Development of new multi-band equatorially orbiting POLinSAR satellite sensors system configurations for varying latitudinal coverage within total tropical belt (Invited Group pres...

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Development of new multi-band equatorially orbiting POLinSAR satellite sensors system configurations for varying latitudinal coverage within total tropical belt

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***Abstract*— The relevance of this challenging still unresolved development of multi-band equatorially orbiting fully polarimetric POLinSAR satellite configurations to the entire terrestrial globe will be highlighted. Special attention will be given to generation of global weather phenomena, supply of an ever more relevant stable food base, extraction of mineral and energy resources with its implicit local environmental deterioration, and of more successfully securing bio-diversity. All of these daunting natural hazards of top international priority should justify the immense financial resources required for pursuing this timely and urgently to be realized proposal. In retrospect, collaboration with additional international National Research Centers involved in advancing multi-band POLinSAR satellite sensors is sincerely desired and so is the financial support from our National, Regional and International governmental sponsors - foremost the United Nations. The proposer (author) and dedicated collaborators consider APSAR-2015 to be the ideal forum for introducing this timely proposal, well suited for the Lead-Session of Space- & Air-borne SAR Systems and Missions.**

***Index Terms*— Polarization radar, Polarimetric Synthetic Aperture Radar (SAR), Environmental remote sensing, Geophysical monitoring, Tropical Equatorial Belt (TEB), Surveillance, Natural and manmade hazard detection, Disaster assessment and reduction, Equatorial orbiting satellite sensors.**

I. Introduction With Formulation Of The Group Project

With the relentless increase in population density, the anthropogenic expansion into natural terrestrial hazard zones has become irreversible resulting in ever more catastrophic disasters, not only in the Asia-Pacific region more so within the entire tropical belts engulfing Mother Earth. Thus not only the Indonesian-Pacific Islands, so also South America, Africa and back via the Indian Ocean Islands to Asia-Pacific, these natural events like volcano eruptions, earthquakes with emerging tsunami, cyclones and severe down pours have caused havoc, loss of lives, destruction of infrastructure. Above all intentional manmade interference resulting in the deterioration of pristine tropical jungle forests have become so bad that proposals are forthcoming for equating oil-palm mono-cultures with pristine tropical jungle habitat biodiversity by greedy developers mostly exterior to local regions with its established communities suffering helplessly from such criminal machinations and future existence of their once so healthy natural earth [1].

What is required is around-the-clock local and wide-area surveillance and remote sensing of the vegetative cover within the effected tropical belt for which first well designed optical equatorially orbiting satellite sensors had been developed [2] but their successful implementation is failing at an alarming rate because of the ever increasing cloud, precipitation, humidity and aerosol cover within the entire equatorial belt. Hence, we must take recourse to microwave sensing, and implement radar and synthetic aperture sensors from air and space operational at day & night independent of weather; and the sensors especially suited are the fully polarimetric POLinSAR sensors.

Several configurations for satellite sensor deployment will be assessed based on currently well established narrow-band [3] and rapidly developing wide-band [4] POLinSAR sensor technology at X-band and L-band to be complemented in addition by S-Band; and later on by P-Band and Ka-Band fully

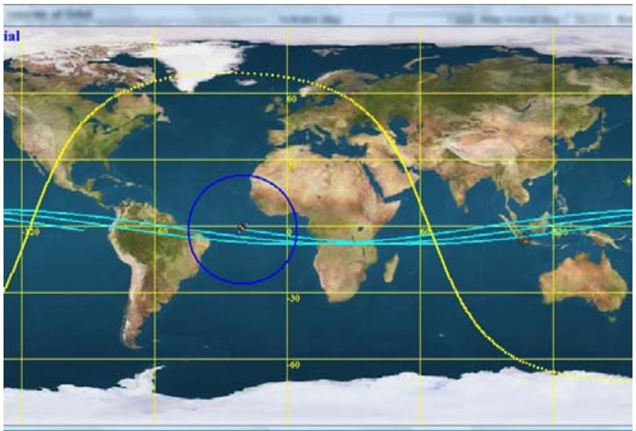

Figure 1. Global circumferential equatorial orbit.

Figure 2. ALOSPALSAR, RADARSAT-2, TerraSAR-X

polarimetric Pol-SAR sensors for simultaneous single-platform observations:

1) The first configuration considered, will be the implementation of the wide-swath extension of W-TanDEM-X and W-TanDEM-L with joined fully polarimetric POL-In-SAR X-Band & L-Band POLSAR sensors placed on the main and the tandem second platform, here denoted as W-TanDEM-X/L PolinSAR.

2) A configuration of a number of less costly, smaller narrow-band TanDEM-X/L-Trop-PolinSAR fully polarimetric POLinSAR satellites with *n* equally spaced sensor platforms along the longitudinal equator with *n* to be determined according to full closure of longitudinal coverage for the Full +/-23.7°, the Prime +/- 18°, and the Inner +/- 6° Tropical Belts [3].

3) Most likely, reduced configurations, such as proposed by LAPAN [2], may first have to be deployed, and pertinent assessments of choices to be discussed on the basis of tests conducted with the airborne Multi-band sensor systems such as the DLR-FSAR [5], ONERA-SETHI [6] and GEO-SAR developed by NASA-JPL [1].

4) The relevance of this challenging still unresolved development of multi-band equatorially orbiting fully polarimetric POLinSAR satellite configurations to the entire terrestrial globe will be highlighted.

Special attention will be given to generation of global weather phenomena, supply of an ever more relevant stable food base, extraction of mineral and energy resources with its implicit local environmental deterioration, and of more successfully securing bio-diversity. All of these daunting natural hazards of top international priority should justify the

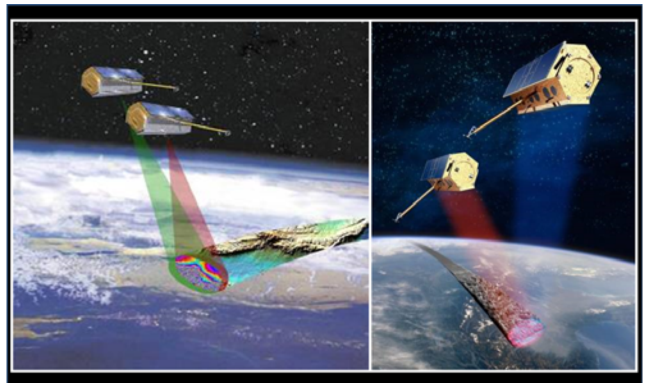

Figure 3. TanDEM-X along cross track imaging

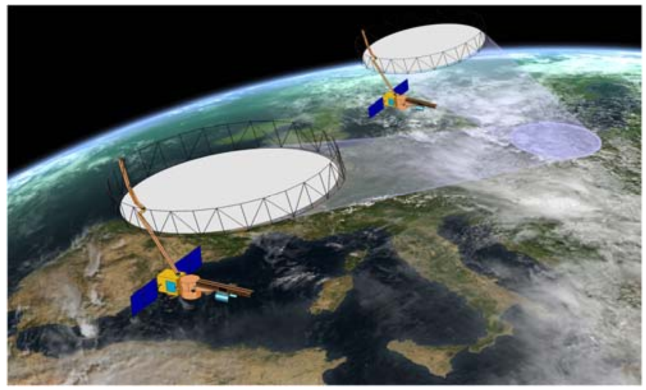

Figure 4. TanDEM-L Bistatic imaging

immense financial resources required for pursuing this timely and urgently to be realized proposal. In order for tackling these tasks, an international consortium is required, and here a first group proposal is being developed.

II. Method of Approach

The basic radar technologies to do the job are the multimodal Synthetic Aperture Radar (SAR) sensors. In the meantime, fully polarimetric multi-modal high resolution SAR systems at multiple frequencies and incidence angles were introduced first with the multi-band AIRSAR of NASA-JPL culminating in the once-only pair of SIR-C/X-SAR shuttle missions of 1994 April and October as well as the SRTM shuttle mission, which laid the ground work for true day/night space remote sensing of terrestrial barren and vegetated land and ocean covers using multi-band polarimetric SAR [1, 3, 4].

Thereafter, the Canadian CCRS, the German DLR and the Japanese NASDA & CRL {now JAXA & NICT} took over introducing and steadily advancing the Convair-580, the E-SAR (F-SAR) [5, 7] and Pi-SAR airborne highly advanced fully polarimetric airborne sensors platforms, respectively. Not to forget are the contributions by the French ONERA with its development of RAMSES being replaced by SETHI [6].

These separate international multi-modal fully polarimetric and also interferometric airborne SAR developmental efforts

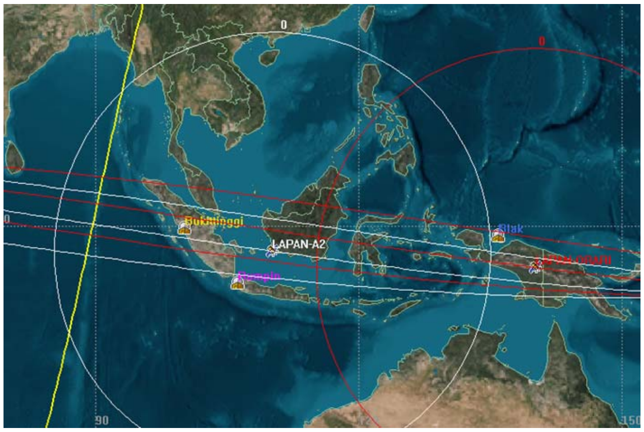

Figure 5. Equatorial Satellite Orbits over Indonesia

culminated in a well-coordinated group effort of these three independent teams eventually launching and operating fully polarimetric Satellite POLSAR Sensors at L-Band (ALOS-PALSAR launched by JAXA/Japan in 2006 January – and to be followed by ALOS-PALSAR-2 & 3 because of the superior 3D imagery recovered [8, 9]); at C-Band (RADARSAT-2 launched by CSA-MDA in 2007 December – to be followed by independent RADARSAT–3 & 4); and at X-Band (TerraSAR-X launched by DLR-Astrium in 2007 July with the follow-on tandem mission Tan-DEM-X launched in June 2010) – and to be followed shortly by TerraSAR-X2 and TanDEM-X2 [1,3]. Thus, international collaboration on advancing day/night global monitoring of the terrestrial covers was accomplished with the launch of the three fully polarimetric multi-modal SAR Satellites currently only at L-, C-, X-Band and its first tandem satellite-pair update of the DLR Tan-DEM-X. All of these efforts will be topped by near-future joint DLR-NASDA Tandem-L/ALOS-Next L-Band POL-SAR tandem-satellite system [4], with reflector-antenna and wide-swath, high-resolution fully polarimetric sensor implementation, which in due time will by increasing demand be enlarged to accommodate next to the L-, C-, X- also P-Band sensors using one and the same reflector, then enabling full assessment also of dense tropical forests which will for example result in curtailing illegal deforestation, there and elsewhere. Because of space limitations no specific examples are provided in this paper; however each collaborating group member engaged in SAR remote sensing in specific regions within the Tropical Belt will be providing specific imagery related to their regions.

III. USE OF EQUATORIAL ORBITING MULTI-BAND POLSAR SATELLITE SENSORS

The challenge is thus to develop equatorially orbiting SAR sensors, preferably POLinSAR satellite sensors for the desirable P/L/S/C/X/Ka multi-bands, which does pose some

Repeat Periode	**3day**
Repeat Cycles	44
Swath Width	547 km
Near Range	180 km
Orbit Inclination	20 degrees
Latitudinal coverage	+/- 23.6 degrees

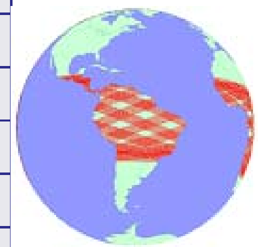

Figure 6. Simulation for a TanDEM-L Satellite by DLR with Equatorial orbit Tropical Belt of +/- 23.6* latitude.

Repeat Periode	**1 day**
Repeat Cycles	15
Swath Width	370 km
Near Range	180 km
Far Range	550 km
Looking Direction	Right
Orbit Altitude	554 km
Orbit Inclination	8 degrees
Latitudinal coverage	+/- 12 degrees

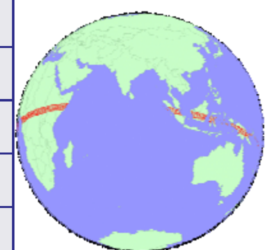

Figure 7. Simulation for a TanDEM-L Satellite by DLR with Equatorial orbit covering of +/- 12* latitude.

technological problems due to the steep incidence-angle illumination on one hand, and because of the fact that the major SAR Technology Designers reside far outside the equatorial belt whose tax-payers are not being excited about SAR sensor development for the tropical belt anywhere. Therefore, we need to mobilize and draw full responsible attention of the main SAR Development Centers worldwide such as NASA/JPL, ESA/ESTEC, JAXA/EORC, CSA/SAR, DLR/SAR, DSTO/SAR, ISRO/SAC, INPE/SERE plus NTU-Temasek, NCU-CSRSR, LAPAN as well as the United Nations UNESCO, and so on; joining forces and strongly contributing to a viable multi-band general bi-static (including cross/along)-track POLinSAR sensor technology [3], well suited for equatorial monitoring within orbits of the Prime +/- 12° ~ 18° latitude for one-day local imaging, and within the Full tropics-latitudinal-belt of +/- 23.7° for three-day local re-observations. Once this urgent goal is achieved, local regions could be observed daily several times for along-track wide-swath observations within the Inner altitudinal +/- 8° coverage pertinent to ocean surface and current assessments; for example, within the Indonesian Archipelago of more than

17000 populated islands and its neighboring regions of the Philippines, Singapore, Malaysia and Thailand. Relevance to the pertinent trans-Atlantic and trans-Pacific as well as African and American tropical belts need be broached because similar hazards exist [3, 4, 8 and 9]. Special emphasis is paid to effects of ionospheric interference for P/L/S-Band POLinSAR satellite sensor deployment within the tropical belt with participation of pertinent expertise of UAF-GI at Fairbanks, Alaska.

IV. Recommendation

At each of the many cited regions and distinct local sites peculiar physical, climatologic and anthropogenic conditions exist, and in order for covering all of these diverse sites, it is indeed essential for not waiting any longer but have a properly chosen set of equatorially orbiting multi-band sensors developed and test sites concurrently established with conducting other near field testing methods by, for example, local island natural, agricultural, forestry and aqua-cultural institutions plus mining companies. In order for realizing this urgently required design and development of equatorially orbiting with multi-band POLSAR satellite sensors with sufficiently wide swath-width for covering the entire extent of e.g., the Indonesian islands and other similar regions across its equatorial belt, all of the worldwide leading multi-band POL-SAR design and development centers need to be called for immediate action without national and/or institutional ego but in view of its superior relevance for future health of Mother Earth. Indonesia with its plethora of natural hazards and a non-reproducible fauna and flora was chosen for serving as the pilot project in order for emulating similar extensive research in all hazard regions within the Tropical Belt; and this group proposal is to serve as the initiation process for establishing a future consortium on the subject matter. In coordination with the international collaborators it will be our foremost goal for soliciting the desired funding.

V. Conclusion

In order for realizing this urgently required mission we need to call to action our top Microwave Satellite Sensor Development Centers including NASA-JPL, ESA-ESTEC/ESRIN, JAXA-EORC, DLR-HR, and many more smaller centers worldwide. More importantly, it must be of top priority to implicate the network of international radar polarimetry community, for example for Indonesia at the National (LIPI, BMKG, LAPAN) and envisioned Indonesian Geomatics & Remote Sensing Centers for influencing a plethora of other local campus wide disciplines engaged in environmental and humanitarian pursuits for implanting the benefits of SAR Polarimetry with a special emphasis on monitoring and maintaining the environmental health of our Mother Earth which is under severe attack worldwide, and re-emphasizing, that it should serve for enabling the prime objective of hazard detection and disaster mitigation not only for SE-Asia and more so for the entire Tropical Belt regions.

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