



A Simulation Testbed for Adaptive Modulation and Coding in Airborne Telemetry (Brief)

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**Tom Young
SET Executing Agent
412 TENG/ENI
(661) 277-1071
Email: tommy.young.1@us.af.mil**

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A Simulation Testbed for Adaptive Modulation and Coding in Airborne Telemetry

Enkuang “Daniel” Wang

Georgia Tech Research Institute
enkuang.wang@gtri.gatech.edu

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Energy and
Environment



Outline

- Objective
- Simulation Framework
 - Architecture
 - MATLAB GUI
 - Tunable Parameters
 - Channel Models
- Link-Dependent Adaptive Radio
- Simulation Results
- Conclusion and Future Work



Objectives

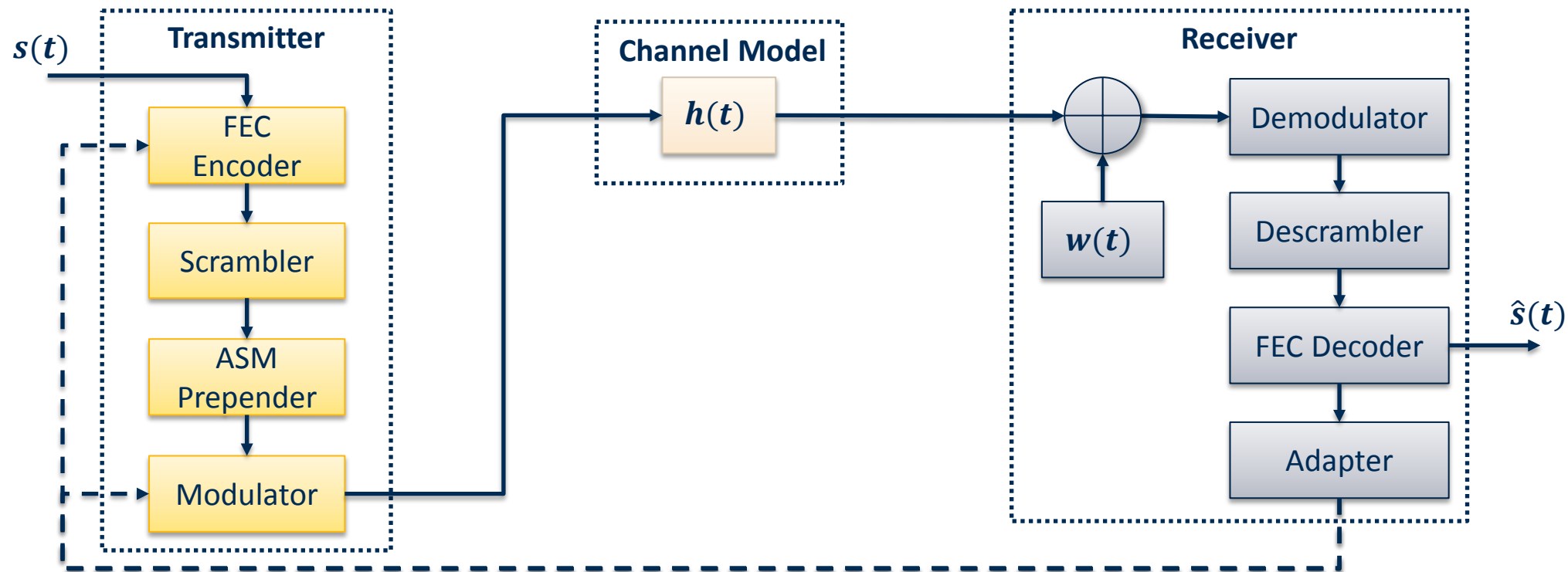
- **Simulation Testbed**

- Develop a simulation framework with adaptive input parameters
 - Apply to many research questions involving airborne telemetry applications

- **Link-Dependent Adaptive Radio**

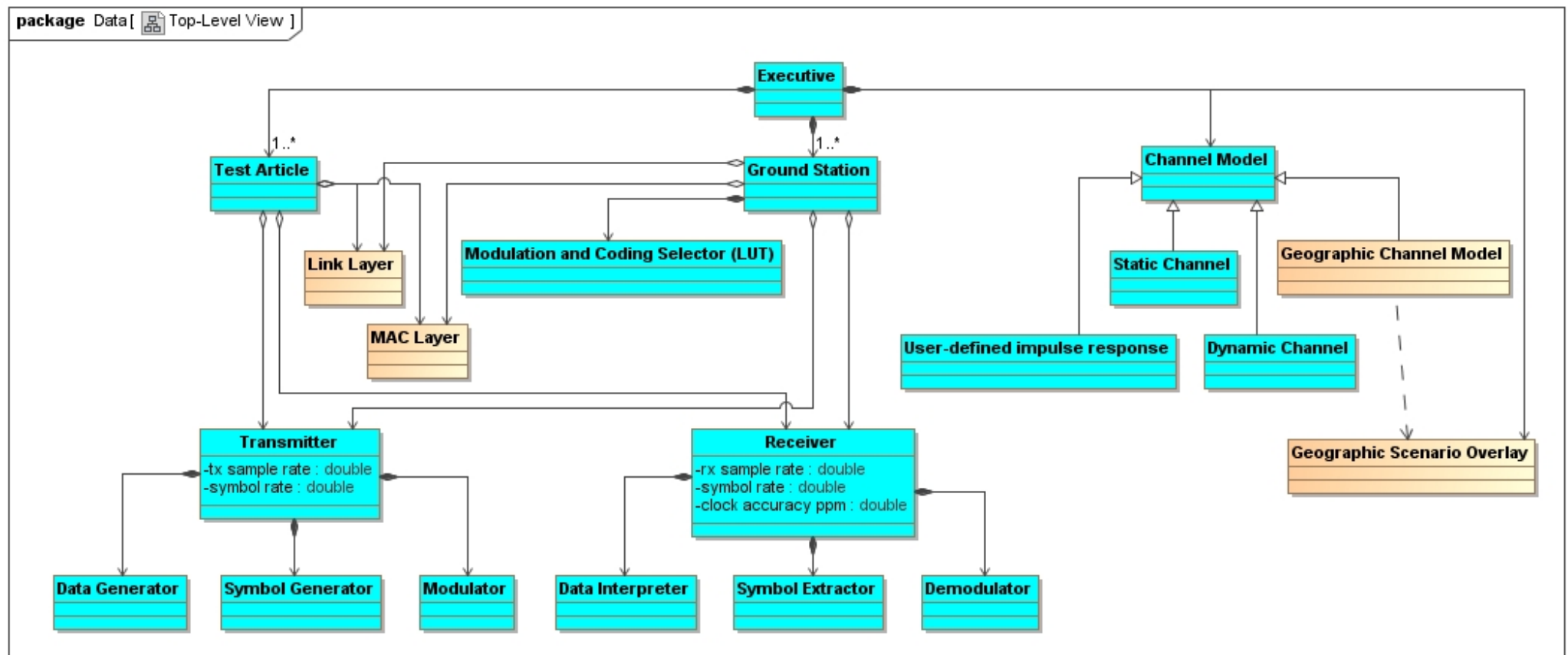
- Develop and test a prototype system that adapts its modulation/coding scheme based on channel conditions
 - Create a set of rules based on various channel models
 - Choose a transmission mode to maximize throughput while maintaining link reliability
 - Demonstrate adaptivity in simulation environment

System Model



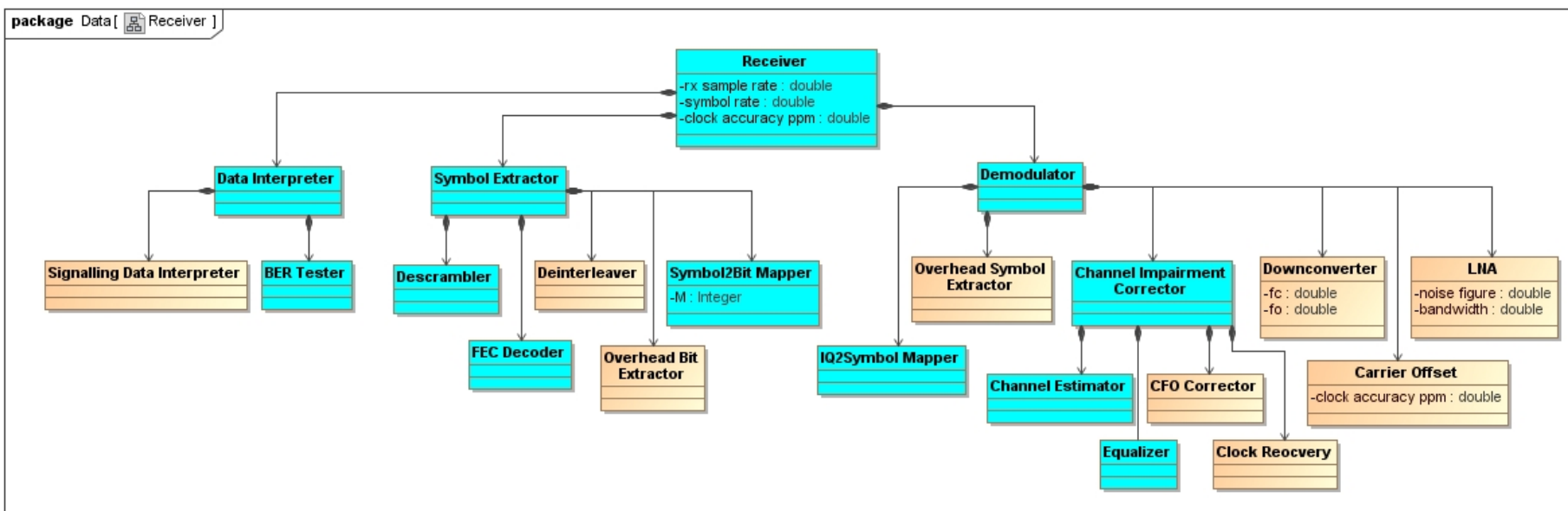
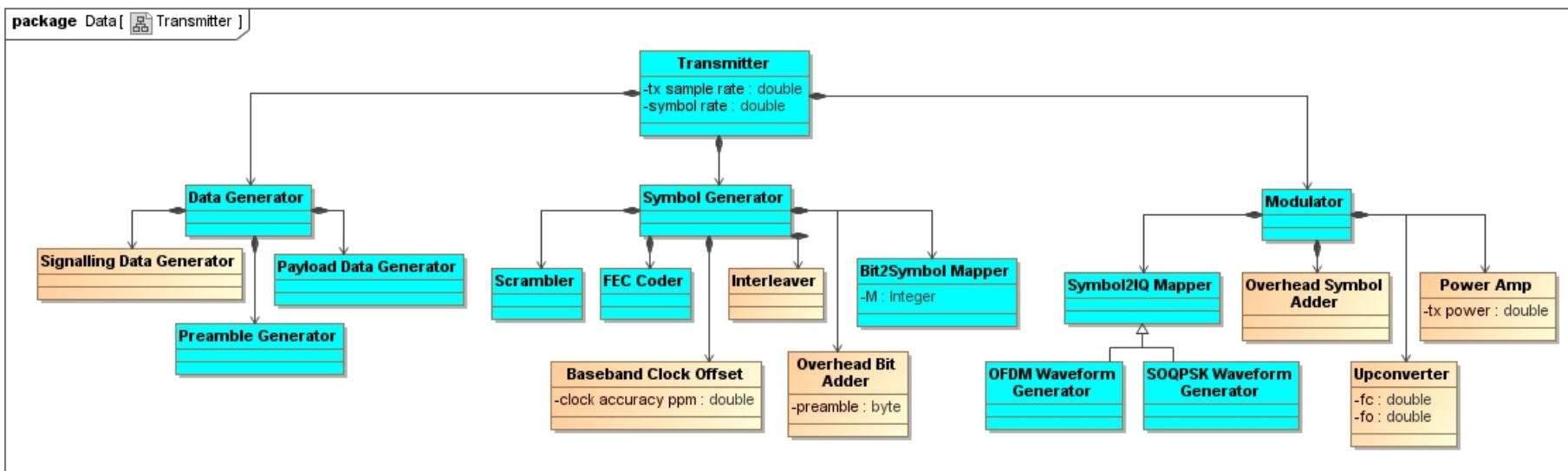
Simulation Framework Architecture

- Object-oriented MATLAB to maximize reusability and flexibility



Phase One

Phase Two



Phase One

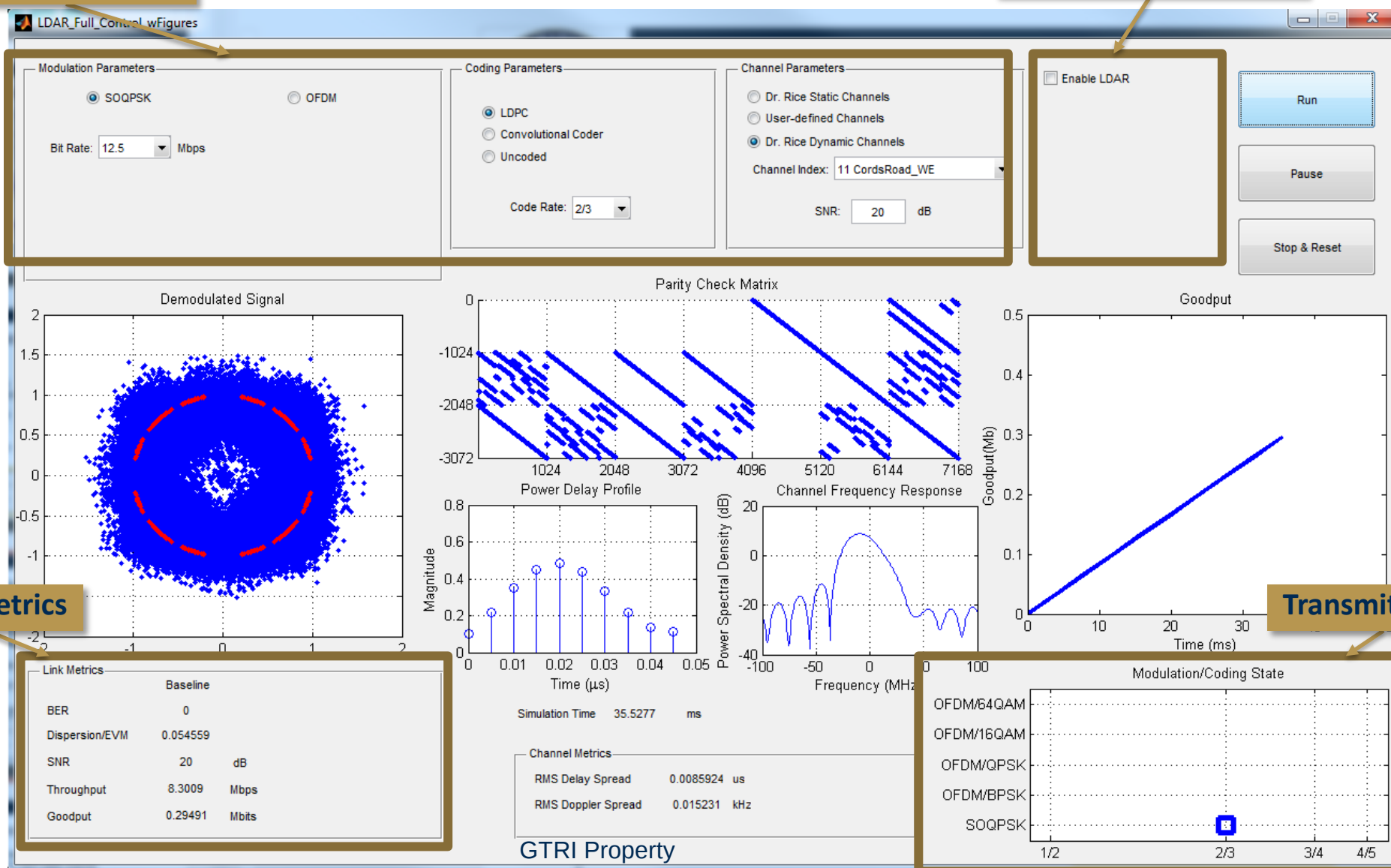
Phase Two



MATLAB GUI Interface

Input Parameters

Application Selection



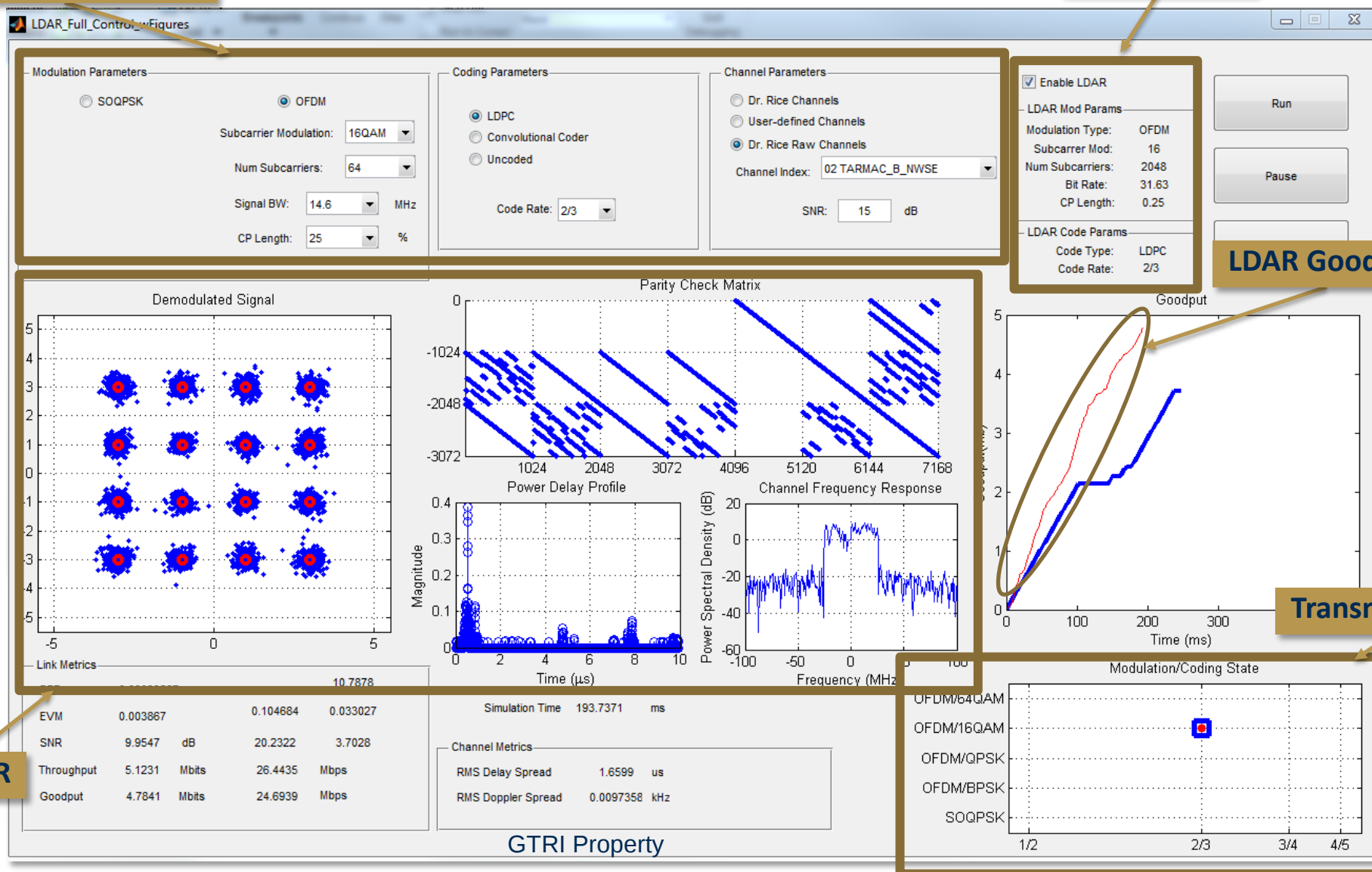
Link Metrics

Transmit Mode

MATLAB GUI Interface

Baseline Parameters

LDAR Values



LDAR

LDAR Goodput

Transmit Mode



Tunable Parameters

- Modulation
 - SOQPSK
 - OFDM (IEEE 802.11a)
 - Modulations: BPSK, QPSK, 16 QAM, 64 QAM
 - Cyclic Prefix Lengths
 - Number of Subcarriers
- Coding
 - LDPC
 - Rates: 1/2, 2/3, 3/4, 4/5

The screenshot displays the GTRI Property configuration window, which is divided into three main sections: Modulation Parameters, Coding Parameters, and Channel Parameters. The Modulation Parameters section is highlighted with a yellow border and shows the OFDM modulation selected, with subcarrier modulation set to BPSK, 64 subcarriers, a signal bandwidth of 14.6 MHz, and a cyclic prefix length of 10%. The Coding Parameters section shows LDPC coding selected with a code rate of 1/2. The Channel Parameters section shows Dr. Rice Channels selected, with a channel index of 1 and an SNR of 15 dB. There are also buttons for Run, Pause, and Stop & Reset, and a checkbox for Enable LDAR.

Section	Parameter	Value
Modulation Parameters	Modulation	OFDM
	Subcarrier Modulation	BPSK
	Num Subcarriers	64
	Signal BW	14.6 MHz
Modulation Parameters	CP Length	10 %
Coding Parameters	Coding	LDPC
	Code Rate	1/2
Channel Parameters	Channel	Dr. Rice Channels
	Channel Index	1
	SNR	15 dB
Enable LDAR		☐
Run		Run
Pause		Pause
Stop & Reset		Stop & Reset

GTRI Property



Channel Models

- Static
 - Representative channels from Dr. Michael Rice's collected data
- User-Defined
 - Arbitrary channel taps (mainly used for AWGN channel)
- Dynamic
 - Dr. Michael Rice's collected data from airborne channel sounding runs
 - We use these to reflect the dynamics of actual telemetry channels
- Tunable SNR

The screenshot displays the GTRI Property software interface, which is divided into three main sections: Modulation Parameters, Coding Parameters, and Channel Parameters. The Channel Parameters section is highlighted with a yellow border.

Modulation Parameters:

- SOQPSK (radio button)
- OFDM (radio button, selected)
- Subcarrier Modulation: BPSK (dropdown menu)
- Num Subcarriers: 64 (dropdown menu)
- Signal BW: 14.6 (dropdown menu) MHz
- CP Length: 10 (dropdown menu) %

Coding Parameters:

- LDPC (radio button, selected)
- Convolutional Coder (radio button)
- Uncoded (radio button)
- Code Rate: 1/2 (dropdown menu)

Channel Parameters:

- Dr. Rice Channels (radio button, selected)
- User-defined Channels (radio button)
- Dr. Rice Raw Channels (radio button)
- Channel Index: 1 (dropdown menu)
- SNR: 15 (text input) dB

Other Controls:

- Enable LDAR (checkbox)
- Run (button)
- Pause (button)
- Stop & Reset (button)
- GTRI Property (text label)



Link-Dependent Adaptive Radio

- Empirically-based rule developed by GTRI
 - Collect data for each static channel
 - Create look-up tables for each static channel
 - Include values of EVM, Dispersion, BER, Throughput for various SNRs
 - Select a near-optimal transmission mode based on throughput and channel impairments
 - RMS Delay Spread
 - Error Vector Magnitude (EVM) for OFDM or Dispersion for SOQPSK

LDAR Algorithm for Selecting New Transmission Mode

- 1: Compute the RMS delay spread of the current channel
- 2: Select a static channel that has the closest RMS delay spread as the representative channel
- 3: Look up the EVM/Dispersion value with the same transmission mode from the LUT of the representative channel
- 4: Select a mode with the highest throughput that has a BER lower than the threshold
- 5: Repeat Steps 1 to 4 for each delivered packet



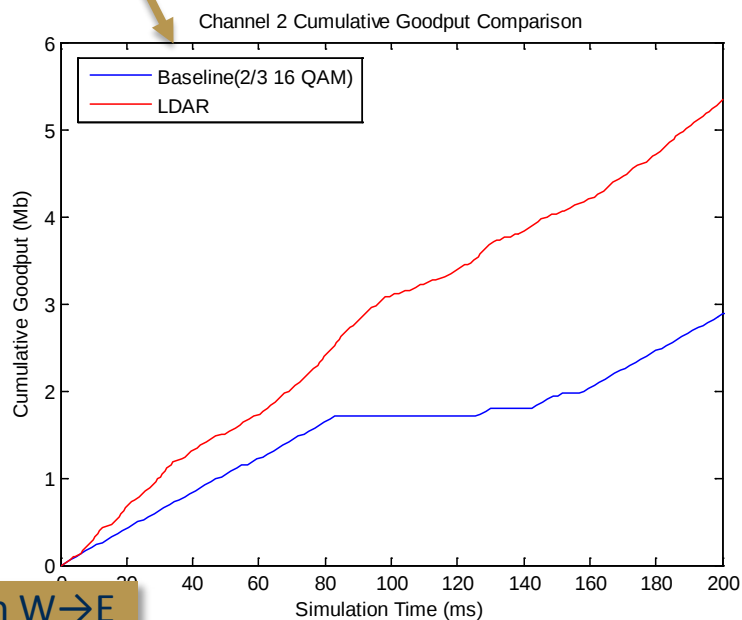
Simulation Results

- Compare goodput performances between a baseline scheme and LDAR scheme
 - Baseline: 2/3 16-QAM OFDM
 - Burst Size: eight codewords
 - Fixed SNR: 15 dB
 - 11 Dynamic Channel Models

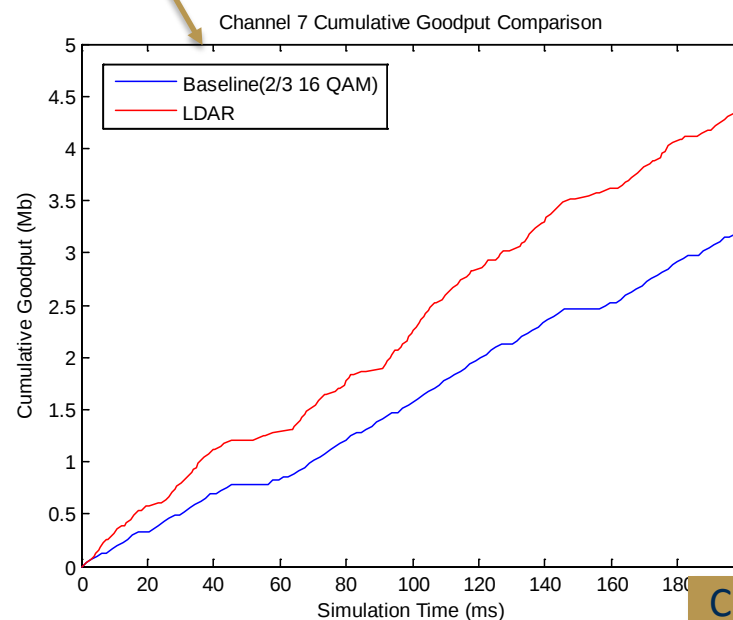
Dynamic Channel	Baseline Goodput (Mb)	LDAR Goodput (Mb)	Performance Increase (%)
1	4.0	5.2	30
2	2.9	5.3	83
3	0	4.2	N/A
4	2.0	4.4	120
5	4.0	8.2	105
6	0	8.1	N/A
7	3.3	4.4	33
8	0	3.7	N/A
9	3.3	5.2	58
10	4.0	8.8	120
11	4.0	8.4	110



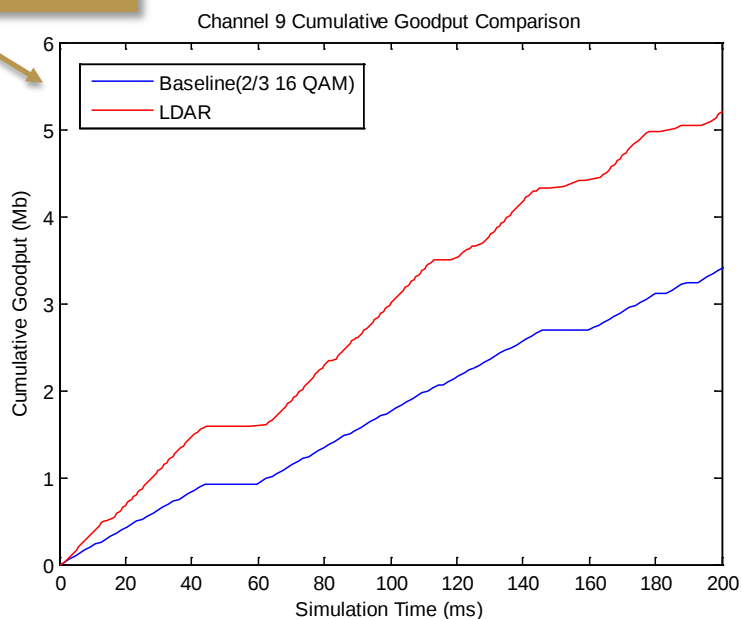
TARMAC



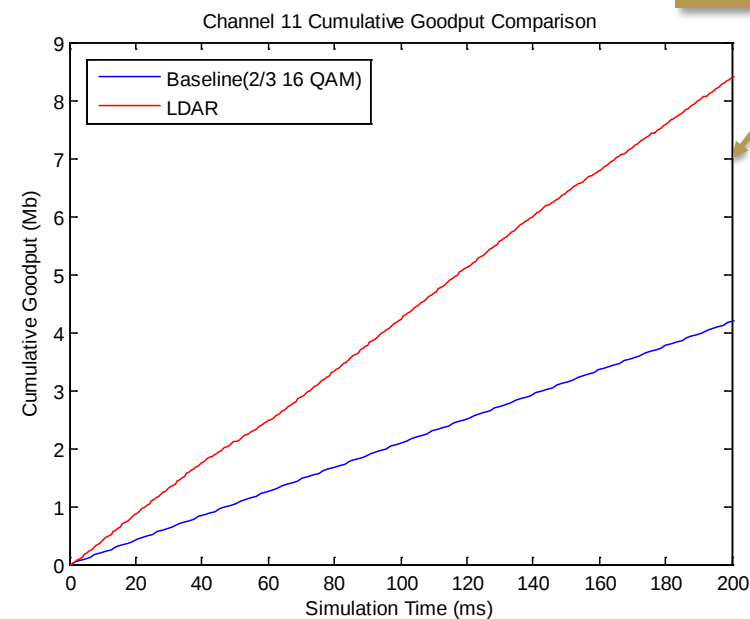
Cords Road E→W



Black Mountain W→E



Cords Road W→E





Conclusion and Future Work

- Developed a simulation testbed for aeronautical telemetry
 - Various Tunable Parameters
 - Example: Link-Dependent Adaptive Radio
 - Other Applications:
 - Tradeoffs of Phased Array Antennas
 - Utility of Multiple access schemes
 - Performance of Command and Control
- Future Work
 - Carrier Frequency Offset (CFO)
 - Doppler Shift
 - Convolutional/Turbo Encode
 - iNET Uplink
 - Mapping between EVM and Dispersion



Questions?

Daniel Wang

ewang9@gatech.edu

404-407-8781