1st GFOI R&D Expert Workshop
Sensor interoperability (and sensor complementarity)

Woods Hole Research Center – June 10-11, 2014

1. Workshop objectives

- Assessment of existing approaches to sensor synergy, i.e., interoperability and complementarity (for forestry);
- Identification of obstacles to operational (widespread use) ;
- Development of action plan to progress development;
- Input/recommendations to CEOS SDCG strategy for R&D (Element 3)

2. Day 1 Presentation summaries: Approaches to sensor synergy

Expert participants each presented their approaches to sensor interoperability/complementarity. The methods and satellite data needs are summarized in Tables 2.1 and 2.2 for land cover mapping and change detection, and above-ground biomass estimation respectively. The presentations provided an overview of current state-of-the-art methods of sensor synergy and identified limitations and data/R&D needs relevant to each organization.

	Table 2.1 Sensor Synergy for Land Cover Mapping and Change Detection			
Methods	**Research Team**	**Presenter**	**Geographic location**	**Data Needs**
Time-series Fusion Optical-Radar	**WHRC**, BU (NASA CMS)	Josef Kellndorfer	Peru, Colombia, Mexico	Landsat-class L- and C-band SAR
Time-series Fusion Optical-Radar	NASA/CMS, WHRC, **BU**	Chris Holden	Peru, Colombia, Mexico	Landsat (20% cloud-free) L-band SAR
Time-series Optical and Radar	IDEAM	Edersson Cabrera	Colombia	MODIS, Landsat-8, SPOT-5, CBERS, PALSAR ScanSAR
Time-series Fusion Optical-Radar	U. Wageningen	Johannes Reiche	Fiji, Guyana	Landsat ALOS PALSAR
Synergy between different SAR frequencies	sarmap	Francesco Holecz	Gambia, Malawi	ALOS PALSAR, Cosmo-SkyMed, ENVISAT ASAR MODIS
Synergy between SAR-Opt and SAR-SAR	CRC/CSIRO	Anthea	Tasmania	Landsat ALOS PALSAR, RADARSAT-2
Conditional Probability Framework	CSIRO	Eric Lehmann	Tasmania, Australia	Landsat ALOS PALSAR
Best Available Pixel (BAP) and trend analysis in time-series; regression tree	CFS, CSA	André Beaudoin	Canada	Landsat, Sentinel-2, MODIS ALOS PALSAR, RADARSAT-2
Iterative Mapping Approach	VTT	Tuomas Häme	Laos, Mexico, DR Congo	ALOS PALSAR ALOS AVNIR, RapidEye
Multi-sensor integration	UNSW, DSITIA/ JRSRP, Aber Uni, USC	Richard Lucas	Australia	ALOS PALSAR ICESat GLAS, Landsat

	Table 2.2 Sensor Synergy for Above Ground Biomass (AGB) estimation			
Methods	**Research Team**	**Presenter**	**Geographic location**	**Data Needs**
MadMEX	WHRC, CONAFOR, CONABIO	Josef Kellndorfer	Mexico	Landsat ALOS PALSAR, SRTM
kNN, BIOMASAR, RVOG	CFS, CSA	André Beaudoin	Canada	Landsat, Sentinel-2, ALOS PALSAR, RADARSAT-2, ENVISAT ASAR, TanDEM-X, LiDAR
SAR-Opt model	VTT	Tuomas Häme	Laos	Landsat, ALOS AVNIR ALOS PALSAR
Multi-sensor integration	UNSW,DSITIA/JRSRP, Aber Uni, USC	Richard Lucas	Australia	ALOS PALSAR, Landsat LiDAR, ICESat GLAS

3. Day 2 Working Group session

3.1 Methodology issues

Expert participants were divided into 2 working groups to discuss methodology issues, i.e., obstacles to widespread use and future prospects including satellite data requirements. The outcomes are summarized in Tables 3.1 and 3.2 for land cover mapping and change detection, and above ground biomass estimation respectively.

Table 3.1 Obstacles and R&D Needs for Land Cover Mapping and Change Detection

Methods (Team)	Obstacles	Steps to Operational (R&D Needs)	Recommendations
Time-series fusion Opt-Radar (NASA CMS, **WHRC**, BU)	-<1 m reference data for training -Time and experience -Improved access to L-band SAR data -Main observational gap: spaceborne LiDAR at Landsat resolution -Access to Sentinel-2 data -Intercalibration between key sensors (L-7, L-8, S-2, SkyBox etc)	-Further analysis of the available datasets (L-7/-8, L-band SAR) -Identify the temporal resolution required to detect disturbance in a given environment/climate (e.g., soil moisture response) -Validation data -Degradation methods	-Need for agencies to support recurrent and coherent observation strategies -Contact Japan Space Systems (prev. ERSDAC/METI) about ISS-LiDAR -Involvement of DLR for access to campaign -Systematic dense time-series
Time-series Fusion Optical-Radar (NASA/CMS, WHRC, **BU)**	-Main observational gap: spaceborne LiDAR at Landsat resolution -Limitations of each sensor type -Free access to L-band SAR data -Improved understanding of availability of Landsat-like imagery to allow for targeted acquisitions -Concerns about potential obstacles to Sentinel-2 data access	-Determine extent to which time-series methods work on historical data -Effects of seasonality and cloud cover -Improve accuracy of detected change using SAR-Opt fusion	-Funding & importance of R&D on sensor synergy -Be clear with space agencies about priorities for acquisition plans -Further development of FAO Open Foris software for generating activity data
Time-series Optical and Radar (IDEAM)	-Political issues when developing MRV/REDD monitoring system. Info needed at local/regional and national scales -Wall-to-wall mapping reliant on continued access to satellite data	-Still in process of determining which sensors/resolutions needed for forest monitoring: testing interoperability using all data types at test site -Future use of ALOS-2 in early warning system -InSAR for forest cover change mapping -SAR-optical time-series -Degradation methods	-Continued access to satellite data through GFOI, e.g., wide beam SAR, multi-frequency SAR, optical -Dedicated connection to Landsat archive (NASA)
Time-series Fusion Optical-Radar (U. Wageningen)	-Spatially complete (SAR) vs spatially incomplete (Landsat) datasets -Time-series methods are limited using SAR (sparse time-series). Optical methods limited by cloud cover -High processing capacity -Reference data	-Automate methods (R code) -Extend methods using C-band SAR (Landsat-C-L SAR) -Transferability in tropical context -Use of Sentinel time-series data -Fusion methods using multi-sensor data -Country-wide application	-Influence PALSAR data access policy -Funding to move R&D/pre-operational methods to operational use -Access to C-band time-series for GEO FCT Val sites (at least 2 yr time-series)
Synergy between different SAR frequencies (sarmap)	-Temporal signature must be interpreted according to the biome: conditio sine qua non for a correct interpretation is the availability of consistent SAR time-series. However: -Consistent SAR time-series rarely available -No access to bistatic TSX data -No access to archive L-band data -Forseen Sentinel-1A/B data coverage for forest application is poor	-Better understanding at biome level of seasonal and annual phonological variations -Coupling EO with intensive field information	-Systematic acquisitions of SAR-Opt targeted during different seasons depending on biome -Sentinel-2 to fill Opt time-series gaps -Aside from data complementarity, data redundancy is essential for developing an automated end-to-end processing chain

	-Temporal gaps in optical data		
Synergy between SAR-Opt and SAR-SAR (CRC/CSIRO)	-Thematic differences dependent on sensor type: translate through time-series processing -Temporally coincident data -Cost of L-band SAR -Available high quality DEM -Cost of commercial software	-Data fusion to improve accuracy of specific forest/land covers -Temporal processing rules -Dense time-series C-band SAR -Quad vs dual pol SAR -Improve C-band results using L-HV -Automation of methods -Transferability to tropical biome	-Open source image processing toolkit for F/NF classification (emphasis on SAR) -Acquire SAR strip extending from PNG to eastern Australia to test transferability of methods from topical to temperate biome
Conditional Probability Framework (CSIRO)	-Data is available, however funding is required (for staff) to progress optical/L-band use -Temporally coincident SAR-Opt data -Sensor bias (F/NF discrepancies)	-Joint SAR-optical monitoring system -SAR-Opt data fusion -Investigate different classifiers, segmentation, SAR entropy/COH, ancillary data	
BAP time-series analysis (CFS, CSA)	-Computing/archiving capacity -Easy & free access to various data streams to speed up operationlization -Temporal consistency & free access to ALOS PALSAR data -Cultural shift in forestry world regarding use of SAR data	-Best use of temporal series and change metrics -Adapt BAP to multi-temporal SAR with limited temporal sets -Preparation for ingesting Sentinel-2	-Address the obstacles over selected regions in Canada -Seek access to Sentinel-2 and ALOS-2 data
Iterative Mapping Approach (VTT)	-Dense time-series of C-band observations over same location	-Further testing of L-band and Opt results for F/NF classification -Automation of methods -Accuracy assessment methods	-Global sampling system of VHR data
integration (UNSW, DSITIA/JRSRP, Aber Uni, USC)	-Free access to ALOS-2 PALSAR-2 -Funding support for transfer of methods outside of Australia -IT/infrastructure needs are high	-Evaluation of consistency of ICESat returns as function of L-HH/HV and persistent cover -Incorporate ALOS-2 PALSAR-2 to generate further baselines of structure/AGB against which to quantify change	-Secure access to ALOS-2 PALSAR-2, Landsat and historical ICESat data -Potential to link with sites in Africa and South America where more open forests/woodlands occur

Table 3.2 Obstacles and R&D Needs for Above Ground Biomass (AGB) estimation

Methods & Team	Obstacles	Steps to Operational (R&D Needs)	Recommendations
MadMEX WHRC, CONAFOR, CONABIO		-Integration of PALSAR-2 and Sentinel-1 -Published for 2007	
Multi-sensor integration (UNSW, DSITIA/JRSRP, Aber Uni, USC)	-Historical ICESat GLAS (no future LiDAR with similar specs)	-Transferability of methods to ALOS-2 (effect of sensor differences on AGB estimates)	-Secure access to ALOS-2 PALSAR-2, Landsat and historical ICESat data
SAR models (sarmap)	-Limited in situ biophysical data for AGB model calibration -The use of bistatic TerraSAR-X data (in combination with L-band) would significantly improve AGB accuracies	-Dedicated missions for forestry applications are essential for the provision of operational products	-Facilitate access to bistatic TSX SAR and ALOS-1 PALSAR-1 and ALOS-2 PALSAR-2 data
kNN, BIOMASAR (CFS)	-Temporal consistency and availability of free ALOS PALSAR data -Lack of high resolution temporal C-band data	-Integration of C-band, L-band and Landsat data in non-parametric modelling or other more sophisticated ones -Understand SAR complementarity and best acquisition dates	-Demo use of PALSAR mosaics for wide-area mapping; ideally access archived PALSAR data for time-series analysis -Seek access to Sentinel-2, TanDEM-X and ALOS-2 data

3.2 Current and proposed research

Current and proposed research activity using specific data types is shown in Table 3.3 below. Most experience is with the integration of SAR and Optical data, and also its combination with LiDAR data. There is great potential for further exploitation of these data combinations (i.e., complementarity) to improve forest, land cover, AGB and degradation map products. VHR optical data is typically required for cal/val purposes.

There is limited ongoing R&D with C-band SAR, presumably due to lack of available time-series data. Further exploitation of dense time-series C-band SAR observations is identified as an important R&D topic. Systematic acquisitions of C-band SAR data are required for this purpose. Further use of X-band SAR data for forest degradation mapping is anticipated.

Table 3.3 Ongoing and Proposed R&D

	Land Cover	LC Change	AGB	Degradation
WHRC	O+L+C+LID+VHR+RE	O+L+C+VHR+RE, C+C	O+L+C+X+LID+VHR	O+L+C+X+RE
BU		O+L+C		
VTT	O+L+C+X+LID+VHR, C+C	O+L+X+LID+VHR, C+C	O+L+X+LID+VHR	O+L+C+VHR
CSIRO/CRC	O+L, L+C	O+L	L+X+LID	O+O, O+L+X+TDX+LID
UNSW	O+L+LID	O+L+LID	O+L+LID	O+L+LID
WUR	O+L	O+L+C, O+L	O+LID	O+L
CFS	O+O	O+O, C+C	O+L+C+X*+LID	C+C
sarmap	O+L+C+X	O+L+C+X	L+X	

O: Optical (30m class), L: L-band, C: C-band, X: X-band, X*: TanDEM-X, LID: LiDAR, VHR: Optical (<1m class), RE: Optical (~6m class)

3.3 Summary: Obstacles to widespread use

Common obstacles to widespread (operational) use of methods included the following:

- Funding for R&D and personnel
- Limited availability of systematic time-series of C-band SAR
- Access to L-band SAR data (JERS, ALOS, ALOS-2 archives)
- Clarify acquisition plans and access to Sentinel-1/-2 data outside the EU
- Access to VHR data (<1 m) for validation and training
- Sharing of field data
- Scaling from field sampling to LiDAR transects to wall-to-wall
- Lack of a spaceborne LiDAR main observational gap
- IT/infrastructure requirements (computing power, archive capacity)
- Complexity of processing and interpretation of data
- Lack of open source software
- Limited familiarity with SAR data and processing (capacity enhancement issue)

4. Action Plan

The action plan identifies the priority R&D topics, data requirements to SDCG/space agencies for dedicated multi-sensor acquisition campaigns over target sites and identification of potential funding sources to progress methods to pre-operational/operational status, with possible future inclusion in the GFOI MGD.

4.1 Priority R&D Topics

The following topics are considered high priority for R&D on sensor synergy:

- Determine optimal observation strategies for C-band SAR data: i.e., better understand the adequate temporal sampling (minimum number of observations) of C-band for different applications and optimal time windows
  - -24-day repeat data available by RADARSAT-2 over FCT Val sites
  - -Assess ERS-1 3-day cycle data for assessment of short temporal baseline
- Metrics on what is the added value of adding a new data source for a certain thematic application (cost/benefit issue) – develop guidance
- Transferability of methods to newly launched and upcoming sensors, e.g. Sentinel-1/-2, ALOS-2
- Investigation of environment and climate effects on accuracy of retrieval of forest structure/biomass estimates
- Further development of data fusion and trend analysis methods using multi-sensor data
- Methods development in interferometric SAR (InSAR) for forest cover change mapping
- Exploitation of SAR texture metrics, entropy, coherence for improved forest/land cover mapping
- Demonstrate the use of JAXA's 25 m ALOS PALSAR mosaics for wide-area mapping – develop guidance. Provide advice to JAXA on how ALOS-2 mosaics could be improved for optimal use.
- Test transferability of methods in tropical biome
- Further methods development for degradation mapping using multi-sensor data
- Automation of methods
- Identify appropriate infrastructure needs in countries for data procurement and access (capacity enhancement issue)
- Software development and training for implementation of MRV systems and inclusion in MGD – link to CEOS working groups on software and capacity (capacity enhancement issue)

4.2 Observation requests to SDCG: Multi-sensor campaign

Collectively, there is a need for improved access to optimum datasets, comprising dense, ongoing time-series of optical and SAR imagery. In response to the CEOS SDCG development of the Element-3 data strategy – Data Supply in support of GFOI R&D – is recommended that the SDCG liaise with relevant space agencies and data providers to launch a coordinated acquisition campaign that aims to address (a selection of) key R&D topics identified during the current workshop.

To capitalize on previous research, it is proposed to take advantage of the coordinated multi-sensor observations undertaken 2009-2011 over the GEO Forest Carbon Tracking (GEO-FCT) National Demonstrator countries and, where feasible, focus R&D activities on Validation Sites in the former NDs that are still active, or relevant to re-activate. But as the geographical focus of GFOI is broader than the

11 countries/regions covered with in the GEO-FCT, and a wider range of R&D topics are being considered, new study sites may also be considered if proper justification can be provided. Access to archive data acquired over GEO-FCT countries is therefore sought and space agencies that contributed to the FCT campaign are encouraged to provide (the GFOI R&D coordnators) with detailed information about the satellite data acquired over the NDs.

In terms of new data acquisitions, both to extend the time-series of satellite data for R&D over GEO-FCT Validation Sites and to build now data series over additional target sites, systematic acquisition of optical, L-band and C-band SAR data will be requested. Access to TerraSAR-X and TanDEM-X data is requested by specific users. VHR optical data is requested on a sampling basis for cal/val.

The GFOI R&D coordinators will work with research teams to develop the acquisition requests to feed into the SDCG Element-3 plan. As a first step, workshop participants wishing to participate are asked to provide details about tentative target sites and the type of satellite data required as indicated in Table 4.1.

Table 4.1 Data Requirements for R&D

Study Site	Lat/long	Data Needs: Optical	Data Needs: SAR	Specific R&D Topics
	Provide centre coordinates and approximate size/coverage (e.g., 50x50m area)	Include sensor name, acquisition mode, spatial/temporal resolution, acquisition dates	Include sensor name, acquisition mode, preferred polarisation, spatial/temporal resolution, acquisition dates	List the specific research tasks that will be addressed

*Sites: Refer to FCT Validation Sites 22DEC11.xls, or submit new site request (site name, lat/long)
Available optical data: Landsat-7/-8, CBERS-2. Include VHR data for cal/val if required: SPOT, RapidEye
Available SAR data: L-band – ALOS-1 PALSAR-1 (archive), ALOS-2 PALSAR-2; JERS-1 (archive), C-band – RADARSAT-2, Sentinel-1, ENVISAT ASAR (archive), ERS-1 (archive); X-band – TerraSAR-X, TanDEM-X

4.3 Funding Opportunities

GFOI aims to complement existing R&D by promoting research that fills the gaps. Many organizations are active in this space; we have critical mass in high priority areas such as sensor synergy for forest degradation mapping and improving activity data. Targeted science workshops such as this one help to identify the gaps and limiting factors, and so establish an action plan to encourage R&D, foster new partnerships and make a significant contribution. Ultimately, technical contribution to the GFOI Methods and Guidance Documentation is sought through the R&D programme, with capacity enhancement to follow. Funding opportunities are available through national scientific research schemes and potential partner organizations. Information on upcoming relevant research grants is provided in Annex B.

The idea of a joint funding proposal was discussed, however, in practice, may be difficult to implement through GFOI. The GFOI R&D team is in the process of identifying potential contributing partners with similar research objectives and may be influential in their issuing calls for targeted scientific proposals.

4.4 Next Steps

- Workshop participants to submit requests satellite data for R&D (complete Table 4.1 and send to Ake) – All
- Integrate User Requests in CEOS SDCG Strategy Document for R&D (Element 3) – Ake/Anthea
- Forward input/recommendations to SDCG/Space agencies for dedicated multi-sensor acquisition campaign – Ake
- Workshop presentations and report included on GFOI R&D website – GFOI Office
- Draft Technology Review paper on state-of-the-art methods of sensor synergy, with contributions from workshop participants – Anthea
- Facilitate contributions to Methods and Guidance Documentation, pending success of R&D – Ake/Anthea
- Spaceborne LiDAR: Japan Space Systems/METI planning to install LiDAR on the International Space Station. Contact JSS to seek information and investigate whether input can be provided – Ake
- Workshop participants are invited to attend and present research outcomes at the GFOI Annual Science Meeting (to be scheduled in 2015)

5. References

Reiche, J., Souza, C., Hoekman, D., Verbesselt, J., Haimwant, P., D., Herold, M. (2013): Feature level fusion of multi-temporal ALOS PALSAR and Landsat data for mapping and monitoring of tropical deforestation and forest degradation. IEEE Journal of Selected Topics in Applied Earth Observation and Remote Sensing, vol.6, no5, pp.2159 - 2173., doi: 10.1109/JSTARS.2013.2245101.

Reiche, J., Verbesselt, J., Hoekman, D., Herold, M. (in review, RSE): Fusing Landsat and SAR image time series for forest change detection in the tropics.

Zhu Z. and Woodcock C. (2014): Continuous change detection and classification of land cover using all available Landsat data. Remote Sensing of Environment, 144, 152–171. doi: 10.1016/j.rse.2014.01.011

1st GFOI R&D Expert Workshop
Sensor interoperability (and sensor complementarity)

Woods Hole Research Center – June 10-11, 2014

Annex A. Workshop participants

Workshop participants		
Andre Beaudoin	CFS, Canada	Andre.Beaudoin@RNCan-NRCan.gc.ca
Yves Crevier	CSA, Canada	yves.crevier@asc-csa.gc.ca
Edersson Cabrera	IDEAM, Colombia	ecabreram@ideam.gov.co
Tuomas Häme	VTT, Finland	tuomas.hame@vtt.fi
Chris Holden	BU, USA	ceholden@bu.edu
Pontus Olofsson	BU, USA	olofsson@bu.edu
Curtis Woodcock	BU, USA	curtis@bu.edu
Francesco Holecz	sarmap, Switzerland	fholecz@sarmap.ch
Josef Kellndorfer	WHRC, USA	josefk@whrc.org
Oliver Cartus	WHRC, USA	ocartus@whrc.org
Jesse Bishop	WHRC, USA	jbishop@whrc.org
Carol Franco	WHRC, USA	cfranco@whrc.org
Johannes Reiche	WUR, The Netherlands	johannes.reiche@wur.nl
Eric Lehmann	CSIRO, Australia	Eric.Lehmann@csiro.au
Anthea Mitchell	UNSW, Australia	a.mitchell@unsw.edu.au
Ake Rosenqvist	soleEO, Japan	ake.rosenqvist@soloEO.com
Simon Eggleston	GFOI Office, Switzerland	simon@gfoi.org

1st GFOI R&D Expert Workshop
Sensor interoperability (and sensor complementarity)

Woods Hole Research Center – June 10-11, 2014

Annex B. Funding Opportunities: Scientific Research Schemes

Funding Opportunities relevant to R&D on Sensor Synergy		
Scheme	**Research Call**	**Deadlines/Caveats**
EU Research & Innovation Programme: Horizon 2020	*Stimulating wider research use of Copernicus Sentinel data* -Methods for operational use, integration with other EO data, contribution to services	**Submission deadline: 27 Nov 2014** EU Member States and Non-EU Associated Countries are eligible. 'Third' countries should confirm funding eligibility
	Bringing EO applications to the market -Commercial service outcome, product shaped by user demand, validated and proven	**Submission deadline: 27 Nov 2014**
	Improved forest management models -Strengthen methodological framework for more accurate harmonized information derived from forest inventories and monitoring systems	**Submission deadline: 25 Feb 2015**
European Space Agency (ESA) INNOVATORS III	-Develop innovative EO products & services in response to authoritative requirements from end-users -Respond to R&D agenda of major international initiatives such as GEO and GFOI, and facilitate exploitation of Sentinels-1 and -2 data	**Submission deadline: 29 Aug 2014** Member States of ESA are eligible to apply. Funding for 12 projects of max 2 years, EUR 200 k each
European Research Council (ERC)	ERC Advanced Grants -Supports investigator-driven frontier research across all fields; funding up to 5 years	**Submission deadline: 21 Oct 2014** Host institution must be in EU Member State or Assoc Country
NASA Research Opportunities in Space and Earth Sciences (ROSES)	-Covers basic and applied research and technology development in space and earth sciences	http://nspires.nasaprs.com/external/ Any US agency can apply. Non-US collaborators are involved on a basis of no exchange of funds

1st GFOI R&D Expert Workshop
Sensor interoperability (and sensor complementarity)

Woods Hole Research Center – June 10-11, 2014

Annex C. Overview of ongoing and proposed R&D

Table C.1 Current Research Activity on Sensor Synergy								
	Team	**Optical**	**L-band**	**C-band**	**X-band**	**LiDAR**	**VHR**	**RapidEye**
LULC	WHRC	X	X	X		X	X	X
	VTT	X	X	Y	X	X	X	
	CSIRO/CRC	X	X, Y	Y				
	WUR	X	X					
	CFS	X						
	sarmap		X	X	X			
	UNSW	X	X			X		
LULCC	WHRC	X	X	X				X
	BU	X	X					
	VTT	X	X	Y	X	X	X	
	CSIRO/CRC	X	X					
	WUR	X	X					
	CFS	X						
	sarmap		X	X	X			
AGB	WHRC	X	X			X		
	VTT	X	X		X	X	X	
	CFS	X	X	X	X	X		
	sarmap		X		X			
	UNSW	X	X			X		
Degradation	WHRC	X	X					X
	VTT		X	X			X	
	CSIRO	X						
	UNSW	X	X			X		

Table C.2 Proposed Research Activity on Sensor Synergy								
	Team	**Optical**	**L-band**	**C-band**	**X-band**	**LiDAR**	**VHR**	**RapidEye**
LULC	WHRC	X	X	X		X	X	X
	VTT	X	X	X	X	X	X	
	CSIRO/CRC	X	X					
	CFS	X						
	sarmap	X	X	X	X			
LULCC	WHRC	X	X	X, Y			X	X
	BU	X	X	X				
	VTT	X	X		X	X	X	
	CSIRO/CRC	X	X					
	WUR	X, Y	X, Y	X				
	CFS	X		X				
	sarmap	X	X	X	X			
	UNSW	X	X			X		
AGB	WHRC	X	X	X	X	X	X	
	VTT	X	X		X	X	X	
	CSIRO/CRC		X		X	X		
	WUR	X				X		
	CFS	X	X		X	X		
	sarmap		X		X			
	UNSW	X	X			X		
Degradation	WHRC	X	X	X	X			X
	VTT	X	X	X			X	
	CSIRO/CRC	X	X		X	X		
	WUR	X				X		
	CFS			X				
	UNSW	X	X			X		

1st GFOI R&D Expert Workshop
Sensor interoperability (and sensor complementarity)

Woods Hole Research Center – June 10-11, 2014

LULC

- Current research activity focuses on integration of Opt-SAR-LiDAR (3 studies)
- Few studies on SAR-SAR (2 studies) and Opt-L (2 studies)
- Fewer studies on Optical (1 study) and C-SAR (1 study)
- Proposed research activity focuses on integration of Opt-SAR-LiDAR (2 studies) and Opt-SAR (2 studies), with fewer studies on Optical (1 study)

LULCC

- Current research activity focuses on integration of Opt-L (3 studies)
- Fewer studies on Opt-SAR-LiDAR (1 study), Opt-SAR (1 study), Optical (1 study), SAR-SAR (1 study)
- Proposed research activity focuses on integration of Opt-SAR (5 studies), with fewer studies on Opt-SAR-LiDAR (1 study), Opt-L (1 study), C-SAR (2 studies)

AGB

- Current research activity focuses on integration of Opt-SAR-LiDAR (3 studies), with few studies on SAR-SAR (1 study)
- Proposed research activity focuses on integration of Opt-SAR-LiDAR (3 studies), with few studies on SAR-SAR (1 study), Opt-LiDAR (1 study) and SAR-LiDAR (1 study)

Degradation

- Current research activity focuses on integration of Opt-SAR (2 studies), with few studies on Optical (1 study)
- Proposed research activity focuses on integration of Opt-SAR (2 studies), with few studies on Opt-LiDAR (1 study), SAR-LiDAR (1 study) and C-SAR (1 study)