BRASS Phase III Demonstration Workshop

SOUTHWEST RESEARCH INSTITUTE®

Austin Whittington – SwRI

VANDERBILT UNIVERSITY

ADVANCED SCIENCE. APPLIED TECHNOLOGY.

swri.org

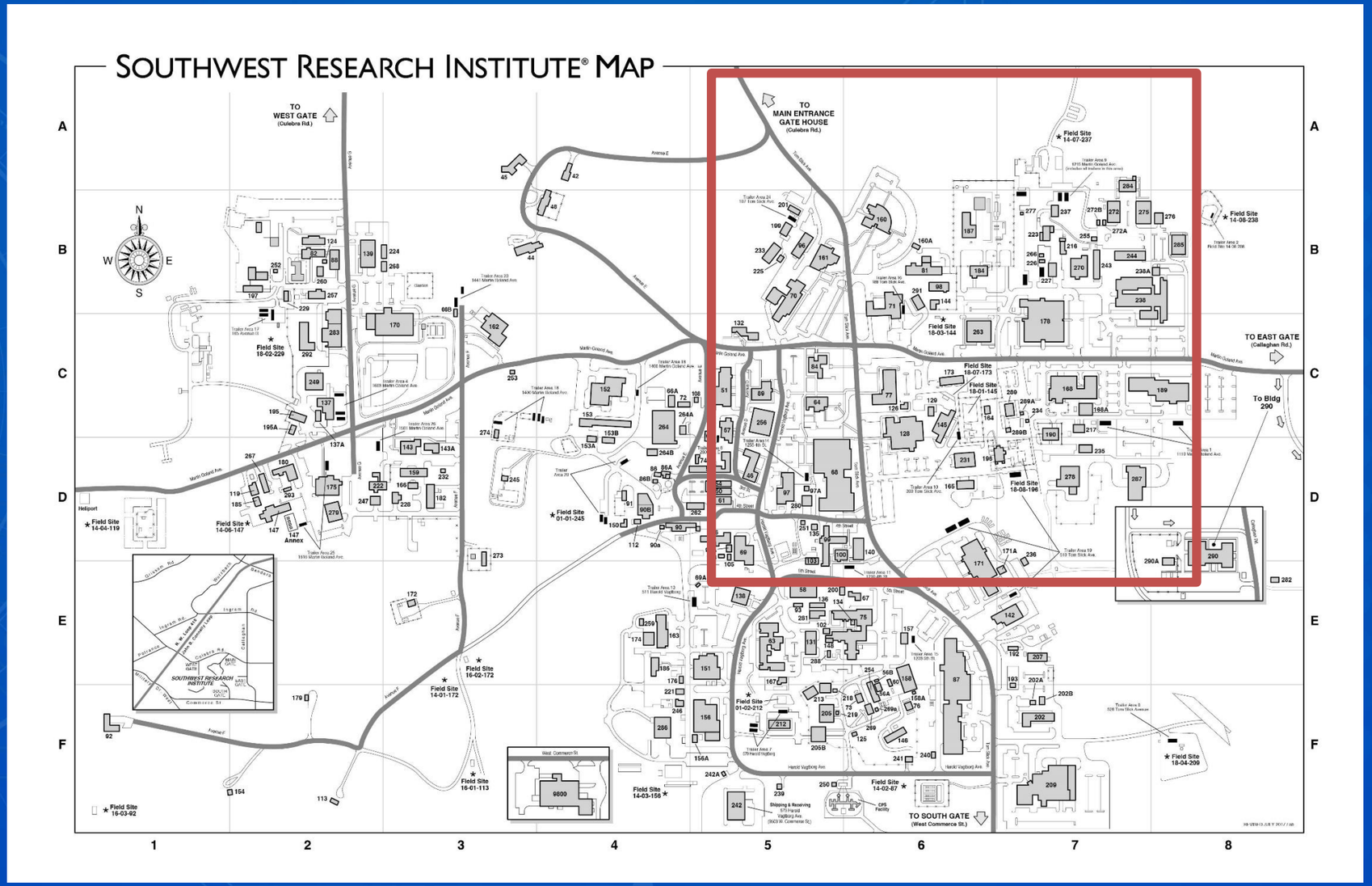
Security Orientation

- Wear your visitor badge at all times
  - Visible above the waist
- Stay in conference areas – don't wander off into other areas
- No photography allowed without SwRI approval
  - Unauthorized photography requires Security notification, review & reporting

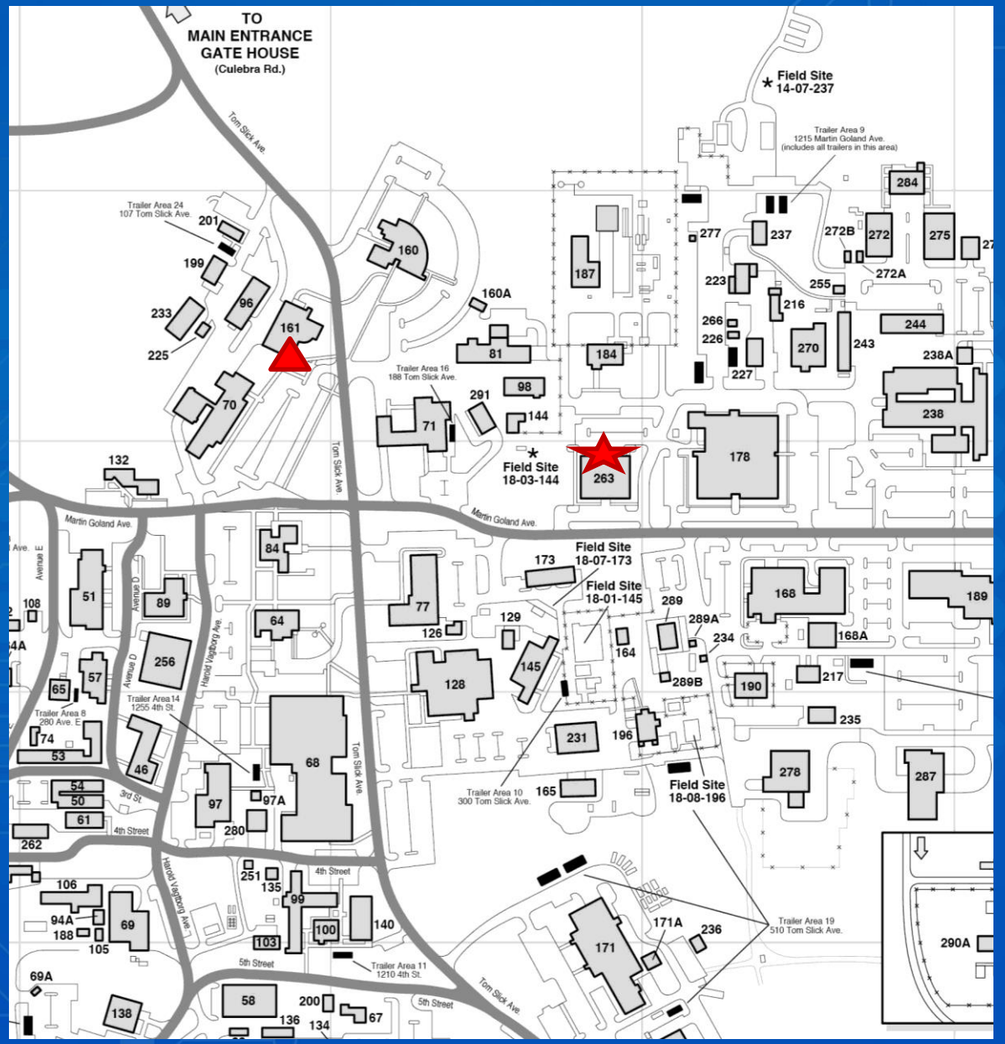
Building Info

- Bathrooms – In hallway next to conference room
- Lunch – on your own
  - Cafeteria has a room reserved for BRASS attendees
- Poster session – in front foyer
  - Overflow in meeting room

SwRI Map

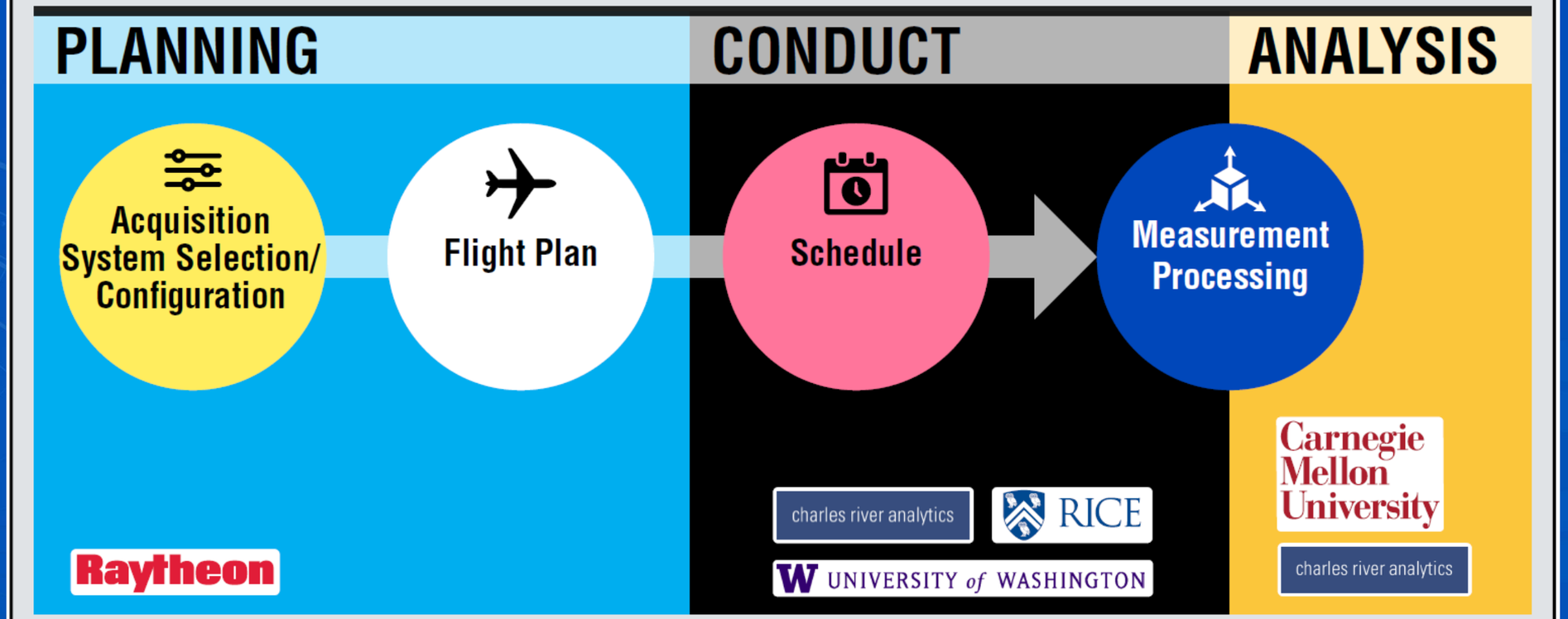


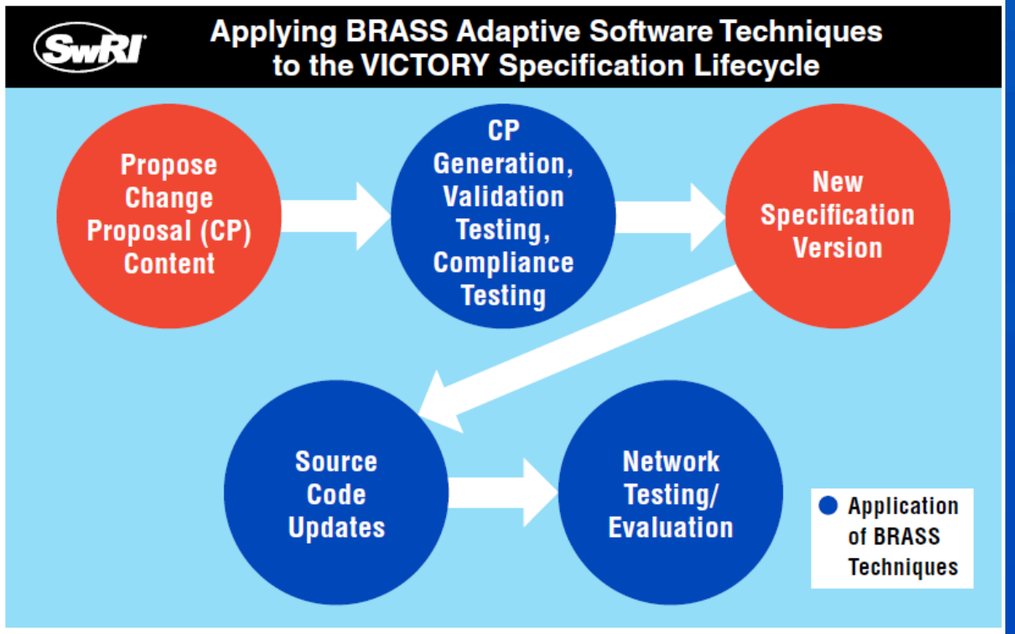
SwRI Map (Zoomed)



Flight Test Demonstrations

VANDERBILT UNIVERSITY





DARPA DEFENSE ADVANCED RESEARCH PROJECTS AGENCY

SwRI SOUTHWEST RESEARCH INSTITUTE®

Flight Test Evaluation Framework

- Built using Bamboo CI
  - Cloud-based build and deployment system
  - Supports both batch mode and real-time interactive evaluation
  - Will be using for demos shortly

- Teams communicate with OrientDB as a common interface
  - Abstraction layer to keep performers from having to create implementation-specific interfaces

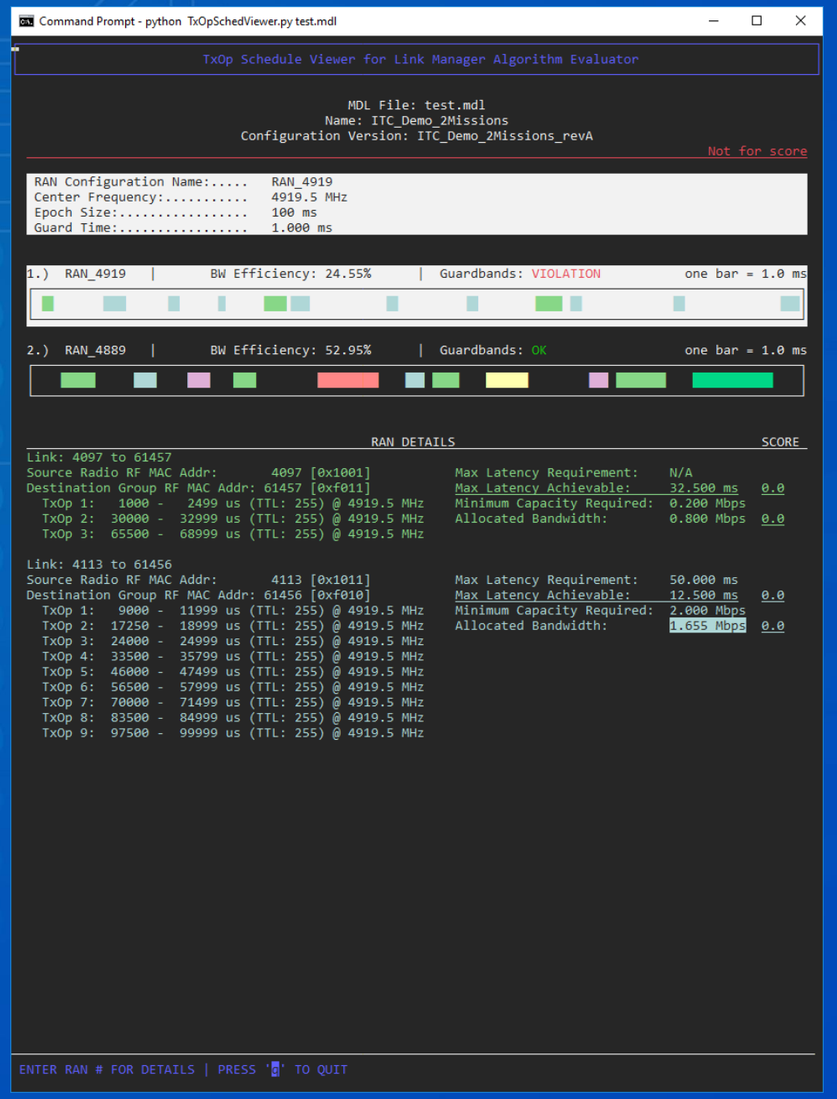
Scheduling Challenge Problems

- Scenarios 1, 2, 4, and 7a
  - Introducing new Test Articles (TA)s into the system
  - Forcing optimization across frequencies
  - Dealing with changing network topologies – relays
  - Optimizing connected TAs with new network bandwidth availability (static schedules)

Scheduling Evaluation

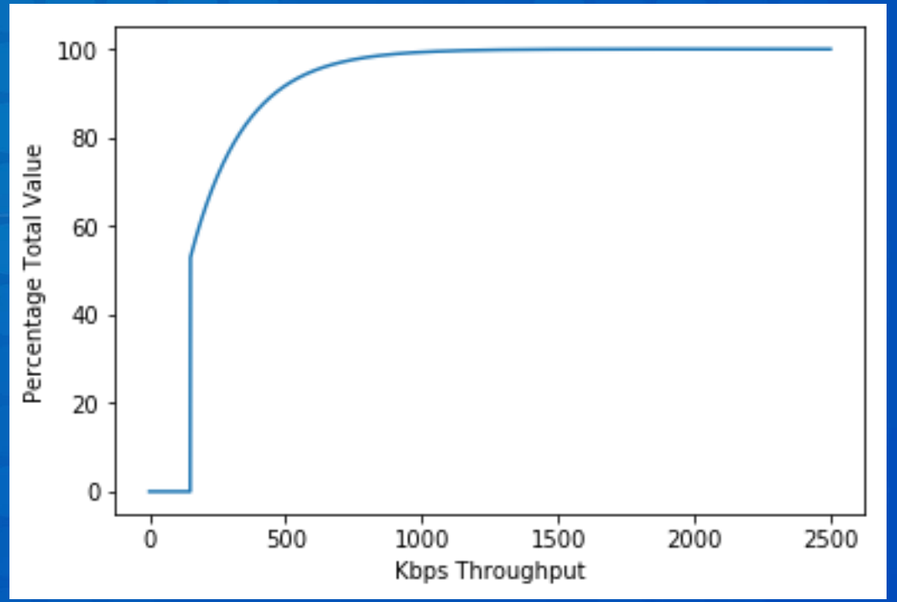
- Tool for visualizing schedules and grading

- Important factors:
  - Epoch size
  - Guard bands
  - Bandwidth efficiency
  - Value function



Scheduling Evaluation (cont.)

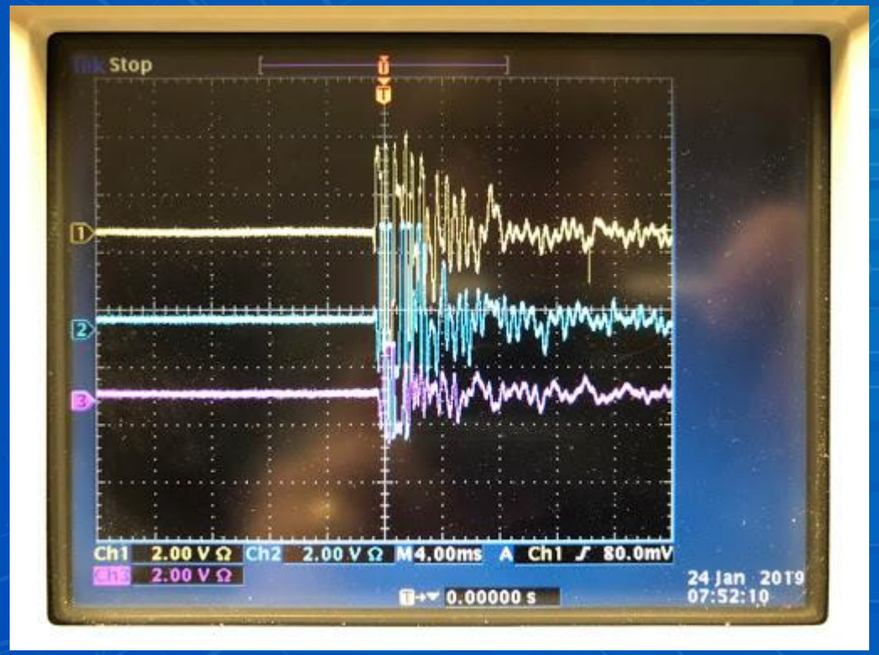
- Value Function
  - Minimum bandwidth before any value is gained
    - Voice and Safety
  - Diminishing returns on bulk data
    - Actual test data
    - Important for fast feedback on test, but after most valuable sensors are telemetered, value declines

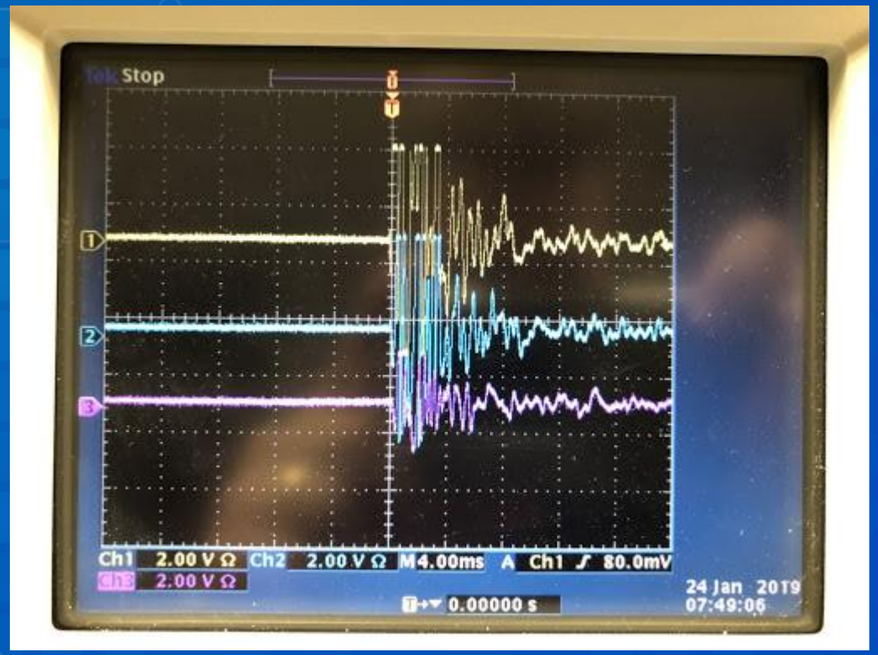


Measurement Fault Detection

- Scenario 3
  - Detect instrumentation failure by monitoring raw data
  - Adapt to preserve system value
    - Drop failed sensor
    - Synthesize data from remaining sensors

Measurement Fault Detection Data





Suspiciously similar…

Measurement Fault Detection Explained

- Common failure modes (not necessarily human visible)
  - One end of accelerometer or strain gauge disconnected
    - Noise introduced with frequency matching power source
  - Transducer cables reversed
    - Signal is 180 degrees out of phase
  - Both ends disconnected
    - Easy: no signal on channel

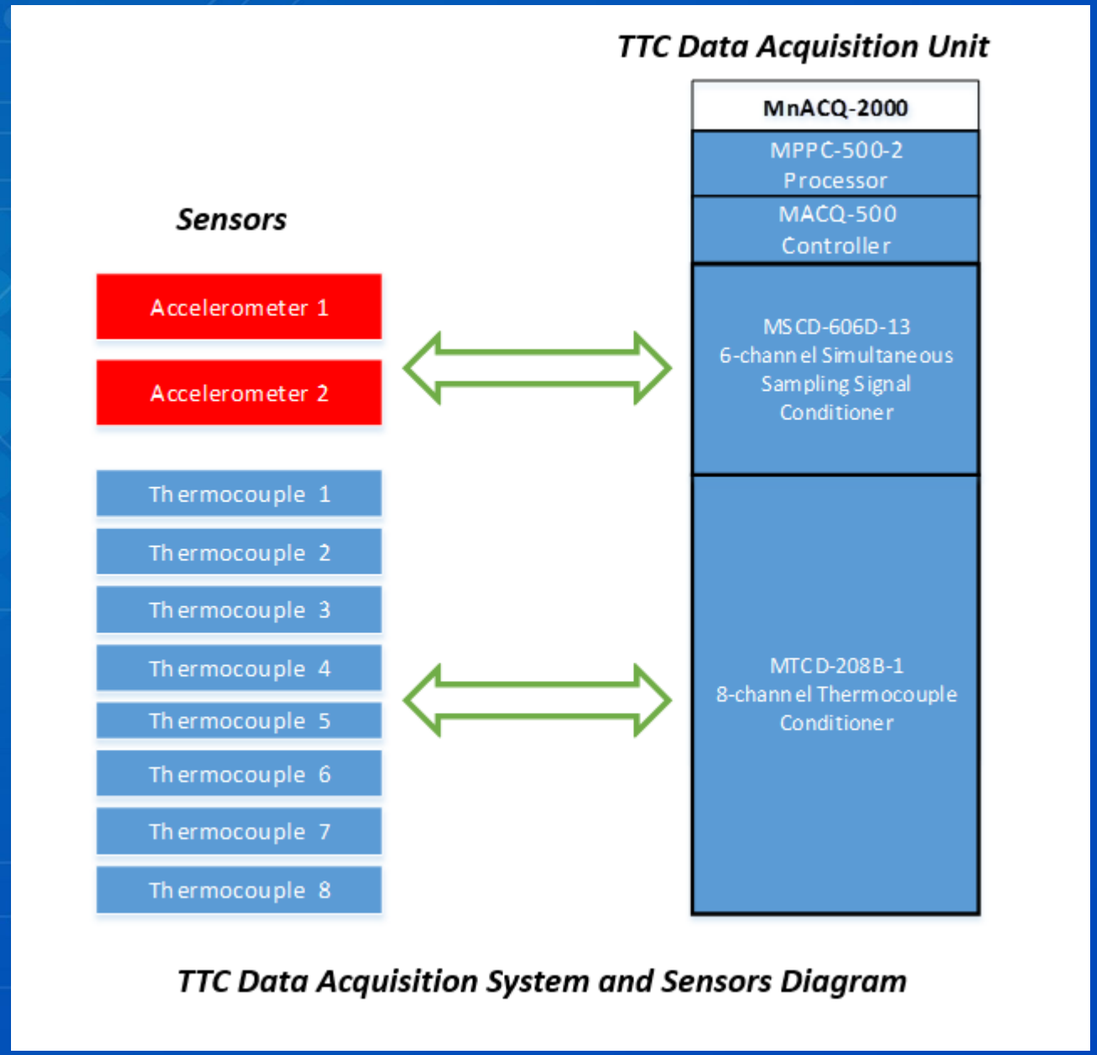
Optimization of Flight Test Hardware

- Scenario 5
  - Given an inventory of available hardware, what is the optimal choice for satisfying the original requirements?
  - Optimize for size, weight, power, and cost

Flight Test Hardware

- Starting hardware gives requirements
  - Sample rates
  - Bit depths

- New hardware may be better, but have to assemble the puzzle to find the right match



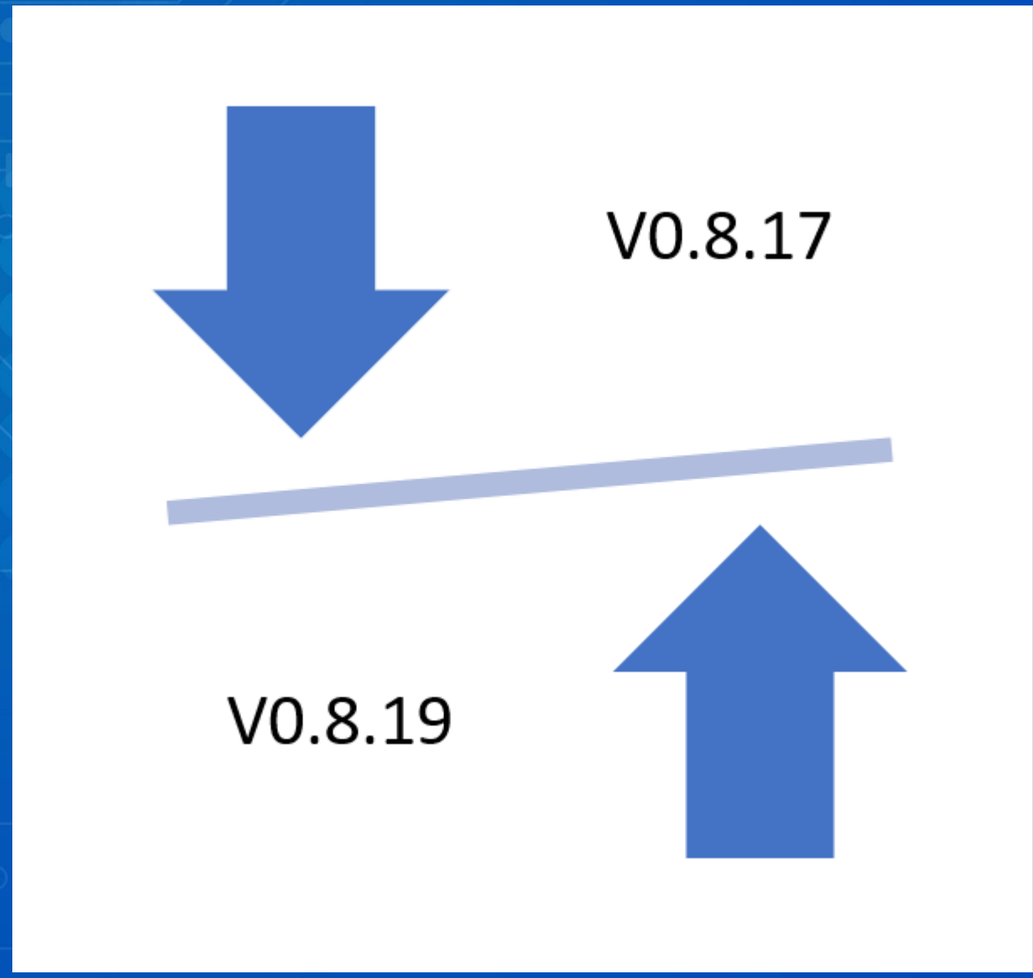
TTC Data Acquisition System and Sensors Diagram

MDL Version Translation

- Scenario 6
  - How to translate between schema versions keeping things as compatible as possible
  - Generate transformations between arbitrary versions that preserve original intent

MDL Version Transformation (cont.)

- Compare interpretations of documents between versions
- Renamed, moved, and other small perturbations
- Verify unaffected parts remain intact



Live Scheduling

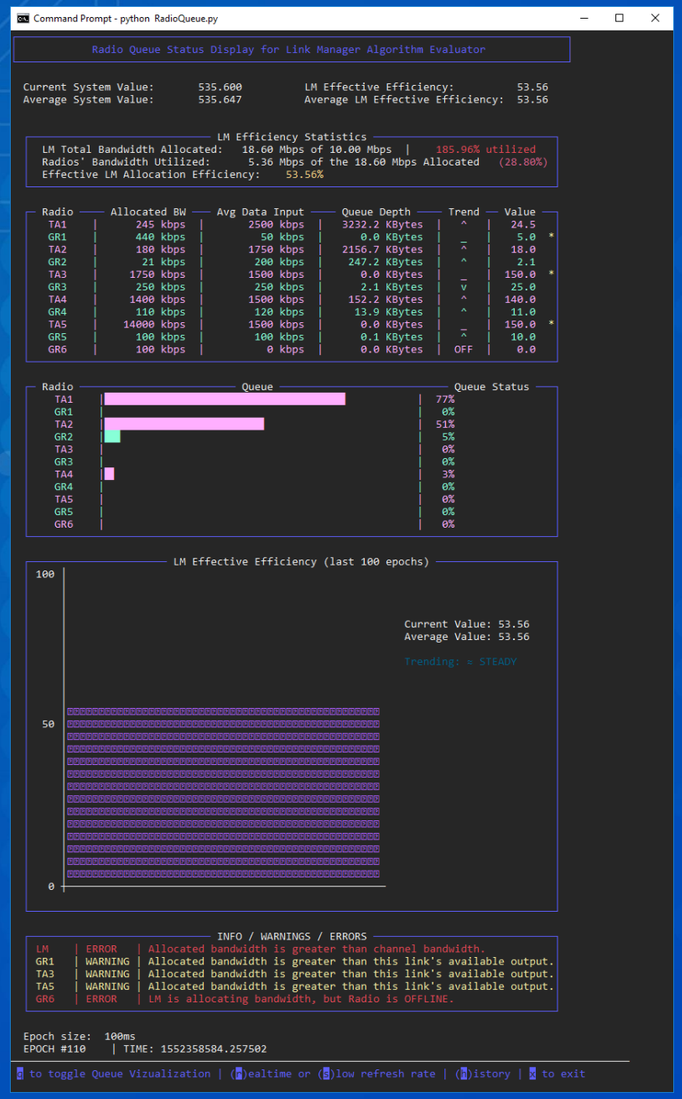
- Scenario 7b
  - Optimizing connected TAs with new network bandwidth availability (dynamic schedules)
  - Maximizing system value by adjusting allocations in real-time

- In iNET terms, these are the decisions Link Manager makes

Live Scheduling Evaluation

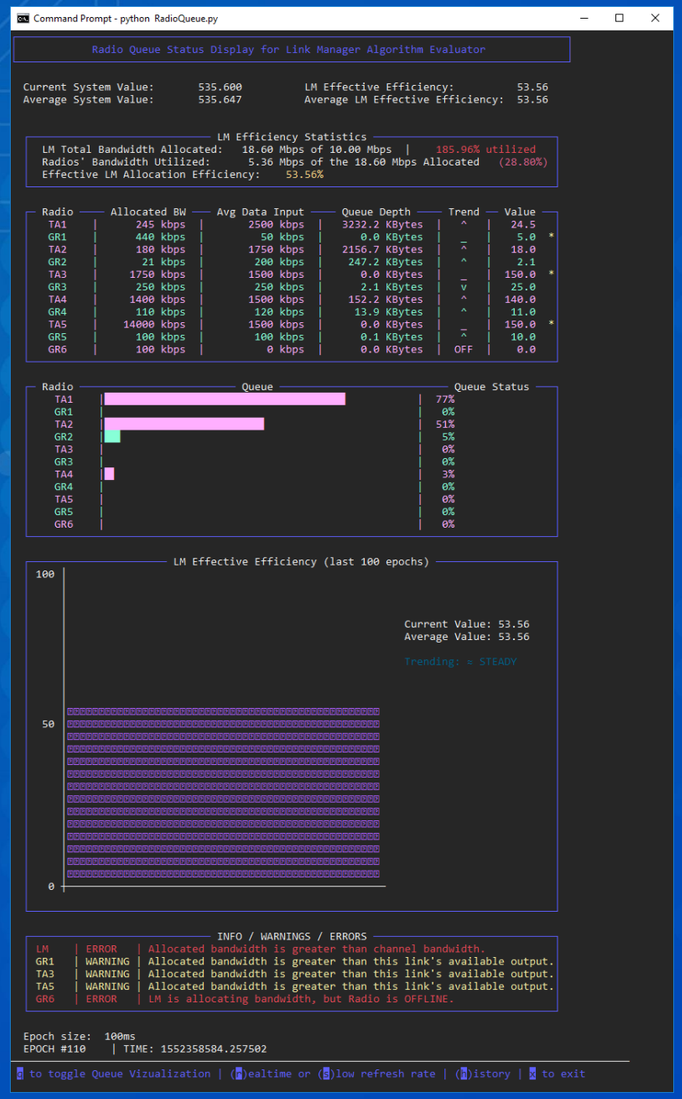
- Tool for visualizing radio queues and system value

- Important factors:
  - Input rate (with variance)
  - Output rate (configurable)
  - Value per TA
  - Correctness
    - Spectrum allocations
    - Input vs output
    - Active radios



Live Scheduling Evaluation

- Main challenge:
  - Maximize value while minimizing queue depths
- Interesting perturbations:
  - Changing input rate
  - Radios going offline



Numerical Processing

- Scenario 8
  - Adapting generalized flight test algorithms for specific target platform
  - Optimizing for performance and platform capability

Numerical Processing (cont.)

- Three major uses
  - Onboard TA for bandwidth optimization
    - Precompute final values from intermediate to prevent extraneous data from being telemetered
  - Groundside for decompressing TA data
    - In cases of constraints computation, precomputed values may not be final values
    - Therefore, expansion to original values may be required
  - Groundside for expanding capabilities of legacy ground processing
    - Some ground processing systems can only handle a subset of algorithms
      - Polynomials and lookup tables with a single input
    - Rework algebraic combinations to computable forms

Demos

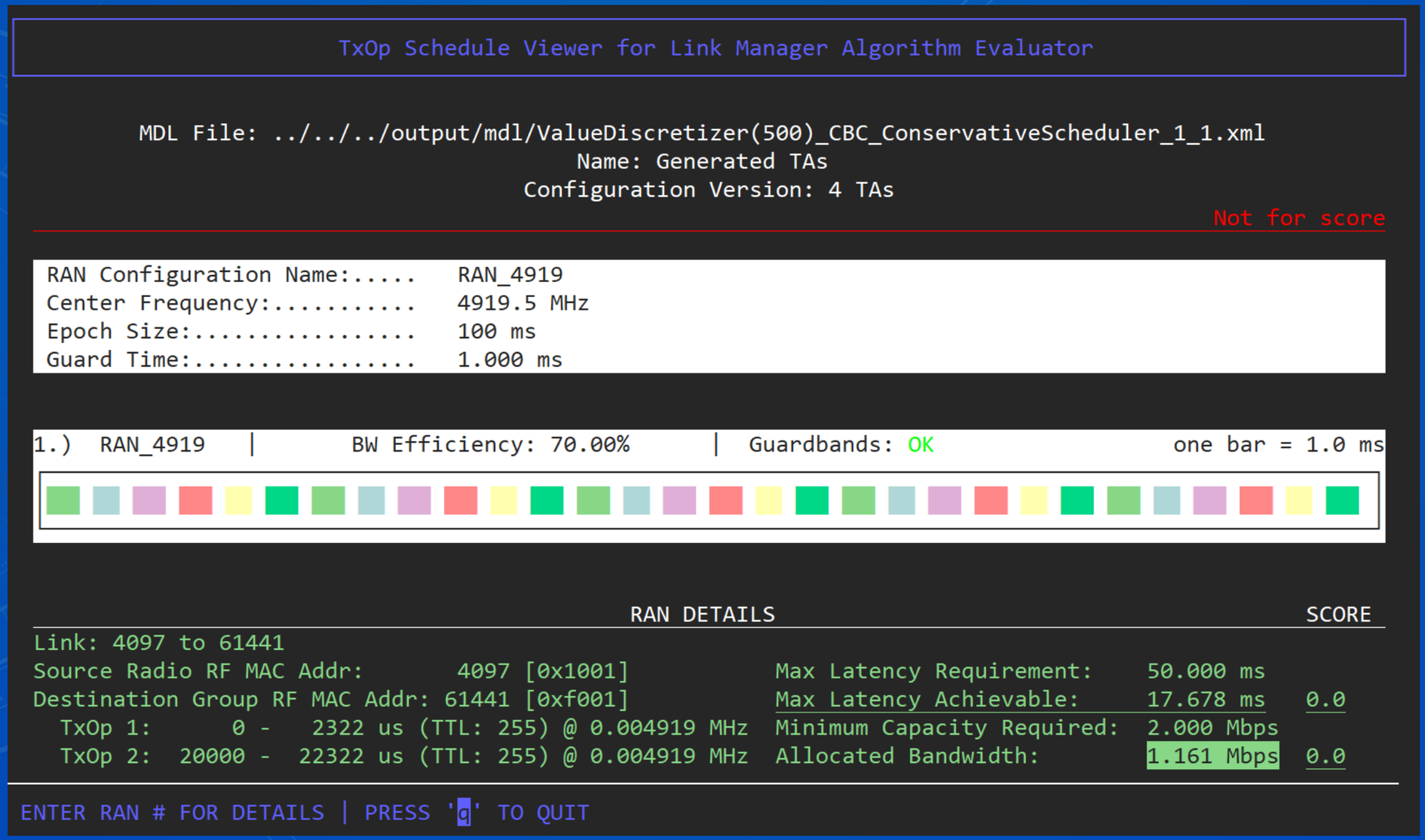
CRA Static Scheduling - Overview

- Static spectrum sharing/scheduling
- Provides approximately optimal and time-critical solutions to TDMA transmission schedules using integer programming

CRA Static Scheduling - Scenario

- 3 currently active test articles (TAs)
  - B-2, F-22, T-7A
- F-35 requests to start test mission
- Software rebuilds schedule based on value equations for each TA

CRA Static Scheduling – 3 TAs



CRA Static Scheduling – 4 TAs

```
                TxOp Schedule Viewer for Link Manager Algorithm Evaluator

        MDL File: ../../../output/mdl/ValueDiscretizer(500)_CBC_ConservativeScheduler_1_1.xml
                                        Name: Generated TAs
                                Configuration Version: 4 TAs
                                                                        Not for score
 RAN Configuration Name:.....   RAN_4919
 Center Frequency:...........   4919.5 MHz
 Epoch Size:.................   100 ms
 Guard Time:.................   1.000 ms

1.)  RAN_4919    |        BW Efficiency: 60.00%       |  Guardbands: OK                one bar = 1.0 ms
```

```
                                        RAN DETAILS                                          SCORE
Link: 4097 to 61441
Source Radio RF MAC Addr:        4097 [0x1001]          Max Latency Requirement:    50.000 ms
Destination Group RF MAC Addr: 61441 [0xf001]           Max Latency Achievable:     18.551 ms   0.0
  TxOp 1:      0 -   1449 us (TTL: 255) @ 0.004919 MHz  Minimum Capacity Required:  2.000 Mbps
  TxOp 2:  20000 -  21449 us (TTL: 255) @ 0.004919 MHz  Allocated Bandwidth:        0.725 Mbps  0.0

ENTER RAN # FOR DETAILS | PRESS 'q' TO QUIT
```

UW Static Scheduling

- Static spectrum sharing/scheduling
  - Including support for relay topologies

- Uses constraint satisfaction technology to calculate valid TDMA schedules after external perturbations
  - Including the maintenance of links over RF relays

UW Live Demo

CRA Measurement Fault Detection

- Provides detection and recovery from acquisition system faults in a flight test telemetry system

CRA Live Demo

BBN Optimization of Flight Test Hardware

- MDL flight test plan adaptation in response to faulty DAUs

- Leverages variational analysis along with a parts inventory to generate a new flight test plan with the faulty component replaced and the new component appropriately configured

BBN Live Demo

Rice Live Scheduling

- Dynamic spectrum sharing/scheduling through machine learning and feedback control-inspired novel runtime

- Provides runtime adaptation to schedule perturbations and bandwidth demands while optimizing system value based on dynamic reallocation

Rice Live Demo

CMU SPIRAL Numerical Processing

- Automatic program generation of high-performance measurement processing from Metadata Description Language (MDL)

- Provides high-performance platform-tuned implementations of complex numerical methods starting from a flight test domain description of the algorithms

SPIRAL Live Demo

Conclusion

- Adaptive technologies have ready applicability to current Department of Defense work

- Teams successfully applied BRASS technologies to flight test challenge problems across the spectrum

Questions?