e-STARS – A New View Into Information

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Abstract

This paper describes a new process of performing on-line documentation for large complex projects. Recent advances in computer power, computer networking and large data storage availably has enabled all aspects of the design process to be captured in the digital form.

e-STARS (Electronic Systematic Archival / Retrieval System) is a process that defines a system that allows for the rapid retrieval of archived data in a systematic fashion. The process is initiated early in the conceptual design cycle to capturing requirements through the specification phase, design, fabrication, test and verification through delivery. Equipment operators then utilize the captured information.

The e-STARS process makes use of current design tools, archives and databases. The goal of e-STARS is to bridge the gap between the tools, archives and databases while providing flexible structure to the design process. e-STARS provides a designers viewpoint into the captured digital data.

The past several years have changed the way that JPL does business. As recently as the early 90's, JPL has developed spacecraft in a vertical manner, similar to figure 1.

JPL designed each mission, designed the spacecraft, the control systems, operating system, communications, power supplies, instruments and provided navigation and mission operations. More current missions have relied on a horizontal approach to mission development. JPL and the science community develops the mission and collaborates with industry partners and academic institutions globally in the development of the spacecraft. This includes outright procurement of major subsystems from an external vendor or partnering in the design, fabrication assembly and test of Avionics and Power Subsystems as well as Science Instruments.

In Andy Grove's Book " Only the Paranoid Survive"[1] this type of change is called a Strategic Inflection Point.

To quote from his book

> "When an industry goes through a strategic inflection point, the practitioners of the old art may have trouble. On the other hand, the new landscape provides an opportunity for people, some of whom may not even be participants in the industry in question, to join and become part of the action."

The Horizontal Development process involves a large number of different organizations and companies located both nationally and internationally. This trend is likely to increase as more and more organizations develop the technology and interest to participate in space research.

This paper will describe a technological process that will aid JPL in attaining its goals of shorter design time (through inheritance), lower overall hardware development costs (avoidance of duplication) and delivery of high quality products (by using the best people possible without regard to geographical location).

Description of e-STARS

As shown in figure 1, the horizontal design process has already begun at JPL. Example projects that have already been developed are DS1 and Stardust. StarLight Express is currently in development. The transition is not in the future, it has already occurred. However the tools and processes that JPL currently utilizes reflect the past vertical development process not the highly interactive communications that is required to be effective in new horizontal environment.

e-STARS (Electronic Systematic Archival / Retrieval System) is the logical method of documenting a design in the world of horizontal development.

e-STARS is an approach to making current project related information available to qualified individuals 24 hours a day / 7 days a week. The approach is to piggyback on developing Internet/Intranet technology to capture project design information and to allow the users to view the information in a manner that relates to their own view of the project.

e-STARS is platform and application independent. The design information can be viewed on any computer capable of running a web browser such as Netscape or Internet Explorer.

Security issues regarding propriety information and ITAR[2] (International Traffic in Arms Regulations) are supported by e-STARS.

History

The current version of e-STARS, which has been prototyped at the subsystem level, is based on almost ten years of on-line documentation experiments.

The first experiment involved the use of Macintosh shared folders. Application Notes and meeting minute memos were stored on-line where other Macintosh computers could access the information.

As the Internet became more popular, we stored requirement documents on-line in the same manner that books might be stored in a bookcase.

The current version has taken a larger view of how design information is used and shared during the design process. This version, which has been prototyped at the subsystem level (Electronics Subsystems), approaches information from the view of the user.
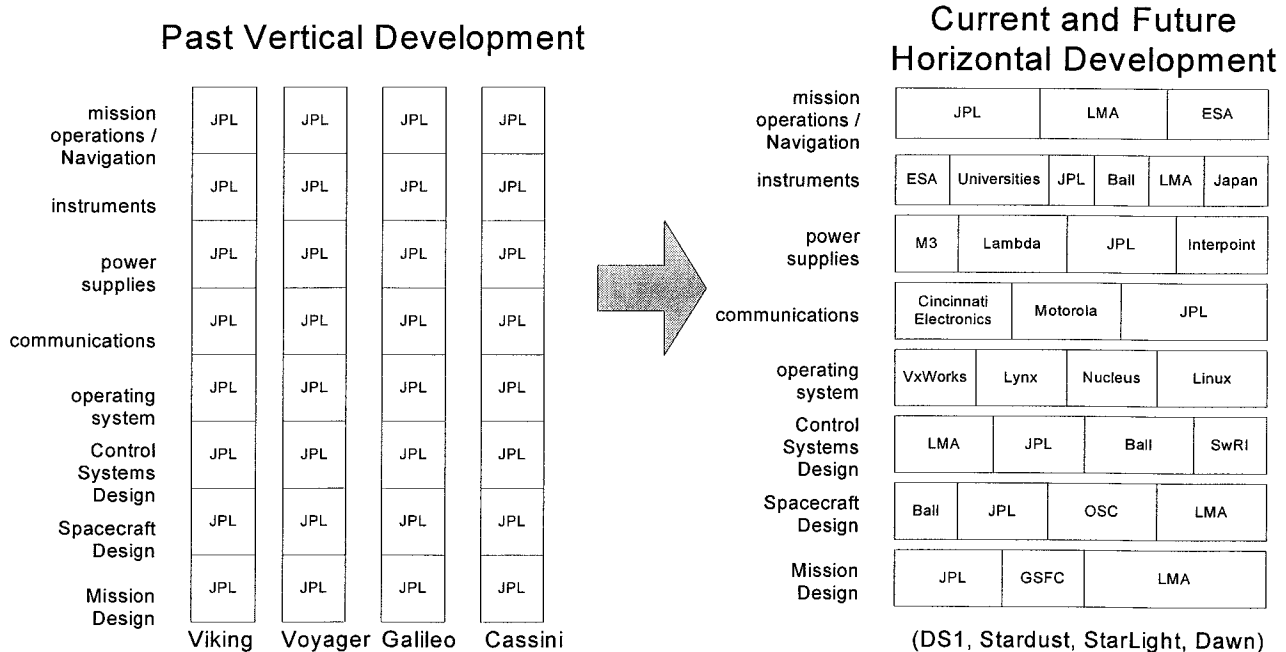
Past Vertical Development

	Viking	Voyager	Galileo	Cassini
mission operations / Navigation	JPL	JPL	JPL	JPL
instruments	JPL	JPL	JPL	JPL
power supplies	JPL	JPL	JPL	JPL
communications	JPL	JPL	JPL	JPL
operating system	JPL	JPL	JPL	JPL
Control Systems Design	JPL	JPL	JPL	JPL
Spacecraft Design	JPL	JPL	JPL	JPL
Mission Design	JPL	JPL	JPL	JPL

Current and Future Horizontal Development

mission operations / Navigation	JPL		LMA		ESA
instruments	ESA	Universities	JPL	Ball	LMA	Japan
power supplies	M3	Lambda		JPL		Interpoint
communications	Cincinnati Electronics		Motorola		JPL
operating system	VxWorks		Lynx	Nucleus		Linux
Control Systems Design	LMA		JPL		Ball	SwRI
Spacecraft Design	Ball		JPL		OSC	LMA
Mission Design	JPL		GSFC		LMA

(DS1, Stardust, StarLight, Dawn)

Figure 1, Past Vertical vs Current/Future Horziontal Comparison

e-STARS Implementation

e-STARS is a model and process in order to design and deliver a product. The model is how JPL as an organization ideally develops a product. The process is used to guild and reinforces the model as set of web-based templates. e-STARS model breaks the design process into the following six critical design phases:

a) **Management**

Includes various areas of management including costing, scheduling, plans, status, reviews and presentations.

b) **Requirements**

What is needed to be done?

c) **Specifications**

How is it going to be implemented?

d) **Design**

Implementation details

e) **Fabrication**

Build and manufacture the design

f) **Test and Verification**

Verification of the design against the requirements and specifications

g) **Delivery**

Deliver the item.

The locating of the information of a specific task (project management or chip design) creates a "component of information" that fully describes that task from a single web location. It's this concept that allows for a flexible and expandable template to be applied to project tasks.

When e-STARS is applied to a portion of the project, then that portion will be able to share information with anyone with internet access. When specific design information as well as schedules, design file memos, resource budgets and procedures are shared on-line, then the design process becomes transparent. The transparency reduces the need for extensive status reporting and duplication of efforts.

The key to implementing e-STARS at a project level is to apply the six critical design phases and management at key levels of the project. It's suggested that the current WBS (Work Breakdown Structure) is a good place to start.

Figure 2 illustrates the typical data structure for a spacecraft with a single instrument. StarLight Express is an example.

In the figure, each "block" represents a container of information customized to the preferences of the user. Particular phases of the six critical design phases and management may be emphasized based on the task of each "block".
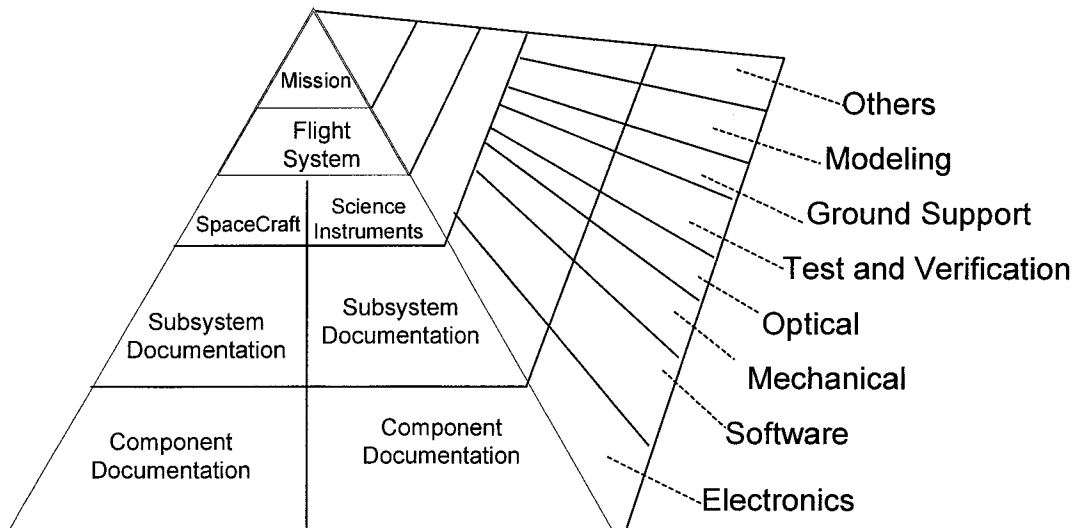

Figure 2, Typical Project Data Structure

As the pyramid is traversed down, the information becomes more and more specific and increases in volume.

You might think of this as type of information matrix that is completed as the program progresses. Since the completed information is immediately available on-line, the information of the design and management process is in essence real-time, which is critical in distributed teaming environments.

Alternatively, information in each of the "blocks" could be viewed as an accordion file with each of the expandable slots marked as Management, Requirements, Specifications, Design, Fabrication, Test and Verification, and Delivery.

For example, the mission management would concentrate on the cost, scheduling, planning and presentation area of the management where a chip designer would input some information regarding scheduling but focus the majority of the effort on Specification, Design and Test and Verification slots in the Design area.

The mission manager would have access to the progress of the design engineer and the design engineer would have access to the most recent project schedule.

It's critical to understand that the information available is the actual design/management information, not just some block diagrams created for a review. The information is changed and updated on an ongoing basis.

Items that are typically released to configuration management system still are. This insures that the correct versions of documents are utilized.

Bill Gates in his book "Business @ The Speed Of Thought (Using A Digital Nervous System)"[3] states that *"Information flow is the primary differentiator for business in the digital age"*.

He also defines the Digital Nervous System as follows:

"The digital processes that enable a company to perceive and react to its environment, to sense competitive challenges and customer needs, and to organize timely responses. A ideal nervous system is distinguished from a mere network of computers by the accuracy, immediacy and richness of the information it brings to knowledge workers and the insight and collaboration made possible by the information. No company has the perfect digital nervous system today; rather it's an ideal use of technology in support of business."

e-STARS Implementation

e-STARS has been beta tested in the electronics area on three projects at JPL (Starlight Express, Micro Arc second Metrology and Mars Exploration Rover (MER).

The development required is a set of e-STARS templates to support the information matrix that e-STARS utilizes to present the data. The creation of the templates reduces the learning curve associated with web based applications and maintains a project level data consistency.
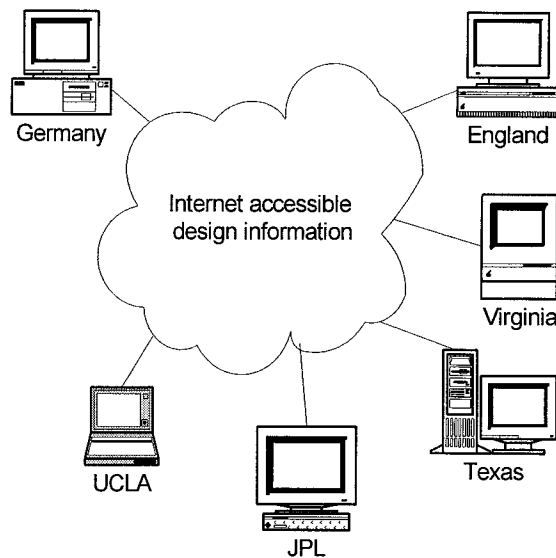

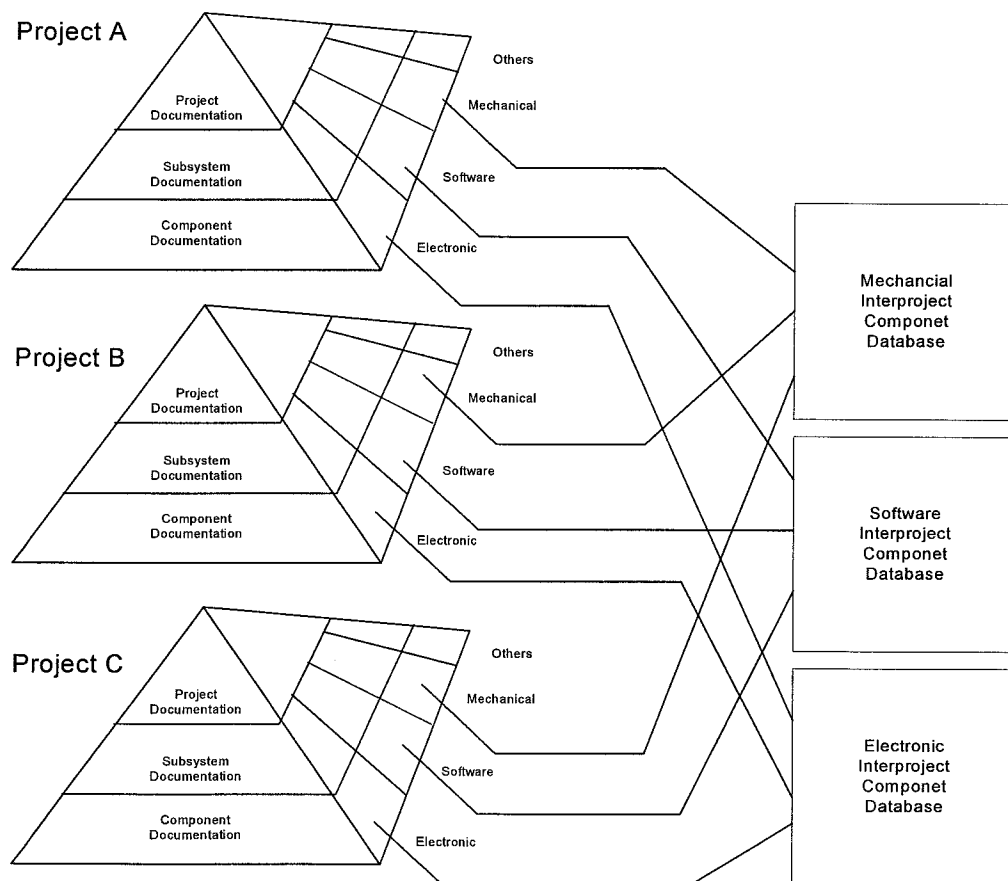Figure 3, Common Design Files and Tools

e-STARS allow the design information to be shared between remote locations through the use of common internet based design files as shown in figure 3. The types of information are; requirements, specifications, schematics, schedules, interface control drawings, test procedures and acceptance tests. As you can gather from the figure 3, the use of e-STARS at a project level forms an information bridge, spanning geography, time zones, disciplines and viewpoints among the project members.

JPL benefits from the implementation of e-STARS method because the design and documentation reflects the horizontal development process that JPL is engaged in.

Inter-Project Connectivity

The typical e-STARS project is shown in figure 2. In order the facilitate the sharing of information between multiple projects (both current and past) and inter project component hyperlinked database is setup as shown below:
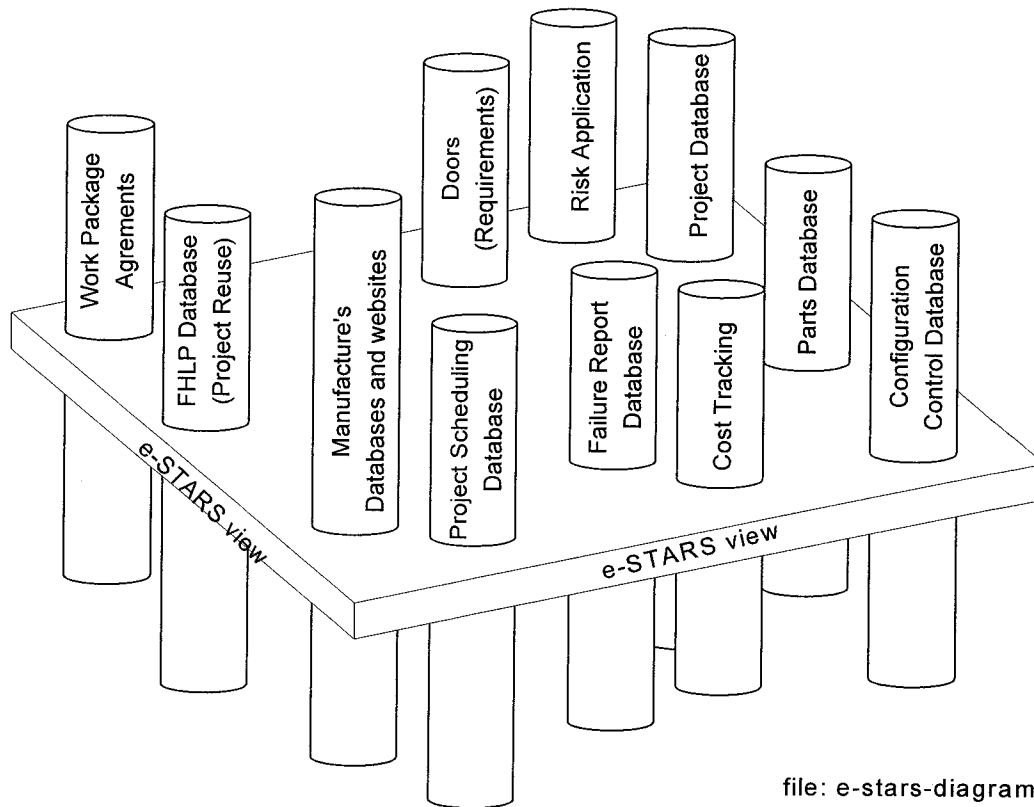
The linking of information as shown in figure 3 allows for the reuse of existing components or the rapid and accurate estimation of new products based on similarity to existing products.

As JPL Director Dr. Charles Elachi said in his May 2, 2001 all hands talk to JPL employees:

"In the next ten to fifteen years there are some 25 flight missions to be launched and some 25 payload packages. JPL is going to be a very busy place. The days ahead will require a new generation of spacecraft and instruments, new technology and new software."[4]

The implementation of e-STARS aids in the goals of shorter design time (though inherence), lower costs (avoidance of duplication) and high quality (by using the best people possible without regard to geographical location).

File: info.vsd

Work Package
Agrements

FHLP Database
(Project Reuse)

Manufacture's
Databases and websites

Doors
(Requirements)

Risk Application

Project Database

Project Scheduling
Database

Failure Report
Database

Cost Tracking

Parts Database

Configuration
Control Database

e-STARS view

e-STARS view

file: e-stars-diagrams.vsd

Inter-Database Connectivity

As the design and documentation process becomes more electronically based, more databases and internet sites and electronic tools are being incorporated.

Ten years ago, the first JPL developed site to be used in the product design / delivery cycle was designed to report and track failures or as JPL calls it Problem Failure Reports (PRF)

Currently JPL uses multiple electronic sites both internally developed and externally developed. With more and more sites being added constantly. We all know that we tend to forget the web address if we don't use it constantly. Some of more complex site have navigation that requires multiple clicks and drop down menus to reach a specific piece of information. e-STARS can act as a bridge that will allow the accessing of multiple sites and databases more easily.

Figure 4 is a diagram showing the e-STARS bridging of multiple sources of information that are utilized during the design process. e-STARS is adaptable to accept additional and changing sources of information.

Project Computer Data Infrastructure

e-STARS relies on the assumption that JPL will be developing plans for secure long-term data storage and will meet the restrictions for sensitive data (including propriety and ITAR restrictions).

The e-STARS architect will work with the JPL data infrastructure to specify a system that will meet the data infrastructure requirements and support the e-STARS technology.

e-STARS Implementation

The implementation of e-STARS is incremental, following the growth of the project. Figure 4 shows the data structure of a typical project. The information data structure is initiated from the top down.

The concepts of e-STARS technology can be employed during the proposal stage and pre-
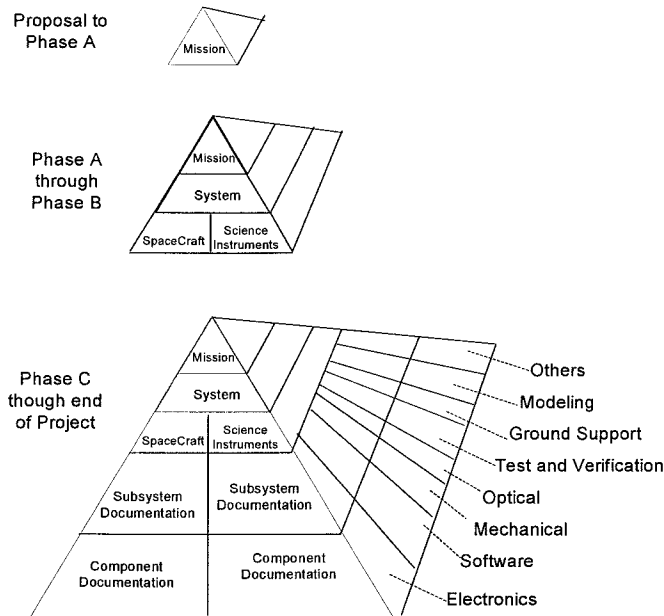
Figure 4, e-STARS Growth vs. Project Phase

project stage as a method of tracking goals, cost and schedules. Think of this as e-STARS lite. The automated tools would not be in place, but development of the information matrix can be established.

As the project comes on-line (Proposal to Phase A) an e-STARS architect and a web implementer, both for about 6 month FTE (Full Time Equivalent) is required. The architect works with the project to determine the optimum format of data exchange with the various participants, both domestic and internationally. The web implementer produces routines that will create e-STARS templates that will be used by the project as it is staffed.

At transition to Phase A, the e-STARS architect evaluates the needs of project and if necessary, modifies the project templates. The architect also conducts e-STARS training classes to promote proper usage of the technology. The time required for both the

architect and the web implementer about 3 month FTE each.

The transition to phase C will result in a large increase in project staffing. The e-STARS architect evaluates the effectiveness of the technology to the project and if necessary make necessary changes to accomplish project goals of effective distributed teaming. Again, the architect will conducts e-STARS training for new project members so that the technology is used effectively.

Measuring Success

The success of the e-STARS technology can judged on several fronts. The most straight forward, is the counting of "hits" and the time and source of the "hits". For example, if the JPL site receives on a regular basis a large number of hits in the early morning from Europe, then it can be assumed that they are accessing information that they find useful.

A second method is by survey. At the transition between phases, a survey could be sent to e-STARS users to judge the effectiveness of the technology.

A third method is whether the information matrix is being completed. e-STARS relies on population of the information matrix by the e-STARS participants. If after the e-STARS training, the information is being populated or not populated, then participants are voting with their keyboards.

The research described in this paper was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under contract with National Aeronautics and Space Administration.

[1] Only The Paranoid Survive, Andrew S. Grove, Doubleday, 1996

[2] U.S. EXPORT CONTROL LAWS AND REGULATIONS, http://www.hq.nasa.gov/office/codei/nasaecp/Webbrfg/tsld001.htm

[3] Business @ The Speed Of Thought, Using a Digital Nervous System, Bill Gates, Warner Books, 1999

[4] JPL & The Next Generation, remarks by JPL Director Dr. Charles Elachi, presented in an all-hands talk in von Karman Auditorium on Wednesday, May 2.