Status Report & Highlights from the Subcommittee for the Examination of the Role and Efficiency of Networking and Networking Research within the Office of Science

Ellen B. Stechel, Presenting

14-August-2007

The Charge:

"weigh & review the organization, performance, expansion, and effectiveness of the current operations of ESnet. .. consider the proposed evolution of ESnet, its appropriateness and comprehensiveness in addressing the data communication needs .. that will enable scientists nationwide to extend the frontiers of science. .. make suggestions and recommendations on the appropriateness and comprehensiveness of the networking research .. with a view towards meeting the long-term networking needs .."

The Distinguished Panel

Last Name	First Name	Affiliation
Bailey	Ron	ASCAC Member
Cheswick	Bill	Lumeta Corporation (on sabbatical)
Corones	Jim	Krell Institute
Foster	Ian	ANL & U. of Chicago
Hitchcock	Dan	OASCR Liaison
Huntoon	Wendy	Pittsburgh Supercomputing Center (PSC)
Newman	Harvey	California Institute of Technology (Caltech)
Rahn	Larry	SNL & DOE-BES-Chemical Sciences
Simon	Horst	ASCAC Member
Sobieski	Jerry	Mid Atlantic Crossroads (MAX), Dir of Res Initiatives
Stechel	Ellen	Chair & ASCAC Member
Williams	Dean	LLNL
Wing	Bill	Co-Chair & ORNL

Interpreting the Charge

- Cornerstone and Framing:
  - **“that will enable scientists nationwide to extend the frontiers of science.”**
- Other Key Phrases
  - With respect to ESnet
    - ***Expansion and effectiveness of current operations, Proposed evolution***
    - In light of the Lehman review, this is de-emphasized and the panel’s report will primarily site that review
  - With respect to needs
    - ***Data communication needs***
    - ***Long-term Networking needs***
    - The panel has been focusing on higher level needs and beyond requirements driven
  - With respect to Networking Research to meet long-term needs
    - ***Appropriateness and comprehensiveness of the Networking Research***
    - The panel has been focusing more on vision and strategy or guiding principles for the research portfolio
- Timeframe – **5-10 Years**

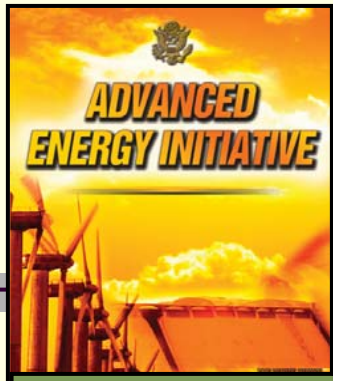
Methodology

- **Meet Regularly**
  - Biweekly **teleconference calls**
    - The panel has met 13 times
- **Draw on and Synthesize From a Number of Information Sources**
  - **"Testimony"** and Panel discussions
    - One or two "non-panelists" at some of the teleconferences
      - W. Polansky, D. Hitchcock, C. Catlett, B. Gibbard, & R. Mount
  - One day Panel discussion at and with **ESNet**, 13-Apr-2007
  - **Workshops & existing reports**
    - ESnet R&D Workshop, April 2007
    - BES- & BER- ESNet Networking Requirements Workshop
    - Uploaded or linked to the Panel's dedicated & access controlled website
  - **Reference websites:**
    - ASCR, ESNet, NITRD, NSF-OCI, Teragrid, OSD, Globus, etc.
- **"Divide and Conquer" Writing Assignments**
- **Feedback** from ASCAC, the OASCR Program Managers, and External Review

Timeline

- Panel Reformulated – Completed Jan 2006
- Teleconferencing, Web Meeting Capability, and Website Established – January 2007
- Two Teleconferences in February
- Status Report – ASCAC Tues 27-Feb-2007
- Bi-Weekly Meetings On-going – 13 to Date
- ESnet Visit (13-April-2007)
- Status Report – ASCAC 14-Aug-2007
- (Bi-Weekly Teleconferences Continues) and Writing Assignments
- DRAFT Preliminary Report – Distributed to ASCAC ~23-Oct-2008
- Preliminary Report – ASCAC 6-Nov-2007
- Final Report – Jan 2008

Disclaimers



- **The case for DOE Science has Already Been Made Including that for:**
  - Petascale computing,
  - Petascale data
  - Large science facilities
- **It is also Clear to the Panel that**
  - The Office of Science leads all agencies in funding the US physical sciences
  - DOE has critically urgent needs in addressing Energy and National Security issues
- **The Panel Recognizes that**
  - Information technology is undergoing a revolution everywhere
  - The Interagency Task Force on Adv. Networking is tasked with providing a strategic vision of future networked environments
  - DOE request is 12.1% of the NITRD (Networking and Information Technology R&D) 2008 Budget Request of $3B
    - 11.3% of the LSN (Large Scale Networking) of $419M
    - NSF 32.5% of the NITRD Budget Request & 25.5% of LSN

Some Notable Trends

- **DOE Science is growing more data-intensive and international in scope.**
- **Experimental facilities are relying more on working in concert with computation for data management, visualization, and interpretation.**
- **Effectively managing data is increasingly multi-dimensional and challenging, but often taken for granted and rarely rewarded.**
  - Generation, Access, Mining, Analyzing, Synthesizing, Integrating, Storing, Retrieving, and Preserving
- **Science is rapidly moving towards greater and more distributed collaborations and shared resources.**
  - Benefit derived from reduction or elimination of temporal and spatial constraints
  - These collaborations or virtual communities are
    - Often self-organizing and depend heavily on being able to establish trust
    - Might be temporary or rapidly reconfiguring
- **Learning and communicating is still a very visual and "contact sport."**
- **DOE Science is widening the gap between network needs and commercial capabilities.**

Major Findings Around Four Topics

- **The Need for a Strategic Vision for the Network and Networking Research**
  - With full Stakeholder Buy-in
- **The Importance of the Network and Networking Research in Enabling DOE Science**
  - Focused on DOE mission-driven science requirements
  - Naturally complementary to NSF, other agencies, and commercial investments
- **Emerging Unmet needs Driven by Petascale Science:**
  - New data-mobility issues including archiving, remote access, re-usability, sharing
  - New issues surrounding distributed collaboration and virtual communities of practice or interest
  - New issues surrounding remote control of experiments or real-time computational steering
- **The 'Interface', 'Valley of Death,' or 'Chasm' Issues – Bridging & Connecting:**
  - Research to test bed-like deployment to production
  - Programmatic stovepipes

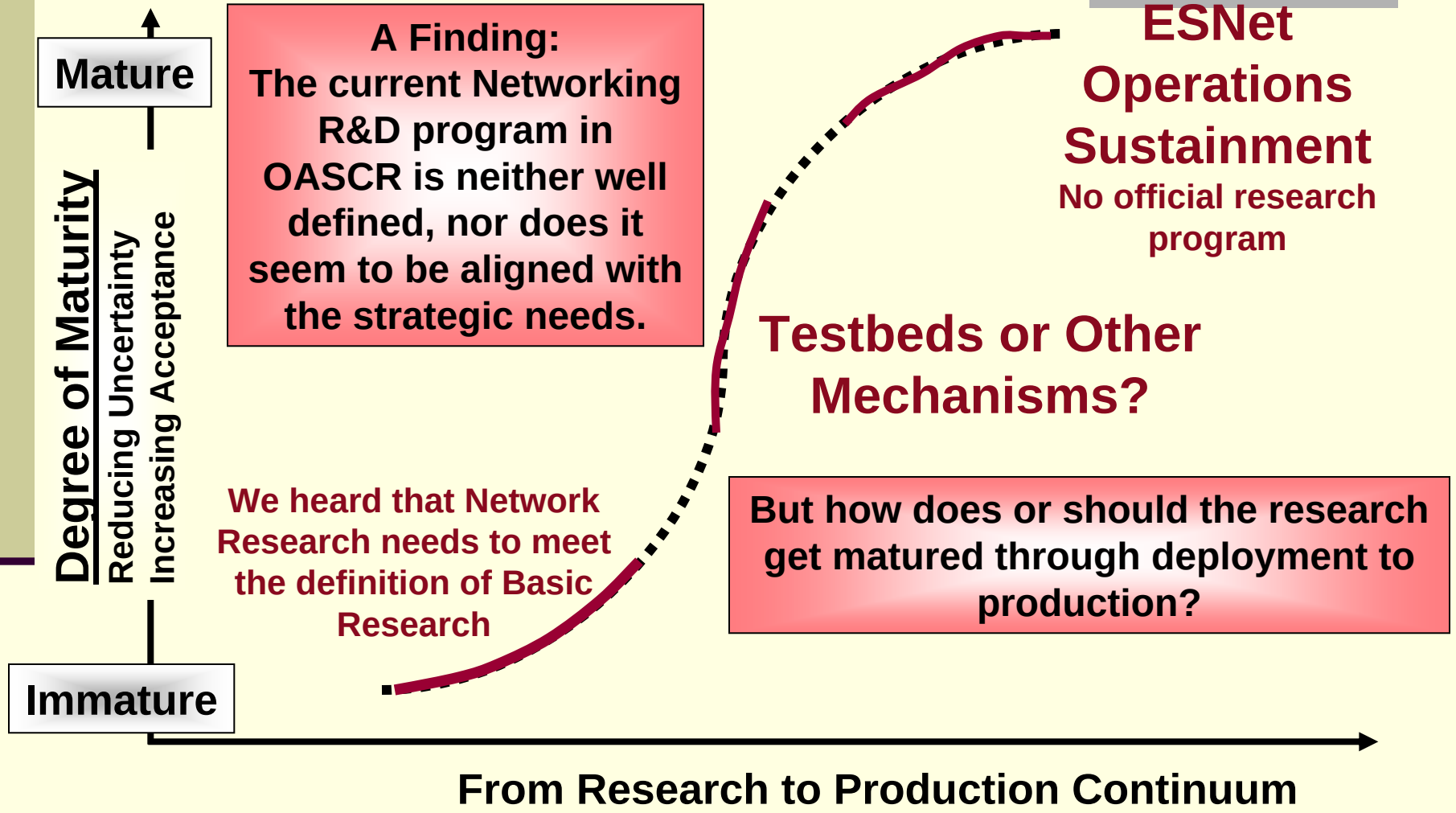
A Few Themes Keep Coming Up

- Esnet Has Done an Excellent Job of Deploying an Optimized and Cost-Effective Network (Including Science Data Network)
- Esnet Has Been Effective in Delivering Bandwidth and Staying Ahead of the Curve
  - Including rapidly and effectively "productizing" circuit switching, as developed by UltraScience Net.
- But …
  - The panel sees a number of 'Chasm' or 'Valley of Death'-like issues
  - The panel sees a complex interdependency of ESNet, Network Research, DOE Science, Facilities, … that pose some unique management challenges – because it is really a **System of Systems**

OASCR's Unique Interface-, 'Valley of Death-' or 'Chasm'-Like Issues

- Gap between Supercomputing Program and Networking Program
  - Supercomputing buys cycles but has no apparent responsibility to improve coupling to the network
  - Network program buys bandwidth, but has no apparent responsibility for improving I/O on a supercomputer
- Similar Gap in Security Arena (switched-circuits vs. firewalls)
- And Who Has The Responsibility To Create Network-Aware Application Codes?
- And More …

The Need to Define 'Guiding Principles' for Network Research



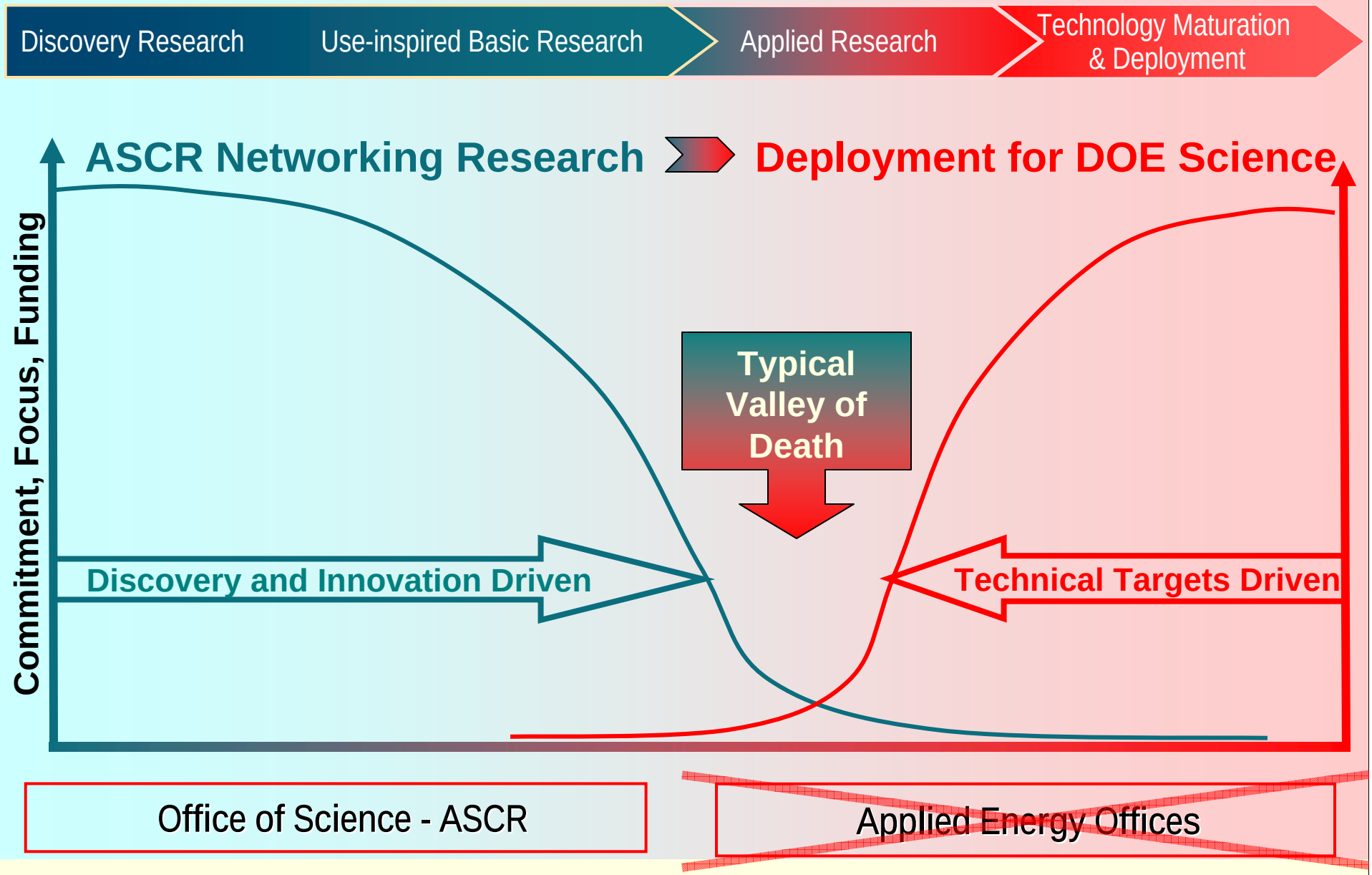
Is There an Analog for Networking Research in the BES Model?

Discovery Research	Use-inspired Basic Research	Applied Research	Technology Maturation & Deployment
▪ Basic research for fundamental new understanding, the science grand challenges. ▪ Development of new tools, techniques, and facilities, including those for advanced modeling and computation	▪ Basic Research for new understanding specifically to overcome short-term showstoppers on real-world materials in the DOE technology programs	▪ Research with the goal of meeting technical targets, with emphasis on the development, performance, cost reduction, and durability of materials and components or on efficient processes ▪ Proof of technology concept	▪ Scale-up research ▪ At-scale demonstration ▪ Cost reduction ▪ Prototyping ▪ Manufacturing R&D ▪ Deployment support

Office of Science - BES
Goal: new knowledge / understanding
Mandate: open-ended
Focus: phenomena
Metric: knowledge generation

Applied Energy Offices
Goal: practical targets
Mandate: restricted to target
Focus: performance
Metric: milestone achievement

But: No Analog to the Applied Energy Offices



These "Gap" Issues are Characteristic of a Larger Problem

- **This "Larger Problem" Is Not Totally Unique And Arises In Other Contexts**
- **The Network And Networking Research Are Indivisible From a Greater Whole.**
  - **The whole "owns" the goal of making frontier science possible**
    - As well as DOE mission-oriented basic and applied research.
  - **Hence the Network is one element of a very complex whole**
    - And is itself a critical piece of making connections between elements of this complex whole
    - And it handles the "bulk transport" very effectively
  - **But there are many interfaces for which explicit responsibility tends to stop short of dealing with crossing the gap**

Recommendation: Systems Think

Focuses on the whole, not the parts, of a complex system. It concentrates on the interfaces and boundaries of components, on their connections and arrangement

- The Network And Networking Research With a Mission Of Enabling Petascale Science as a Systems of Systems (SoS)
- System of Systems Typically Exhibit the Behaviors of Complex Adaptive Systems
  - Operational Independence of Elements
  - Managerial Independence of Elements
  - Evolutionary Development
  - Geographical Distribution
  - Inter-disciplinary
  - Heterogeneity of Systems
  - System of Networks
  - Emergent Behavior

System of Systems Science is an emerging discipline not yet claimed by anyone, but can provide a critical organizing principle

See for example: Carlock, P.G., and R.E. Fenton. "System-of-Systems (SoS) Enterprise Systems for Information-Intensive Organizations," Systems Engineering, Vol. 4, No. 4 (2001), pp. 242-261.

The Elements in that Whole Constitute a System of Systems

- **The Mission Of the Network And Networking Research Element is to Make These Elements Work Together in a System Of Systems**
- **Complex Systems with Many Similar and Different Components**
  - Producing data at a phenomenal rate
  - Producing large amounts of heterogeneous, geographically dispersed data
  - Relationship and coupling of data and computation
  - Cultural barriers
- **Systems, Projects, People**
  - Computing System
  - Experimental Facilities, Instruments, and User Centers
  - Observational Networks
  - Data, Information Resources, and Visualization
  - Virtual Organizations and Distributed Collaborations
  - OASCR Research Projects:
    - Applied Math, Computer Science, Networking Research, SciDAC
  - Researchers, Facility Staff, Center Staff, Program Managers
- **The Emergent Behavior is Advancing Scientific and Engineering Research**
  - Change the way people think and do things
  - Accelerating and Amplifying Impact

Major Findings Around Four Topics

- **The Need for a Strategic Vision for the Network and Networking Research**
  - Vision and Plan could benefit from an understanding of the SoS challenge and needs full stakeholder buy-in
- **The Importance of the Network and Networking Research in Enabling DOE Science**
  - Focused on DOE mission-driven science requirements
- **Emerging Unmet Needs Driven by Petascale Science:**
  - New data-mobility issues including archiving, remote access, re-usability, sharing
  - New issues surrounding distributed collaboration and Virtual Communities of Practice or Interest
  - New issues surrounding remote control of experiments or real-time computational steering
  - Need for on-demand End–to–End Solutions that accelerate "time to solution."
- **The 'Interface', 'Valley of Death,' or 'Chasm' Issues – Bridging & Connecting:**
  - Research to Test Bed-like Deployment to Production
  - Programmatic stovepipes

The Panel is now Focusing on a Preliminary Draft

- Each Section Will be Structured
  - High level findings and conclusions
  - Evidence supporting such
    - Including references
  - High level recommendations
- The Panel is seeking feedback from ASCAC on direction and focus

Questions/Discussion

Thank-you for your Attention