The On-Demand, Information-Driven Satellite Control Network

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Why On Demand and Info Driven?

- Responsive Automated Services to smaller missions[1]
- Flexible services[1]
- Demand access based on event – event-driven demand
- Enables missions to rapidly re-point instruments for observation of cosmic and earth-based events[1]
- Supports SV 911 initiative
- Supports availability, continuity of ops and mission assurance

[1] "THE NASA SPACE NETWORK DEMAND ACCESS SYSTEM (DAS)," Thomas A. Gitlin (NASA GSFC), Walter Kearns & William D. Horne (ITT Industries), Space Ops, 2002

Aspects and Capabilities for On Demand

- Global coverage
- Multiple contact/multiple access
- Supports all aspects of TT&C
- Supports all users – LEOs, MEOs, HEOs
- Supports all mission phases: launch, early orbit, anomaly resolution and on-station
- Guarantees availability of resources
- Mission assurance -- all mission phases

Aspects and Capabilities of On Demand

- Based on service-oriented architecture (SOA)
- Provides tiered views for monitoring, service execution, FDFI, performance and condition monitoring — app based
- Provides multiple tracking –all mission phases
- BEM –reduce contact time
- Exploits satellite house keeping
- Directive driven—match contact type/support to satellite activity blocks (SABs)
- Supports SV 911 initiative

Aspects/Capabilities of Information Driven*

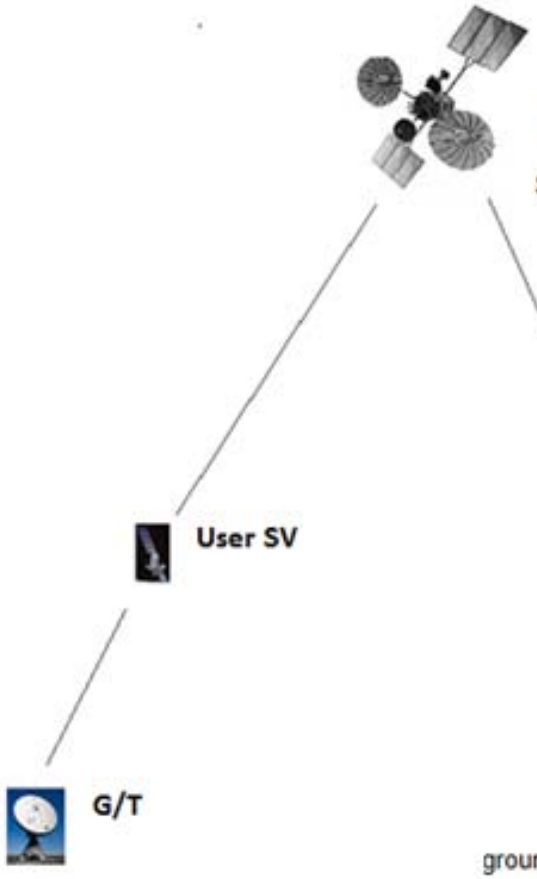
- Tiered view of system
  - Network
  - Site
  - Functionality /thread
  - Subsystem /LRU
  - LRU/book/panel
- Provides of view environment
  - Threats/situation awareness
- Provides analytics

*Supports continuity of ops, availability, mission assurance

Information/Knowledge

- Health— overall, to LRUs (DSPs), subsystems books, includes currents, temps (standard, mean)
- Performance—during support/contacts
  - Includes all TT&C (ranging, Doppler, TLM, etc.)
- Configuration and status –upon change
- Self test – off-line and online
- Situational awareness
- Analytics
- Trending/comparative analysis/recognition
- Across networks (if interoperable)

Present architectures –TDRSS n AFSCN



ground segment of TDRSS consists of three ground stations

Present Capabilities		AFSCN	TDRSS
Multiple Access		FDM	CDMA / Spread Spectrum
Multiple Contact		No	MA / BFN
SOA		ESD	SGSS
Tiered Architecture		RBC	NO
CBM+		RBC not Deployed	No
Accountability		Limited by interface	Not Tracking
Global Coverage		No - Terrestrial	Yes -for SV above
Information Driven		No	No
SOA Scheduling & Planning		Yes	Yes
Multiple Contact Tracking		No	No
App Capability		RBC	No
On Demand Access		No	DAS

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Present architectures (summary)

- Terrestrial systems – SA parabolic dishes
- Prior user scheduling and network coordination– works for fewer larger SV
- Not bandwidth efficient modulation (BEM) or spectrally efficient
- Maintenance is reactive or corrective
- Data intensive – archive everything
- Tracking –not low signal; Σ to Δ

Building Towards On-Demand

SEGMENT ALLOCATION	CAPABILITY	ARCHITECTURE
	Coverage	Site location /SV spatial range
	Directivity	Site/SV knowledge
	Multiple contact	Antenna type n number of antenna
LINK	Spectrum	Based on allocation
	Segmentation	Based on allocation
	Spectrum access	Multiplexing (FDM, CDMA, TDMA)
	Contact duration	Modulation - BEM/SV house keeping
	Tracking-all phases	Low signal tracking
	EIRP- all phases	Antenna design/type
	Availability of service	FDFI, CBM+ , app design
	Capacity design	# Of mission(s)/mission types requirement

Building Toward On-Demand

	SCHEDULING	SOA/KNOWLEDGE/AUTOMATED/GUI /APP
Network Cntl	Availability of network	FDFI, CBM+
	Flexible/event driven	Directive driven via MOC
	Cross-network	Interoperability
	911 event-driven	SV based directive --preamble/routing info
	Analytics	Trending --usage/ types

	CONTACT DURATION	SV HOUSEKEEPING / MISSION PHASE/BEM
SV/User	Directive-based	SABs --for MVRS, OBC, TLM, science/ mission
	911 event-driven	Preamble -- Site/MOC directives
Mission Assurance == Link + Network Cntl + SV/User Note: Does not cover gateway Site to MOC /SOC		

TDRSS DAS and AFSN GDPAA insertion*

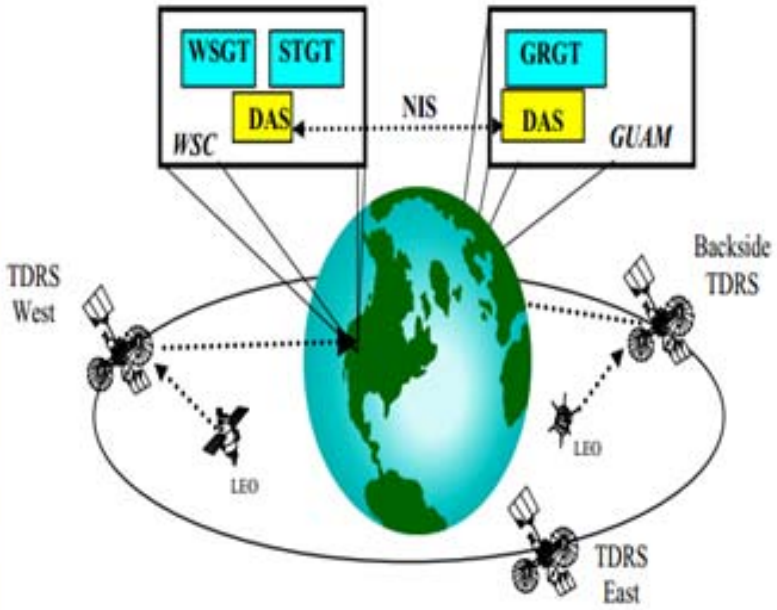
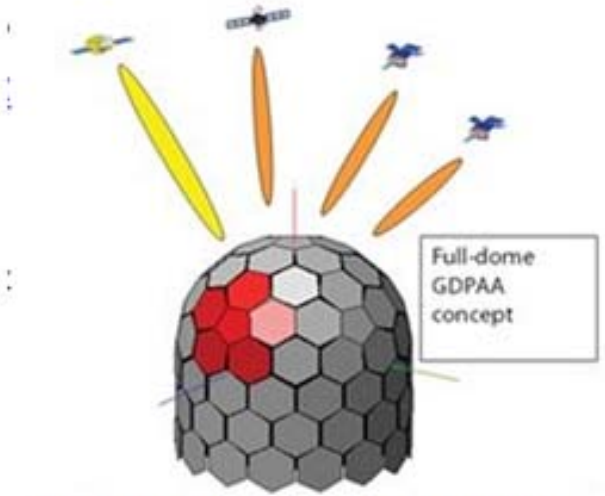


Figure 1: NASA Space Network and DAS



The Geodesic Dome Phased-Array Antenna Advanced Technology Demonstration proved the antenna's capacity to provide multiple, simultaneous, dual-band (L-band and S-band) contacts for telemetry, tracking, and command of Air Force Satellite Control Network satellites.

*A good start if exploited or implemented

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Architectural Drivers

- Coverage— SV in view
- Tracking — user/SV position location (ephemeris); low signal level
- Multiple contact antenna – phased arrayed systems
- Multiple access waveforms
- Coordination alleviation (automation)
- SV 911 initiative
- Directive driven based on SABS/contact type
- Info based, CBM+, tiered FDFI

Types of Maintenance Programs

Two types of maintenance:

1. Reactive or corrective maintenance
2. Preventive maintenance

Preventive maintenance is divided into:

- Planned maintenance
- Condition-based or predictive maintenance

Summary

- Exploit SABs, SV housekeeping
- Reduce contact time (BEM, spectral efficiency)
- Increase capacity (multiple contact/multiple access)
- Develop low signal detect tracking (find/detect SV 911 call)
- Develop MA/BFN scanning to detect 911 call
- Develop tiered views for FDFI and CBM+
- Provide trending/analysis and analytics (cloud)
- Store information not data (cloud)
- Recognize dedicated demand missions

Info Driven/Tiered Architecture -FDFI/ CBM+/Apps

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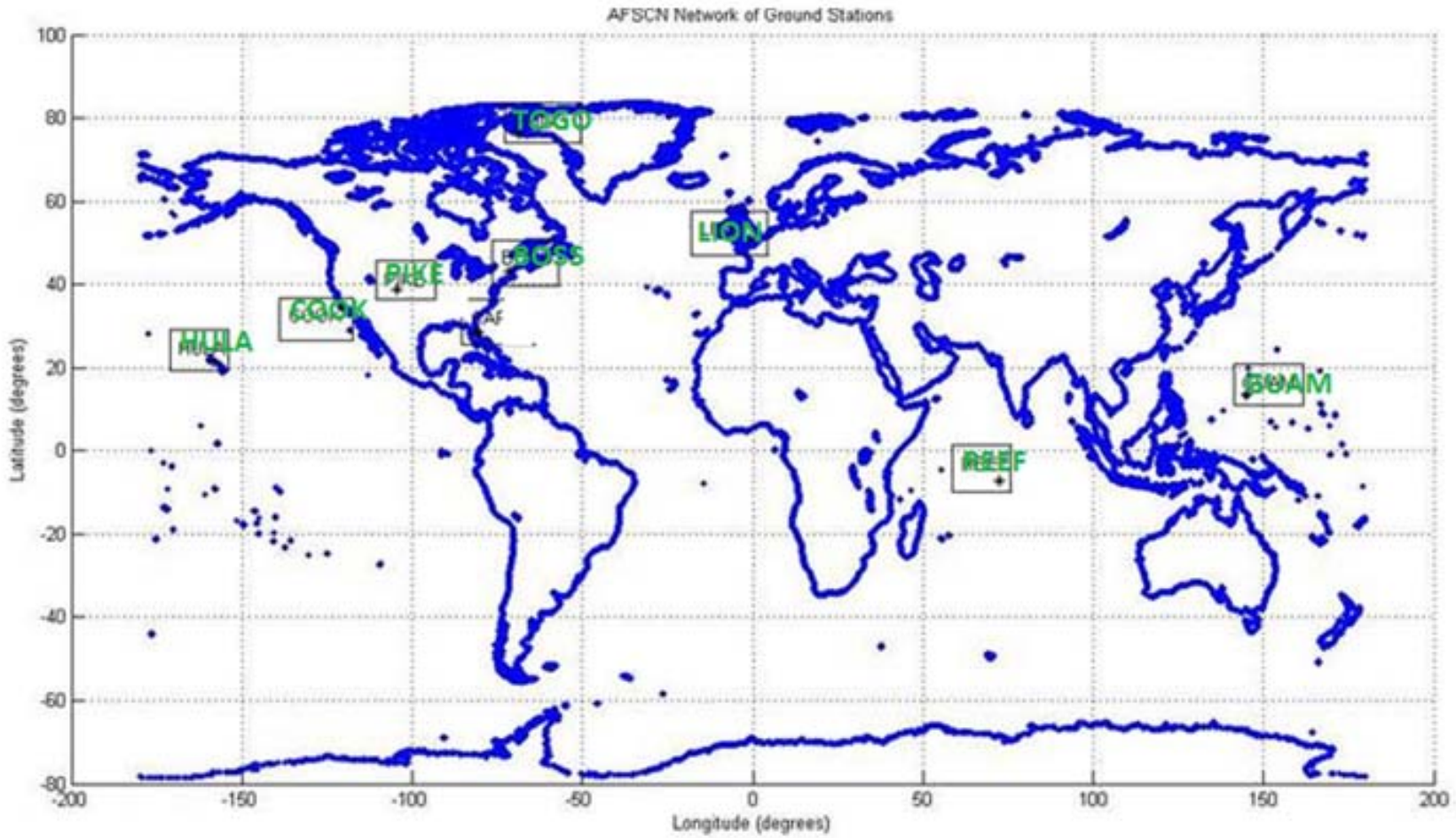
Back up charts

AFSCN (Top Tier) -- All Green



User clicks "COOK" site ICON/app icon

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First Tier at Site – FDFI Summary Performance

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Second Tier FDFI – LRU

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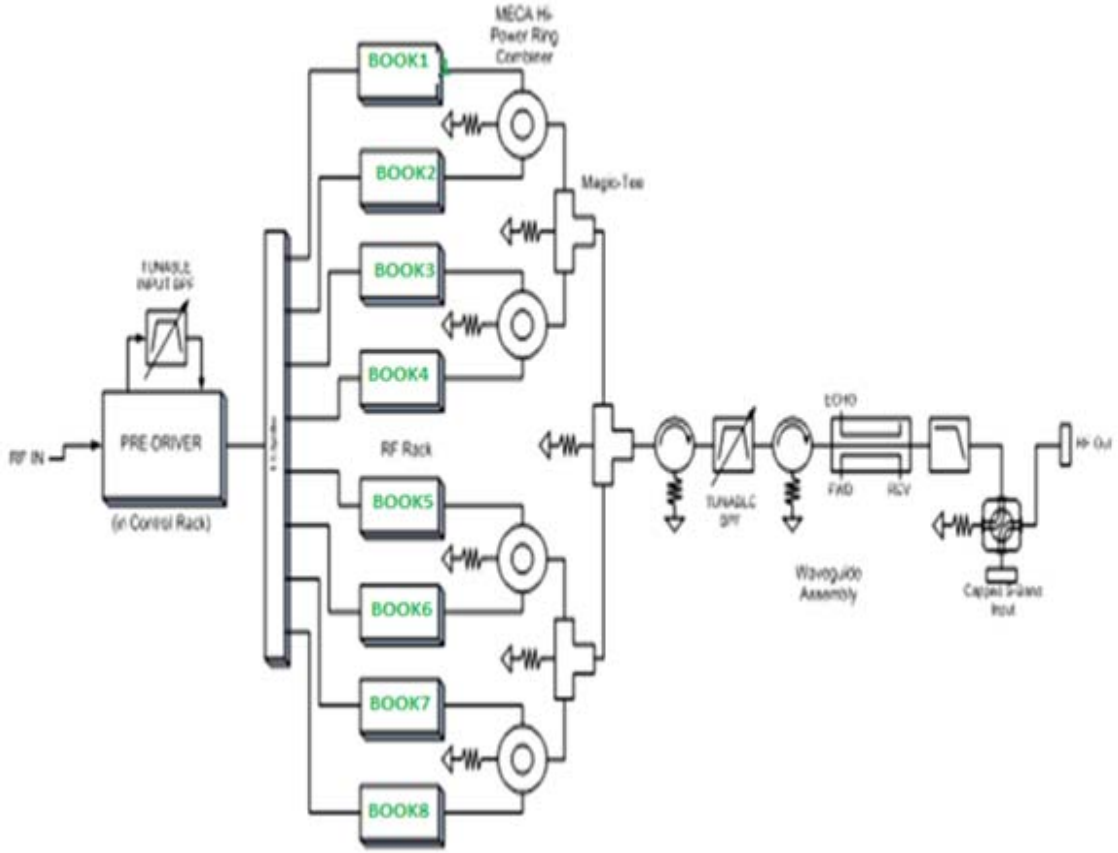
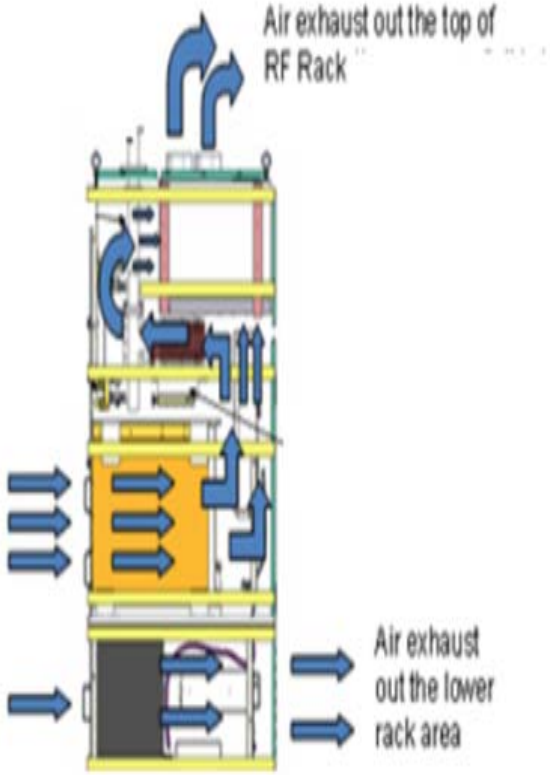
2nd Tier HPA Subsystem – RF Combining





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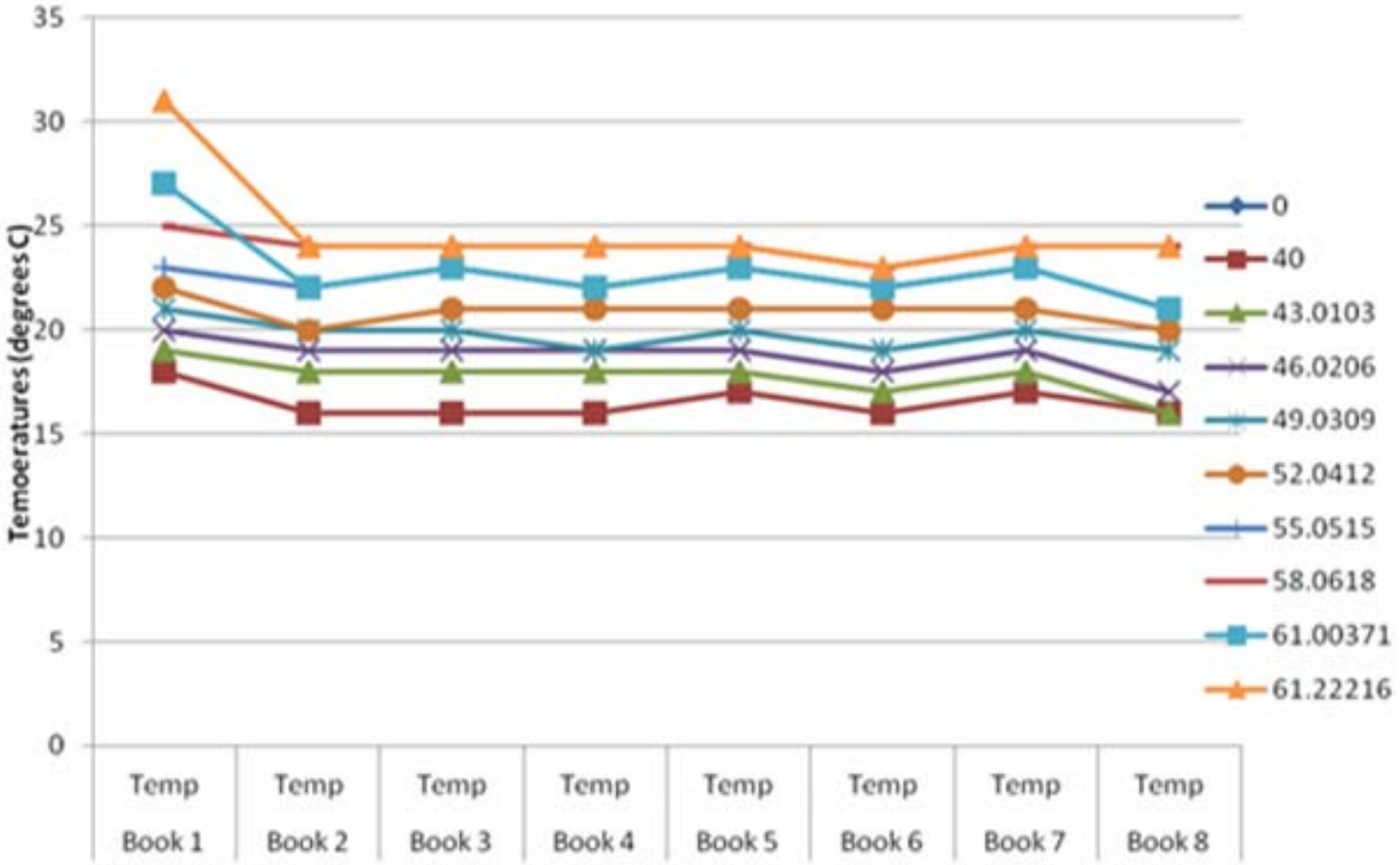
Book Temperatures vs Total Output Power



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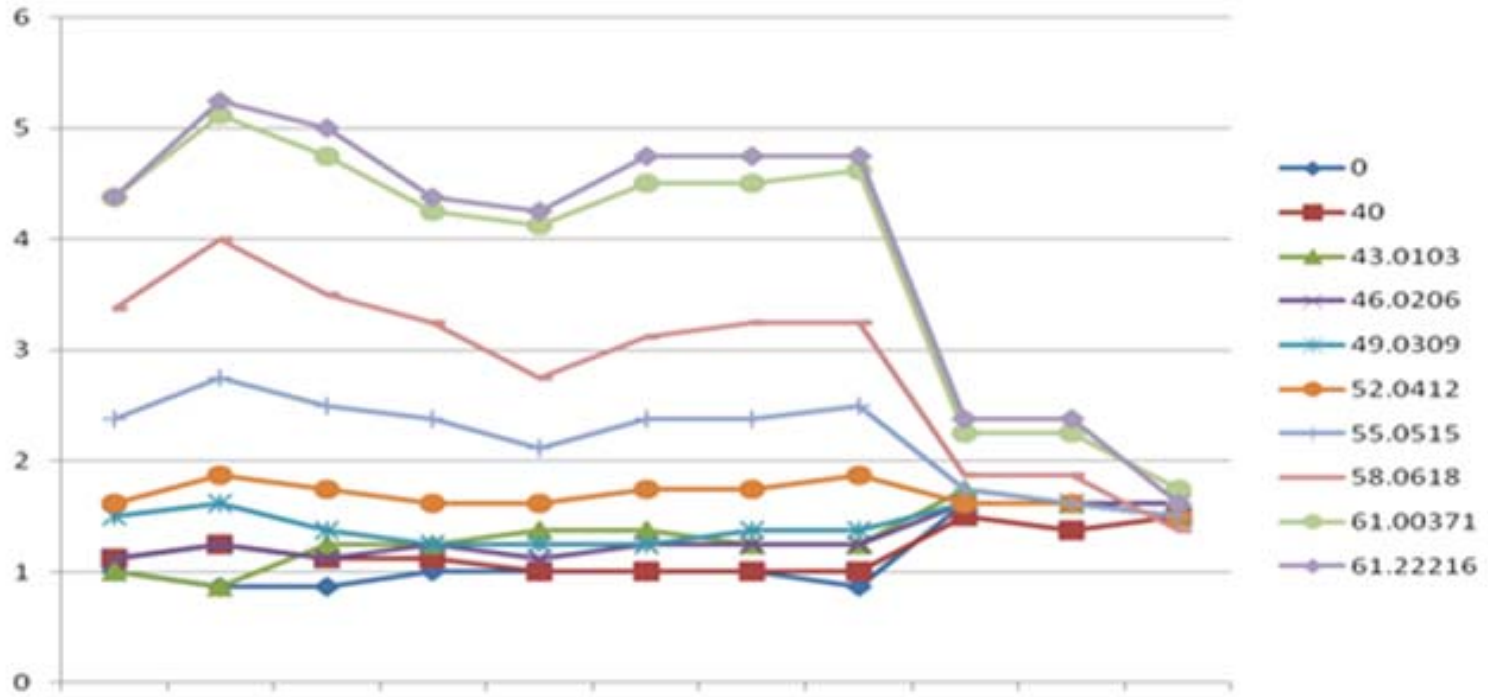
Internal Book Currents vs Total Power



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G/T types of Information

RTS types of information (data)

- FDFI information
- Performance data- real-time data during SV contact
- Configuration/status data – upon change
- Health – preprocessed data
- Long-term trending data – processed data at site

References

1) "THE NASA SPACE NETWORK DEMAND ACCESS SYSTEM (DAS)," Thomas A. Gitlin (NASA GSFC) ,Walter Kearns & William D. Horne (ITT Industries), Space Ops, 2002

2) "Inserting the GDPAA into the AFSCN," Unpublished Aerospace TOR, Bruno J. Calanche, December 2004

3) "Advanced Ephemeris Update Receiver" Air Force SBIR, Bruno Calanche and Capt . Joe Spagnolia , Vinay Swimanathan 2011

4) "RTS Performance Monitoring (RPM) – Guidance for Prototype Development," Bruno Calanche ,Capt. Joe Spagnolia, Vinay Swimanathan, 2010

5) "Condition Monitoring of a High-Power Amplifier Subsystem based on RF Combining using a Built in Self-Test and Performance Templates," Bruno Calanche , unpublished technical memo, Feb. 18, 2012—possible submission to IEEE


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