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Spoken Testimony of
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Mr. Chairman and members, thank you for the opportunity to appear today to discuss research and development for information technology.

I am going to make the case to you that strategic federal IT R&D is now more important than before, and that we need pro-active leadership to move forward.

1. Pervasive and immature

We rely on IT systems pervasively in our economy, for national security, for health care, and for the operations and safety of our infrastructure.

The industry and research community have made rapid progress in the capability, performance, and interconnection of IT systems.

Despite this rapid progress, software and IT generally remain immature as engineering disciplines.

We continue to struggle with quality challenges related to cybersecurity and software dependability.

We do not yet know how to achieve high levels of quality in critical systems without huge sacrifices in capability and flexibility – and huge cost to test and inspect.

2. Need for fundamental change.

For both cybersecurity and software dependability, we are not in a good state.

In cybersecurity our stop-gaps of firewalls, spam filters, intrusion detection, and the like are not slowing the growth in exploits and vulnerabilities. [*show: CERT curves*]

We are not succeeding in evaluation and validation – the Common Criteria (ISO 15408), for example, does not yield guarantees regarding an absence of malicious code.

In software dependability we find that conventional approaches to testing and inspection are inadequate to enable us to make strong promises – the coverage is not good enough. We supplement this by looking at *how* code was developed and *who* did it. But these are poor proxies. We cannot, in general, fully evaluate software artifacts directly. We cannot make promises about the systems we build.

It is tempting to conclude that this bad state is intrinsic to IT. That:

Things are the way they will be.
(*Ex:* Because we get email, we will also get huge volumes of spam.)

Or: We are at a plateau.
(*Ex:* The pace of innovation is slowing down – the 1990s are over.)

Or: The sheer mass of the deployed base will inhibit any fundamental change.
(*Ex:* Can we switch the entire country over to drive on the left side of the road?)

3. Fundamental change does happen

These conclusions are counter to the historical truth of IT for the past 40 years.

There has been a **constant technology revolution under the hood –** in operating systems, databases, client-server architectures, networking, languages, and so on

The research community, the successful IT companies, and their customers all know how to handle the pace of change, because they have been doing so for so long.

In many areas this is happening right now: But not in the most critical areas related to quality. We're almost complacent with our extreme vulnerability.

However, there is reason for hope for the future. There are promising research results in the pipeline that bear on these major challenges. For example:

More secure network protocols and services.
Improved identity and authorization management
Techniques for the direct evaluation of software
Securable architecture for resilient designs

4. Federal role essential

Given this, it is tempting to think that with their large R&D budgets, the IT industry will take care of this and the government can step back.

This is wrong – part of that historical truth is that **the federal government has consistently been an active player and leader in the process.**

I'm going to give you four reasons why:

1. Many of the most significant research results that bear on IT quality are **non-appropriable** – their value diffuses rapidly across the market and cannot be retained. It becomes a public good and only government will support this work at scale.

   In software dependability, many of the most advanced tools emerging in industry practice derive from university research results sponsored by NSF, DARPA, and other NITRD agencies.

   Ex: Bill Gates talks about a tool now used – successfully – to reduce the frequency of Windows blue-screens. This tool is based on technologies developed a decade ago by my university colleagues – binary decision diagrams and model checking. That work was sponsored by NSF and DARPA.

2. The **early definition of standards** has a particularly significant role in IT. This is the so-called pre-normative work most vividly illustrated by the role of the IETF in the early days of the Internet and the role of the W3C more recently. Consensus in the community of innovators is important to broad deployment.

Ex: The world of e-commerce is held together by standards such as TCP, IP, XML, HTTP, and HTML.

3. Government is a major IT consumer. It needs to collaborate with its entire **supply chain – just like the auto industry**.

Ex: Long ago, DARPA exerted profound influence on networking, operating systems, and processor design to create an amazingly scalable foundation for net-centric warfare and modern command-and-control generally. It worked directly with the critical elements of its supply chain to stimulate invention and achieve the innovation – vendors, inventors, and researchers.

4. The main input to the IT food chain is **university research and education**.

Without the people **and** the expertise **and** the innovative attitude, we have nothing. The food chain is made of people.

And there is another reason: IT innovation leadership is pivotal to the future of our country. I'm here from Pittsburgh. We can argue about the strategic necessity of leadership in steel, or in consumer electronics.

But IT innovation leadership is different. **We cannot give it up.**

It is a driver of productivity, as Alan Greenspan as noted.

It is a principal force multiplier in Defense.

Perhaps most importantly, we still see no bounds on the potential for creating new value – new kinds of capability and cognitive powers. The frontier of innovation will continue to exist well beyond the frontier of commoditization. It will be our future for a long time.

My conclusion is that we need pro-active federal R&D leadership.

We need ***both*** **basic science** ***and*** **mission-motivated federal R&D** in order to retain our leadership position and to address the new challenges we face.

In the **public-private partnerships** – the collaborations of industry, academia, and government – the **government must be a full partner**.

I appreciate the opportunity to appear before you today.