Telemetry of the Future

...and the future is not too far off!

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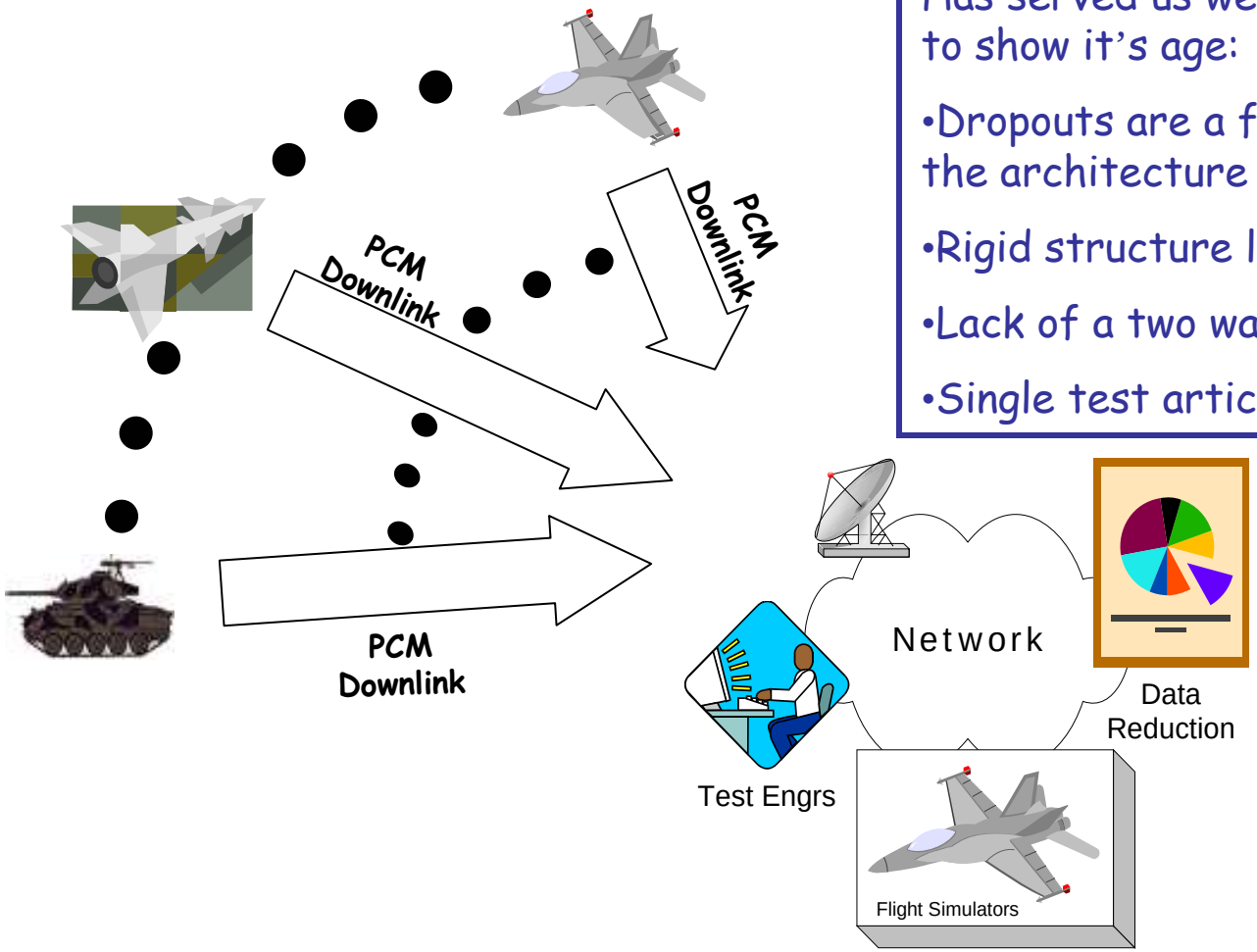
50 Years of Service



Has served us well but it is starting to show it's age:

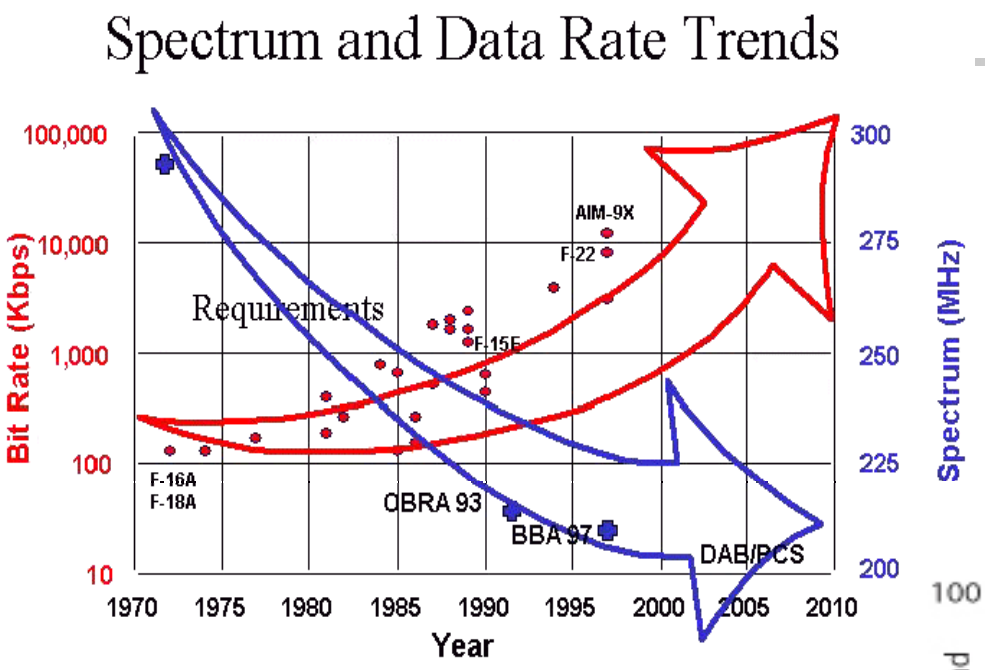
- Dropouts are a fundamental flaw of the architecture
- Rigid structure lacks flexibility
- Lack of a two way link limits options
- Single test article focused

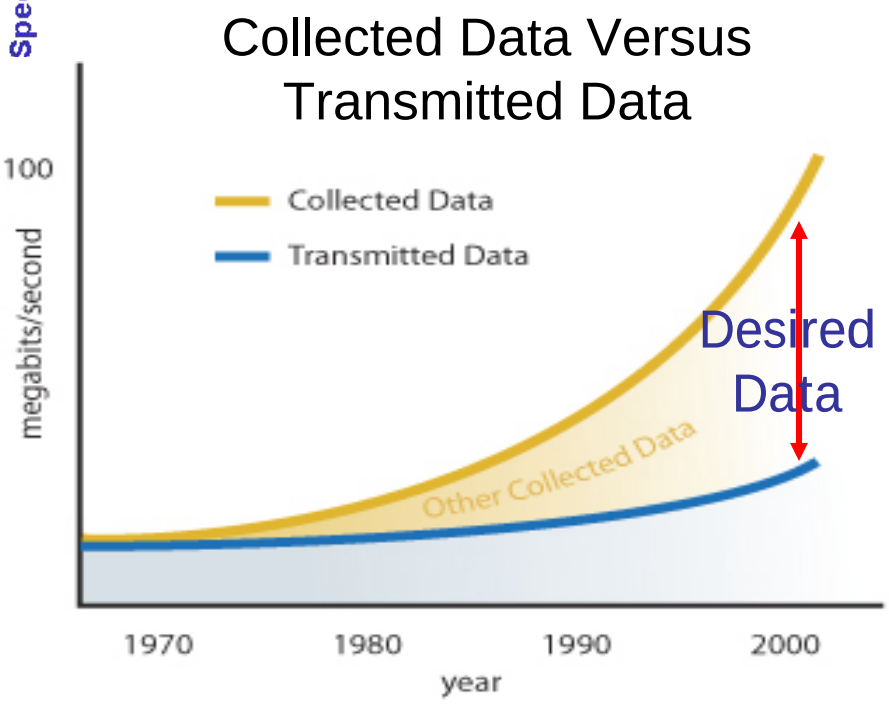
A Great Ride …

- In 1960 IRIG 106 Chapter 4 was published
  - 3 pages in length
  - Ushered in the era of PCM Telemetry
- 48 years later Chapter 4 is still being used
- Virtually every major weapons system in use today was tested using Chapter 4

However, in the late 1990s it began to show it's age

Disturbing Trends

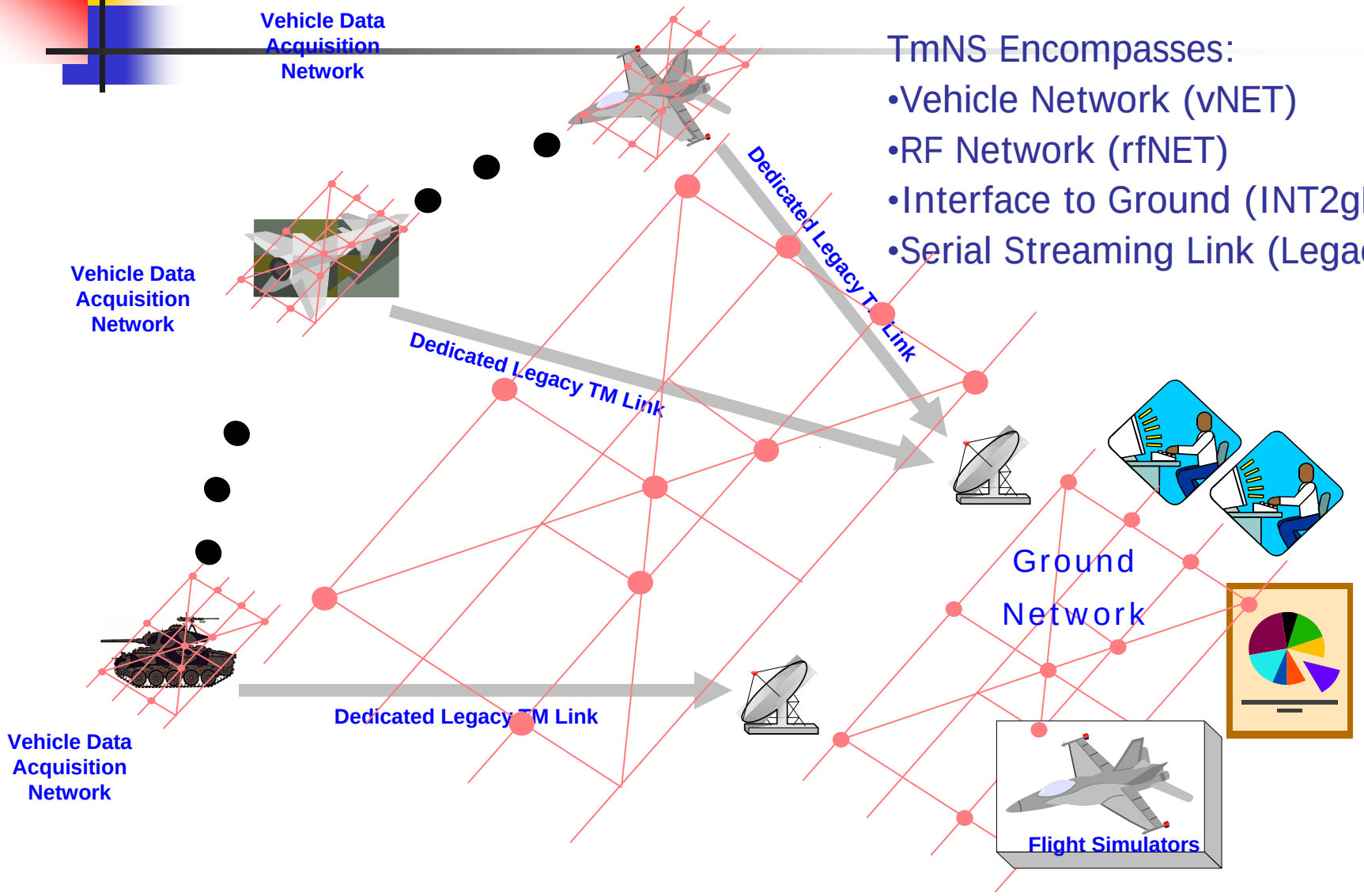




Rationale for Change

- Decrease time and cost associated with T&E
  - Reduce rework associated with:
    - Tm Dropouts , need to return to base to access data on onboard archive, etc.
- Provide flexibility to respond to future needs
  - Lack of two way connectivity limits flexibility.
- More Efficient Use of Spectrum
  - Real-time transmitter control, data set selection, etc...
- Leverage Sim/Stim capability with two-way connectivity to test article
- Leverage the Wireless Revolution
  - DoD and Private Sector are investing huge amounts of intellectual and financial capital in wireless networks

Telemetry Network System



TmNS Encompasses:

- Vehicle Network (vNET)
- RF Network (rfNET)
- Interface to Ground (INT2gNET)
- Serial Streaming Link (Legacy TM)

Laying the Foundation

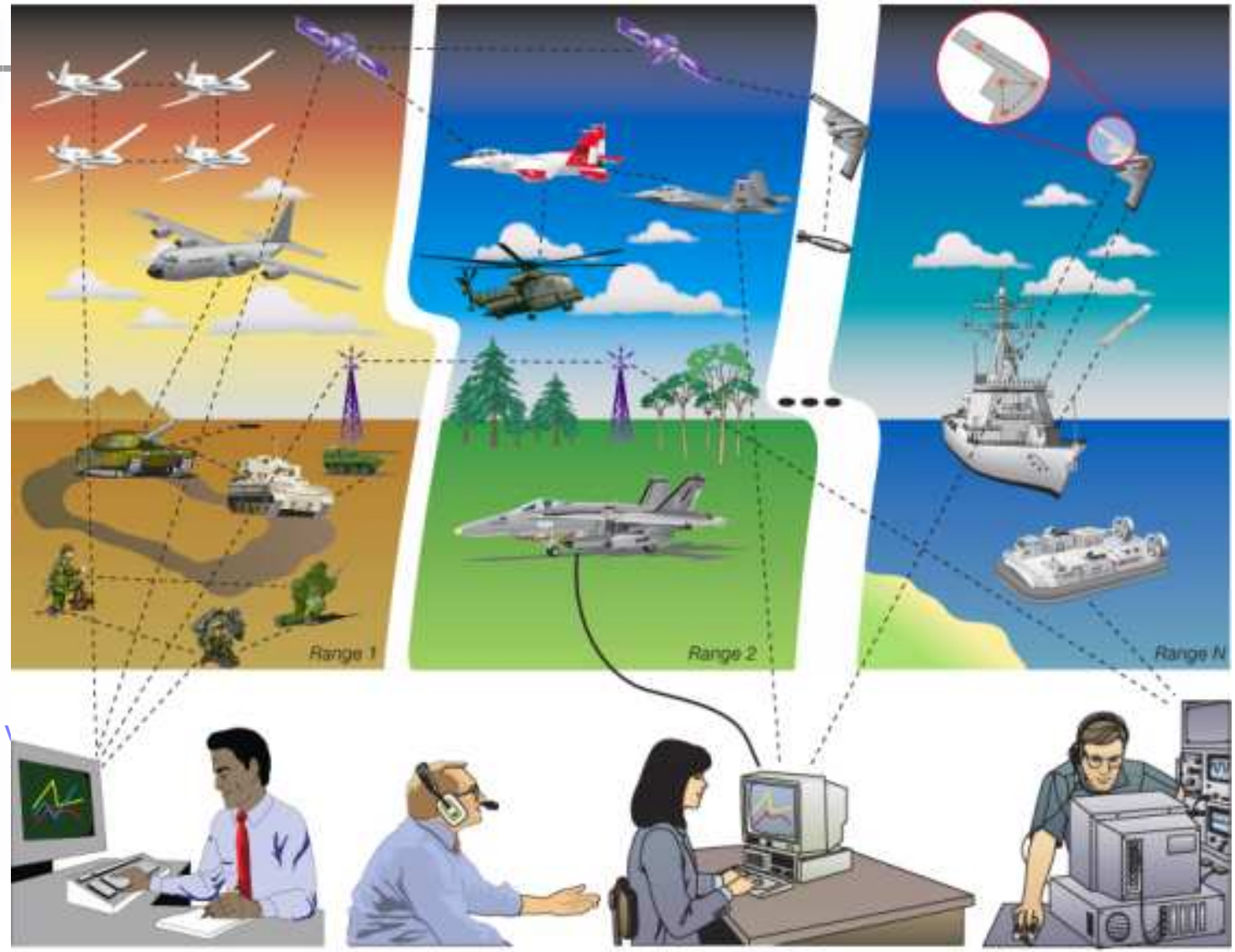
- Needs Discernment
  - What needs does this new architecture need to meet?
- Experimental Architecture
  - Can network enhancement of telemetry meet the needs?
- Technology Shortfalls
  - What technology gaps exist to deploying the experimental architecture?
- Investment Roadmap
  - Where does the sponsor need to invest to make iNET a reality?

The Needs Discernment is the cornerstone upon which the Architecture is built

Needs Discernment - Scenarios

- 52 Test scenarios documented
  - Narrative descriptions of a wide range of test scenarios
    - Near-term to long-term, simple to exotic, etc...
    - Mostly targeted at the aeronautical environment
- Based on
  - Site visits to MRTFBs
    - EAFB, PMRF, Aberdeen, Eglin, Pax (and NASA Dryden)
      - Brainstorming sessions with test engineers, project managers, range folks, instrumentation folks, spectrum managers, etc....
  - Workshop (CTTRA)
    - Attended by 130 people
      - Virtually all MRTFB ranges were represented
- Validated by the private sector aviation industry
  - Aerospace and Flight Test Radio Coordinating Council (AFTRCC) reviewed scenarios
    - Added one and endorsed them as describing their future needs!

Extensive Network Connectivity

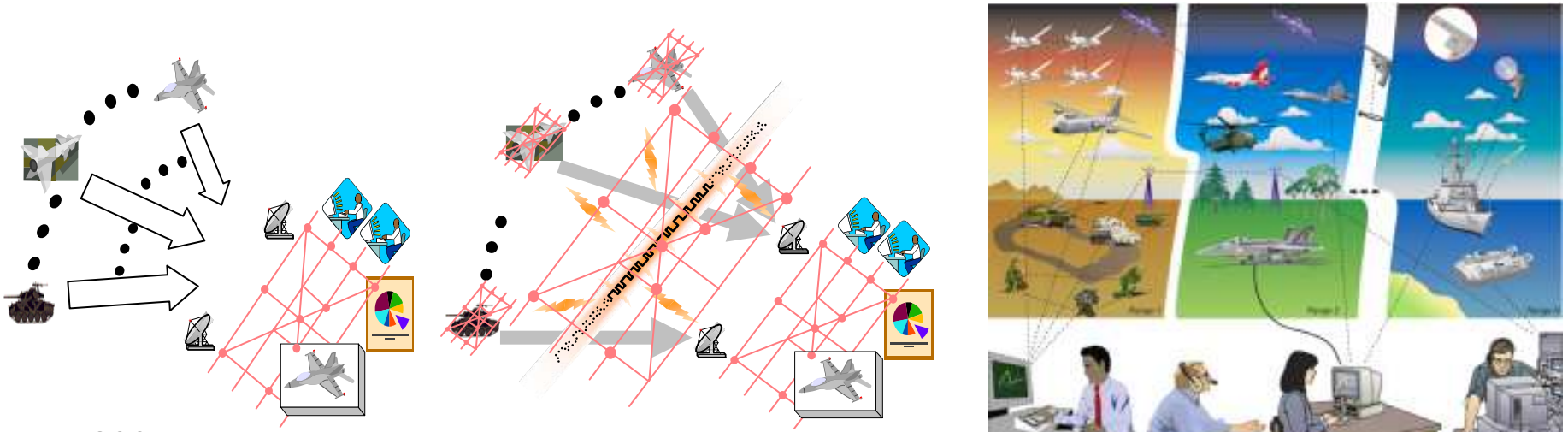


Long-term Vision: Near-term Results

Today

iNET Project Fielded Capability

Long-term Vision



2004

2025

Vision is achieved through Block Releases of the Architecture

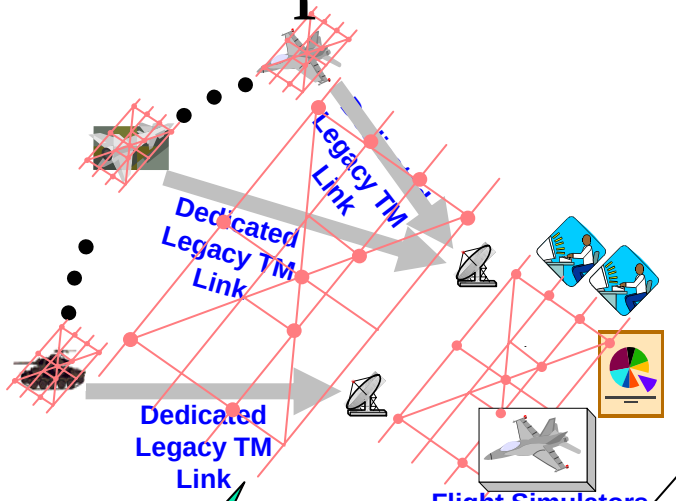
Block 1

Block 2

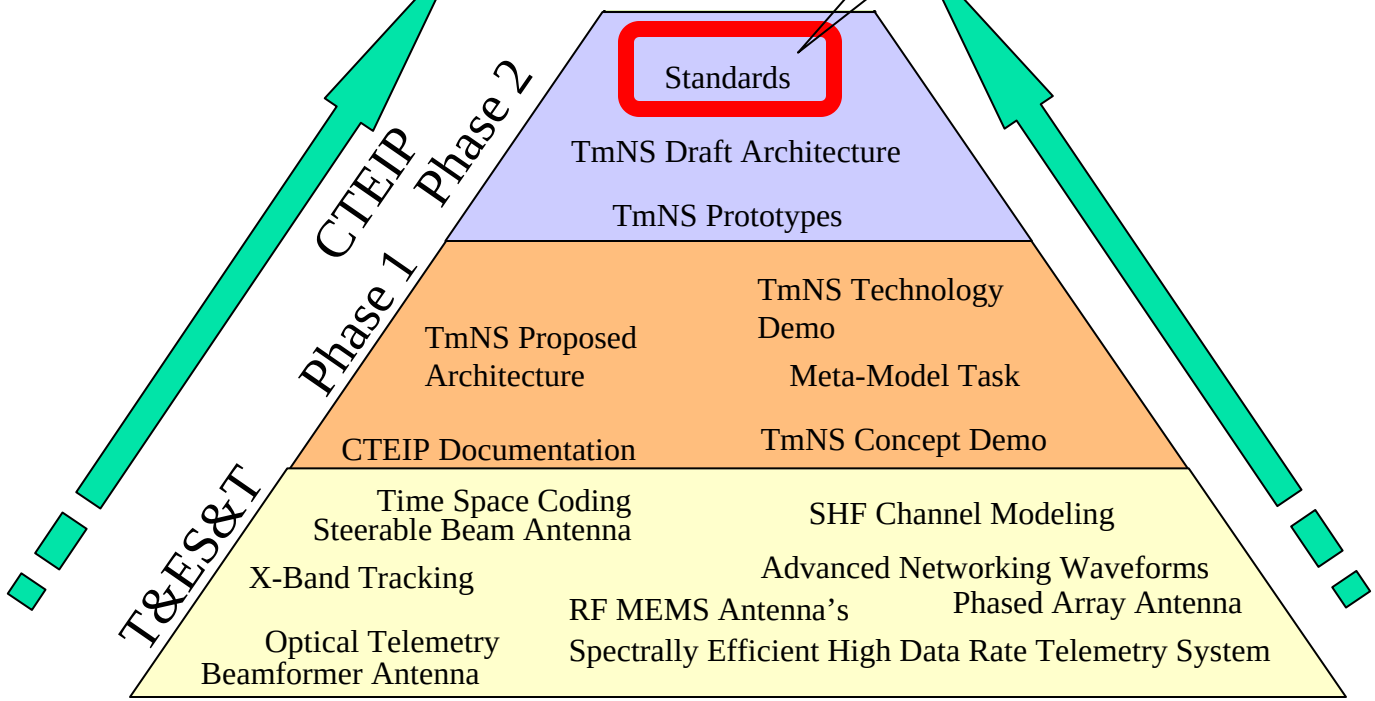
N greater than or equal to 3

Block N

A Complex Undertaking



The Goal of iNET is to repeat the Success of IRIG 106 Chapter 4 for Network Enhanced Telemetry



TmNS Architecture

- The Telemetry Network System (TmNS) Architecture is the core component of iNET
- Architecture is going through a 4 step maturation process
  - Experimental, Proposed, Draft and Final
- Proposed Architecture completed May, 2007
- Significant community review planned
  - Workshop (CTTRA)
    - June ‘07 in Virginia Beach
  - RCC (TG Meeting)
    - March ’07 at WSMR
- Community feedback will be incorporated
  - 75% Proposed architecture delivered in July, 2007

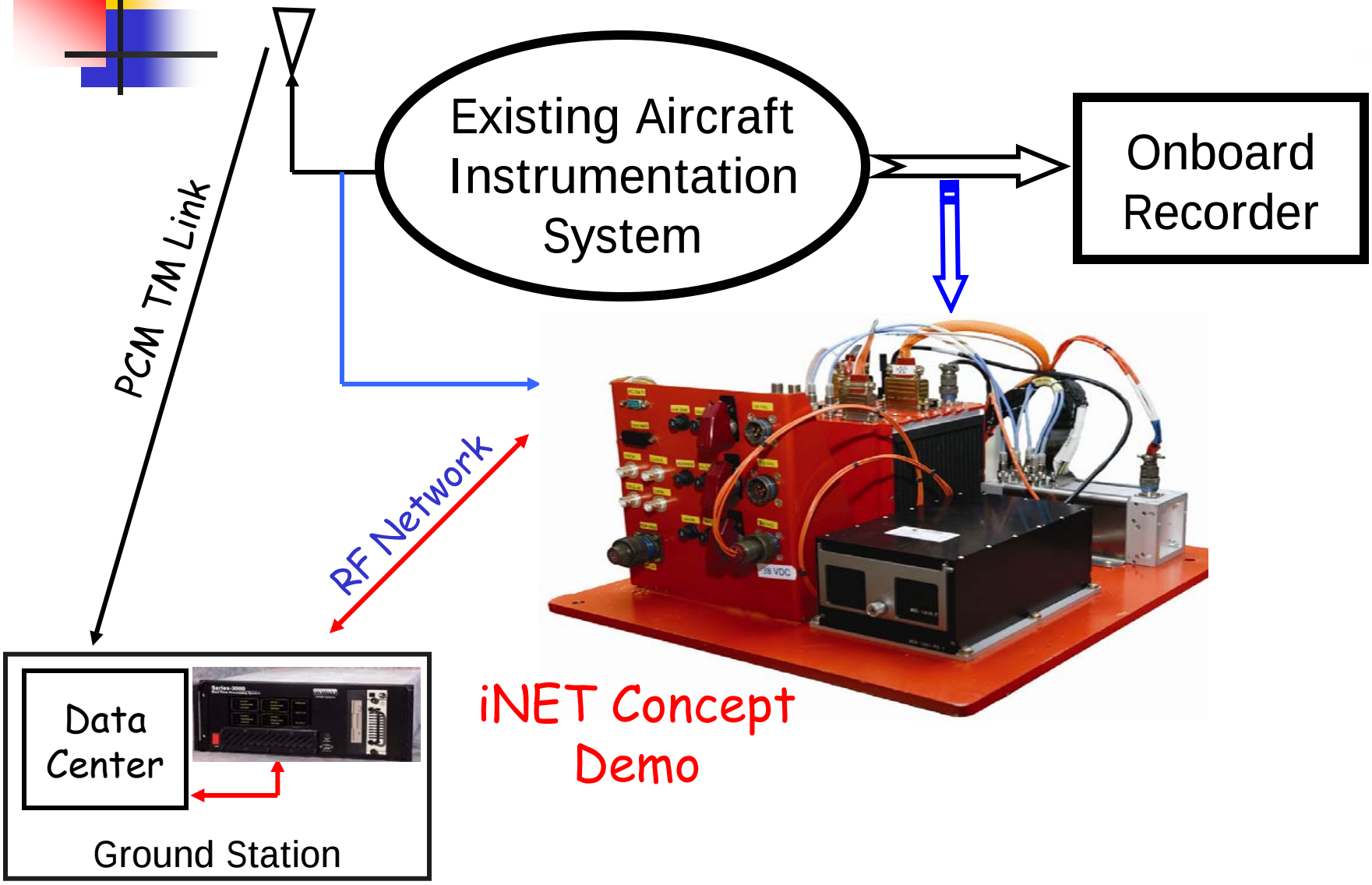
Architecture-Some Key Details

- Test Article Segment
  - Switched network architecture
  - Gigabit Ethernet
  - IEEE 1588 used for time correlation on vehicle
    - Achieving few hundred nanosecond time synchronization
  - Network link and PCM can use the same antenna!
- Ground Station Segment
  - Existing telemetry antennas can be upgraded
    - Used for network and PCM at same time
- RF Characteristics
  - TDMA over OFDM will be employed

Standards Work

- Working Groups
  - RF Communications Link
  - Test Article Network
  - Ground Station Applications
  - System Management
  - Metadata
- Architecture Refinement
  - Standard work being feedback
  - Process for tracking and addressing architecture compliance issues within the SWGs
  - Maturing for completing the Proposed Architecture in ’09

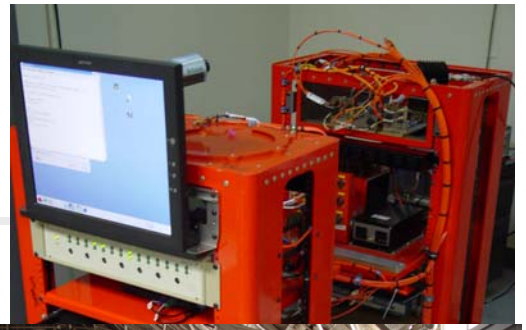
Concept Demo



Drive Before Fly!

- Initial Testing
  - Aberdeen Proving Grounds
    - Vehicle Test track
    - Installed on Humvee
    - Existing Range Infrastructure
      - Cisco 802.11 network
    - Replicate Dropouts
      - Network Dropouts
      - Tm Dropouts

...and Fly We Did!



- Flight Testing
  - Edwards AFB
    - Install on C-12
    - Create rf network over Edwards
      - Harris SecNet 11
  - First flight August 1st, 2006!
- Successfully Demonstrated
  - Mining of data from onboard recorder
  - Remote control of instrumentation system
  - Creation of error-free and drop-out free PCM telemetry

Operational Demo

- Spring ’08
  - Comm Links Team tested 802.11b with transverter
    - Flight tests went well – Paper at ITC
  - Once operational verified they delivered it to the Test Article Segment Team
- Spring/Summer ’08
  - Comm Link Hardware is being integrated with a Test Article Network
  - Installed in Test Pilot School H-60
- Fall ’08
  - First Flight of OP’s Demo
    - Control On-board Instrumentation, Fetch data, Fix SST, etc.
- Plan
  - Test in helo environment
  - CONOPS Validation
  - Integrate into Range infrastructure

Deployment

- FY12
  - System Design and Development
    - Fully deployed system at two ranges
      - Air Force Flight Test Center – Edwards
      - Naval Air Warfare Center- Aircraft Division – Patuxent River
      - ???
    - Initial Operational Capability (IOC)
      - Support for most scenarios

What Others Are Saying

- The Japanese Gov't has launched and official study of iNET
  - Goal is to put iNET like capability on their range
  - Sent a delegation to ITC to investigate iNET
- iNET received the ITEA Publication Award for 2006
  - "Through in-depth research and a concise presentation, the authors precisely convey how iNET is taking a systems approach to reengineer telemetry...thus meeting the challenges of testing the next generation of weapon systems
- Recent Letter signed by Range Commanders Council
  - "iNET is designed to enable the ranges to conduct our missions with system-of-systems weapons in a manner that replicates how we intend to fight with them. "

Questions???

Capability Enhancements

- Recover telemetry dropouts
- Access (random) to data on onboard recorder
  - More efficient test
  - Unexpected event investigation
  - Inter-maneuver analysis
- Error free data delivery
  - Many processing algorithms cannot tolerate errors
- Control of instrumentation from the ground
  - Control Instrumentation operation
  - Reprogram PCM downlink
  - Etc.
- Hot Mic
  - Test Team Unique/between multiple assets
- Etc.

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Leverage the Revolution

- Within DoD and the private sector
  - Networks are the solution of choice!
  - Virtually all new wireless services are network based
- Vast investment of intellectual and financial capital
  - Modulation schemes, coding, protocols, etc
  - Huge investment in a common problem
    - The wireless movement of data!
    - Unprecedented in our history

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Flexibility For Tomorrow!

- The ability to meet as yet unforeseen future requirements is critical
  - How will we test future weapons?
    - Complex systems of systems?, swarming UAVs?, sensor networks?, etc.
- Networks are inherently very flexible
  - The internet, phone system, etc.
- Layered approach facilitates technology upgrades

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Spectrum – Use It All!

- Networks hold the promise of allowing the management of pooled spectrum
  - All available spectrum shared among test articles
  - Real-Time and priority based allocation of spectral resources
  - Allow on demand transmission of data
    - Vice continuous transmission
  - Meet demand for large numbers of parameters with average bandwidth of data
- Retain continuous transmission for time critical and safety of flight data

Spectrum – Use It Efficiently!

- Traditional Telemetry
  - Point-to-point telemetry only
  - Single level of service provided
    - All data receives time critical quality of service delivery
  - It is spectrally inefficient to provide time critical delivery for ALL telemetry data
- Network Enhanced Telemetry
  - Point-to-point and network telemetry combined
    - Multiple levels of service provided
      - Move **ONLY** time critical data within milliseconds
      - Down-link the rest over the next few seconds or minutes
    - Multiple levels of service allow more flexible and efficient use of scarce spectral resources!

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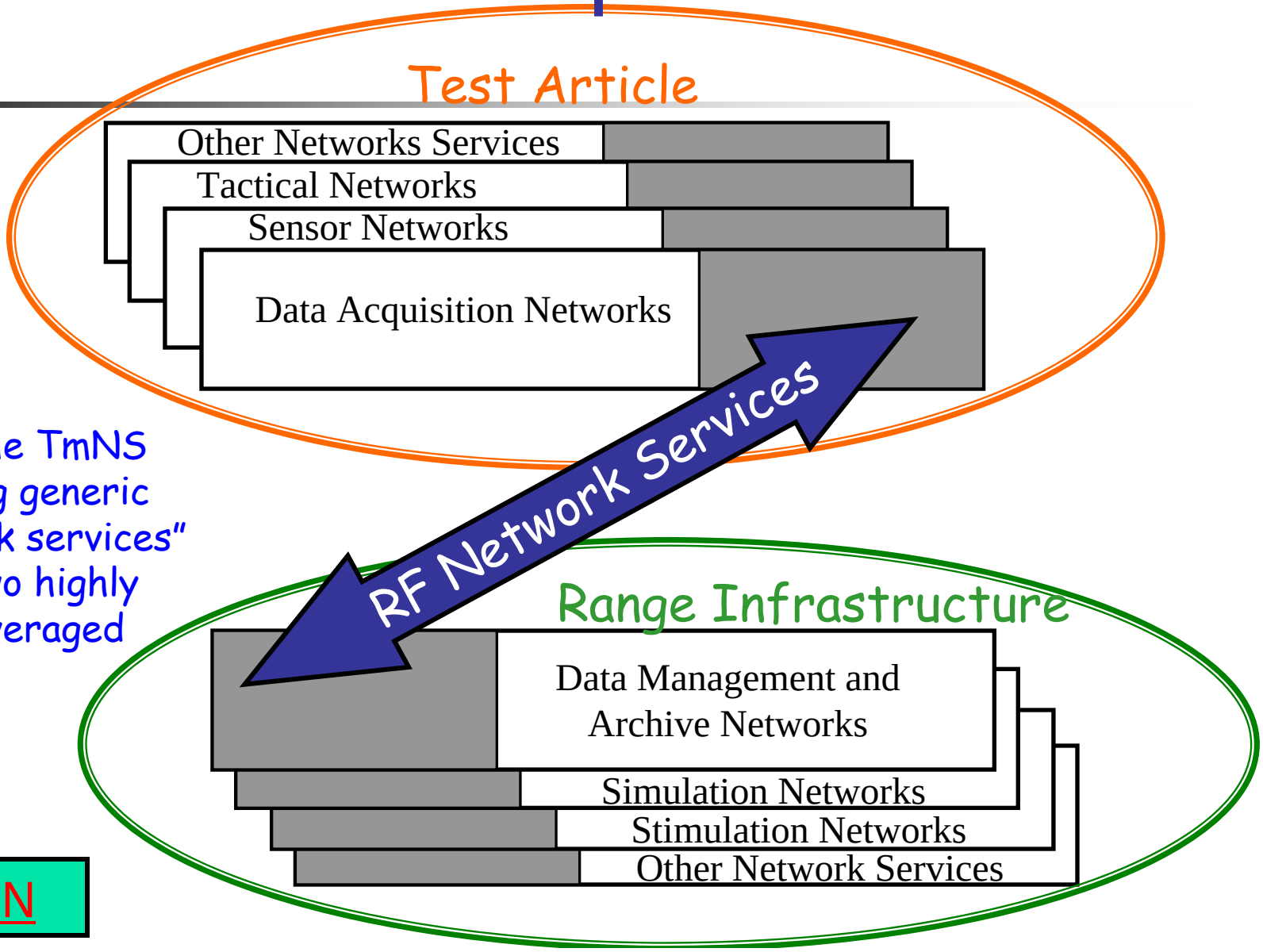
More than Just Tm!

A Broader Perspective



Consider the TmNS as providing generic "RF network services" between two highly network leveraged assets

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