Welcome

8:30 – 8:45	Welcome	Dr. Freebersyser
8:45 – 9:30	MNM Brief	Dr. Freebersyser
9:30 – 10:15	Intelligent RF Front Ends	Edgar Martinez
10:15 – 10:30	Break	
10:30 – 11:15	Spectrum Supremacy Field Measurements	Joe Mitola
11:15 – 12:00	Go/No-Go Demonstration Description	Tim Krout
12:00 – 12:45	LUNCH	
12:45 – 13:15	Go/No-Go Field Test Tools	Ed Althouse
13:15 – 13:45	OLSR MANET Routing Protocol	Ed Althouse
13:45 – 14:00	Discussion, Action Items, Wrap-Up, etc.	

14:20 - ??	Scheduled One on One Meetings with Dr Freebersyser

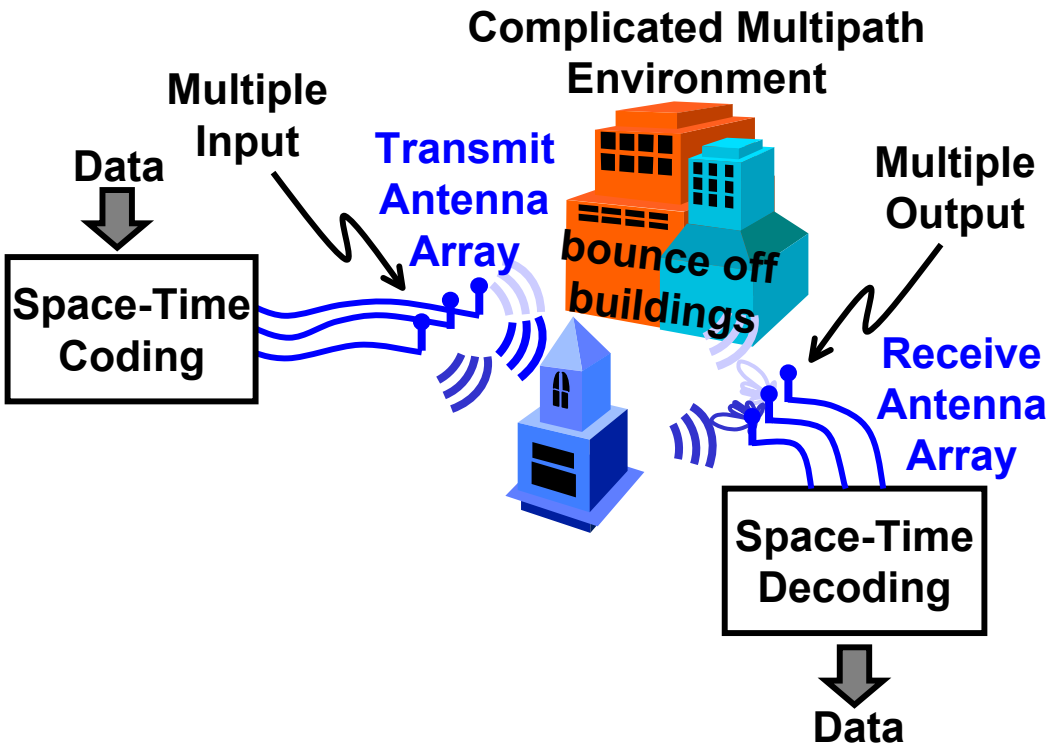
Mobile Network MIMO = MNM

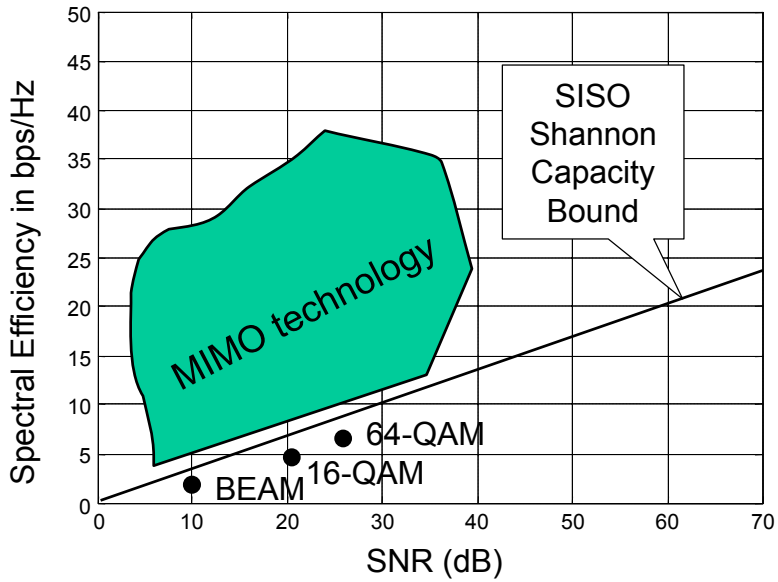
MNM Bidder's Meeting – 25 June 03

Dr. James A. Freebersyser – DARPA/ATO

Mobile Networked MIMO

Multiple-Input, Multiple-Output (MIMO) communication systems have the potential for a 10-20x improvement in channel capacities in the spectrum limited JTRS bands under dynamic urban NLOS multipath channel conditions where conventional SISO techniques degrade

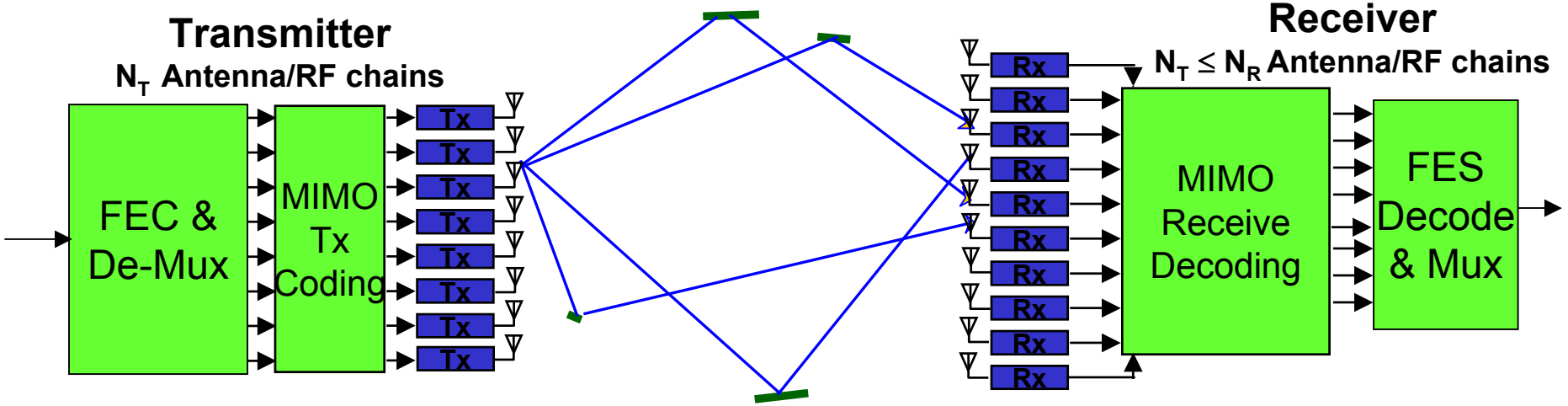




Significantly Improved Data Rates in Urban Settings

MIMO Concept

- MIMO uses multipath to create parallel channels in the same band
  - Each transmit antenna transmits a unique (non-orthogonal) data stream
  - Multipath scattering decorrelates the transmitted signals creating multiple, independent channels effectively increasing system capacity
    - Rather than just mitigating the multipath interference (e.g. Rake filtering)
    - MIMO reverts to beamforming in the absence of multipath
  - Channel training is used by the receiver to separate/decode the data streams

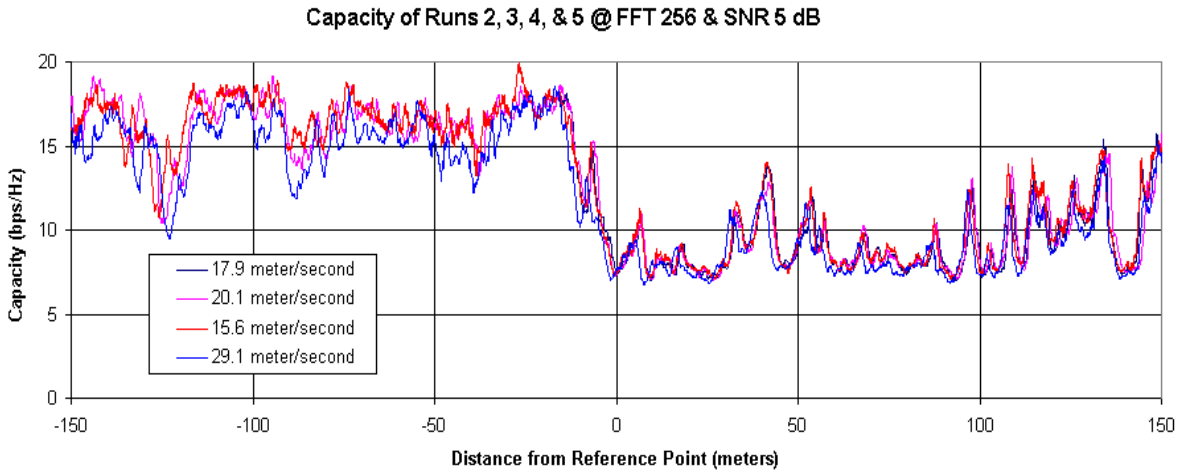


Total Power (P_o / N_T) and bit rate R_b is held constant on each channel

Data Rate $\approx N_T x R_b$ - Capacity Increases Linearly with N_T!

Point-Point MIMO Field Experiments

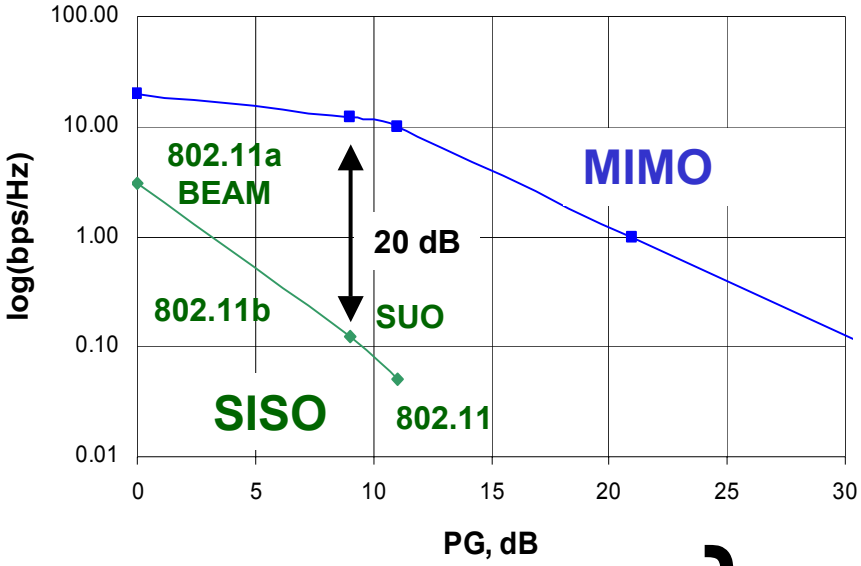
- Fixed-fixed suburban (Lucent - DARPA NGI)
  - 900 kbps in 50 KHz (OFDM) (~18 bps/Hz)
- Fixed-mobile rural foliated (Lucent - DARPA FCS-C)
  - Achieved channel capacities of 10-20 bps/Hz ground-ground and air-ground



MIMO Is Relevant to the Tactical Military Environment

Adapting MIMO for Military Use

- MIMO can achieve simultaneous high data rates, LPD, and A/J
  - High data rates via high bps/Hz
  - AJ and LPD properties via DS
    - With sufficient PG, jammers are effectively tuned out in channel training
    - Intercepting/exploiting MIMO is extremely difficult since the Tx and Rx train for a unique multipath channel unavailable to an eavesdropper



- Challenges remain
  - Increasing channel training update rates to handle high mobility rates without degrading network goodput — Phase 1
  - Cost of multiple, broadband RF transmit/receive chains — Phase 2
  - Computationally intense MIMO signal processing — Phase 2

DARPA Hard Challenge – Mobile AND Networked MIMO

DARPA Hard Challenges: Mobile AND Networked MIMO

MIMO and MANET development must come together at the MAC

Point-to-Point Link	Mobile Ad Hoc Network
Fixed-Fixed MIMO (FDD)	Omni MANET
Fixed-Mobile MIMO (FDD)	Directional MANET

MIMO MANET

Phase 1 Approach

Goal: Validate MNM concept with 20 mobile node Lakehurst demo (6/04)

- COTS antenna and RF hardware
- MIMO signal processing algorithms and hardware implementing at least a 4x4 system
- MAC supportive of MIMO PHY layer
  - E.g. channel training feedback, if used
- NRL OLSR for MANET protocol will be GFE'd
  - Already proven at Lakehurst in FCS-C baseline test
  - Allows performers to concentrate on MAC/PHY development
  - Gives the government better visibility into MAC/PHY performance
- Platform integration
- Field demonstration to Go/No-Go metrics

Demonstrate the 1st MIMO-Based Mobile Ad Hoc Network!

Phase 2 Approach

Goal: Demonstrate a form factored spectrally agile MNM (12/05)

- Low cost, broadband, (0.3-3.0 GHz) antennas and RF front ends with small (operational) form factors and high (linear) dynamic range able to adapt carrier frequency and bandwidth
  - Leverage MTO/Intelligent RF Front-End (IRFFE) Program (later brief)
- Computationally efficient MIMO signal processing implementing at least a 4x4 system that adapts to varying multipath and antenna wavelength spacing due to frequency agility
  - Utilize spectrally agile waveforms (e.g. OFDM) for non-contiguous spectrum
- MAC & Networking protocols that exploit the MIMO physical layer for multipoint delivery and multipath routing
- Multipath propagation models of low computational complexity and high fidelity
- Platform integration
- Field demonstration to Go/No-Go metrics

Demo 20 Mobile Nodes in an Urban Setting; Single Board MAC/PHY

MNM Go/No-Go Metrics

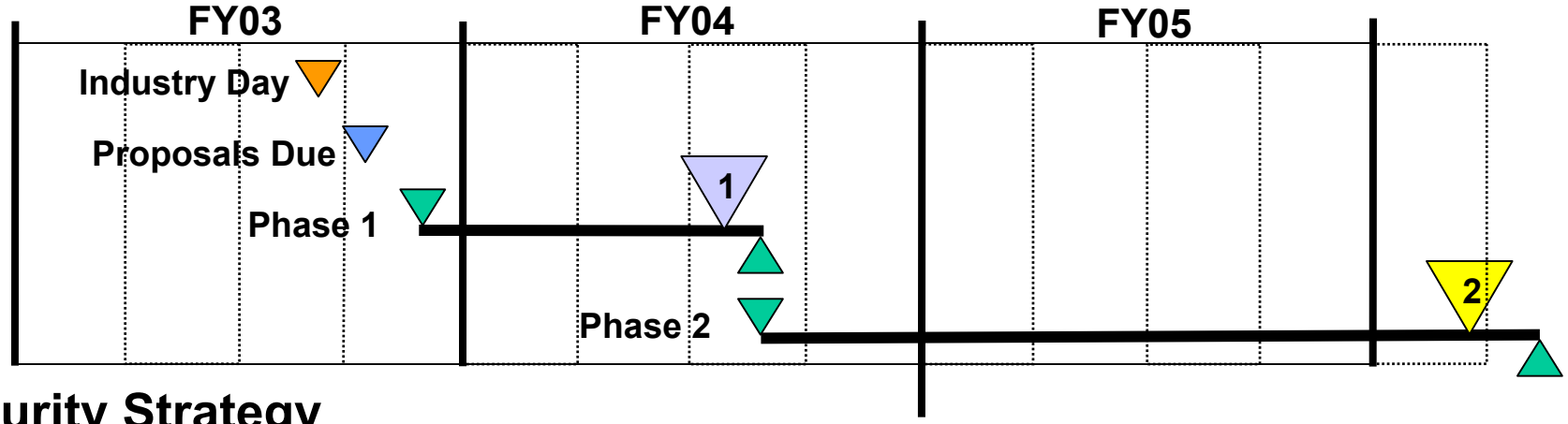
Go/No-Go Metrics	FCS-C Demo 1 Go / No-Go Criteria (Threshold)	MNM Demo 1 Go / No-Go Criteria (Threshold)	MNM Demo 2 Go / No-Go Criteria (Objective)
20 Node Average Network Aggregate Throughput (Goodput)	1.0 Mbps	1 – 10 – 1000 Mbps	AJ/LPD 100 kbps HDR 2 Gbps
Spectral Occupancy	22 MHz (actual)	1 – 10 – 25 MHz	AJ/LPD 25 KHz HDR 25 MHz
LPD/AJ Processing (PG, nulling, etc.) per stream	11 dB (actual)	20 – 20 – 0 dB	40 dB 0 dB
Latency Type 1 (10% of the avg sys load) Type 2 (30% of the avg sys load) Type 3 (60% of the avg sys load) (Retransmit up to 3 times)	 N/A 90% < 2 sec N/A	 N/A 90% < 2 sec. N/A.	 90% < 200 msec. 90% < 1 sec. 90% < 30 sec.
Packet Delivery Type 1 (10% of the avg sys load) Type 2 (30% of the avg sys load) Type 3 (60% of the avg sys load) (Retransmit up to 3 times)	 N/A 80% N/A	 N/A 80% N/A	 90% 90% 90%
20 Node Network Initialization Time	<10 min.	<10 min.	<6 min.
Node Entry Time	<2 min.	<2 min.	<30 sec.
Detect Node Exit Time	<30 sec.	<30 sec.	<10 sec.

Low Latency QoS: Robotic Control and Call for Fire where latency and high reliability drives effectiveness and losses of data are not tolerable.
High Throughput QoS: Large sensor data sets such as MTI and SAR radar where latency is important and losses of data are tolerable because of the streaming nature of the traffic.
High Reliability QoS: File transfers for logistics and other administrative traffic where latency is not a driver but data loss is not tolerable.

Programmatics and Schedule

Acquisition Strategy

- Potentially multiple performers for Phase 1 and Phase 2
- Release BAA June 03 for Phase 1 Sept 03 start
- Phase 1 Go/No-Go Demo in June 04 at Lakehurst, NJ
- Release Phase 2 BAA Jan 04 for Phase 2 Sept 04 start
- Phase 2 Go/No-Go Demo in December 05 at a TBD location



Security Strategy

- Program to be unclassified except for government vulnerability assessment

Transition Strategy

- Target: Ground mobile platforms
- Process: MIMO Wideband Network Waveform (WNW)

Questions?