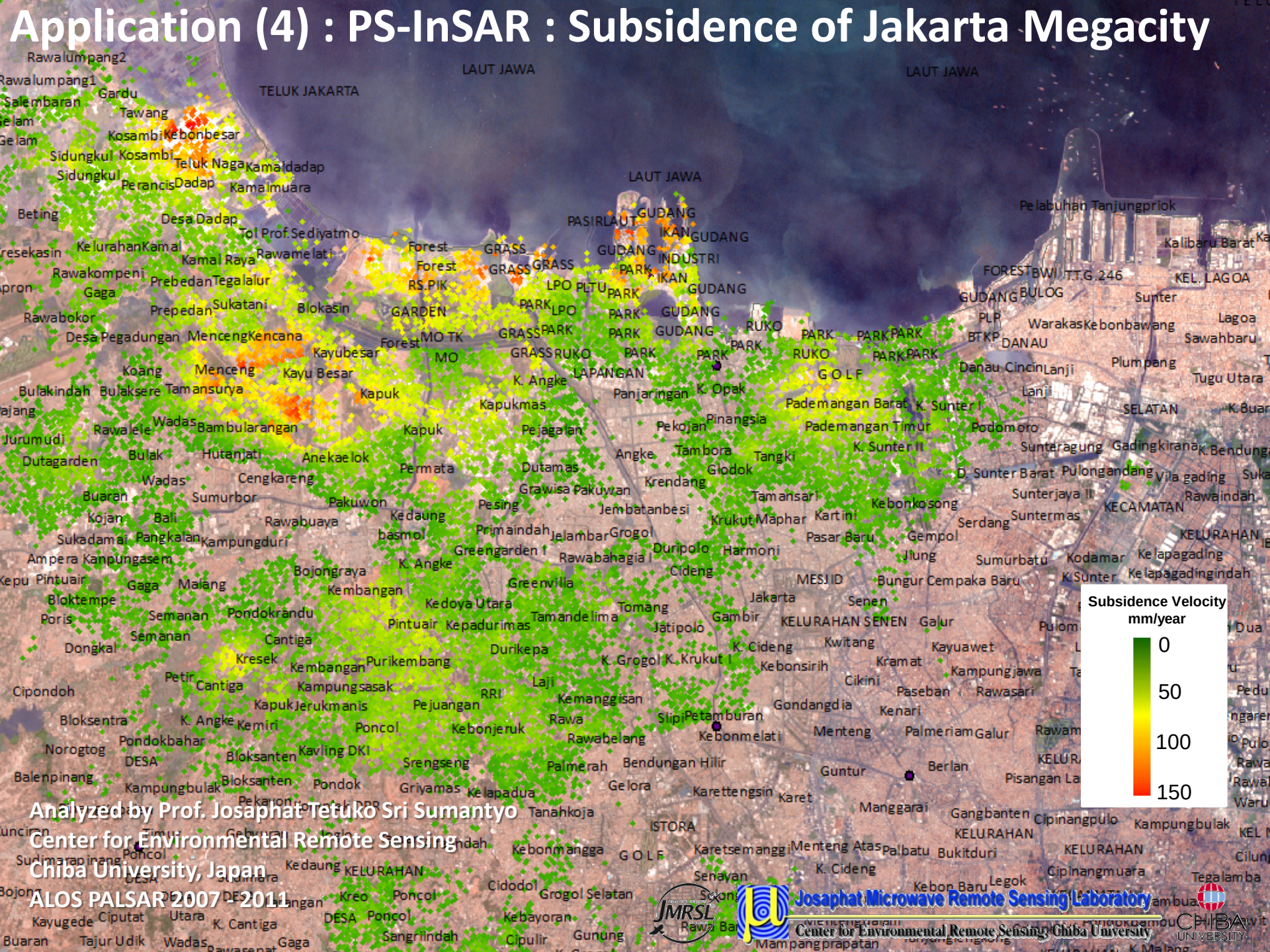
CHIBA UNIVERSITY

Application (4) : PS-InSAR : Subsidence of Jakarta Megacity



Summary

Chiba University collaborates Indonesian counterparts to run Integrated Earth Environmental Diagnosis Research Program and Advance Microwave Remote Sensing Research Center to develop Circularly Polarized Synthetic Aperture Radar (CP-SAR) system for microsatellite, Aircraft, UAV, Car and Ground platforms.

Future Research

Flight test of CP-SAR onboard aircraft and UAV at Indonesia in January – March 2015

Thank you for your attention !

Josaphat Laboratory Satellite Ground station

Contact Person :
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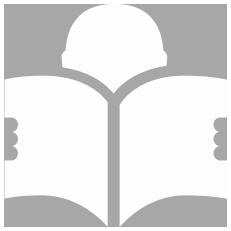
Telp. +81(0)43-290-3840 Fax +81(0)43-290-3857
Email jtetukoss@faculty.chiba-u.jp
Website http://www2.cr.chiba-u.jp/jmrsl/

Fujikawa Airfield, 29 August 2013 UTC 06:09:54.521

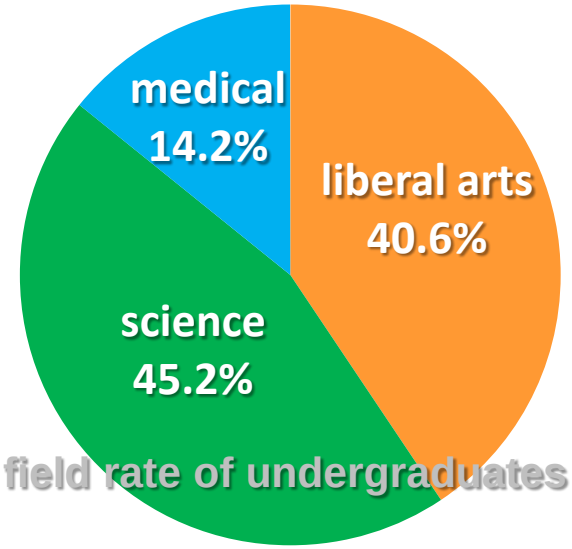
Josaphat Microwave Remote Sensing Laboratory
Center for Environmental Remote Sensing, Chiba University

Number of Students



Total 14,242 Students

10,756 Under Graduate
2,171 Masters Degree
1,214 Doctoral Degree
101 Professional Degree



field rate of undergraduates

1,385
International Students

638
Students Going Abroad

as of 2015.5.1 / FY2014

Number of Staff

Total 3,349 Personnel

9 Executives
1,322 Academic Staff
2,018 Technical / Administrative Staff

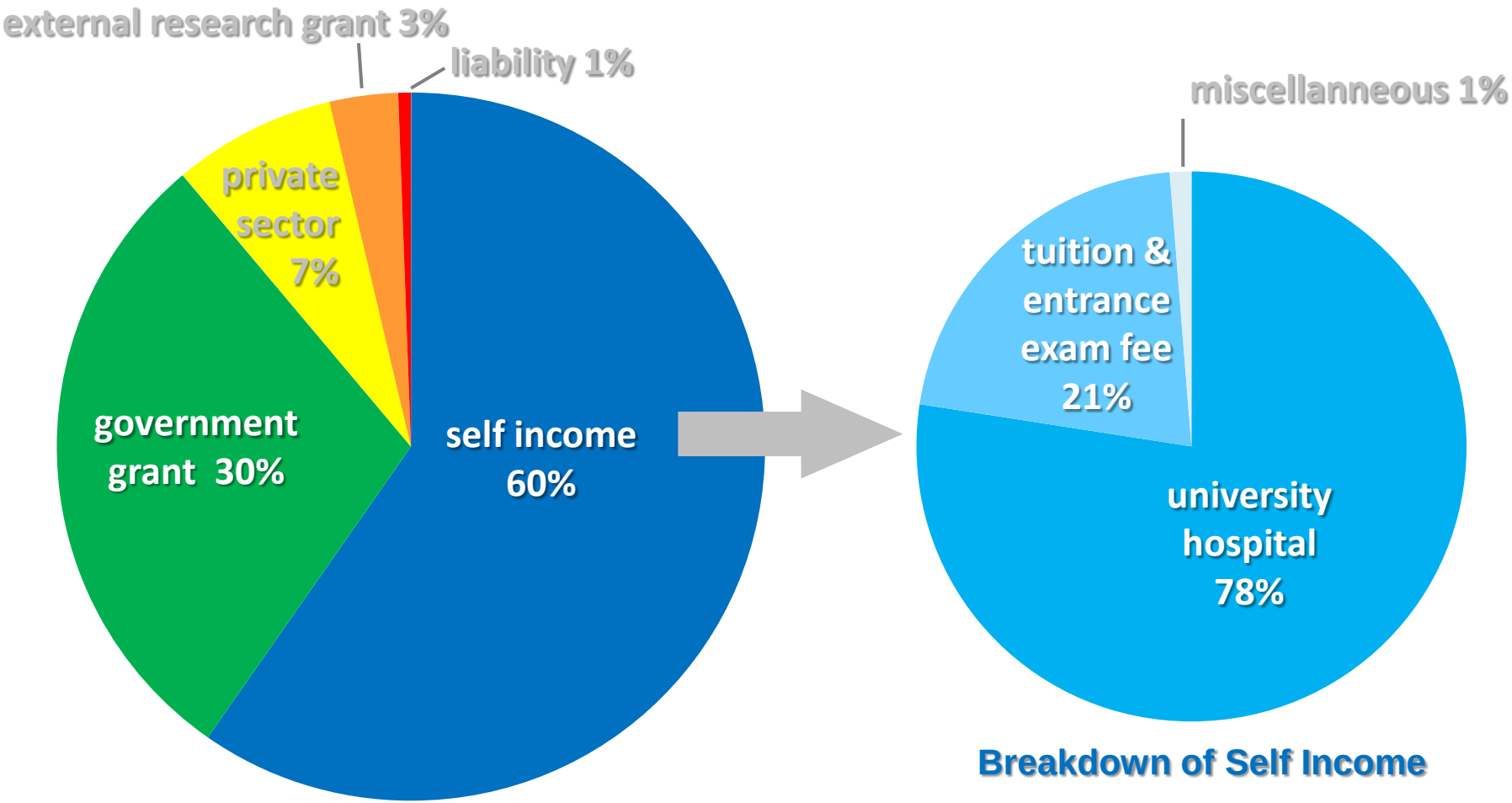
390
International Researchers

1,680
Staff Going Abroad

as of 2015.5.1 / FY2014

Annual Budget FY 2015

Total 64,033 Million Yen



9 Undergraduate Faculties

Letters
- Behavioral Science
- History
- Japanese Studies
- Int'l Language & Cultures

Science
- Mathematics & Informatics
- Physics
- Chemistry
- Biology
- Earth Sciences

Engineering
- Architecture
- Urban Environment Systems
- Design
- Mechanical Engineering
- Electrical & Electronic Engineering
- Medical System Engineering
- Nanoscience
- Applied Chemistry & Biotechnology
- Image Science
- Information & Image Systems

Education
- Elementary School Teachers
- Junior High School Teachers
- Education of Children with Special Needs
- Kindergarten Teachers
- Health Nursing Teachers
- Sports Sciences
- Lifelong Education

Medicine

Pharmaceutical Sciences
- Pharmacy
- Pharmaceutical Sciences

Nursing
- Nursing

Law, Politics & Economics
- Law
- Economics
- Management & Accounting
- Politics & Policy Sciences

Horticulture
- Horticulture
- Applied Biological Chemistry
- Environment Science & Landscape Architecture
- Food & Resource Economics

11 Graduate Schools

Humanities & Social Sciences
- Area Cultures
- Public Affairs
- Social Sciences
- Synthetic Cultural Studies
- Advanced Management Sciences

Education
- School Education
- The Study of School Subjects
- The United Graduate School of Education

Law Schools
- Professional degree programs

Medical & Pharmaceutical Science
- Medical Sciences
- General Pharmaceutical Sciences
- Frontier Pharmaceutical Sciences
- Frontier Medicine & Pharmacy
- The United Graduate School of Child Development

Pharmaceutical Sciences

Engineering
- Architecture & Urban Science
- Design Science
- Artificial Systems Science
- Applied Chemistry & Biotechnology

Advanced Integration Science
- Nanoscience
- Information Technology

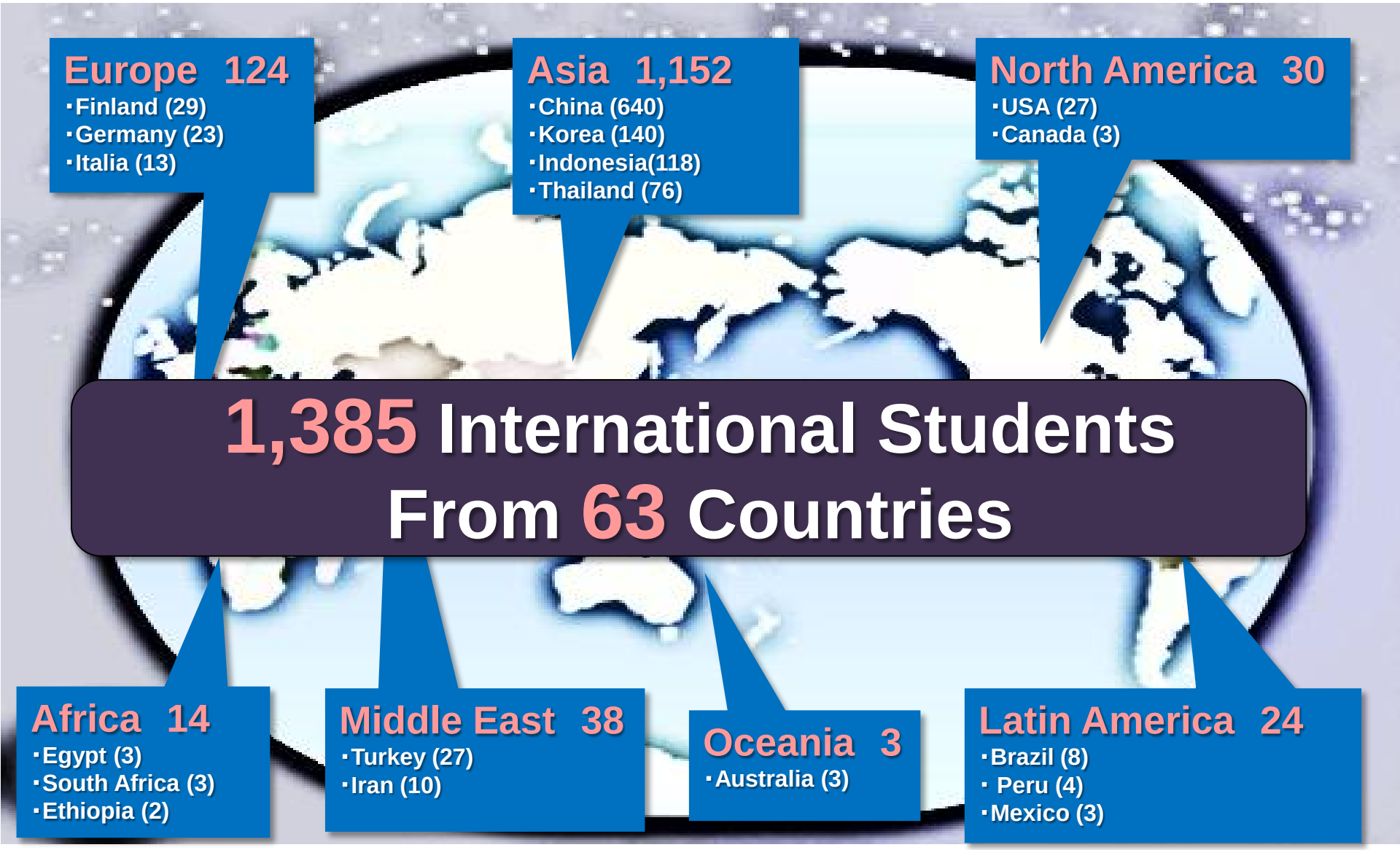
Horticulture
- Environmental Horticulture

Medicine

Science
- Mathematics & Informatics
- Physics
- Chemistry
- Biology
- Earth Sciences

Nursing
- Nursing
- Nursing Systems Management
- Disaster Nursing Global Leadership Program

International Students



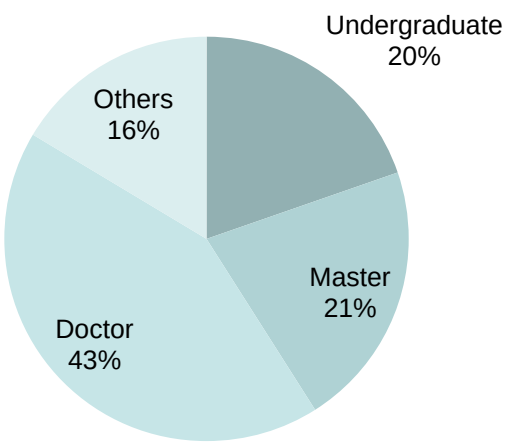
FY2014

Incoming students from Indonesia

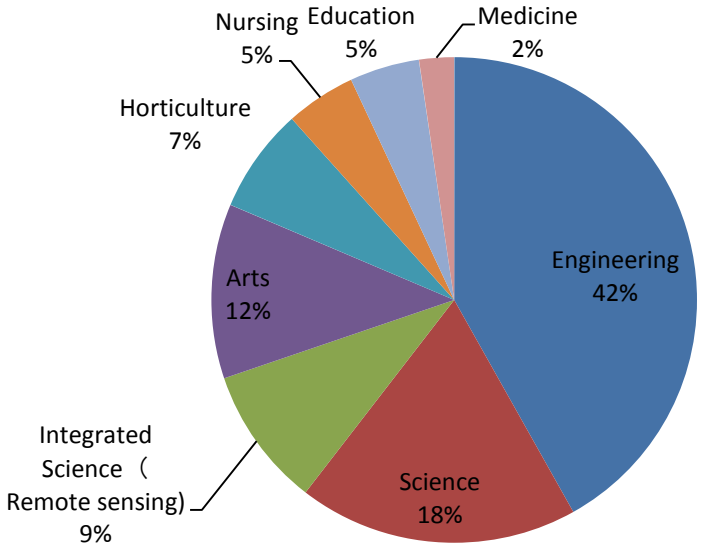
From Sister Universities in Indonesia for 5 years (2009-2013)

Universitas Indonesia	31
Universitas Gadjah Mada	40
Institut Teknologi Bandung	36
Universitas Hasanuddin	3
Institut Pertanian Bogor	20
Universitas Udayana	27
Universitas Padjadjaran（2010-）	17
Institut Teknologi Sepuluh Nopember	2
Universitas Diponegoro（2012-）	4

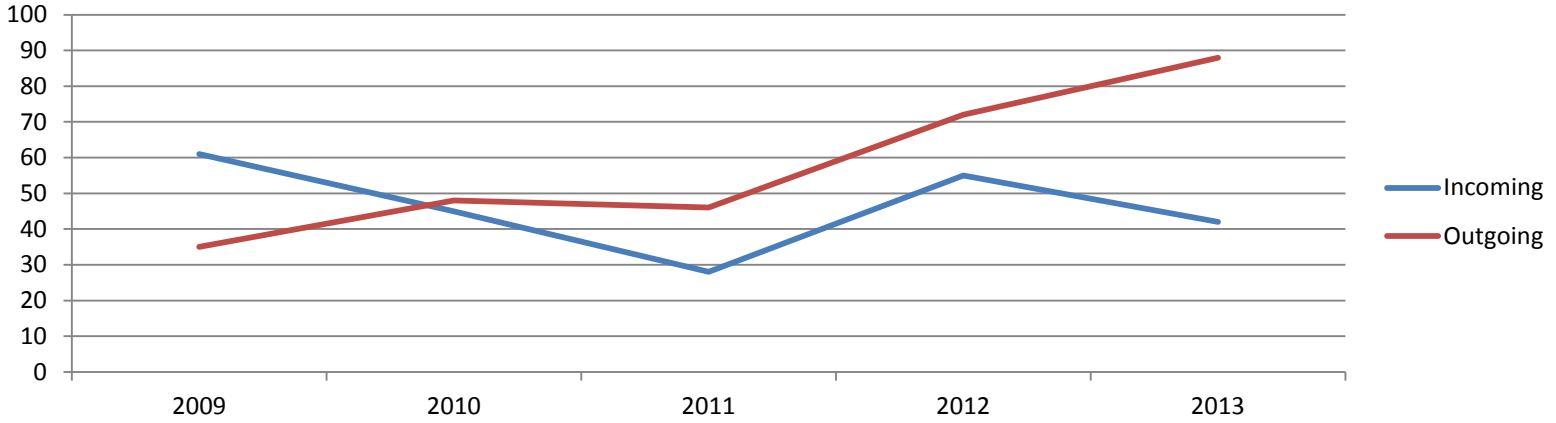
Indonesian Students in Chiba U. (2014)



Research Themes of Indonesian Students in Chiba U. (2014)



Personnel Exchanges in Research



Sister Universities in Indonesia	5 years (2009-2013)	
	Incoming	Outgoing
Universitas Indonesia	62	103
Universitas Gadjah Mada	34	39
Institut Teknologi Bandung	36	31
Universitas Hasanuddin	23	7
Institut Pertanian Bogor	24	31
Universitas Udayana	34	54
Universitas Padjadjaran（2010-）	12	16
Institut Teknologi Sepuluh Nopember	7	5
Universitas Diponegoro（2012）	4	2

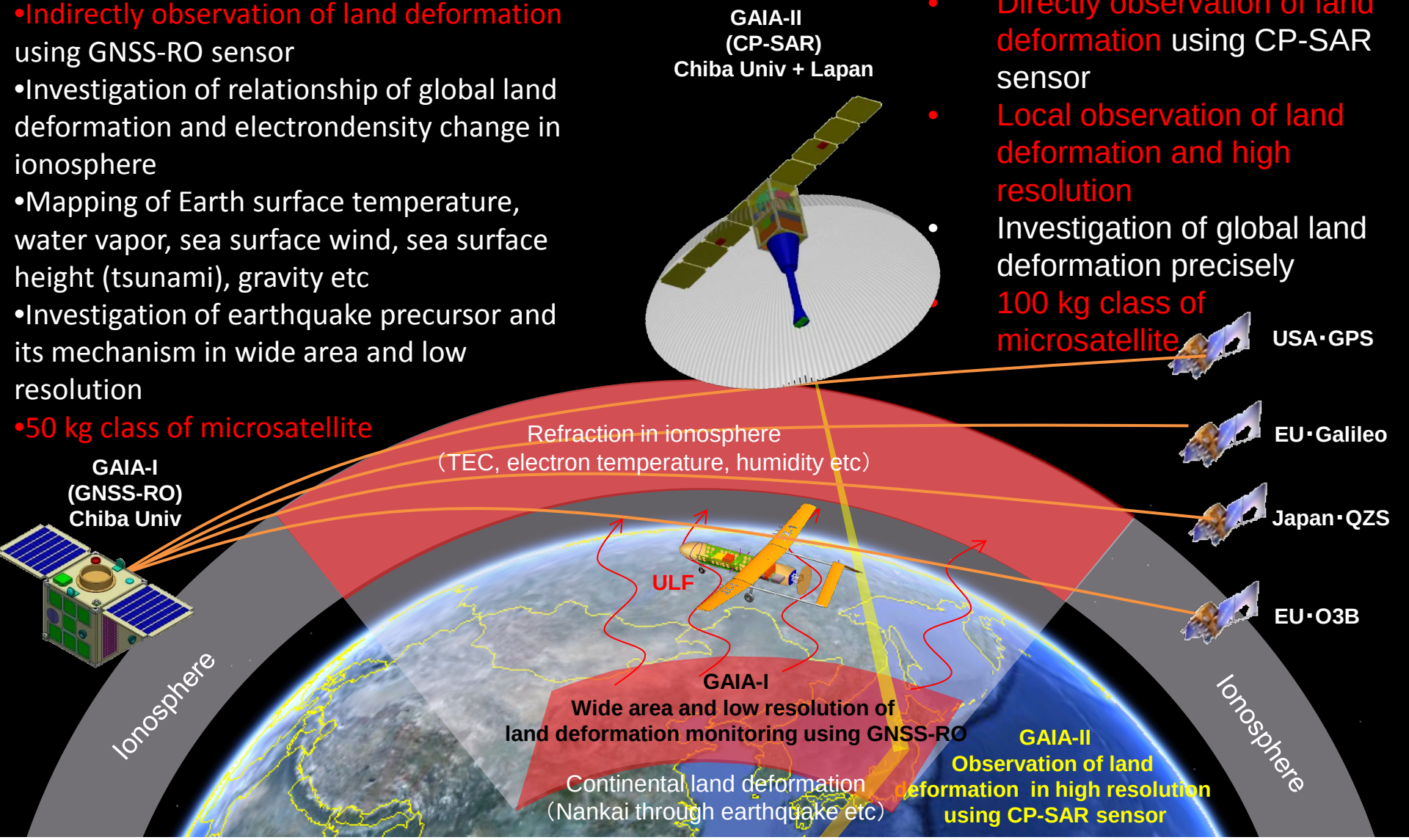
Earth Observation using the GAIA-I and GAIA-II

GNSS-RO onboard microsatellite（GAIA-I）:

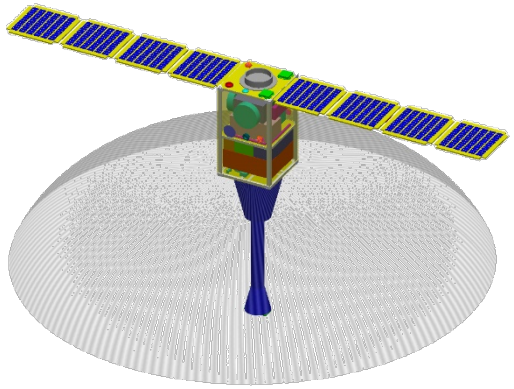
- Indirectly observation of land deformation using GNSS-RO sensor
- Investigation of relationship of global land deformation and electrondensity change in ionosphere
- Mapping of Earth surface temperature, water vapor, sea surface wind, sea surface height (tsunami), gravity etc
- Investigation of earthquake precursor and its mechanism in wide area and low resolution
- 50 kg class of microsatellite

CP-SAR onboard microsatellite（GAIA-II）:

- Directly observation of land deformation using CP-SAR sensor
- Local observation of land deformation and high resolution
- Investigation of global land deformation precisely
- 100 kg class of microsatellite

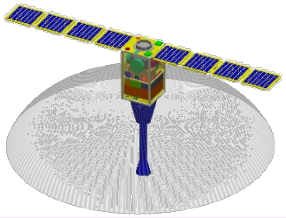


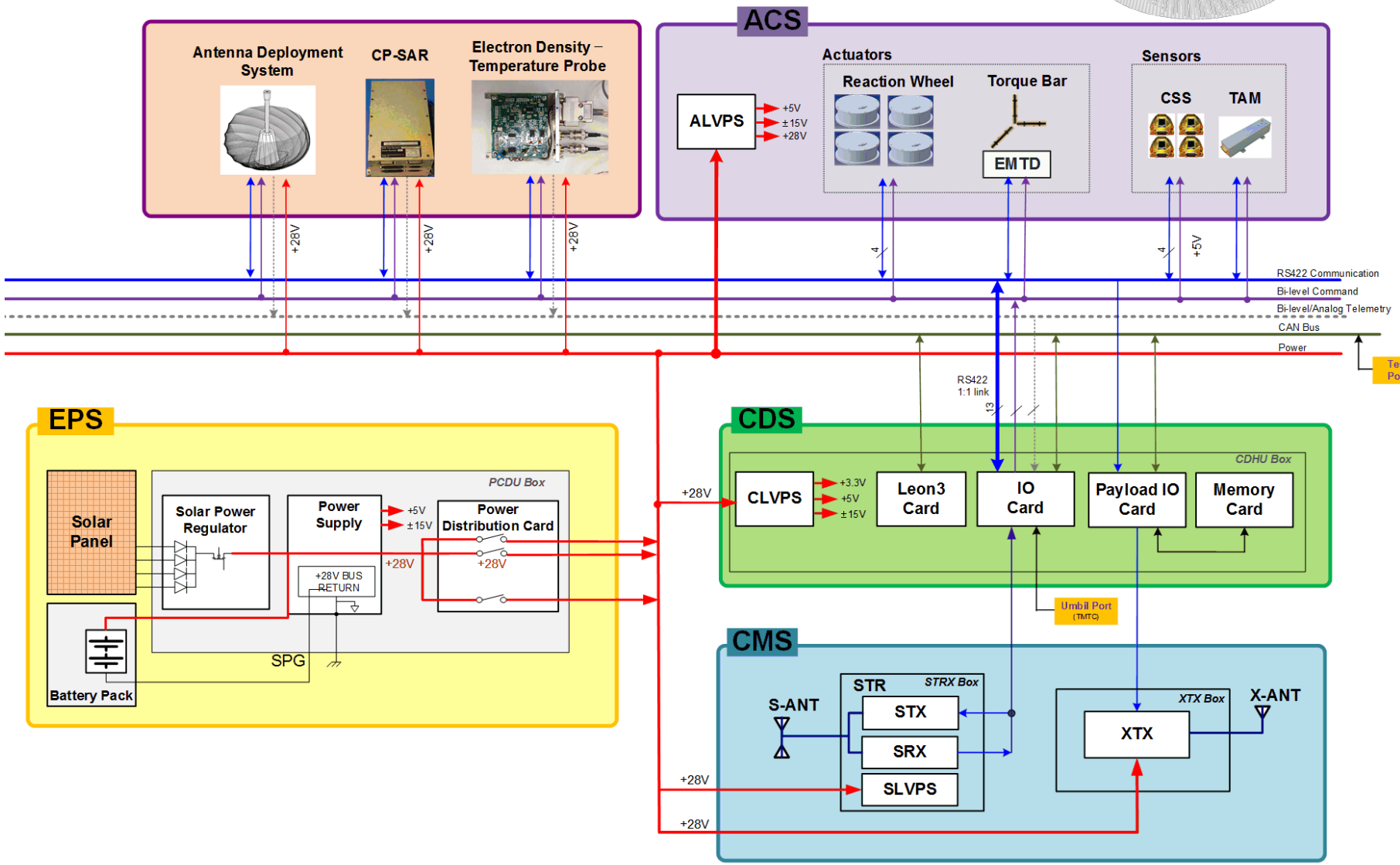
Specification of GAIA-I and GAIA-II Microsatellites



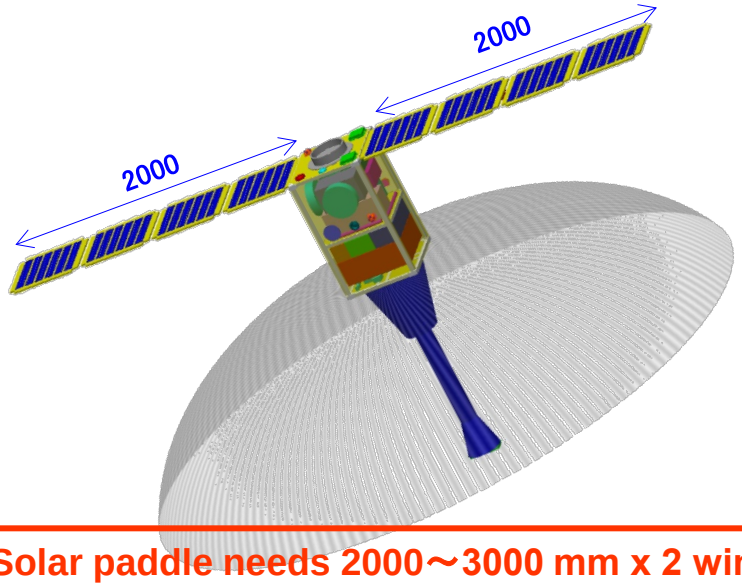
	GAIA-I	GAIA-II
Altitude	Polar Orbit, 500～900 km	Polar Orbit, 500～900 km
Mission Devices	GNSS-RO Sensor	Circular Polarized SAR（CP-SAR）
	Electron Density – Temperature Probe（EDTP)	Electron Density – Temperature Probe（EDTP)
Mission Period	1 Year	1 Year
Payload	< 50 kg	100kg – 150 kg
Power	Average < 100W	Average < 600W
Altitude Control	3 axis, accuracy 0.1°	3 axis, accuracy 0.1°
	CSS,IRU,STT,MAGS,GPSR,RWA,MTQ	CSS,IRU,STT,MAGS,GPSR,RWA,MTQ
Data rate	TBD Mbps	120Mbps
Telecommunication	S Band（TLM/CMD）	S Band（TLM/CMD）
	X Band（Mission Data, 10 Mbps）	X Band（Mission Data, 20 Mbps）
Memory	128 (or256）MBytes	10 GBytes
Size	About 500 X 500 X 500 mm（launch）	About 500 X 700 X 800 mm（launch）

GAIA-II : Subsystems

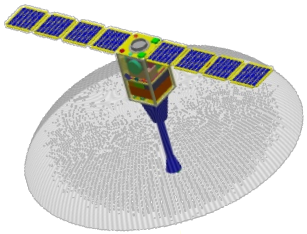


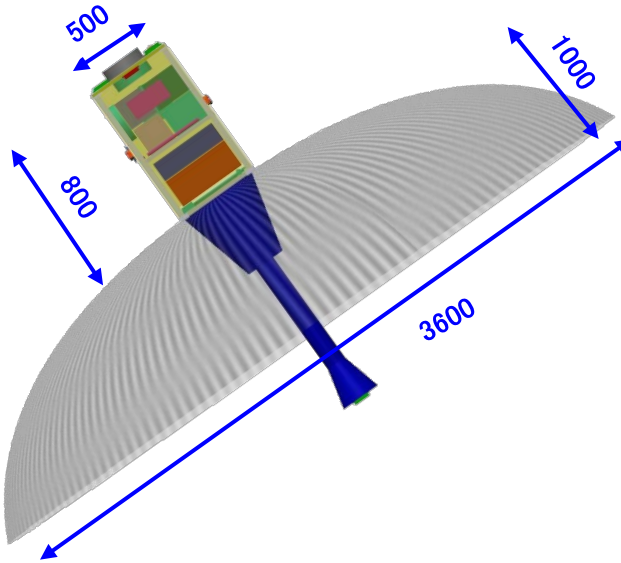


SAR Small-Satellite Outline - Satellite size

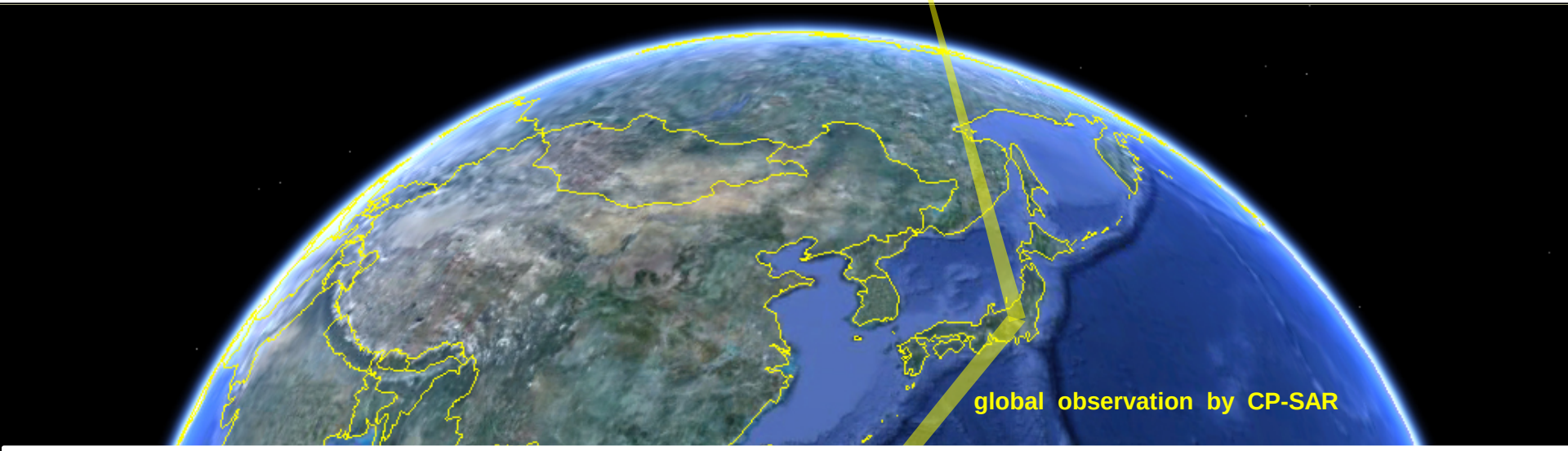


SAR Small-Sat.
(CP-SAR)

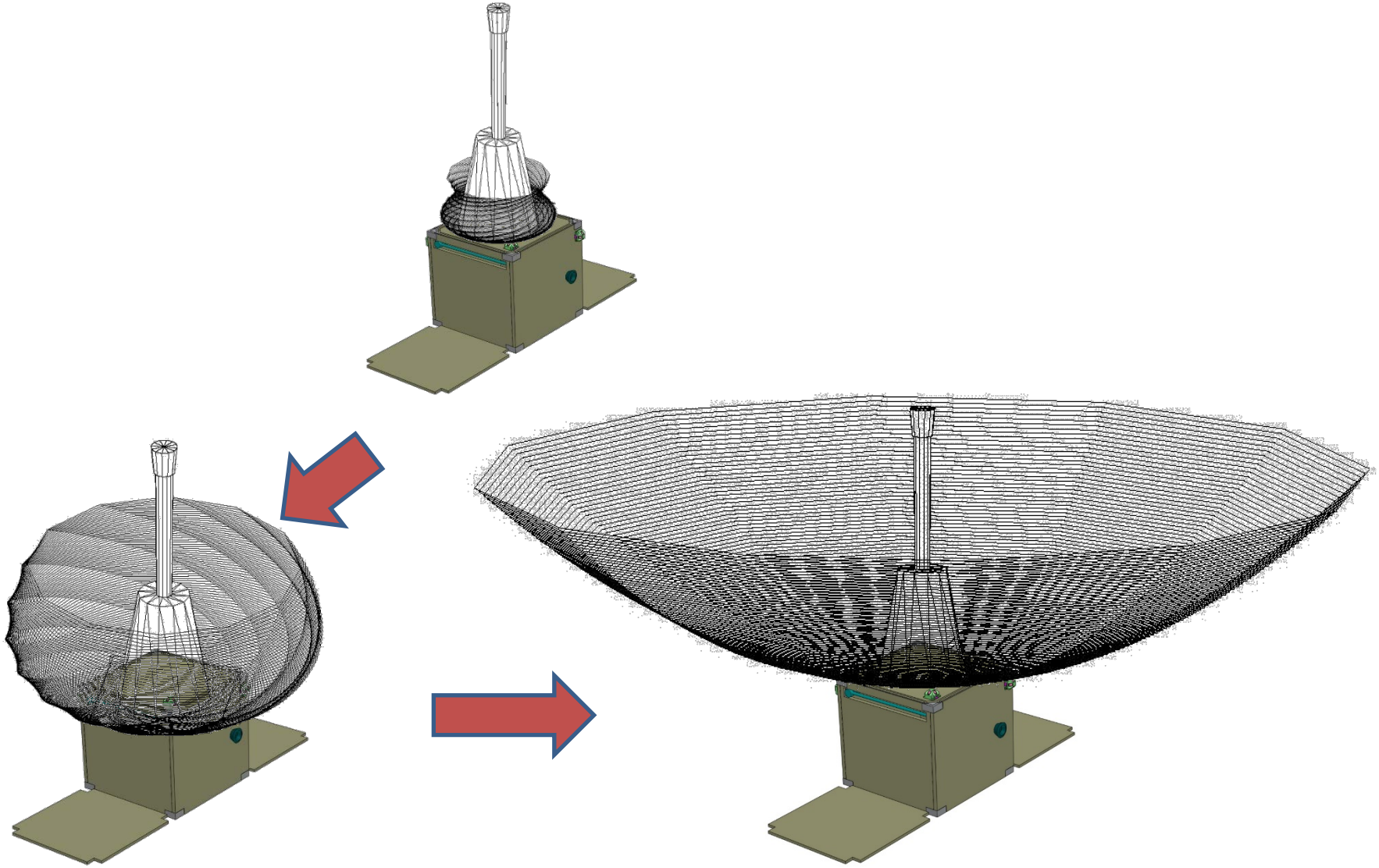




- Solar paddle needs 2000～3000 mm x 2 wing + α
- SAR antenna size (diameter) : 3,000～3,600 → 3,600 mm

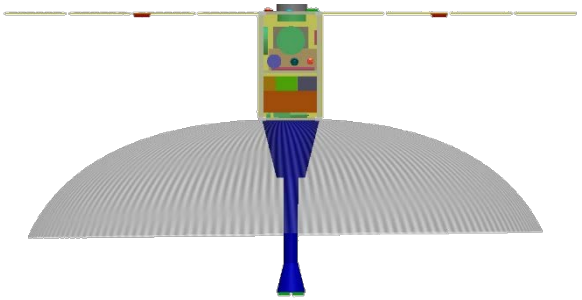


GAIA-II : Antenna Deploying Mechanism

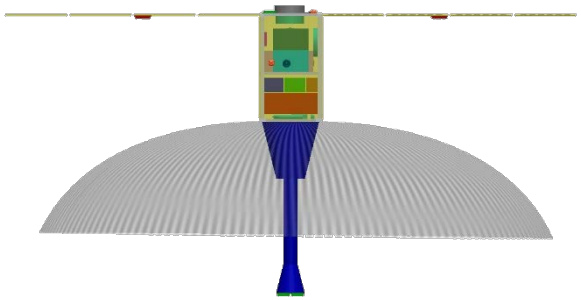


(EP-SAR & CP-SAR : Patent Pending 2014-214905)

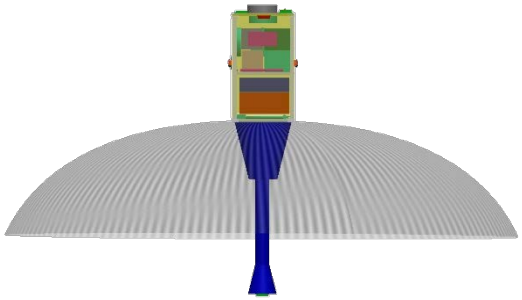
GAIA-II



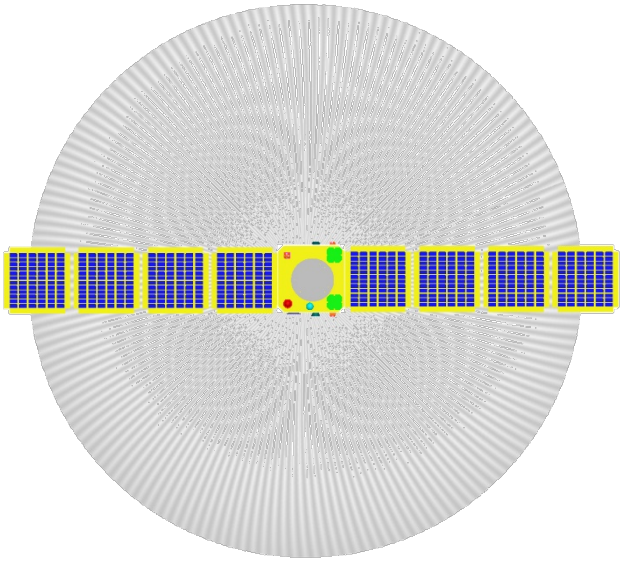
Forward
+X



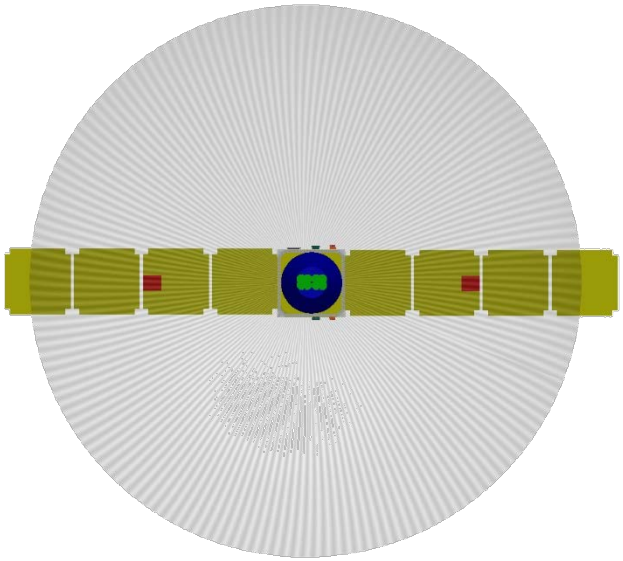
Backward -X



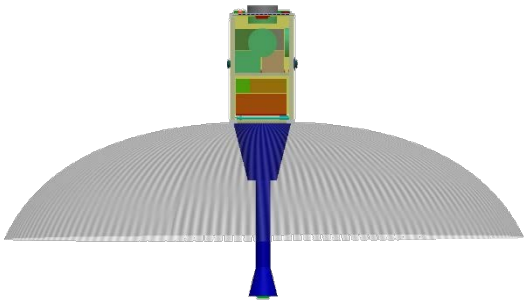
Right -Y



Top +Z



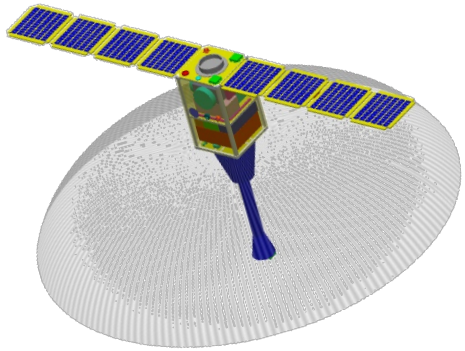
Bottom -Z



Left +Y

SAR Small-Satellite Outline - System Main Performance

The specification below depends on high experience estimation



	Performance
Orbit	Sun-synchronous orbit、500～900 km
Mission equipment	L-Band　CPSAR
Life	1 year
Mass	100kg-150kg
Consumption Power	Average 600W (Peak power : 10kW)
Attitude control	3 axis　attitude control, Accuracy　0.1°
	CSS, IRU, STT, MAGS, GPSR, RWA, MTQ
Data Rate	120Mbps
Com. Frequency	S-Band(TLM/CMD)
	X-Band(Mission Data,　20 Mbps)
Record Capacity	10 G Bytes
Satellite Size	500 x 700 x 800(Lunching)

SAR Small-Satellite Outline - SAR ANT Main Performance

The specification below depends on high experience estimation and considering of L band Spaceborne SAR

Item	Performance
Carrier Frequency	L-band, 1275 M Hz
Wavelength	23.8cm
Band Width	15 M Hz
Polarization	HH
Off Nadir	25～35°
Resolution	10～20m
Swath width	15～20km
Transmit Pulse Width	10～20 μ sec
PRF	TBD
Transmit Duty Cycle	TBD
Antenna	Deployment type
Antenna Size	3600 x 1000
Surface Accuracy	1mm rms.
Antenna Gain	20～30 dB
σ_0	TBD
S/A	TBD
Peak Output Power	TBD (target : about 10kW)
Consumption Power	600 W
Mass	TBD
SAR Output Rate	120 M bps
Translate Rate	120 M bps
Temperature	-25℃～+50 ℃

Telecommunication Systems (Spacecraft side)

■ Frequency is employing S band and X band as below.

○ Satellite→Earth:	Telemetry S Band:	Transmitter	2,200～2,300 MHz
	Mission Data X Band:	Receiver	8,025～8,400MHz
○ Earth→Satellite:	Command S Band	Receiver	2,025～2,120 MHz

■S Band Receiver (Command Signal Receiver and Demodulator)

- ・Command Modulator : FSK
- ・Data rate: 9,600bps
- ・Dynamic range: -105～50dBm
- ・Bit error rate: $<1x10^{-5}$
- ・Output signal type : RS422

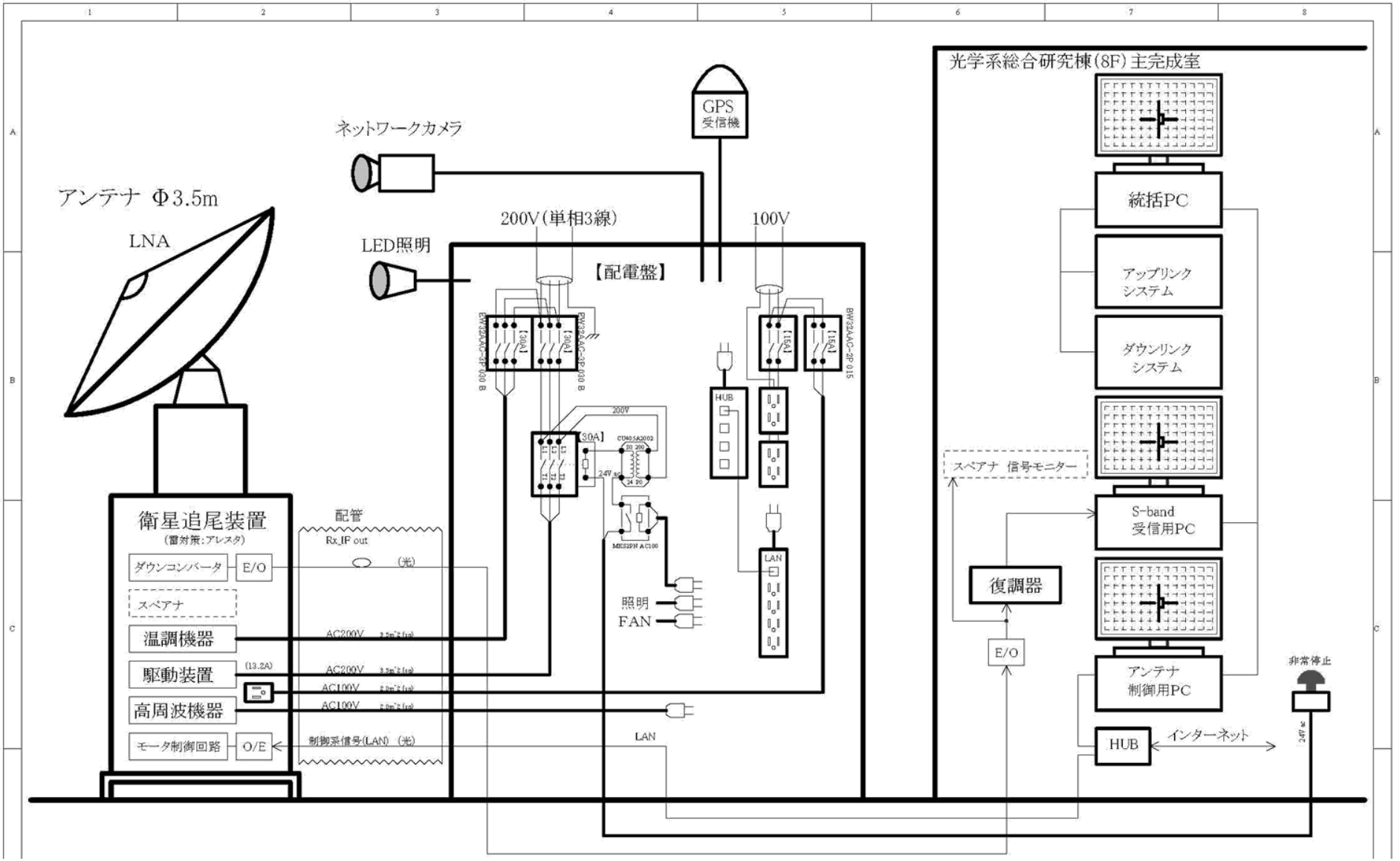
■S Band Transmitter (Telemetry Signal Modulator + Transmitter)

- ・Command Modulator: FSK
- ・Data rate: 38.4kbps
- ・Output power: >1.5W (satisfy PFD : Power Flux Density)
- ・Bit rate error: $<1x10^{-5}$
- ・Input signal type: RS422

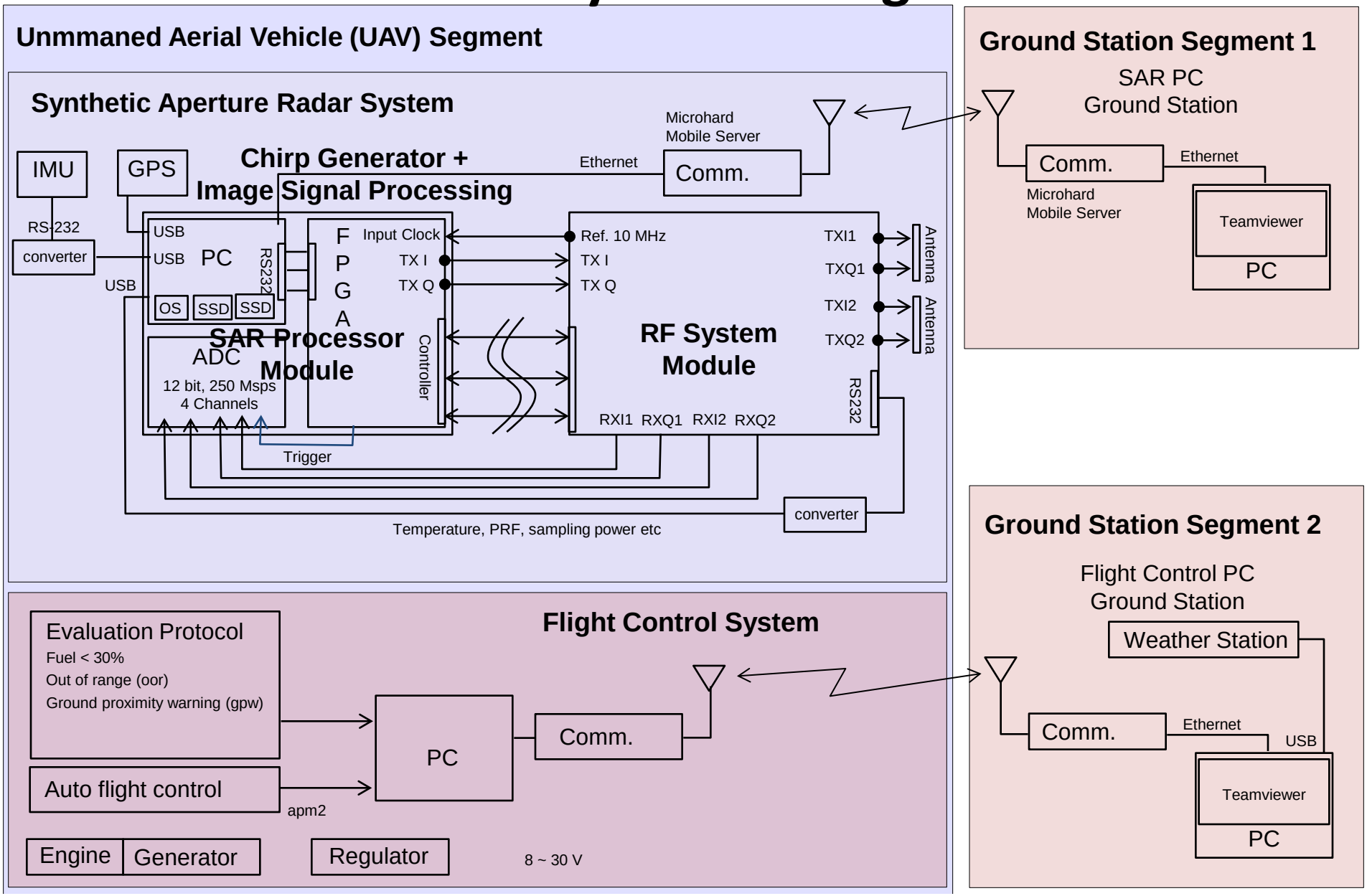
■X Band Transmitter (X Band Mission Data Processing)

- ・Command Modulator: QPSK
- ・Data rate: 20Mbps
- ・Output Power: >1W (Satisfy the PFD)
- ・Bit error rate: $<1x10^{-6}$
- ・Input Signal Type: RS422

Josaphat Laboratory Satellite Ground Station (JG-1)



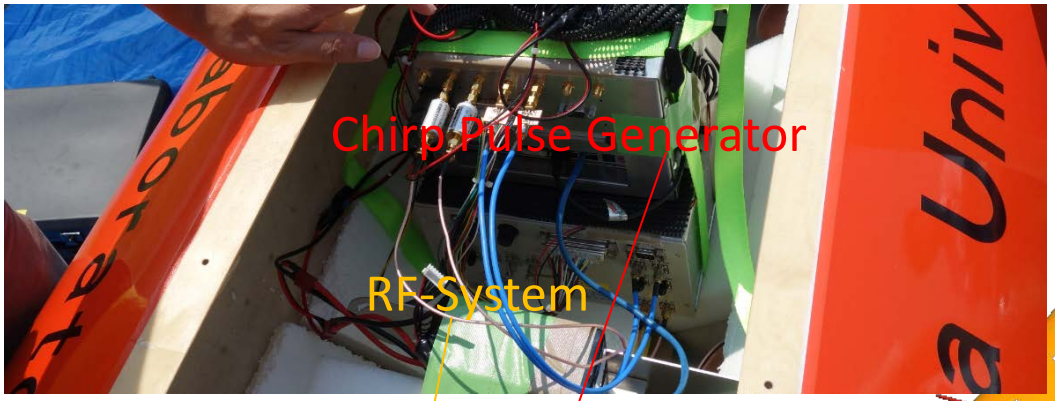
CP-SAR onboard UAV System Configuration



Specifications for CP-SAR

Radar wavelength	23.62 cm (1.27 GHz)
Baseband bandwidth	150 MHz
Polarization	Circular, full polarized
Modes of operation	Stripmap
Spatial resolution	1 m (azimuth), 1 m(range)
Ground swath width	150 m – 1200 m
Incidence angles	30 deg
Target types	Distributed targets with σ^o between 0 dB and –30 dB
Minimum radar cross section	–30 dB
Operating platform	Unmanned Aerial Vehicle (UAV)
Operating altitude	500 m –1500 m
Platform speed	30 m/s
Payload	< 25 kg
Dimension of sensor	30 cm x 50 cm x 25 cm
Dimension of antenna	0.7 m x 0.2 m x 4 panels

Bird Eye View : JX-1



Hyperspectral camera

Josaphat Tetuko Sri Sumantyo, Chapter 12. Circularly Polarized Synthetic Aperture Radar onboard Unmanned Aerial Vehicle (CP-SAR UAV), Kenzo Nonami et al. edn., Autonomous Control Systems and Vehicles, Springer, December 2012.

C and X Band CP-SAR System for Aircraft

Work Station

Software
- SAR
- GUI

Hub
(LAN)

Battery

Power
DC/AC Inv.

Signal Processing

FPGA

Software

RTL

ADC

DAC

Power
AC/DC Conv.

9.4G RF Unit (TX)
Software

9.4G RF Unit (TX)
Software

9.4G RF Unit (RX)
Software

9.4G RF Unit (RX)
Software

Oscillator

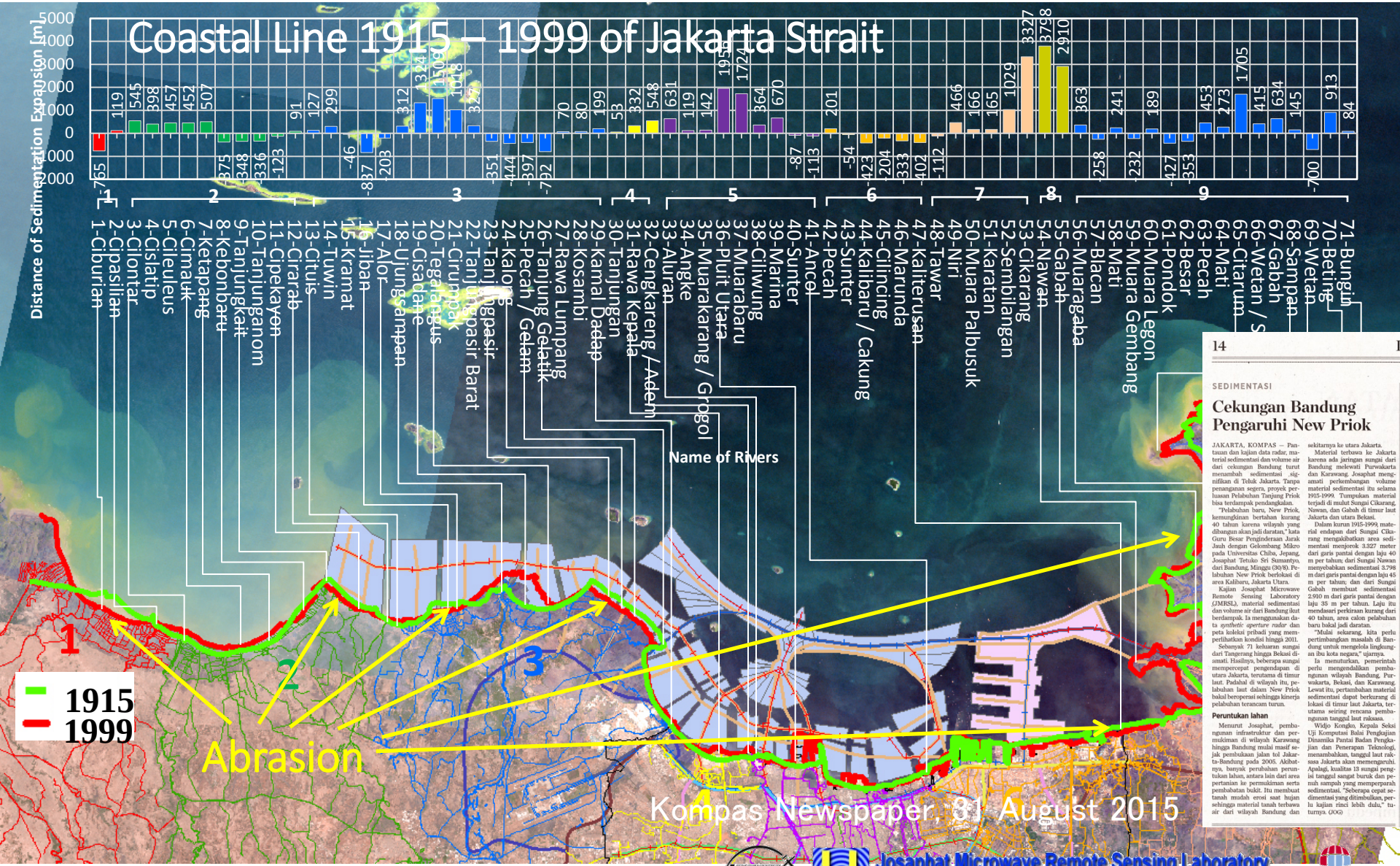
Antenna
(TX1)

Antenna
(TX2)

Antenna
(RX1)

Antenna
(RX2)

Mounting bracket & cables

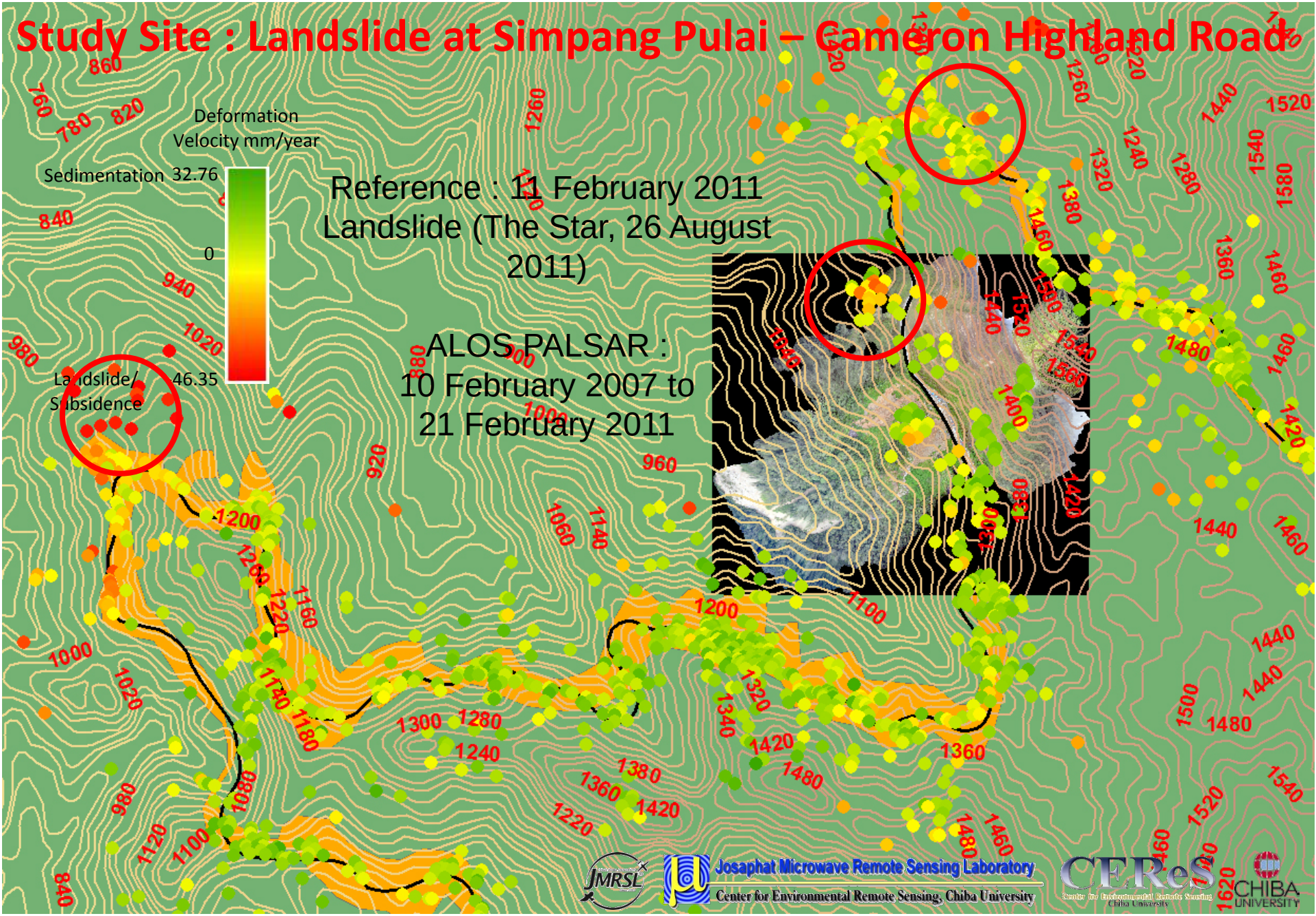

Coastal Line 1915 – 1999 of Jakarta Strait
Distance of Sedimentation Expansion [m]
5000
4000
3000
2000
1000
0
-1000
-2000
-765
119
545
398
457
452
507
375
348
336
123
91
127
299
-46
-87
208
312
324
509
1018
327
351
444
397
792
70
80
199
53
332
548
631
119
142
1951
1724
364
670
87
113
201
54
423
204
333
402
112
466
166
165
1029
3327
3798
2910
363
258
241
232
189
427
853
453
273
1705
415
634
145
700
913
84
1
2
3
4
5
6
7
8
9
1-Ciburian
2-Cipasilian
3-Cilontar
4-Cislatip
5-Cileuleus
6-Cimauk
7-Ketapang
8-Kebonbaru
9-Tanjungkait
10-Tanjunganom
11-Cipekayen
12-Cirarab
13-Cituis
14-Tuwin
15-Kramat
16-Jiban
17-Alor
18-Ujungsamaan
19-Cisadane
20-Tegaldalus
21-Cirumpak
22-Tanjungpasir Barat
23-Tanjungpasir
24-Kaloran
25-Pecah / Gelam
26-Tanjung Gelatik
27-Rawa Lumpang
28-Kosambi
29-Kamal Dadap
30-Tanjungan
31-Rawa Kepala
32-Cengkareng / Adem
33-Aluran
34-Angke
35-Muarakarang / Grogol
36-Pluit Utara
37-Muarabaru
38-Ciliwung
39-Marina
40-Sunter
41-Ancol
42-Pecah
43-Sunter
44-Kalibaru / Cakung
45-Cilincing
46-Marunda
47-Kaliterusan
48-Tawar
49-Niri
50-Muara Palbusuk
51-Karatan
52-Sembilangan
53-Cikarang
54-Nawan
55-Gabah
56-Muaragaba
57-Blacan
58-Mati
59-Muara Gembang
60-Muara Legon
61-Pondok
62-Besar
63-Pecah
64-Mati
65-Citarum
66-Wetan / S
67-Gabah
68-Sampan
69-Wetan
70-Beting
71-Bungin
Name of Rivers
1915
1999
Abrasion
14
SEDIMENTASI
Cekungan Bandung Pengaruhi New Priok
JAKARTA, KOMPAS — Pantauan dan kajian data radar, material sedimentasi dan volume air dari cekungan Bandung turut menambah sedimentasi signifikan di Teluk Jakarta. Tanpa penanganan segera, proyek perluasan Pelabuhan Tanjung Priok bisa terdampak pendangkalan.
"Pelabuhan baru, New Priok, kemungkinan bertahan kurang 40 tahun karena wilayah yang dibangun akan jadi daratan," kata Guru Besar Penginderaan Jarak Jauh dengan Gelombang Mikro pada Universitas Chiba, Jepang, Josaphat Tetuko Sri Sumantyo, dari Bandung, Minggu (30/8). Pelabuhan New Priok berlokasi di area Kalibaru, Jakarta Utara.
Kajian Josaphat Microwave Remote Sensing Laboratory (JMRSL), material sedimentasi dan volume air dari Bandung ikut berdampak. Ia menggunakan data *synthetic aperture radar* dan peta koleksi pribadi yang memperlihatkan kondisi hingga 2011.
Sebanyak 71 keluaran sungai dari Tangerang hingga Bekasi diamati. Hasilnya, beberapa sungai mempercepat pengendapan di utara Jakarta, terutama di timur laut. Padahal di wilayah itu, pelabuhan laut dalam New Priok bakal beroperasi sehingga kinerja pelabuhan terancam turun.
Peruntukan lahan
Menurut Josaphat, pembangunan infrastruktur dan permukiman di wilayah Karawang hingga Bandung mulai masif sejak pembukaan jalan tol Jakarta-Bandung pada 2005. Akibatnya, banyak perubahan peruntukan lahan, antara lain dari area pertanian ke permukiman serta pembabatan bukit. Itu membuat tanah mudah erosi saat hujan sehingga material tanah terbawa air dari wilayah Bandung dan sekitarnya ke utara Jakarta.
Material terbawa ke Jakarta karena ada jaringan sungai dari Bandung melewati Purwakarta dan Karawang. Josaphat mengamati perkembangan volume material sedimentasi itu selama 1915-1999. Tumpukan material terjadi di muhut Sungai Cikarang, Nawan, dan Gabah di timur laut Jakarta dan utara Bekasi.
Dalam kurun 1915-1999 material endapan dari Sungai Cikarang mengakibatkan area sedimentasi menjorok 3.327 meter dari garis pantai dengan laju 40 m per tahun; dari Sungai Nawan menyebabkan sedimentasi 3.798 m dari garis pantai dengan laju 45 m per tahun; dan dari Sungai Gabah membuat sedimentasi 2.910 m dari garis pantai dengan laju 35 m per tahun. Laju itu mendasari perkiraan kurang dari 40 tahun, area calon pelabuhan baru bakal jadi daratan.
"Mulai sekarang, kita perlu pertimbangan masalah di Bandung untuk mengelola lingkungan Ibu kota negara," ujarnya.
Ia menuturkan, pemerintah perlu mengendalikan pembangunan wilayah Bandung, Purwakarta, Bekasi, dan Karawang. Lewat itu, pertambahan material sedimentasi dapat berkurang di lokasi di timur laut Jakarta, terutama seiring rencana pembangunan tanggul laut raksasa.
Widjo Kongko, Kepala Seksi Uji Komputasi Balai Pengkajian Dinamika Pantai Badan Pengkajian dan Penerapan Teknologi, menambahkan, tanggul laut raksasa Jakarta akan memengaruhi. Apalagi, kualitas 13 sungai pengisi tanggul sangat buruk dan penuh sampah yang memperparah sedimentasi. "Seberapa cepat sedimentasi yang ditimbulkan, perlu kajian rinci lebih dulu," tuturnya. (JOG)
Kompas Newspaper, 31 August 2015
JMRSL
Josaphat Microwave Remote Sensing Laboratory
Center for Environmental Remote Sensing, Chiba University
CHIBA UNIVERSITY

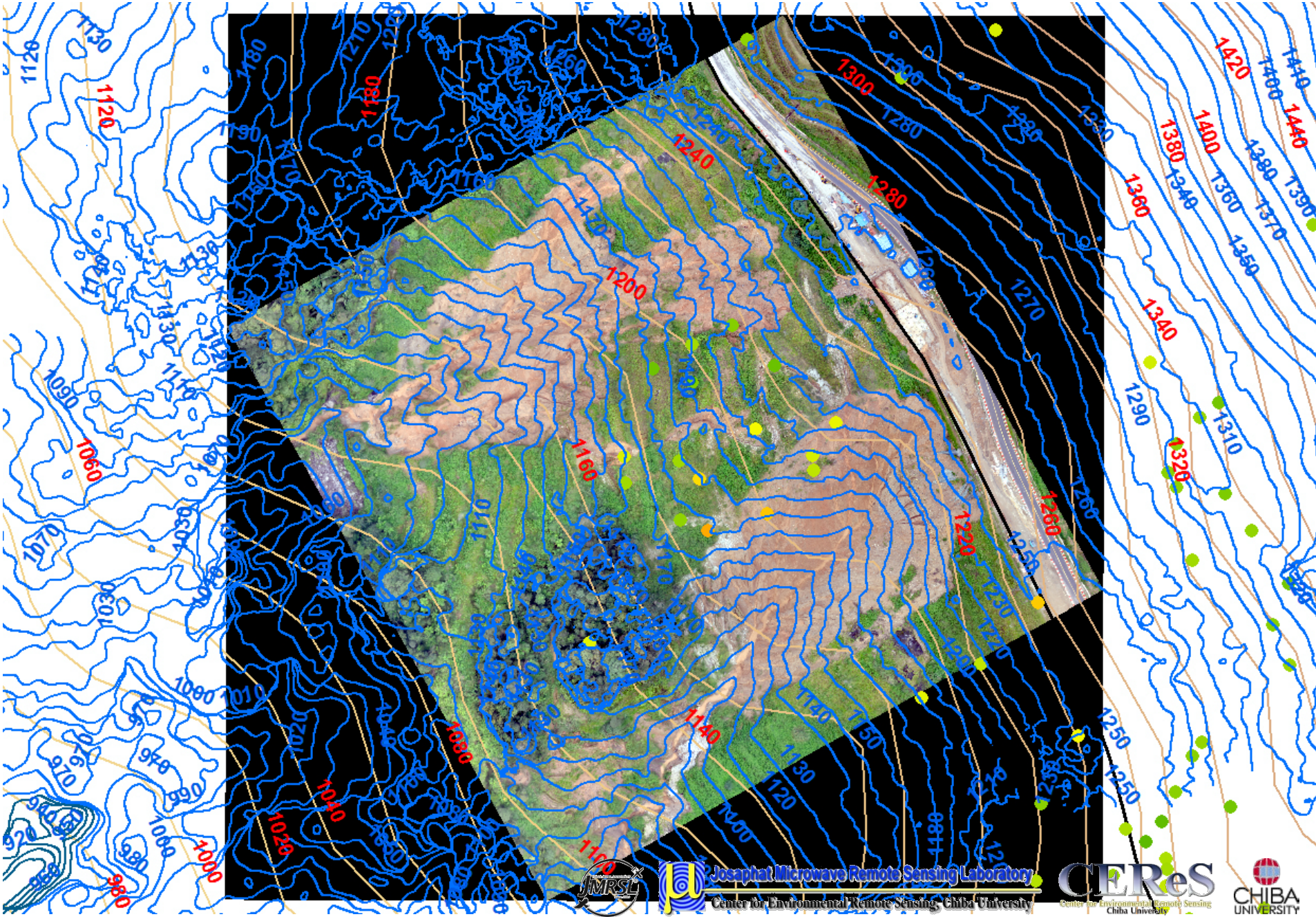
Malay Peninsula Landslide Monitoring using Small UAV : Cameroon Highland

Cameroon Highland ground campaign with Malaysian Government JGR, Universiti Sains Malaysia, and JICA on 20 September 2014

Josaphat Microwave Remote Sensing Laboratory
Center for Environmental Remote Sensing, Chiba University
CHIBA UNIVERSITY

Study Site : Landslide at Simpang Pulai – Cameron Highland Road

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Application (8) East-West Highway : Lake Site Malaysia

Deformation
Velocity mm/year
Sedimentation 56.79
0
Landslide/ Subsidence -49.49

Lake site

Scale : 1:50,000

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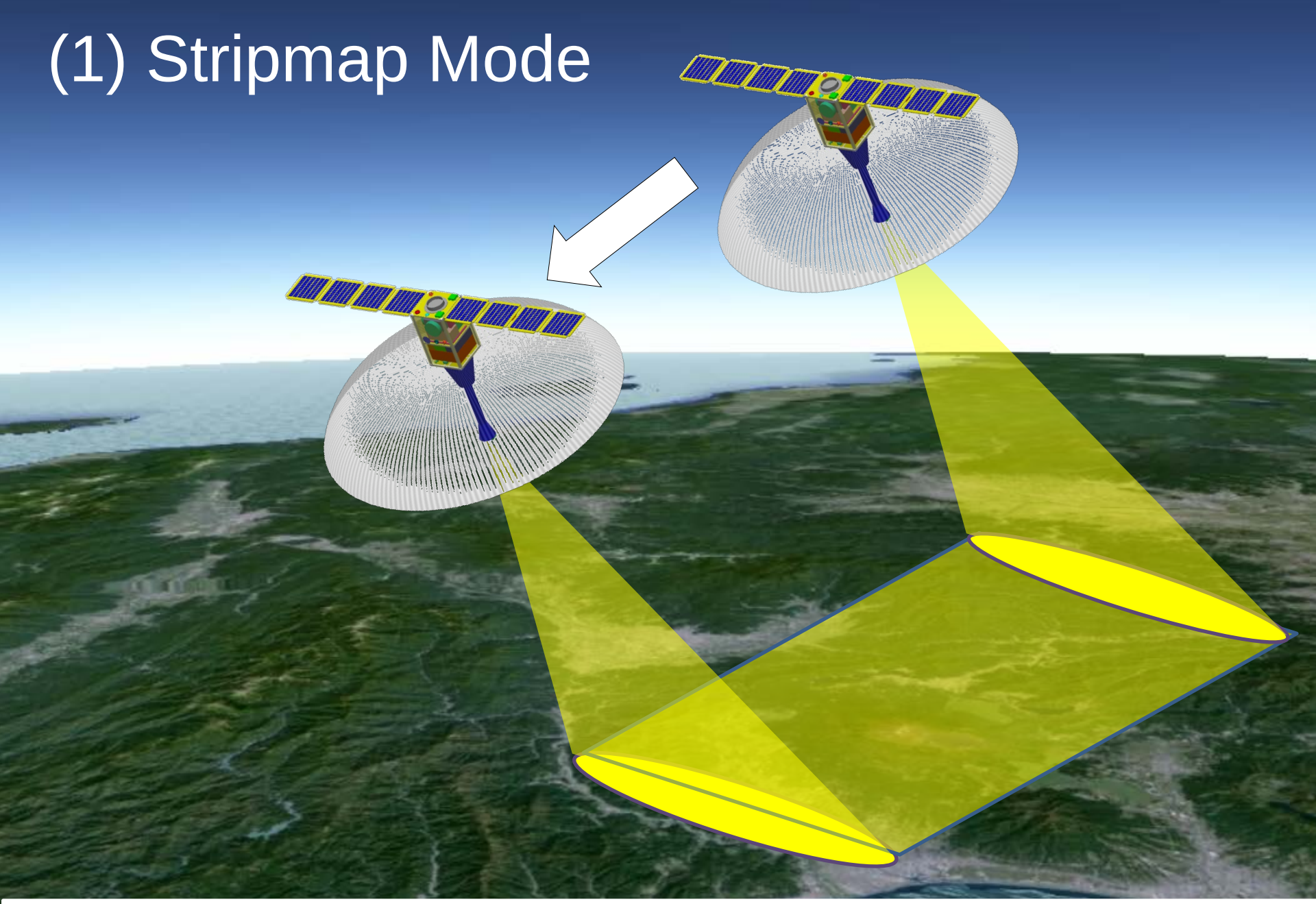
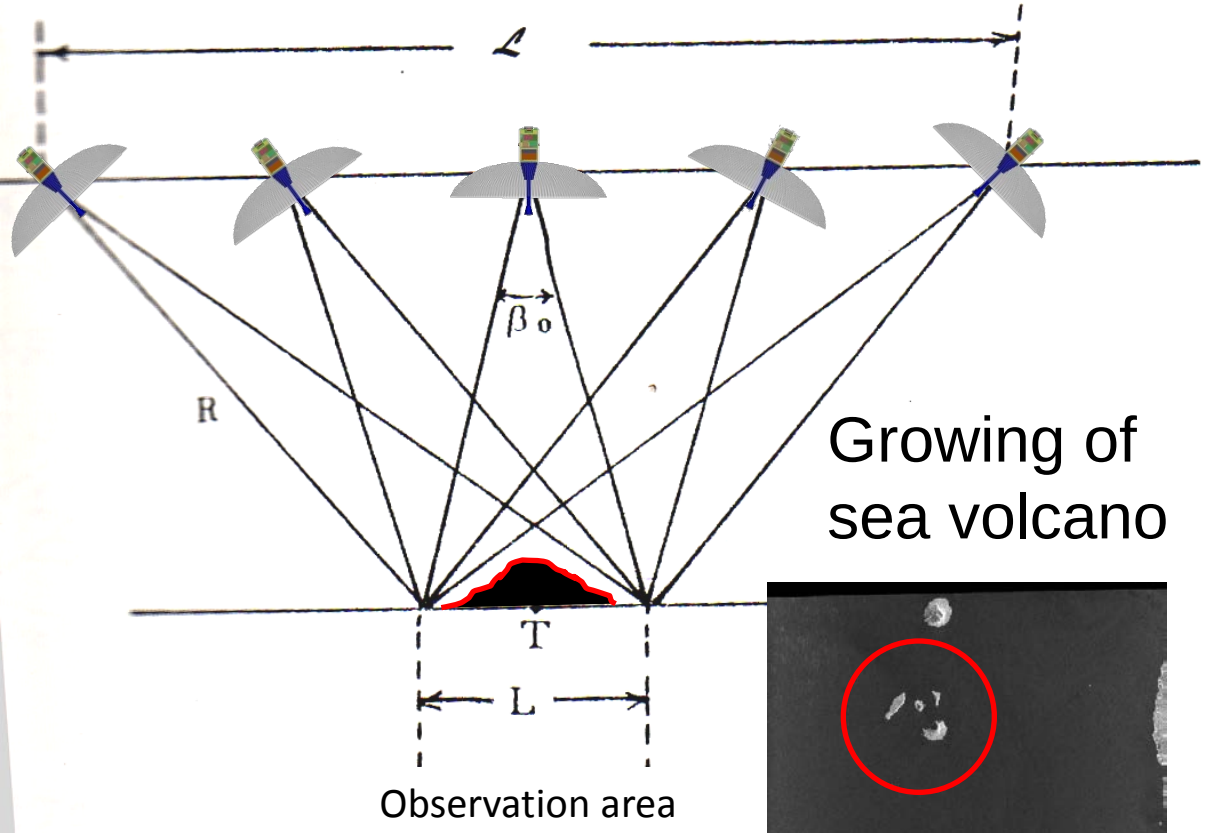
(1) Stripmap Mode



(2) Spotlight Mode SAR



Observation area

Figure : Spotlight Mode SAR

Growing of sea volcano

Characteristics :

- One type of Squint mode SAR
- Synthetic Aperture length L *is* length of observation area. If real antenna beam width is large, the observation time to illuminate the area is to be longer.
- In Spotlight SAR, the antenna beam is tracing to object / target when platform moving, therefore observation time to target in observation area is more longer, and long synthetic aperture antenna $\mathcal{L}$ could improve the ground resolution.
- Resolution of Spotlight mode SAR is

$$\rho = \frac{\lambda R}{\mathcal{L}}$$

If $\mathcal{L}$ is approching to R, therefore we obtain

$$\rho = \frac{\lambda R}{L} \doteqdot \lambda$$

(3) Burst Mode SAR

Characteristics：

- Saving the data number and power of SAR sensor → Microsatellite
- SAR observation is repeating in constant period t_1, then stop period t_2.
- If $v(t_1+t_2)<L$, even the resolution is to be worse l/vt_1 , but no blank observation area.
- In Figure A : Resolution to be $(t_1+t_2)/t_2$ times
- Burst mode SAR could be realized by stopping far mode of ScanSAR.

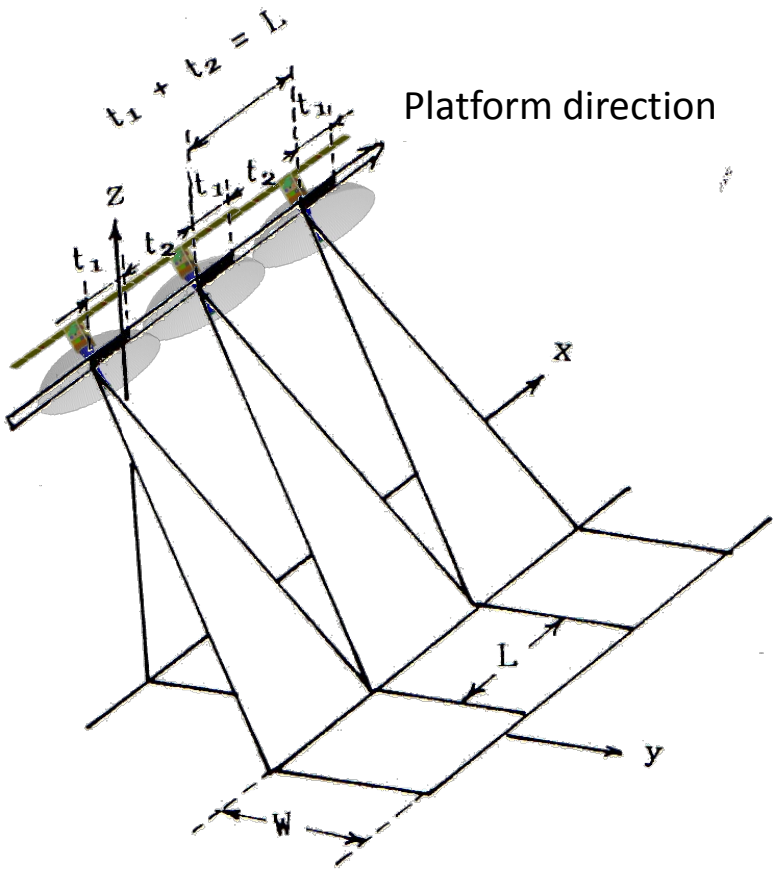


Fig. Burst Mode SAR

(4) Wave Mode SAR

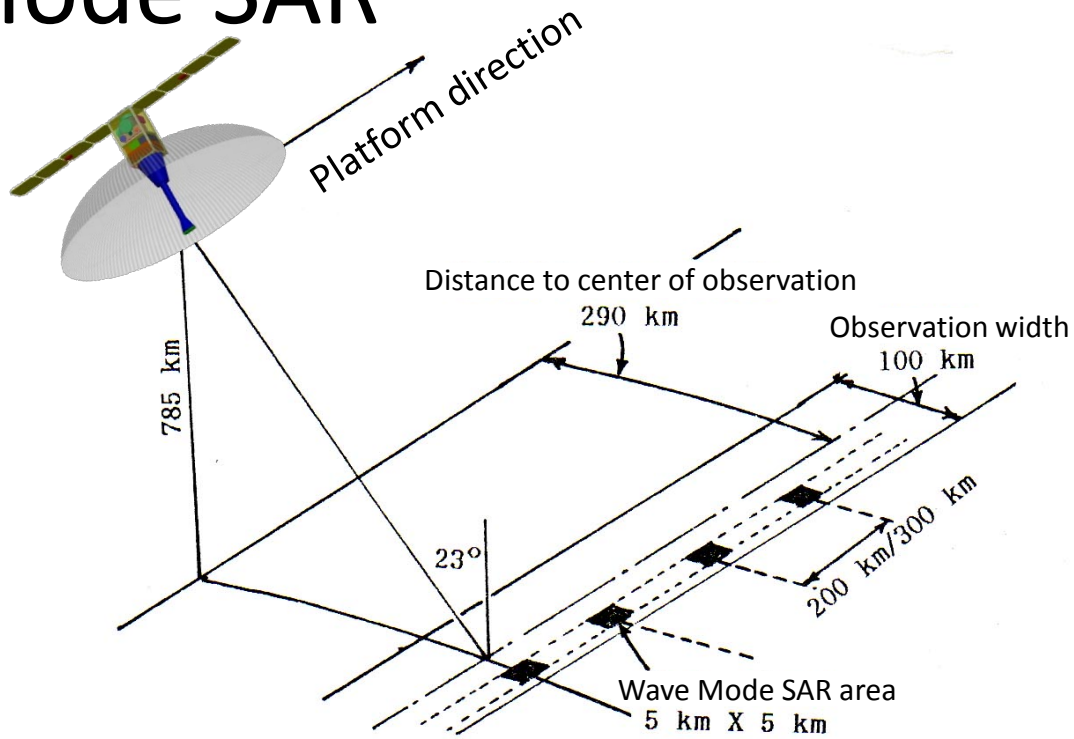


Figure : Wave Mode SAR

Characteristics :

- The condition of ocean wave in width area is approximately homogeneous. The mode is saving data transfer. Common SAR observation is continuously observation with width about 100 km. Wave mode SAR is resampling the target area (about 5 km^2) every 200 km ~ 300 km. Therefore the data could be reduces to 1/1,000. This mode is mainly for global ocean wave observation.