



Quantitative Capability Delivery Increments (QCDI): a Novel Approach for Estimating and Assessing DoD Future Network Needs

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QCDI Bottom Line Up Front

- **QCDI demand model provides quantitative estimates of DoD Joint network user demand over three eras**
 - 2012, 2016 and 2020
- **Covers information transport, enterprise services, information assurance, and network management joint capability areas**
- **QCDI in use throughout the community, as acknowledged by recent meetings with Services and Joint Staff**
 - Applied to approximately 20 major studies/analysis efforts across DoD
- **Versions 1 and 2 of the demand model are complete and data is available to the NC community: qcdi.rand.org (password required)**
- **Model added to OSD/CAPE M&S tools registry: <https://jds.cape.osd.mil/Default.aspx> (CAC required)**



Outline

- **Background**
- **Net-Centric Joint Capability Areas**
- **User and device perspectives on network demand**
- **QCDI user areas**
- **QCDI device types**
- **QCDI metrics**
- **Summary**



Why Are DoD'S Bandwidth Needs Growing?

- **“There’s a world market for maybe 5 computers.”***
 - There will be 1 billion PCs on Earth by 2009
 - Google data centers contain over 3M processors**
- **“640 kbytes of RAM ought to be enough for anyone.”*****
 - Current PC memory sizes ~ 1-2 GB
 - HP building 4 PB data warehouse
- **Digital information continues to grow at a rapid rate**
- **Digital Information has to be moved to be useful**
 - Increasingly data is easy to store, but difficult to move...

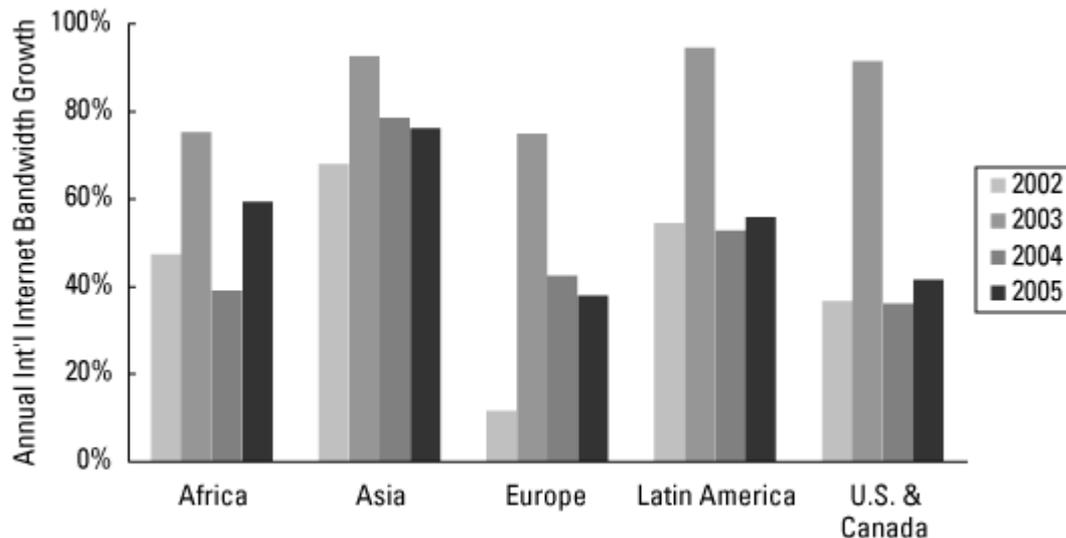
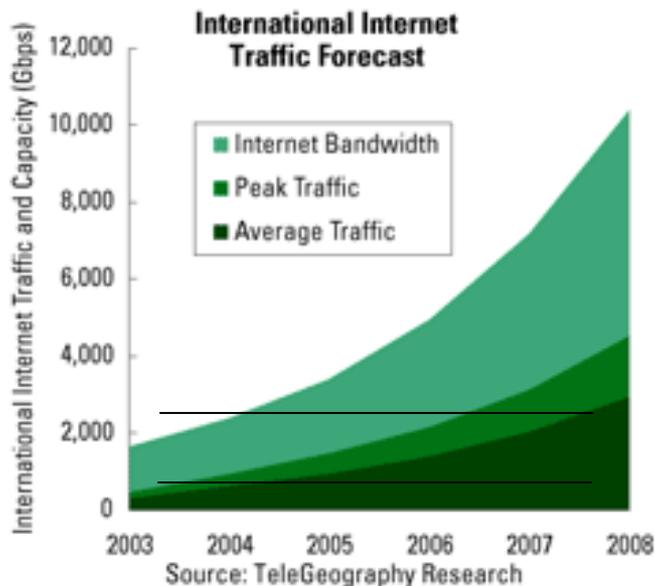
* IBM CEO Thomas Watson, 1943.

** Randall Bryant, CMU, Data Intensive Supercomputing, 2008.

*** Microsoft CEO, Bill Gates, 1980.



Internet Bandwidth Demand is Growing At Exponential Rates



© PriMetica, Inc. 2005

- **Global peak demand is doubling every two years**
- **Demand in Asia growing by 80% a year mid decade**
- ***Increased use of video and online collaboration will drive network traffic to an annual growth rate of between 300% and 500% over the next several years****
- **How will DoD bandwidth demand grow in the future?**

*John Chambers, Chief Executive CISCO Systems, NXTcomm telecommunications industry trade show, June 19, 2007

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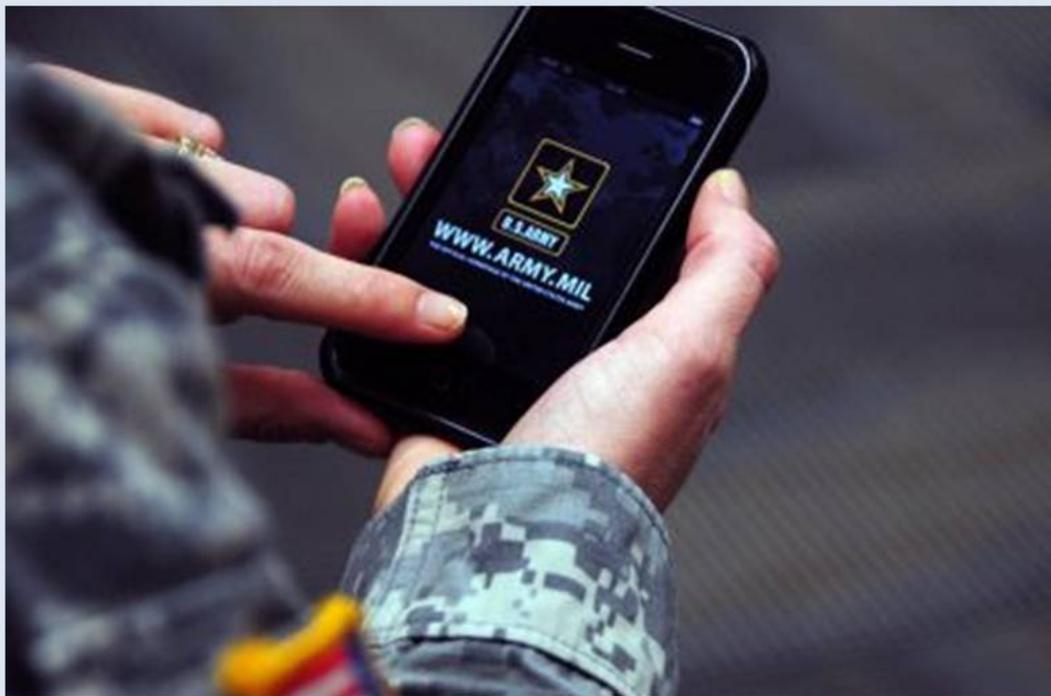
Nexus of Increasing User Demands - Increasing Capability of Mobile Devices



- The “Smartphone Tsunami” is creating user demand....



Army is Testing Smart Phones

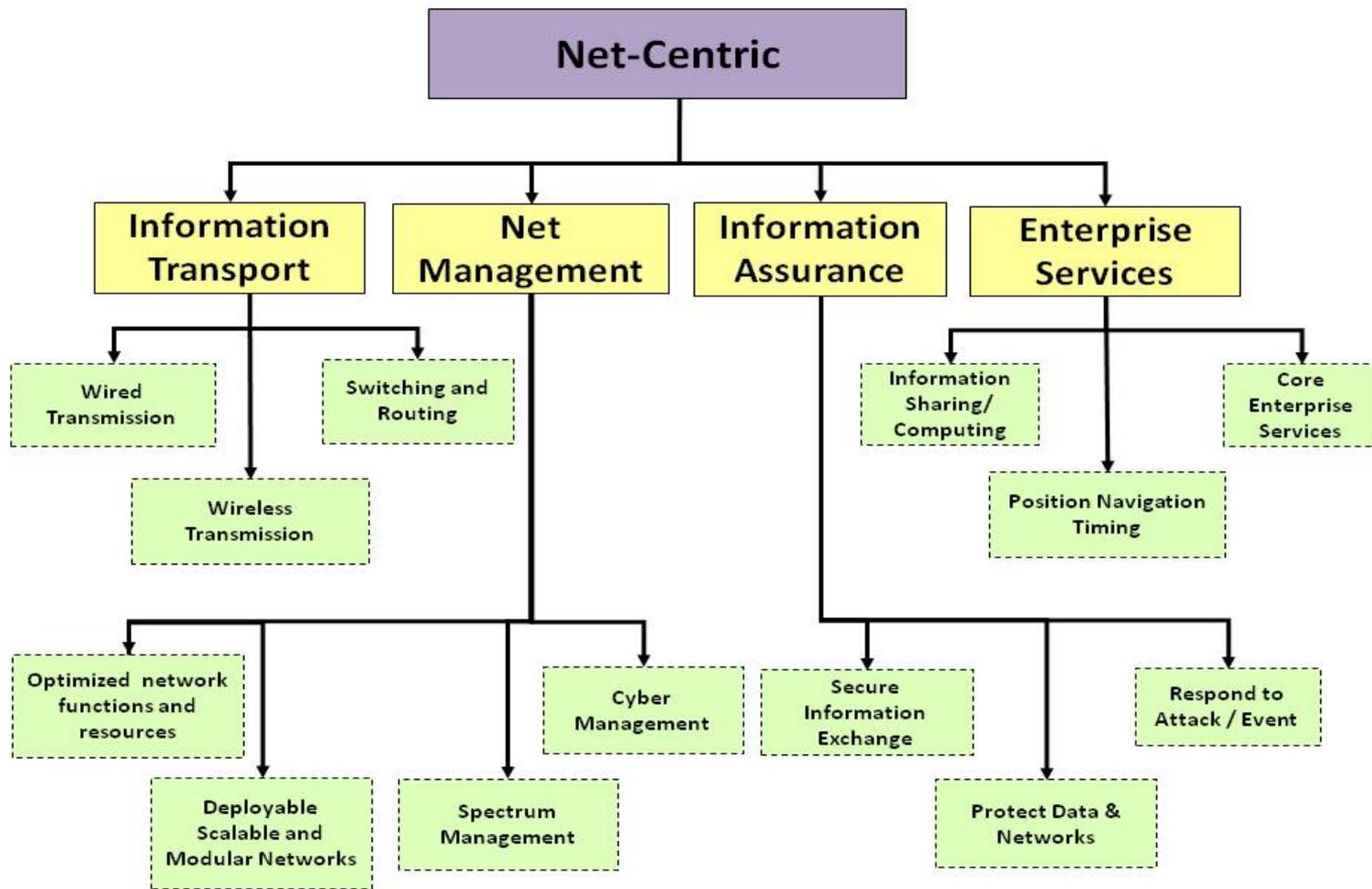


Soldiers and others can now read the latest Army news on their iPhones, thanks to a new application created by the team that developed the Army's Web site, (Photo by U.S. Army)

- **“ Army soldiers will get an “iPhone-like device” with digital apps installed and ... “various apps for system maintenance, instruction manuals”**
 - MG Keith Walker, director of the Army’s [Future Force Integration Directorate](#) at Fort Bliss



DoD Net Centric Joint Capability Areas

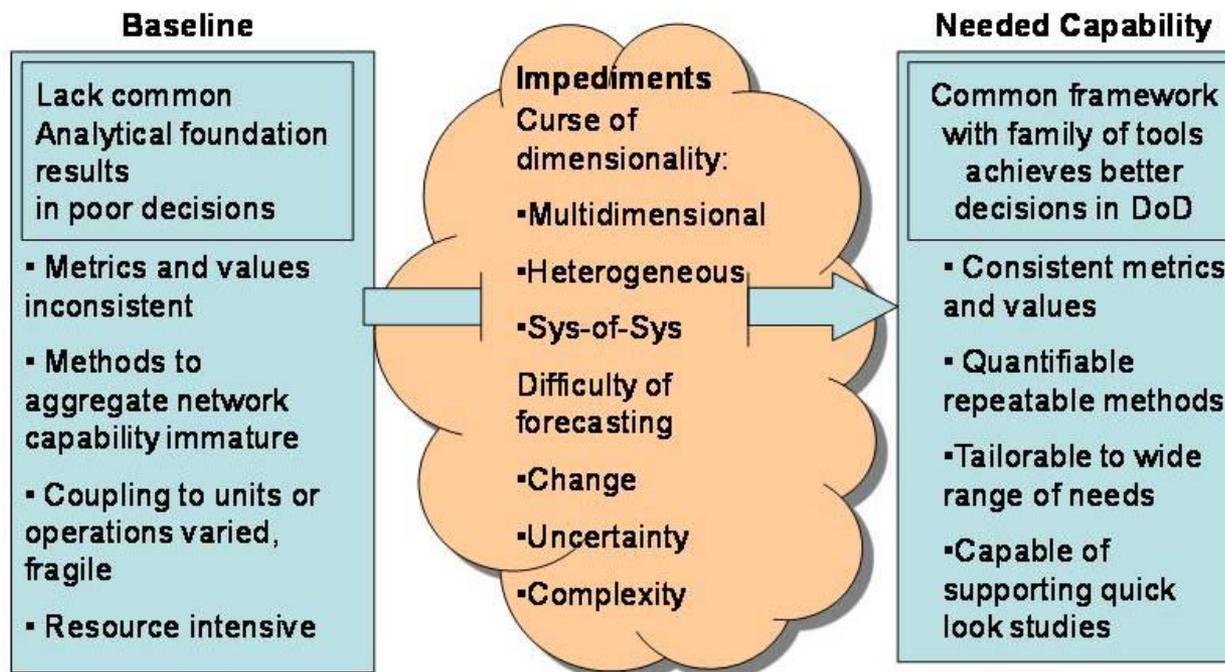


- DoD networks provide more than just bandwidth
- Demands in all areas need to be estimated, understood



New Methods Needed to Meet the Analytic Challenge of Estimating Future Network Needs

The Analytical Challenge: rapidly determining how much network capability is enough to support a wide-range of future missions



- A comprehensive assessment framework is needed that covers all net-centric JCAs



QCDI Demand Model for Joint Network Needs

- **Approach:**
 - Take a joint perspective
 - Integrate over all users
 - Integrate over all user devices
 - Include all network enabled

- **To determine network capability needs from a joint perspective a number of assumptions are needed**
 - That are applicable across spectrum of joint operations and organizations

- **Important assumptions**
 - Users, regardless of Service, can be grouped into classes with similar network demands
 - Demand for Joint network capability may also be different at different echelons and domains



QCDI User Classes by Domain (Ground, Airborne, Maritime) and Tier (Core, Intermediate, Edge)

		Core	Intermediate	Tactical Edge
Ground Terrestrial/ Airborne Maritime	Terrestrial/	Local Worker CP High CP Low Commander USS High USS Low UAS High UAS Low Static Sensor	Dismnted Ground Surface Mobile Local Worker CP High CP Low Commander USS High USS Low UAS High UAS Low Static Sensor	Dismnted Ground Surface Mobile Local Worker CP High CP Low Commander USS High USS Low UAS High UAS Low Static Sensor
	Airborne		Commander C2 Air ISR Air UAS High	Commander LO Air Mobility Air TAC Air UAS High
	Maritime		Surface Mobile Local Worker CP High CP Low Commander USS High USS Low UAS High UAS Low Static Sensor	Surface Mobile Local Worker CP High CP Low Commander USS High USS Low UAS Low Static Sensor



Deriving Warfighter Needs

- **Establish warfighter need framework**
 - User needs vary by domain and echelon
 - Users needs mitigated by what is feasible
- **Use CDI to identify appropriate metrics and values**
 - Architectural assumptions documented
 - Other sources and engineering judgment applied
 - Needs vary by time

User Classes Framework

	Core	Intermediate	Tactical Edge
Terrestrial / Ground	Local Worker	Local Worker	Dismounted Ground
	CP Large	CP Large	Surface Mobile
	Commander	CP Mobile	Local Worker
	Local Unmanned System	Commander	CP Mobile
	Primary Unmanned	Local Unmanned System	Commander
	Smart Agent	Primary Unmanned	Local Unmanned System
	Static Sensor	Smart Agent	Smart Agent
	ES Infrastructure	Static Sensor	Static Sensor
	NM Infrastructure	ES Infrastructure	ES Infrastructure
	IA Infrastructure	IA Infrastructure	IA Infrastructure
Airborne		CP Mobile	Commander
		Commander	LO Air
		C2 Air	Mobility Air
		ISR Air	Tac Air
		Primary Unmanned	Primary Unmanned
		Smart Agent	Smart Agent
		ES Infrastructure	ES Infrastructure
		IA Infrastructure	IA Infrastructure
		NM Infrastructure	NM Infrastructure
	Maritime		Surface Mobile
		CP Large	CP Mobile
		Local Worker	Local Worker
		Commander	Commander
		Smart Agent	Local Unmanned System
		Static Sensor	Smart Agent
		Local Unmanned System	Static Sensor
		Primary Unmanned	ES Infrastructure
		ES Infrastructure	IA Infrastructure
		IA Infrastructure	NM Infrastructure

Capability Improvements

CDI Coordinating Draft

- + Architectural Assumptions
- + Technical Feasibility
- + Existing Body of Work

User Metrics and Values

Metric	Dismounted Ground	Surface Mobile
Cross-Domain Transfer Time(sec)		1200
Validation Time(min)	13406	13406
IAMMj Time(min)	4824.33	4824.33
Redge production rate(%)	33%	33%
DAR compromise time (days)	20	20
Compliant COMSEC Tier		
Intrusion Detection Time (min)		
ONDR response Time (min)		
Sharing Factor		
Cross-Domain Transfer Time(sec)		1200
Validation Time(min)	13406	13406
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Compliant COMSEC Tier		
Intrusion Detection Time (min)		
ONDR response Time (min)		



QCDI Metrics by Net-Centric JCAs

Information Transport

- Typical Req. DR (Mbps)
- Protected Comm. DR (Mbps)
- Voice DR (Mbps)
- Availability (%)
- Voice Packet Delivery Ratio (%)
- Packet Delivery Ratio (%) (min)
- Comm. Set-up time (min) (max)
- Data End-to-End Delay (sec) (max)
- Voice End-to-End Delay (sec) (max)
- Upload (%)
- External Traffic (%)

Information Assurance

- Cross-Domain Transfer Time (sec)
- Validation Time (min)
- Authorization Management Time (min)
- Pedigree production rate (%)
- DAR compromise time (days)
- Compliant COMSEC Tier
- Incident Detection Time (min)
- Incident Response Time (min)

Enterprise Services

- Amt. Assured Data Storage (GB)
- Service Discovery Requests (Req/Hr)
- Chat Requests (Req/Hr)
- Auth. Serv (Req/Hr)
- Email (Req/Hr)
- Search (Req/Hr)
- File Dlvry (Req/Hr)
- DNS (Req/Hr)
- Service Discovery Response Time (sec)

Network Management

- Interoperability Depth - Network Tier #
- Response Time (sec)
- Time to Refresh contextual SA (sec)
- Priority Information Delivery Mgt (%)
- Connection Resilience (%)
- End User Device RF Spectrum Eff (bps/Hz)
- RF Spectrum Reallocation Time (sec)



QCDI Device Types

DEVICE TYPE	DESCRIPTION
Direct BLOS –	User demand directly supported through a BLOS wireless device (generally direct use of a low data rate SATCOM terminal).
Direct LOS –	User demand directly supported through use of line-of-sight (LOS) wireless device.
Indirect –	User demand not directly supported by a wireless receiver or transmission device. This demand is aggregated with demand from other users before transport outside of local area networks.



Aggregating Joint User Needs

- **The QCDI accomplishes this by representing groups of users, based on real organizations**
- **Joint users of a specific organizations are mapped to an appropriate mixes of users from the QCDI user classes**
 - In appropriate domains, echelons and eras
 - Including non-human users such as unmanned systems and sensors
- **QCDI Model currently characterizes 360 military organizations across echelons and from all Services**
- **Human organization of most units assumed to be static over the timeframes considered in the QCDI**
 - 2012, 2016, and 2020
- **QCDI recognizes rapid growth in the use of unmanned systems**
 - Air, ground, and maritime robotic systems



Aggregation Formulas Include Overhead Factors, Sharing Factors and Duty Cycles

$$\begin{aligned} DR_{unit} &= \left(\sum_j \sum_{i \text{ in } j} DR_i \right) OH \\ &= \left(\sum_j N_j (DDR_j) (SF_j) (DC_j) (1 + ADF_j) \right) OH \end{aligned}$$

$$OH = (1 + ES + NM)(1 + IA)$$

Sum is over all users and all user devices

Where DDR_i is the *device* Data Rate for i 's demand device

SF_i and DC_i are i 's Sharing Factor and Duty Cycle

ADF_i is the *agent demand factor* for a particular user device



Screenshot of Options in the QCDI Tool

QCDI Demand Model Tool

High Level Unit Aggregation

Raw Data

Monte Carlo Sensitivity Analysis

Version 1.06

Utilities

File Locations User Matrix Refresh Tool Data

Testing Data Management



QCDI Web Based Tool



Unit Level Aggregation

[Return to Front Menu](#)

Capability Area
 Era
 Connection
 Metric

[Movement Options \(Show/Hide\)](#)

Marine Units

- Army Units
- MEB (USMC)
- Army Combat Teams
 - HBCT (USA)
 - STRYKER BCT (USA)
 - IBCT (USA)
 - ACR (USA)
 - MEB (Maneuver Enhancement Brigade) (USA)
 - AV BDE (USA)
- AF Air

CJTF [\(Clear\)](#)

Unit	Quantity
HBCT (USA)	1
STRYKER BCT (USA)	1
IBCT (USA)	1

Total Aggregation

Unit	Quantity
HBCT (USA)	9.00
STRYKER BCT (USA)	6.141
IBCT (USA)	4.491

[Aggregation Overview \(Show/Hide\)](#)

Aggregation Overview

UNIT AGGREGATION RESULT	HBCT (USA)	STRYKER BCT (USA)	IBCT (USA)	CJTF AGGREGATE
Total Users	4178.03	2160.67	1918.66	8257.359
Typical Req. DR	8.93	6.141	4.491	19.562

- [HBCT \(USA\) \(Show/Hide\)](#) -- [Export](#)
- [STRYKER BCT \(USA\) \(Show/Hide\)](#) -- [Export](#)
- [IBCT \(USA\) \(Show/Hide\)](#) -- [Export](#)



Summary

- **QCDI demand model provides quantitative estimates of DoD Joint network user demand over three eras**
 - 2012, 2016 and 2020
- **Covers information transport, enterprise services, information assurance, and network management joint capability areas**
- **Covers over 350 military units in the DoD at all network tiers**
 - Core to tactical edge
- **QCDI in use throughout the community, as acknowledged by recent meetings with Services and Joint Staff**
- **Versions 1 and 2 of the demand model are complete and data is available to the NC community: qcdi.rand.org (password required)**
- **For 2010, focus is on building an Irregular Warfare version and providing link-by-link outputs to support Mission Assurance and other analysis needs**



Questions?