Project	**IEEE 802.16 Broadband Wireless Access Working Group <http://ieee802.org/16>**
Title	**Key System Characteristics and Evaluation Criteria for the TG3 Air Interface Standard**
Date Submitted	**2001-03-08**
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Re:	This document responds to the TG3 Call for Contributions 802163-00_25 on Key Characteristics and Evaluation Criteria. It consolidates inputs from earlier documents 802163-00_02r4, 802163-00_07r1, 802163c-00_02 and 802163c-00_27.
Abstract	Document 802163-00_07r1 included a "placeholder" sub-section on System Key Characteristics and Evaluation Criteria. Some contributions were received (e.g. 802163c-00_02 and 802163c-00_27.) but no further action was taken. This contribution consolidates these previous contributions, together with the FRD Requirements Summary (802163-00_02r4 Appendix A) into a proposed Evaluation worksheet.
Purpose	This document is proposed to be used as the basis for a compliance response worksheet to be used for the system level evaluation of alternative TG3 air interface proposals beyond Meeting 12 and/or system level characterization of the eventual standard.
Notice	This document has been prepared to assist IEEE 802.16. It is offered as a basis for discussion and is not binding on the contributing individual(s) or organization(s). The material in this document is subject to change in form and content after further study. The contributor(s) reserve(s) the right to add, amend or withdraw material contained herein.
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SUMMARY

Proposed Key System Characteristics and Evaluation Criteria

1. Compliance against Functional Requirements Summary (802163-00_02r4 Appx A)

- **Mandatory Requirements (Chart A1)** Score 1 — 10, Weighting 0.5
- **Recommended Requirements (Chart A2)** Score 1 — 10, Weighting 0.3
- **Optional Requirements (Chart A3)** Score 1 — 10, Weighting 0.2

Weighted Score 1 - 10

2. Deployment Cost Factors (See 802163c-00_27)

- **Initial Coverage and Capacity (Chart B)** Score 1 — 10, Weighting 0.3
- **Maximum Capacity — Single Cell (Chart C)** Score 1 — 10, Weighting 0.3
- **Maximum Capacity — Multi-Cell (Chart D)** Score 1 — 10, Weighting 0.2
- **Installation Predictability (Chart E)** Score 1 — 10, Weighting 0.2

Weighted Score 1 - 10

3. Regulatory Compliance (See 802163c-00_02)

- **Chart F**

US MDS Band	Score 1-10, Weighting 0.3
International 3400-3700 Band	Score 1-10, Weighting 0.3
Other US Bands	Score 1-10, Weighting 0.2
Other International Bands	Score 1-10, Weighting 0.2

Weighted Score 1 — 10

Charts A — F Follow

A Functional Requirements

Each candidate short-listed for evaluation shall complete a compliance response to the following Requirements, copied from the 802.16.3 Functional Requirements Document (FRD). A score will be assessed in accordance with the following scale :

A.1 Mandatory Requirements : Score 1 (low) – 10 (high) degree of compliance.

A.2 Recommended Requirements : Score 1 (low) – 10 (high) degree of compliance.

A.3 Optional Requirements : Score 1 (low) – 10 (high) degree of compliance

Apply weighting factors to A.1, A.2 and A.3 scores to yield an overall weighted score of 1 - 10

A.1 Mandatory

It is mandatory that the 802.16.3 standard support or specify the items in Table 2.

Table 1: Mandatory Requirements

#	Section	Requirement	Compliance
M1		The forthcoming air interface standard MUST comply with the system requirements.	
M2		The 802.16.3 air interface interoperability standard SHALL be part of a family of standards for local, metropolitan and wide area networks.	
M3	2	802.16.3 systems SHALL be deployable in multiple-cell frequency reuse systems and single cell (super cell) frequency reuse systems.	
M4	2.3	Since all data traffic in a single cell of an 802.16.3 network MUST go through the base station, that station SHALL serve as a radio resource supervisor.	

#	Section	Requirement	Compliance
M5	2	The base station radio SHALL be P-MP, radiating its *downstream* signal with a shaped sector or adaptive array (spatial reuse) antenna achieving broad azimuthal beam width to “cover” a prospective number of subscribers.	
M6	2.1	The standard SHALL specify MAC layer protocols and PHY transmission techniques suitable for providing access between one or more subscriber stations and base stations to support UNI and CNI requirements.	
M7	2.2	The 802.16.3 protocols SHALL support the optional deployment of repeater functions.	
M8	2.2	The repeater function SHALL NOT affect the MAC protocol other than the delay which the repeater might introduce into the system.	
M9	2.3	In the upstream direction, 802.16.3 protocols MUST provide the means to multiplex traffic from multiple subscriber stations, resolve contention, and allocate capacity.	
M10	3	The MAC and PHY protocols will not have explicit support for each and every service, due to the fact that generic data streams SHALL be used for transport.	
M11	3	The MAC and PHY protocols SHALL provide for QoS service specific support, resulting in appropriate BER for data services, limited delay for real time services, etc.	
M12	3.1	802.16.3 systems SHALL support voice communications for subscribers in a way that eases the migration of legacy voice communications equipment and public switched telephone network (PSTN) access technologies to 802.16.3 systems.	

#	Section	Requirement	Compliance
M13	3.1	The 802.16.3 voice access transport SHALL be packet based (as opposed to circuit-switched based).	
M14	3.2	The 802.16.3 system MUST directly transport variable-length IP datagrams efficiently.	
M15	3.2	Both IP versions 4 and 6 MUST be supported.	
M16	3.2	The 802.16.3 IP service MUST provide support for real-time and non-real-time service capabilities.	
M17	3.4	These services SHALL NOT place any additional requirements on 802.16.3 systems (MAC and PHY protocols) not already covered in the above sections.	
M18	4	The IEEE 802.16.3 MAC and PHY protocol stacks SHALL be the same for all the supported services.	
M19	4	Further details, and finalization of the protocol reference model, SHALL be worked out by the 802.16.3 MAC and PHY task groups while developing the air interface interoperability standard.	
M20	4	Since key layers above the MAC require service guarantees, the MAC protocol MUST define interfaces and procedures to provide guaranteed service to the upper layers.	
M21	4	Since customer units will contend for capacity to/from one or more base stations, the MAC protocol MUST efficiently resolve contention and resource allocation.	
M22	5.2	802.16.3 protocols SHALL be optimized to support the peak data rate in either or both directions to a subscriber station within the specified distance from the base station.	

#	Section	Requirement	Compliance
M23	5.4	The PHY and MAC protocols SHALL provide for multirate support.	
M24	5.6	The 802.16.3 specifications SHALL NOT preclude the ability of the radio link to be engineered for different link availabilities, based on the preference of the system operator.	
M25	5.6	802.16.3 MAC and PHY protocols MUST accommodate these conditions, perhaps consuming more radio bandwidth and/or requiring smaller radio propagation distance (radius) to meet the availability requirements.	
M26	5.6	Since statistical atmospheric and path conditions vary widely in geography, the 802.16.3 protocols MUST be flexible in consumed radio bandwidth (spectral efficiency), cell radius, and transmit power.	
M27	5.7	The error rate, after application of the appropriate error correction mechanism (e.g., FEC), delivered by the PHY layer to the MAC layer SHALL meet IEEE 802 functional requirements with the following exception: the radio link bit error ratio (BER) SHALL be $10E^{-6}$ (in accordance with ITU FWA recommendations or better.	
M28	5.9	The standard SHALL support careful planning to ensure that subscribers' quality of service guarantees and minimum error rates are met.	
M29	5.9	The delivered base station capacity can vary depending on attenuation due to atmospheric conditions, LOS blockage, transmit power, etc., and SHALL be calculated as the aggregate capacity of all sectors supported by a base station.	

#	Section	Requirement	Compliance
M30	5.9	The MAC and PHY protocols MUST accommodate channel capacity issues and changes in channel capacity to meet contracted service levels with customers.	
M31	5.9	As subscribers are added to 802.16.3 systems, the protocols MUST accommodate them in an automated fashion.	
M32	6.1	This standard SHALL permit two duplex modes of operation: Frequency Division Duplex (FDD) and Time Division Duplex (TDD).	
M33	6.1	The PHY and MAC protocols MUST provide for duplex (i.e. bi-directional) operation, while preserving the QoS, BER and spectral efficiency requirements for data and voice traffic.	
M34	6.1	The MAC and PHY protocols MUST provide means to resolve applicable collocation and interference problems.	
M35	6.2	The MAC and PHY protocols MUST permit the operation with channel spacing of 1.75, 3.5 and 7MHz when using ETSI masks and 1.5 to 25MHz when using other masks.	
M36	7	The FRD provides a summary of the QoS requirements that the PHY and MAC SHALL provide.	
M37	7	802.16.3 protocols MUST support classes of service (CoS) with various quality of service (QoS) guarantees to support the services that an 802.16.3 system MUST transport.	
M38	7	Thus, 802.16.3 protocol standards MUST define interfaces and procedures that accommodate the needs of the services with respect to allocation and prioritization of resources.	

#	Section	Requirement	Compliance
M39	7	802.16.3 protocols MUST provide the means to enforce QoS contracts and Service Level Agreements.	
M40	7	For QoS-based, connectionless services, the 802.16.3 protocols MUST support resource negotiation “on-demand”.	
M41	7	If 802.16.3 is to be a “link” in the IP network, an IWF MUST interface with 802.16.3 to negotiate resource allocation.	
M42	7.2	802.16.3 protocols SHALL define a set of parameters that preserve the intent of QoS parameters for IP-based services.	
M43	7.3	The classes of service and QoS parameters of services SHALL be translated into a common set of parameters defined by 802.16.3.	
M44	8.1	The 802.16.3 protocols MUST permit operators to enforce service level agreements (SLAs) with subscribers by restricting access to the air link, discarding data, dynamically controlling bandwidth available to a user or other appropriate means.	
M45	8.1	The 802.16.3 protocols MUST also permit subscribers to monitor performance service levels of the 802.16.3 services being provided at the delivery point.	
M46	8.2	When such capabilities are available, the 802.16.3 protocols SHALL support a secure function.	
M47	8.2	The operator MUST have means to shut down and reactivate a subscriber station if necessary, remote from the subscriber station, in the face of a malfunction.8.2	

#	Section	Requirement	Compliance
M48	8.3	The 802.16.3 system management framework, architecture, protocols and managed objects MUST allow for operators to effectively administer accounting and auditing.	
M49	8.3	An operator MUST be able to account for resource utilization and various service features for each subscriber service separately.	
M50	9	The 802.16.3 system SHALL enforce security procedures described in this section.	
M51	9	The security system chosen by 802.16.3 SHALL be added to the protocol stack and reference points to include security protocols, and “database” servers for authentication, authorization, key management, service suspend/resume, relocation, anti-cloning, etc.	
M52	9.1	There are two types of authentication for an 802.16.3 system. In the first type, a subscriber station MUST authenticate itself with the network every time it registers with the network. This authentication MUST prevent unauthorized subscriber station from entering the network or an unauthorized base station from emulating an authorized base station. This type of authentication MUST be supported by the 802.16.3 MAC layer.	
M53	9.1	The authentication mechanisms MUST be secure so that an “enemy” subscriber station is not able to gain access to an 802.16.3 system, or to the core network beyond.	
M54	9.1	Passwords and secrets MUST NOT be passed “in the clear” through the air interface.	
M55	9.2	The 802.16.3 standard SHALL identify a standard set of credentials and allow for vendors to extend the defined credentials with non-standard credentials.	
M56	9.2	For each service offered, the 802.16.3 protocols MUST be capable of securely supporting authorization requests and responses.	

A.2 Recommended (R)

It is recommended that the 802.16.3 standard support or specify the items in Table 3 Recommended means that there may exist valid reasons in particular circumstances to ignore an item, but the full implications should be understood and the case carefully weighed before choosing a different course.

Table 2: Recommended Requirements

#	Section	Requirement	Compliance
R1	1.1	Other goals of this document are to formulate reference models and terminology for both network topology and protocol stacks that help the 802.16 working group to discuss and develop the MAC and PHY protocols. As far as possible, these SHOULD be common across 802.16 systems.	
R2	2.2	The repeater function SHOULD NOT affect the end-to-end operation of 802.16.3 protocols between BS and SS.	
R3	3.2	For efficient transport of IPv6, TCP/IP header compression over the air interface SHOULD be supported.	
R4	3.2	It SHOULD be possible to support the emerging IP Quality of Service (QoS) efforts: Differentiated Services and Integrated Services.	
R5	3.3	The 802.16.3 protocols SHOULD support bridged LAN service capabilities, whether directly or indirectly, including always on, ad hoc and on-demand communication in either or both directions.	
R6	4	Note that the function of the MAC protocols SHOULD include error correction by retransmission, or Automatic Repeat Request (ARQ), whereas, in the 802 model, those functions if necessary, are provided by the LLC layer.	

#	Section	Requirement	Compliance
R7	5.1	The 802.16.3 protocols SHOULD allow for different “scales” of capacity and performance for 802.16.3 system instances.	
R8	5.2	The 802.16.3 MAC protocol SHOULD allow the peak data rate to scale beyond 10 Mbps.	
R9	5.3	The PHY and MAC protocol SHOULD provide for far CPEs’ propagation delay compensation.	
R10	5.5	802.16.3 protocols SHOULD allow for flexibility between delivered upstream and downstream capacity and CoS/QoS.	
R11	5.6	An 802.16.3 system SHOULD be available to transport all services at better than their required maximum error rates (see section ….) from about 99.9 to 99.99% of the time, assuming that the system and radios receive adequate mains power 100% of the time and not counting equipment availability.	
R12	5.6	802.16.3 MAC and PHY protocols SHOULD specify functions and procedures to adjust transmitter power, modulation, or other parameters to accommodate rapid changes in channel characteristics.	
R13	5.9	Given the propagation characteristics in a given frequency band and geographic area, and the development of a link budget, the following parameters of an 802.16.3 system SHOULD be addressed by the MAC and PHY protocols: • Radio range (up to 50 Km) • Upstream/downstream channels’ data rates • Allocation of prospective subscriber data rate to channels. Note: the MAC and PHY standards MAY allow subscribers to hop between channels • Types of modulation	

#	Section	Requirement	Compliance
R14	6.2	The typical value [channel spacing] for performance analysis SHOULD be 3.5MHz for the ETSI mask and 3MHz for the MDS mask.	
R15	7.3	802.16.3 protocols SHOULD include a mechanism that can support dynamically-variable-bandwidth channels and paths (such as those defined for IP environments).	
R16	8	The 802 standards define a framework for LAN/MAN management in ISO/IEC 15802-2: 1995(E). The framework contains guidelines for managed objects, management protocol, and the relationship to ITU management protocols. 802.16.3 protocols SHOULD comply with the above-mentioned standards and guidelines.	
R17	8.2	The operator also SHOULD have the means to securely shut down and reactivate a base station remotely.	
R18	8.2	The 802.16.3 protocols SHOULD support functions that automatically shuts down transmission from a subscriber station or base station in case of malfunction (e.g., power limits exceeded).	
R19	9.3	802.16.3 standards SHOULD allow a suitable cryptographic algorithm to be employed that is internationally applicable.	
R20	9.3	Facilities SHOULD also be defined in the protocol for the use of alternate cryptographic algorithms that can be used in certain localities and that can replace algorithms as they are obsoleted or “legalized” for international use.	
R21	10	802.16.3 SHOULD strive to fit into the 802 system model.	

A.3 Optional (O)

It is optional that the 802.16.3 standard support or specify the items in Table 4.

Table 3: Optional Requirements

#	Section	Requirement	Compliance
O1	2.1	The model depicts the relevant points between subscriber networks and “core” networks (the networks that MAY be accessed via 802.16.3 air interface).	
O2	2.1	A single SS MAY support multiple customer premises networks that transport data, voice and video through one or more UNIs.	
O3	2.1	Base stations MAY support multiple core networks through one or more CNIs.	
O4	5.9	The MAC and PHY standards MAY allow subscribers to hop between channels.	
O5	5.9	Flexible modulation types, power level adjustment, and bandwidth reservation schemes MAY be employed [which affect how the MAC and PHY protocols meet contracted service levels with customers].	
O6	7	[To support on-demand resource allocation,] The MAC protocol MAY allocate bursts of PDUs to services that require changes in resource allocation.	
O7	7	The 802.16.3 MAC layer interface MAY provide a connection-less service interface that requires a higher-layer “adaptation” to maintain the “state” of a connection and periodically allocate resources.	
O8	9.1	The second type of authentication is between the subscriber and the BWA system. This may or may not be the responsibility of the 802.16.3 protocols. It MAY be handled by higher layer protocols.	

B Initial Coverage

A Service Provider must establish initial coverage using as few base station sites as possible in order to minimize initial build-out cost and time-to-market. The key characteristics which determine how many base stations are needed to initially cover a target market are the link budget and fade margin assumptions used for RF planning and installation purposes. The capacity of the minimum cost base station configurations will then determine what subscriber penetration can occur before incremental costs and/or additional base-station sites must be deployed. For each potential frequency band listed below, state the proposed link budget, installation margin and initial capacity of a single cell base station. Separately describe the deployment assumptions used to support these statements.

Licensed Allocation	Block Structure Structure	Example	Link Budget Down / Up	InstlIn. Margins Down / Up	Initial Capacity Down / Up
5 MHz	contiguous	USA WCS C or D			
6 MHz	contiguous	USA UHF, MDS			
7 MHz	contiguous	????			
	3.5 + 3.5	ETSI			
10 MHz	contiguous	????			
	5 + 5 PCS	USA, CITEL			
	5 + 5 WCS- A	USA			
	5 + 5 WCS-Other	USA			
	5 + 5 General	USA			
12 MHz	contiguous	USA UHF, MDS			
	6 + 6	USA UHF, MDS			
12.5 MHz	contiguous	USA 3650			
	6.25 + 6.25	USA 3650			
14 MHz	contiguous	????			
	7 + 7	ETSI			
18 MHz	contiguous	USA UHF, MDS			
	6 + 12	USA UHF, MDS			
20 MHz	contiguous	????			
	10 + 10	USA WCS, PCS			
	5 + 15	USA WCS			
24 MHz	contiguous	USA UHF, MDS			
	6 + 18	USA MDS			
	12 + 12	USA MDS			
25 MHz	contiguous	USA 3650 , CITEL			
	12.5 + 12.5	USA 3650			
	10 + 15	???			
28 MHz	contiguous	???			
	14 + 14	ETSI			
30 MHz	contiguous	USA MDS			
	15 + 15	USA PCS			
	18 + 12	USA MDS			
36 MHz	contiguous	USA MDS			
	18 + 18	USA MDS			
48 MHz	contiguous	USA MDS			
	24 + 24	USA MDS			
	18 + 30	USA MDS			
50 MHz	contiguous	USA 3650			
	25 + 25	USA 3650, CITEL			

C Maximum Capacity – Single Cell

A Service Provider must increase the capacity of the initial base-station(s) to accommodate growth in the number of subscribers and the increases in traffic demand from subscribers over time. For each potential frequency band listed below, state the maximum capacity of a single cell base station, re-using the same deployment assumptions as in (B) above. Explain the scalability / modularity steps between the initial and maximum capacity limits.

Licensed Allocation	Block Structure Structure	Example	Maximum Capacity	
			Down	Up
5 MHz	contiguous	USA WCS C or D		
6 MHz	contiguous	USA UHF, MDS		
7 MHz	contiguous	????		
	3.5 + 3.5	ETSI		
10 MHz	contiguous	????		
	5 + 5 PCS	USA, CITEL		
	5 + 5 WCS- A	USA		
	5 + 5 WCS-Other	USA		
	5 + 5 General	USA		
12 MHz	contiguous	USA UHF, MDS		
	6 + 6	USA UHF, MDS		
12.5 MHz	contiguous	USA 3650		
	6.25 + 6.25	USA 3650		
14 MHz	contiguous	????		
	7 + 7	ETSI		
18 MHz	contiguous	USA UHF, MDS		
	6 + 12	USA UHF, MDS		
20 MHz	contiguous	????		
	10 + 10	USA WCS, PCS		
	5 + 15	USA WCS		
24 MHz	contiguous	USA UHF, MDS		
	6 + 18	USA MDS		
	12 + 12	USA MDS		
25 MHz	contiguous	USA 3650 , CITEL		
	12.5 + 12.5	USA 3650		
	10 + 15	???		
28 MHz	contiguous	???		
	14 + 14	ETSI		
30 MHz	contiguous	USA MDS		
	15 + 15	USA PCS		
	18 + 12	USA MDS		
36 MHz	contiguous	USA MDS		
	18 + 18	USA MDS		
48 MHz	contiguous	USA MDS		
	24 + 24	USA MDS		
	18 + 30	USA MDS		
50 MHz	contiguous	USA 3650		
	25 + 25	USA 3650, CITEL		

D Maximum Capacity – Multi-Cell

A Service Provider must increase the number of base station sites to extend the coverage and/or capacity of the deployed network. For each potential frequency band listed below, state the maximum capacity of a multi-cell base station. State the frequency re-use assumptions used.

Licensed Allocation	Block Structure Structure	Example	Maximum Capacity		Frequency Reuse
			Down	Up	
5 MHz	contiguous	USA WCS C or D			
6 MHz	contiguous	USA UHF, MDS			
7 MHz	contiguous	????			
	3.5 + 3.5	ETSI			
10 MHz	contiguous	????			
	5 + 5 PCS	USA, CITEL			
	5 + 5 WCS- A	USA			
	5 + 5 WCS-Other	USA			
	5 + 5 General	USA			
12 MHz	contiguous	USA UHF, MDS			
	6 + 6	USA UHF, MDS			
12.5 MHz	contiguous	USA 3650			
	6.25 + 6.25	USA 3650			
14 MHz	contiguous	????			
	7 + 7	ETSI			
18 MHz	contiguous	USA UHF, MDS			
	6 + 12	USA UHF, MDS			
20 MHz	contiguous	????			
	10 + 10	USA WCS, PCS			
	5 + 15	USA WCS			
24 MHz	contiguous	USA UHF, MDS			
	6 + 18	USA MDS			
	12 + 12	USA MDS			
25 MHz	contiguous	USA 3650 , CITEL			
	12.5 + 12.5	USA 3650			
	10 + 15	???			
28 MHz	contiguous	???			
	14 + 14	ETSI			
30 MHz	contiguous	USA MDS			
	15 + 15	USA PCS			
	18 + 12	USA MDS			
36 MHz	contiguous	USA MDS			
	18 + 18	USA MDS			
48 MHz	contiguous	USA MDS			
	24 + 24	USA MDS			
	18 + 30	USA MDS			
50 MHz	contiguous	USA 3650			
	25 + 25	USA 3650, CITEL			

E Installation Predictability

A Service Provider needs to reliably predict the feasibility of providing the desired service at the customer location, given only the candidate base station location(s), the customer location and an appropriate propagation / coverage prediction tool. The Installation Margin quoted in (B) above assures link availability / reliability after an installation is completed. State the additional Margins needed to assure :

a) 90, 80 and 70 percent coverage (shadow margin) assuming professional (outdoor) installation at the customer location with standard antenna height and alignment

b) 90, 80 and 70 percent coverage (shadow margin) assuming non-professional (outdoor) installation at the customer location with standard antenna height and alignment

c) 90, 80 and 70 percent coverage (shadow margin) assuming professional (indoor) installation at the customer location

d) 90,80 and 70 percent coverage (shadow margin) assuming non-professional (indoor) installation at the customer location.

F Regulatory Compliance and Co-existence Criteria

State the level of compliance, or any known issues, related to the following Regulatory and Licensing Requirements.

Authority	Requirement	Compliance
USA (FCC)		
UHF	Part 27 (proposed) – TV/PSA Protection	
WCS-A	Part 27 - limited emissions (DARS protection)	
WCS - Other	Part 27	
Cellular & PCS	Parts 22 and 24	
MDS	Part 21 – ITFS and PSA protection	
3650	Part 27 (proposed)	
4900	Part 27 (proposed)	
Canada		
UHF	??	
PCS	??	
MMCS	??	
3400 - 3600	??	
3600 - 3700	??	
CITEL		
PCS	??	
3400 - 3700	??	
AUSTRALIA		
???	??	
3400 - 3700	??	
NEW ZEALAND		
???	??	
3400 - 3700	??	
ETSI 3400-4200	EN 301 021:P-MP systems,with TDMA access method.	
	EN 301 080:FDMA	
	EN 301 124:DS-CDMA	
	EN 301 253:FH-CDMA	
	EN 301 085:Antenna standard	
	DEN/TM-04080:Draft standard in progress for DS-CD/TDMA	
	EN 301 126-2:Conformance test for P-MP systems	
	EN 301-126-3:Conformance tests for antennas in that band.	