Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**802.16a PHY Proposals - Proposed Improvements and Mergers**
Date Submitted	**2001-03-08**
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Re:	This document responds to the TG3 "Call for Improvements and Mergers" 802163-01/08 and is therefore submitted prior to the presentation and discussion of the invited PHY proposals.
Abstract	Documents 802163c-01/31, 802163c-01/32 and 802163c-01/33 are the three PHY proposals submitted in response to the Meeting 11 "Invitation for Proposals" 802163-01/05 This contribution suggests some improvements and mergers based on key business case drivers repeatedly expressed by potential BWA Service Providers.
Purpose	This document is intended as a framework for reorganizing the proposals into a market driven draft standard.
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Proposal 1 : Merger of Proposals 31 and 32.

Contributions 802163c-01/31 and 802163c-01/32 contain significant overlap, both in content and in the list of contributors. For the purposes of evaluation, these two proposals should be merged and evaluated as a single proposal. This means that only TWO proposals would be presented and evaluated at Meeting 12, on behalf of two groups of contributors.

Proposal 2 : Improvement in structuring the Draft Standard

Given the numerous factors contained within the submitted proposals, and bearing in mind the interests and priorities of Service Providers plus regulators, the information should be edited into the following structure for an IEEE 802.16a Standard, allowing for the fact that certain options might be eliminated as the result of the ongoing task group and work group discussions :

PHY Mode A Frequency Division Duplex (FDD)

A1 : Framing, Coding, Modulation, etc

A2 : Diversity Enhancement Options

A3 : Frequency Reuse Options

PHY Mode B Time Division Duplex (TDD)

B1 : Framing, Coding, Modulation, etc

B2 : Diversity Enhancement Options

B3 : Frequency Reuse Options

The following Improvements are aimed at linking the IEEE 802.16a Standard to the business case drivers of potential FWA Service Providers / Investors and the imperative to establish a successful high volume market for systems based on the Standard, especially with respect to residential and SME applications.

Proposal 3 : Duplexing Mode

Service Providers regularly quote **CPE cost, Spectrum Flexibility and Flexible Payload Asymmetry** among their highest priority requirements. These characteristics favor TDD rather than FDD modes. The IEEE 802.16a Standard should specify TDD as its preferred mode for high volume residential and SME deployments and optimize the Standard accordingly.

Note : This envisages the use of TDD mode in paired, fragmented and contiguous frequency blocks and satisfactory resolution of any coexistence issues with broadcast or FDD systems operating in adjacent or co-channel spectrum.

Proposal 4 : Benchmark Modulation Rate

Expectations of high volume residential and small business deployments place an over-riding priority on Non LOS operation with predictable, economical and reliable (semi or non-professional) installation procedures.

The IEEE 802.16a Standard should specify **16-QAM** as the benchmark modulation rate for capacity and deployment planning purposes in residential and SME applications and optimize the Standard accordingly.

Any proposal to adopt 32-QAM or 64-QAM as the benchmark for these applications would need to clearly demonstrate satisfactory NLOS and installability experience based on detailed simulations and field deployments in the frequency bands concerned.

Lower rates (8-PSK and QPSK) would be permitted (e.g. on a configured or adaptive basis) to cope with specific propagation impairments, range extensions, etc.

Higher rates (32-QAM and 64-QAM) would be optionally supported (e.g. on a configured or adaptive basis) in their appropriate deployment and service scenarios.

Proposal 5 : System Capacity and Spectrum Utilization Efficiency

In frequency bands below 11GHz, the (limited) spectrum allocations and deployed cost per customer become the driving limitations of economic viability for high volumes of customers and / or payload per geographic area, forcing a Service Provider to reduce cell radius and install higher quantities of base stations to achieve the necessary coverage / capacity profiles.

High Intra-cell frequency reuse factors (through sectorization and/.or adaptive beamforming techniques) plus low inter-cell frequency reuse factors must therefore play a large part in the resolution of the 802.16a Standard, especially with the requirements of Proposal 4 in mind.

The IEEE 802.16a Standard should therefore benchmark a System Payload Efficiency of at least **2 - 10♦ Mbs per MHz (of allocated spectrum) per cell** at the benchmark Modulation rate etc.

This efficiency is calculated by multiplying a Frequency Reuse Index by the individual Channel Payload Efficiency rates (in Mbs per MHz). The Frequency Re-use Index is calculated by dividing the Intra-cell Frequency Re-use factor (R) by the Inter-cell Frequency Re-use factor (N), as shown in the example table below

Channel Payload Efficiency	**Intra-Cell Reuse**	**Inter-Cell Reuse**	**Frequency Reuse Index R / N**	**System Payload Efficiency** Mbps/MHz/Cell
3 Mbps per MHz	R = 2	N = 1	**2.00**	**6.0**
		N = 3	**0.67**	**2.0**
		N = 5	**0.40**	**1.2**
	R = 6	N = 1	**6.00**	**18.0**
		N = 3	**2.00**	**6.0**
		N = 5	**1.20**	**3.6**
	R = 10	N = 1	**10.00**	**30.0**
		N = 3	**3.33**	**10.0**
		N = 5	**2.00**	**6.0**

Given the concerns for base-station costs (per customer) and the probable geographic dispersion of customers around the base station location, the IEEE 802.16a Standard should be optimized to enable advanced frequency reuse options (e.g. adaptive beamforming) in order to meet the business case needs of Service Providers with typical amounts of allocated spectrum, and to also meet the future growth needs of Service Providers with larger allocations of spectrum.

♦ In Transcomm s experience, Service Providers need a maximum deployed CAPEX cost of $500 per residential customer and $1000 per SME customer for a viable / competitive high volume BWA business case in developed countries.

Taking all the necessary factors into account (e.g. appropriate mixtures of voice and data services, QoS and SLA commitments, base station / site and backhaul cost allocations etc) this translates into an average payload capacity requirement (downstream + upstream) of 50 — 100 Mbps per cell in the short term (2 — 5 yrs), 100 — 300 Mbps per cell in the medium term (five years) and 300 — 500 Mbps per cell in the longer term (5 — 10 years).

With wide area spectrum allocations per Service Provider varying from 10 — 50 MHz in most countries / applications, 50 — 100 MHz in some countries / applications and 100 — 200 MHz in a few specific countries / applications, this gives an average payload efficiency requirement per cell of 2 — 10 Mbps per MHz per cell, as summarized in the table below.

PAYLOAD REQUIREMENT (MBPS PER CELL)	**PAYLOAD EFFICIENCY (MBPS PER MHZ PER CELL)**			
	SPECTRUM ALLOCATION			
	10 MHz	**50 MHz**	**100 MHz**	**200 MHz**
50	**5**	1	0.5	0.25
100	**10**	**2**	1	0.5
300	30	**6**	**3**	1.5
500	50	**10**	**5**	**2.5**