A Low Cost, Quick Reaction TM Acquisition System Solution for Deployed Testing

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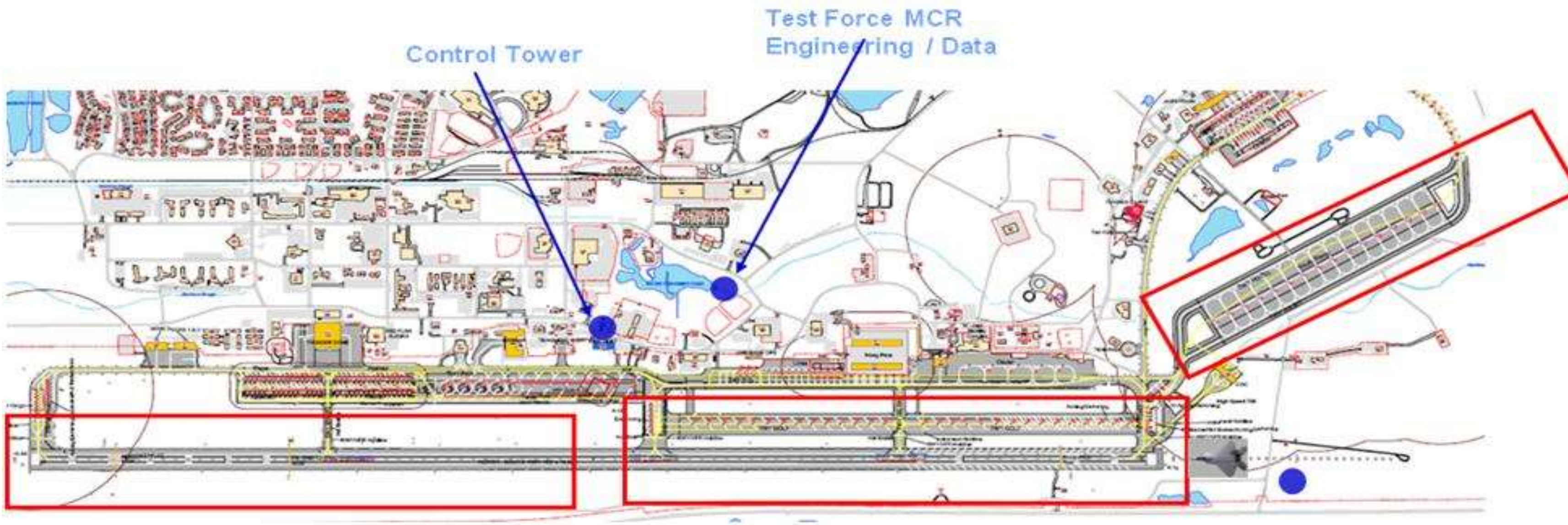
Introduction

- Austere real-time TM receive /re-radiation system (TMR/R)
  - very short planning, design, fab, integration and testing period
  - supported deployed testing in Alaska
  - provided real-time TM data acquisition to “feed“ a real-time processing and display system
  - enabled safe and efficient testing.
- A very quick response at a low cost
  - Leveraged broad resources available at a major test center like the Air Force Flight Test Center (AFFTC) at Edwards AFB
  - Short time period was driven by test planning decisions
    - Initially no real-time TM planned, only post-test processing (cost)
    - Planning trips included Instrumentation/Data Processing personnel
    - Decision to include a full real-time capability only three and one half weeks (24 calendar days) prior to equipment deployment!

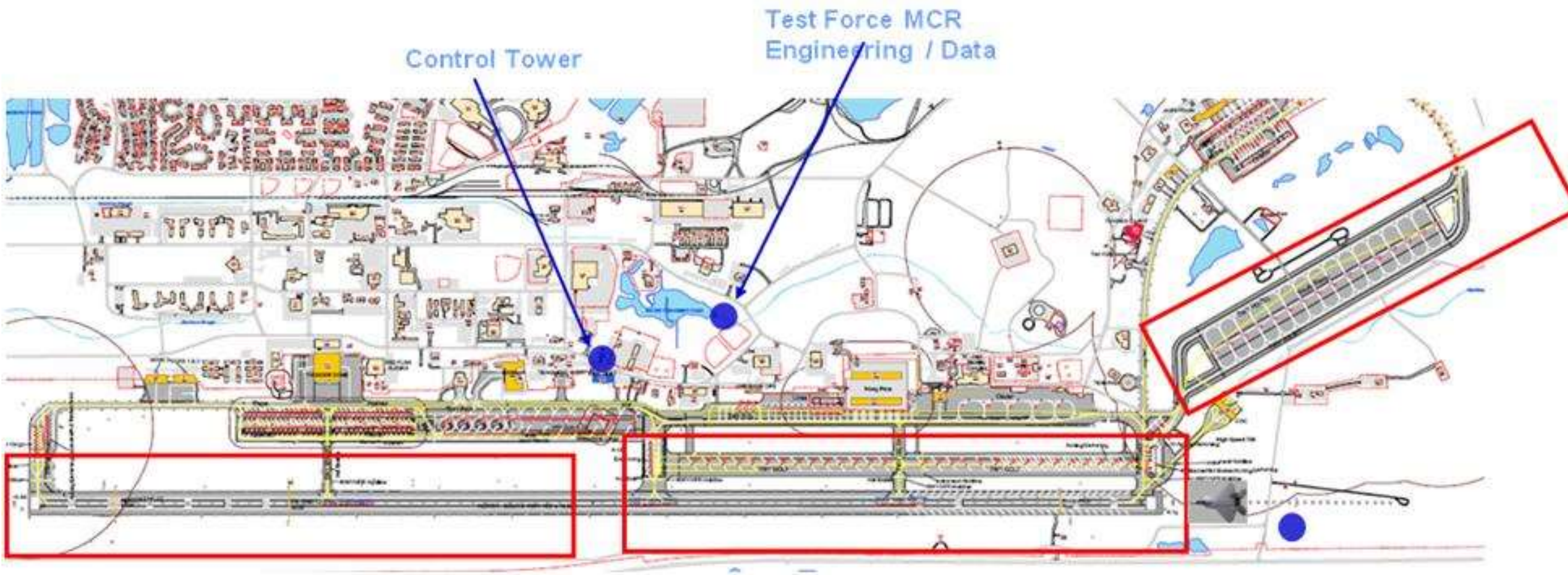

Test Force MCR
Engineering / Data
Control Tower

Background

- Mission: Test an F-22 aircraft on icy runways
  - Determine/validate ground handling qualities and stopping distances on icy runways (low Runway Condition Report (RCR)
  - Validate Technical Order Data
- Emphasis was on minimizing the test program costs, while finishing the testing prior to that aircraft type being deployed to Alaska (See SETP referenced paper)
- Test aircraft/support deployed to suitable location/environment
- Value-added of real-time TM data acquisition processing and display identified and strongly recommended
  - Enhanced test efficiency and effectiveness
- Real-time TM capability eliminated; perceived savings
  - less equipment, transport costs and less deployed personnel
  - Chose to deploy an instrumented aircraft with on-board recording and post-mission processing
- Subsequent test planning decisions resurrected real-time TM requirement
- Real-time TM system had to be ready in less than 24 days
- Later ground station arrival drove TMR/R system checkout requirements

System Design

- TMR/R System design drivers
  – Probable TMR/R locations
    - Slant-ranges and azimuth angle ranges
    - Three candidate test locations
  – Test aircraft antenna patterns and EIRP
- Traditional approach considered
  – ground telemetry rcvrs/bit syncs/tracking antennas for TM acquisition
    - Required climate controlled enclosure (container or a TM van)
  – Range portable microwave link for “re-rad” to the ground station
  – Unfeasible given the time remaining and the cost of deployment
- Alternative approach required
  – Locate entire TMR/R system on the catwalk of the base control tower
    - Required equipment that could survive environment and was on hand
    - Weapons bay active re-rad systems reviewed and selected
    - Potential electromagnetic compatibility (EMC) concerns
    - Needed custom antenna system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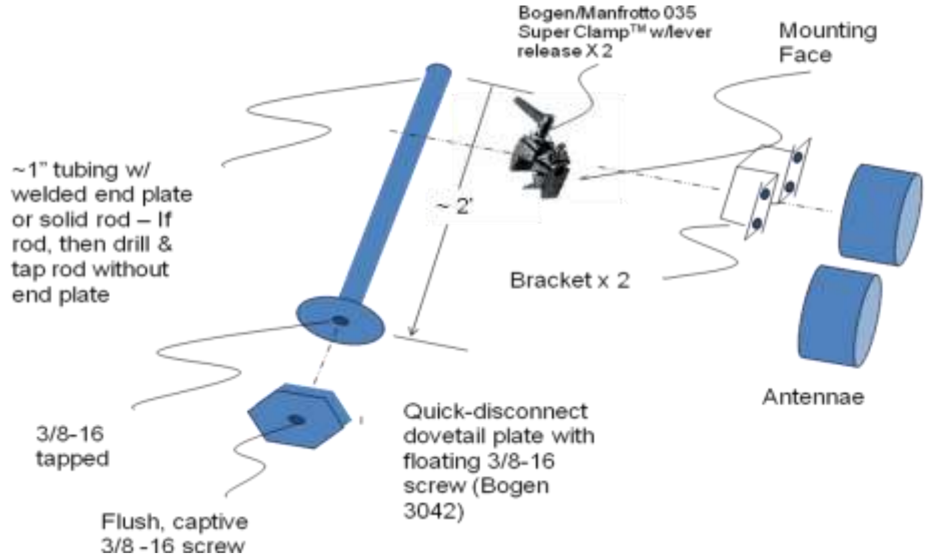
Antenna System Design

- No complex antenna mounting/pointing system could be designed and fabricated in the short time available.
- Size and type of antennae were limited to those on hand
- Hoped to eliminate az/el tracking during test runs
  - Available antennae could not cover candidate test areas
  - Omni-directional antenna gains were too low to provide the link margin required
- Chose cylindrical stacked dipole antenna
  - ~5 db gain over 20 deg azimuth (-3dB)
  - Vertically staggered 2 antennae to increase azimuth to ~35 deg
    - Potential elevation nulls; acceptable due to small range
- Concerns about test areas changes => B/U manual tracking
  - Selected photo tripod-rod-clamp to satisfy all requirements

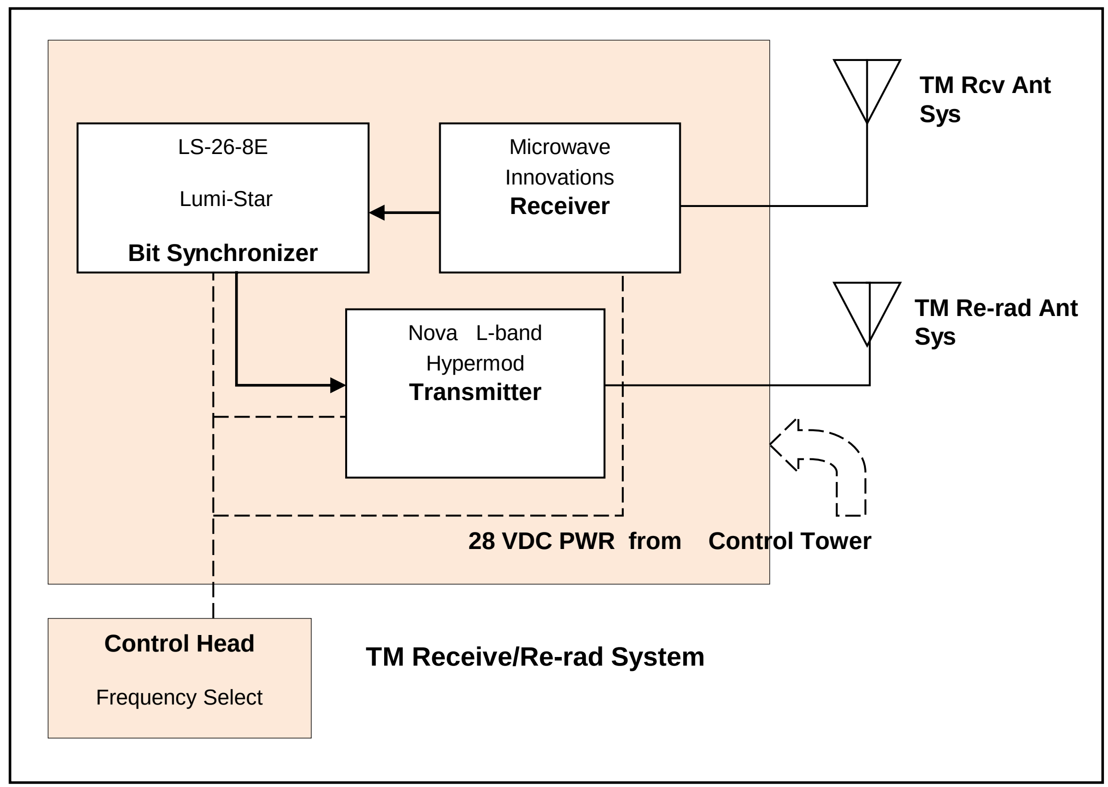

Bogen/Manfrotto 035
Super Clamp™ w/lever
release X 2
Mounting
Face
~1" tubing w/
welded end plate
or solid rod – If
rod, then drill &
tap rod without
end plate
~ 2'
Bracket x 2
Antennae
3/8-16
tapped
Quick-disconnect
dovetail plate with
floating 3/8-16
screw (Bogen
3042)
Flush, captive
3/8 -16 screw

Receive/Re-rad System Selection

- **Limited shop capacity => "pre-packaged" system that could work in Alaska**
- **Canvassed Edwards' Combined Test Force (CTF) lead test instrumentation engineers**
- **Global Power Bomber CTF had integrated receive/re-rad systems that were designed to operate in bomb bay environments**
  - **Tunable for receive and re-rad frequencies**
  - **Set-up via RS 232 interfaces; one laptop + SW**
  - **Measured system sensitivity to confirm utility**
  - **Iterative design w.r.t. antenna system**

Receive/Re-rad System Selection

– **Anomalies identified, developed procedures to fix**
– **Calibration and checkout imperative for success**
– **Unlikely ID/Fix could have been identified in the field**



TM Simulator Details

- TM receive /re-radiation system had to be tested and validated at the deployed location, prior to ground station arriving
- Selected bit error rate testing methodology
  - Minimal Equipment; Quantitative Results
  - Needed Mobile, simulated aircraft signal simulator
    - Extant Aircraft TM xmtr test mode could generate signal
      - 5 Mbps 2^{15}-1 Pseudo Random sequence – serendipity
    - Found small Pallet with xmtr & heat sink plus antenna
    - Developed power supply and mounting for truck

AFFTC

Sparing and Test Equipment

- All design and system selection included consideration of adequate spare components to accommodate system failures.
- General purpose test equipment (oscilloscope, spectrum analyzer, digital voltmeter …) was secured and deployed
  - enabled isolation fo component failures
  - Made spares viable
  - complemented the equipment deployed to do quantitative performance testing of the TTR/R system

Pre-Deployment Checkout/Test

AFFTC

- Integrated system was set-up and tested two days prior to tear-down packing
- Functional test on ramp in CTF compound
  - Test aircraft tx to TMR/R system with re-rad to GSU
  - Shorter slant-range; stationary aircraft
- Next day deployed TMR/R to Edwards tower
  - Successful TM acquisition and re-rad to GSU
    - Representative slant range, azimuth/elevation
    - Representative aircraft TM rate and antenna
    - Confirmed no EMC problems
    - Facilitated approval to install at deployment site tower

Deployed System Checkout/Test

- System assembled and set up at test location
- Aircraft TM simulator installed on vehicle
- Multiple "runs" over candidate test areas
  - Significant drop outs repeatable in prime area
  - Test aircraft taxi with xmtr in test mode were AOK
- Elected single antenna, manual tracking
- TMR/R system failed
  - Isolated problem (test equipment); installed spare

System Flexibility

- **After deployment and setup of the TMR/R system, the test areas were modified.**
  - **New area added**
    - **Longer slant-range; potentially obstructive trees**
    - **Narrow azimuth range for new tests**
    - **BER Testing validated TMR/R system for new area**
      - **Antenna mounting azimuth /elevation adjustment capability enabled proper pointing to optimize antenna gain.**
  - **Real-time TM enabled use of add'l parameters**
    - **External brake temp. measurements problematical**
    - **Instrumented brake temps were used – enabled 3 runs/day**
    - **Test execution time greatly reduced; shorter deployment**
    - **Saved resources; enabled timely test results/report**

Conclusions

- A low-cost, austere TM Receive and Re-radiate system can be assembled, tested and deployed successfully in a very short time if one has broad test range resources to draw from.
- Using existing TM systems in "unintended" applications may be the key to a successful system integration.
- One must follow systematic design methods to identify key performance parameters in order to provide a viable solution.
- One must functionally and quantitatively test as much of the system as possible, prior to deployment, and at the deployed location, to ensure adequate system performance.
- One must also design and implement deployable test systems required to stimulate/test a TMR/R system.
- Finally the resulting system must provide flexibility to meet new requirements after deployment.
- The limiting factors at the time of design and limited time to deliver the system were actually beneficial
  - drove a “Keep It Simple Stupid (KISS) approach
  - Ripple effect of this KISS approach definitely greatly reduced cost of the TMR/R system
  - KISS contributed to a supportable system once deployed.

Acknowledgements

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References

"Stopping the Raptor on Ice: A Detailed Approach for Low-RCR Brake Testing", presented at the Society of Experimental Test Pilots (SETP) 52nd Annual Symposium, September 2008

Stopping the Raptor on Ice

A Detailed Approach for Low-RCR Brake Testing