Canadian Evaluation Group

Raouia Nasri, Shiguang Guo, Ven Sampath
Canadian Evaluation Group (CEG)

www.IMT-Advanced.ca

Overview

- What the CEG evaluated
- Compliance tables
  - Services
  - Spectrum
  - Technical Performance

CEG – evaluation

- Anticipates evaluating:
  - IEEE P802.16m submission ✔
    - Both FDD and TDD modes/components ✔
- Participants
  - Manufacturers, Service providers, Universities and Research Institutions

CEG – procedure

- Used the self-evaluations
  - Description template
    - Gained an understanding of the radio interface
  - Compliance templates
    - Verified
  - Evaluated parameters as explained in Report M. 2135-1
    - Through “inspection,” “analysis” and “simulations”
  - Contributions on the above evaluations were made by participating organisations

CEG – commitment matrix

Institution	Chart summarizing the commitment of CEG participants in the evaluation activity														
	Peak Spectral Efficiency	Control Plane Latency	User Plane Latency	Handover			Bandwidth	Deployment in one identified IMT band	Channel bw scalability	Support wide range of services	Cell spectral efficiency	Cell-edge spectral efficiency	Mobility	VoIP capacity	Link budgets
				Intra-freq HO interruption time	Inter-freq HO interruption time	Inter-system									
	Analysis	Analysis	Analysis	Analysis		Inspection	Inspection	Inspection	Inspection	Inspection	Simulation	Simulation	Simulation	Simulation	Verification
Bell	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP					3GPP
Ericsson (CAN)	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP
Aviat Networks															IEEE
Huawei (CAN)	3GPP; IEEE	3GPP, IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP	3GPP	3GPP	3GPP	3GPP; IEEE
Intel (CAN)	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE	IEEE
RIM	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP	3GPP	3GPP		3GPP
Rogers	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE					3GPP; IEEE
Telesat															
Telus	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP					3GPP
Carleton															3GPP; IEEE
INRS	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE
Memorial	IEEE										3GPP; IEEE	3GPP; IEEE	3GPP; IEEE		3GPP; IEEE
Univ. Laval															
Ottawa U.															
U-of-Tor	3GPP; IEEE	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP	3GPP			
Waterloo															
CRTC															
IC															
CRC	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE	3GPP; IEEE			3GPP; IEEE
Section Coordinator	Andy M.	Remi C.	Remi C.	Andy M.	Andy M.	Andy M.	P.F. Ng	P.F. Ng	P.F. Ng	Jose C.	Sofiene (3GPP) Remi (IEEE)	Sofiene (3GPP) Remi (IEEE)	Sofiene (3GPP) Remi (IEEE)	Sofiene (3GPP) Remi (IEEE)	Ivo (3GPP) Vishnu (IEEE)
Target Compl	Mar/2010	Mar/2010	Mar/2010	Mar/2010	Mar/2010	Mar/2010	Mar/2010	Mar/2010	Mar/2010	Mar/2010	May/2010	May/2010	May/2010	May/2010	Feb/2010

Simulation assumptions (1)

Parameter	Values used for evaluation
Deployment scenario	• Indoor hotspot • Urban micro-cell • Urban macro-cell • Rural macro-cell Parameters and assumptions not shown here for each scenario are shown in ITU guidelines [ITU-R Report M.2135].
Duplex method and bandwidths	FDD: 10+10 MHz for data & 5+5 MHz for VoIP for all except InH 20+20 MHz for data & 5+5 MHz for VoIP for InH TDD: 20 MHz for data & 10 MHz for VoIP for all except InH 40 MHz (2x20 MHz) for data & 10 MHz for VoIP for InH TDD DL-UL Ratio: 5 DL subframes & 3 UL subframes for data for all environments 4 DL subframes & 4 UL subframes for VoIP for all environments
Network synchronization	Synchronized
Handover margin	1.0 dB

Simulation assumptions (2)

Downlink transmission scheme	Data: Scheme for all environments: OL-SU-MIMO using 2x2 configuration Scheme for InH and UMi: 6-bit Transformed Codebook based MU-MIMO using 4x2 configuration; adaptive switching among rank-1 CL-SU-MIMO, two stream CL-MU-MIMO, three stream CL-MU-MIMO and four stream CL-MU-MIMO Scheme for UMa and RMa: MU-MIMO with long term beamforming using 4x2 configuration (20 ms reporting period for the long-term covariance matrix); adaptive switching among rank-1 CL-SU-MIMO, two stream CL-MU-MIMO, three stream CL-MU-MIMO and four stream CL-MU-MIMO VoIP: SU-MIMO with wideband beamforming using 4x2 configuration
Downlink scheduler	Proportional Fair for full buffer data and delay-weighted Proportional Fair with persistent scheduling for VoIP
Downlink link adaptation	Choice of 16 MCS schemes inclusive of coding rate and rate matching, see Section 11.13 of IEEE 802.16m-09/0034
CSI assumption at eNB	Based on feedback from Mobile Station
Downlink HARQ scheme	Incremental Redundancy Asynchronous, adaptive, 3 subframe ACK/NACK delay, maximum 4 HARQ retransmissions, minimum retransmission delay 3 subframes

Simulation assumptions (3)

Downlink receiver type	MMSE for both channel estimation and data detection
Uplink transmission scheme	Data Scheme for InH and UMi: 3-bit Codebook based MU- MIMO using 2x4 configuration; adaptive switching between single user and collaborative spatial multiplexing Scheme for UMa and RMa: MU-MIMO with long term beamforming using 2x4 configuration; adaptive switching between single-user and collaborative spatial multiplexing VoIP SU-MIMO using 2x4 configuration with SFBC + non-adaptive precoding
Uplink scheduler	Proportional Fair for full buffer data and delay-weighted Proportional Fair with persistent scheduling for VoIP
Uplink Power control	Open loop power control as described in 3.3.5.4 of IEEE 802.16m-09/0047; values for γ and SINRMIN should be chosen such that the average IoT meets the IMT-Advanced requirement
Uplink link adaptation	Choice of 16 MCS schemes inclusive of coding rate and rate matching, see Section 11.13 of IEEE 802.16m-09/0034
Uplink HARQ scheme	Incremental Redundancy Synchronous, non-adaptive, 3 subframe ACK/NACK delay, maximum 4 HARQ retransmissions, minimum retransmission delay 3 subframes

Simulation assumptions (4)

Uplink receiver type	MMSE for both channel estimation and data detection
Antenna configuration base station	DL: 4x2, BS: co-polarized, 4λ spacing (illustration for 4 Tx: | | | |)
Antenna configuration UE	UL: 2x4, MS: Vertical polarized, 0.5λ spacing
Channel estimation (Uplink and downlink)	Channel estimation error modeling included for both uplink and downlink simulations (for both data and VoIP simulations)
Control channel and reference signal overhead, Acknowledgements etc.	Control channel overhead modeling included for both uplink and downlink (for both data and VoIP simulations)
Feedback and control channel errors	Feedback and control channel error modeling included for both uplink and downlink (for both data and VoIP simulations)

Compliance Template for Services – IEEE (FDD, TDD)

4.2.4.1.1	**Support of a wide range of services** Does the proposal support a wide range of services?: If bullets 4.2.4.1.1.1 - 4.2.4.1.1.3 are marked as "yes" then 4.2.4.1.1 is a "yes". √ YES / NO	See Section 9.8 of the Final Report.
4.2.4.1.1.1	**Ability to support basic conversational service class** Is the proposal able to support basic conversational service class?: √ YES / NO	See Section 9.8 of the Final Report.
4.2.4.1.1.2	**Support of rich conversational service class** Is the proposal able to support rich conversational service class?: √ YES / NO	See Section 9.8 of the Final Report.
4.2.4.1.1.3	**Support of conversational low delay service class** Is the proposal able to support conversational low-delay service class?: √ YES / NO	See Section 9.8 of the Final Report.

Compliance Template for Spectrum – IEEE (FDD, TDD)

4.2.4.2.1 **Spectrum bands (FDD)**

Is the proposal able to utilize at least one band identified for IMT?: √ YES / NO

Specify in which band(s) the candidate RIT or candidate SRIT can be deployed.

See Section 9.6 of the Final Report. A number of bands (698-862 MHz, 1710-1770 and 2110-2170 MHz, 2500-2690 MHz, 3400-3600 MHz, etc.), as identified for IMT in the ITU-R Radio Regulations are supported.

4.2.4.2.1 **Spectrum bands (TDD)**

Is the proposal able to utilize at least one band identified for IMT?: √ YES / NO

Specify in which band(s) the candidate RIT or candidate SRIT can be deployed.

See Section 9.6 of the Final Report. A number of bands (2300-2400 MHz, 2500-2690 MHz, 3400-3600 MHz, etc.), as identified for IMT in the ITU-R Radio Regulations are supported.

Note on the values

- The numbers in the technical performance section are being finalized – so a *preliminary* set is proposed. These could be revised for the June 2010 meeting of WP5D

Compliance template for tech perf – IEEE (FDD, TDD) – Cell SE

Minimum technical requirements item (4.2.4.3.x), units, and Report ITU-R M. 2134 section reference[1]	Category: Test environment	Downlink or uplink	Required value	Value[2], [3]	Require-ment met?	Comments
4.2.4.3.1 Cell spectral efficiency (bit/s/Hz/cell) *(4.1)*	Indoor	Downlink	3	6.85 FDD 6.75 TDD	√ Yes No	See Section 9.9 of the Final Report.
		Uplink	2.25	5.40 FDD 5.20 TDD	√ Yes No	
	Microcellular	Downlink	2.6	3.72 FDD 3.45 TDD	√ Yes No	
		Uplink	1.8	2.66 FDD 2.60 TDD	√ Yes No	
	Base coverage urban	Downlink	2.2	2.99 FDD 2.62 TDD	√ Yes No	
		Uplink	1.4	2.46 FDD 2.38 TDD	√ Yes No	
	High speed	Downlink	1.1	3.58 FDD 3.58 TDD	√ Yes No	
		Uplink	0.7	2.54 FDD 2.45 TDD	√ Yes No	

Compliance template for tech perf – IEEE (FDD, TDD) – PSE & BW

Minimum technical requirements item (4.2.4.3.x), units, and Report ITU-R M. 2134 section reference[1]	Category: Test environment	Downlink or uplink	Required value	Value[2], [3]	Require-ment met?	Comments
4.2.4.3.2 Peak spectral efficiency (bit/s/Hz) *(4.2)*	Not applicable	Downlink	15	TBC FDD TBC TDD	Yes No	See Section 9.1.1 of the Final Report.
		Uplink	6.75	TBC FDD TBC TDD	Yes No	
4.2.4.3.3 Bandwidth *(4.3)*	Not applicable	Up to and including (MHz)	40	Upto 100 MHz supported.	√ Yes No	See Section 9.5 of the Final Report.
		Scalability	Support of at least three band-width values[4]	Upto 5 (5, 7, 8.75, 10 & 20 MHz) supported.	√ Yes No	See Section 9.7 of the Final Report.

Compliance template for tech perf – IEEE (FDD, TDD) – Cell edge SE

Minimum technical requirements item (4.2.4.3.x), units, and Report ITU-R M. 2134 section reference[1]	Category: Test environment	Downlink or uplink	Required value	Value[2], [3]	Require-ment met?	Comments
4.2.4.3.4 Cell edge user spectral efficiency (bit/s/Hz) *(4.4)*	Indoor	Downlink	0.1	0.239 FDD 0.235 TDD	√ Yes No	See Section 9.10 of the Final Report.
		Uplink	0.07	0.377 FDD 0.361 TDD	√ Yes No	
	Microcellular	Downlink	0.075	0.145 FDD 0.087 TDD	√ Yes No	
		Uplink	0.05	0.141 FDD 0.137 TDD	√ Yes No	
	Base coverage urban	Downlink	0.06	0.0745 FDD 0.071 TDD	√ Yes No	
		Uplink	0.03	0.117 FDD 0.113 TDD	√ Yes No	
	High speed	Downlink	0.04	0.095 FDD 0.095 TDD	√ Yes No	
		Uplink	0.015	0.130 FDD 0.125 TDD	√ Yes No	

Compliance template for tech perf – IEEE ($_{FDD, TDD}$) – C- & U-plane latencies

Minimum technical requirements item (4.2.4.3.x), units, and Report ITU-R M. 2134 section reference[1]	Category: Test environment	Category: Downlink or uplink	Required value	Value[2], [3]	Require-ment met?	Comments
4.2.4.3.5 Control plane latency (ms) *(4.5.1)*	Not applicable	Not applicable	Less than 100 ms	< 81 ms (idle-to-active). < 31 ms (total C-plane connection establishment delay).	√ Yes No	See section 9.2 of the Final Report.
4.2.4.3.6 User plane latency (ms) *(4.5.2)*	Not applicable	Not applicable	Less than 10 ms	5.13 ms (FDD) and 7.32 ms (TDD) at 10% HARQ BLER.	√ Yes No	See section 9.3 of the Final Report.

Compliance template for tech perf – IEEE ($_{FDD, TDD}$) – Mobility classes

Minimum technical requirements item (4.2.4.3.x), units, and Report ITU-R M. 2134 section reference[1]	Category					
	Test environment	Downlink or uplink	Required value	Value[2], [3]	Require-ment met?	Comments
4.2.4.3.7 Mobility classes *(4.6)*	Indoor	Uplink	Stationary, pedestrian		√ Yes No	See Section 9.11 of the Final Report.
	Microcellular	Uplink	Stationary, pedestrian, vehicular up to 30 km/h		√ Yes No	
	Base coverage urban	Uplink	Stationary, pedestrian, vehicular		√ Yes No	
	High speed	Uplink	High speed vehicular, vehicular		√ Yes No	

Compliance template for tech perf – IEEE (FDD, TDD) – Mobility traffic channel link data rates

Minimum technical requirements item (4.2.4.3.x), units, and Report ITU-R M. 2134 section reference[1]	Category: Test environment	Category: Downlink or uplink	Required value	Value[2], [3]: Avg over NLOS, LOS	Require-ment met?	Comments
4.2.4.3.8 Mobility Traffic channel link data rates (bit/s/Hz) *(4.6)*	Indoor	Uplink	1.0	3.60 FDD 3.46 TDD	√ Yes No	See Section 9.11 of the Final Report.
	Microcellular	Uplink	0.75	1.77 FDD 1.49 TDD	√ Yes No	
	Base coverage urban	Uplink	0.55	1.48 FDD 1.42 TDD	√ Yes No	
	High speed	Uplink	0.25	1.44 FDD 1.39 TDD	√ Yes No	

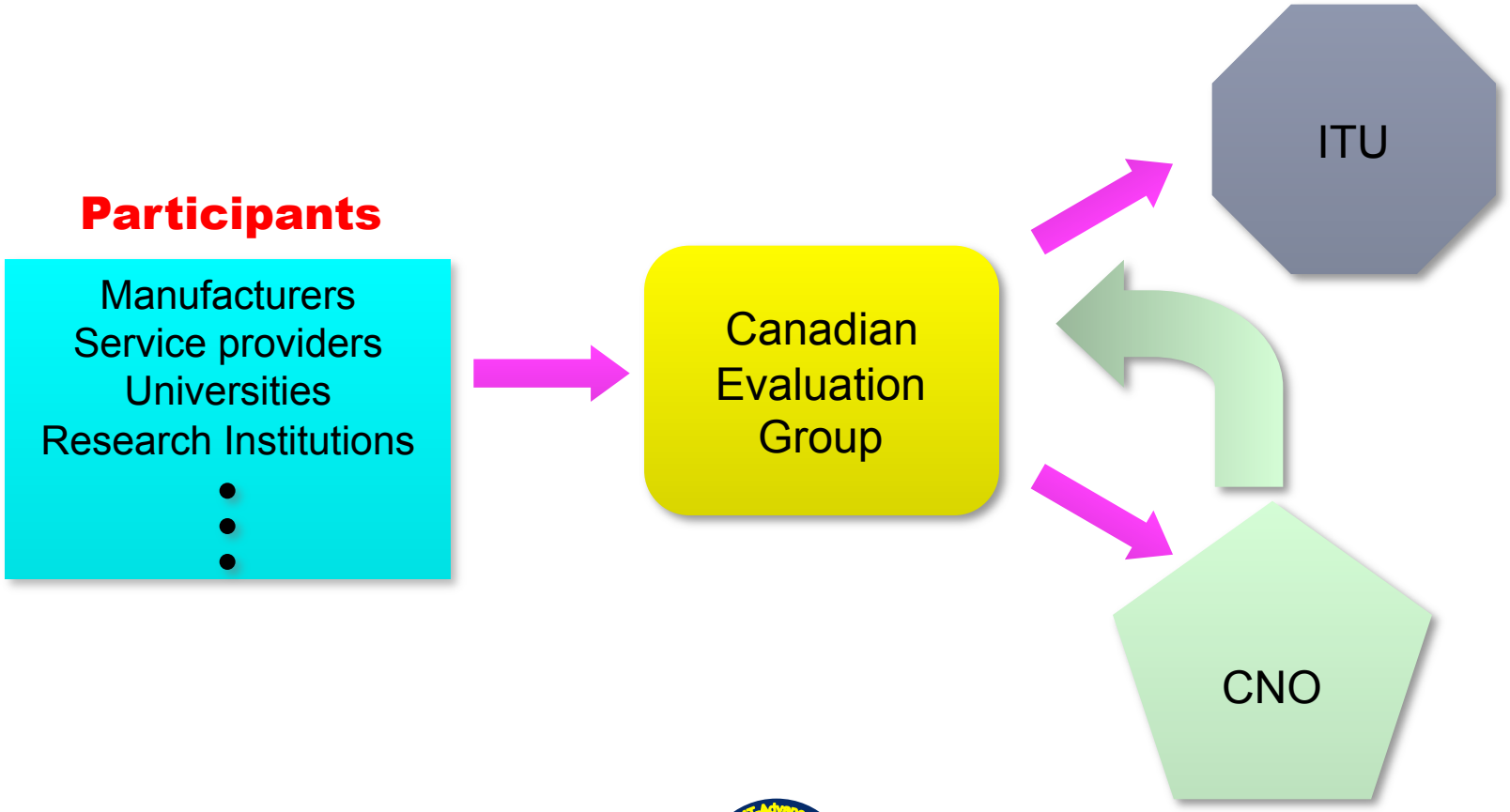
Compliance template for tech perf – IEEE (FDD, TDD) – Handover

Minimum technical requirements item (4.2.4.3.x), units, and Report ITU-R M. 2134 section reference[1]	Category: Test environment	Category: Downlink or uplink	Required value	Value[2], [3]	Requirement met?	Comments
4.2.4.3.9 Intra-freq HO interruption time (ms) *(4.7)*	Not applicable	Not applicable	27.5	0-15 ms	√ Yes No	See Section 9.4.2 of the Final Report.
4.2.4.3.10 Inter-freq HO interruption time within a spectrum band (ms) *(4.7)*	Not applicable	Not applicable	40	5-35 ms	√ Yes No	See Section 9.4.2 of the Final Report.
4.2.4.3.11 Inter-freq HO interruption time between spectrum bands (ms) *(4.7)*	Not applicable	Not applicable	60	5-35 ms	√ Yes No	See Section 9.4.2 of the Final Report.
4.2.4.3.12 Inter-system HO *(4.7)*	Not applicable	Not applicable	Not applicable	Not applicable	√ Yes No	See Section 9.4.3 of the Final Report.

Compliance template for tech perf – IEEE (FDD, TDD) – # VoIP users

Minimum technical requirements item (4.2.4.3.x), units, and Report ITU-R M. 2134 section reference[1]	Category: Test environment	Downlink or uplink	Required value	Value[2], [3]	Require-ment met?	Comments
4.2.4.3.13 Number of supported VoIP users (active users/ sector/MHz) *(4.8)*	Indoor	As defined in Report ITU-R M.2134	50	144 (FDD) 146 (TDD)	√ Yes No	See Section 9.12 of the Final Report.
	Microcellular	As defined in Report ITU-R M.2134	40	80 (FDD) 84 (TDD)	√ Yes No	
	Base coverage urban	As defined in Report ITU-R M.2134	40	74 (FDD) 78 (TDD)	√ Yes No	
	High speed	As defined in Report ITU-R M.2134	30	96 (FDD) 99 (TDD)	√ Yes No	

CEG – process


Participants
Manufacturers
Service providers
Universities
Research Institutions
Canadian Evaluation Group
ITU
CNO

Simulation results - how

- Each study had different antenna configurations
- Could not average over the results – obviously – so decided to stick with the median (or average of 2 middle values when # of results was even)

CEG – additional methods

- No additional methods were used
- However, the CEG did evaluate the link budgets in detail – the spread-sheets verifying the information provided by the IEEE candidate will be presented in the Final Report

Summary

- All parameters for evaluation (by inspection, analysis or simulation) have been examined
- Most meet the minimum requirements (remainder at Vietnam WP5D meeting)
- Over 10 organizations contributed to evaluation activity
  - Mix of Industry, Regulators, Academia