

21st Century Internet Trends

Vint Cerf

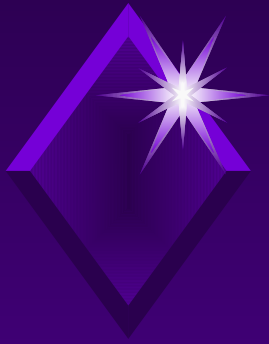
MCI WorldCom

January 2000



Life Lesson #113

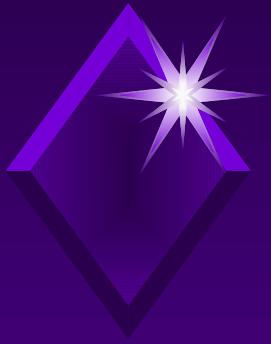
**Friends may come and go,
but enemies accumulate.**



Famous Last Words

- ◆ "The wireless music box has no imaginable commercial value. Who would pay for a message sent to nobody in particular?"

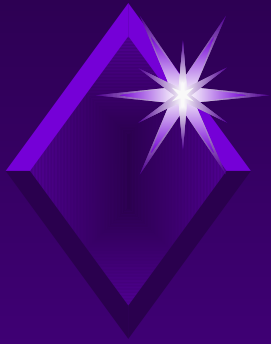
--David Sarnoff's associates in response to his urgings for investment in the radio in the 1920s.



Famous Last Words

- ◆ "640K ought to be enough for anybody."

-- Bill Gates, 1981



Famous Last Words

- ◆ “32 bits should be enough address space for Internet”

-- Vint Cerf, 1977

What is the Internet?

The largest network
of networks in the world.

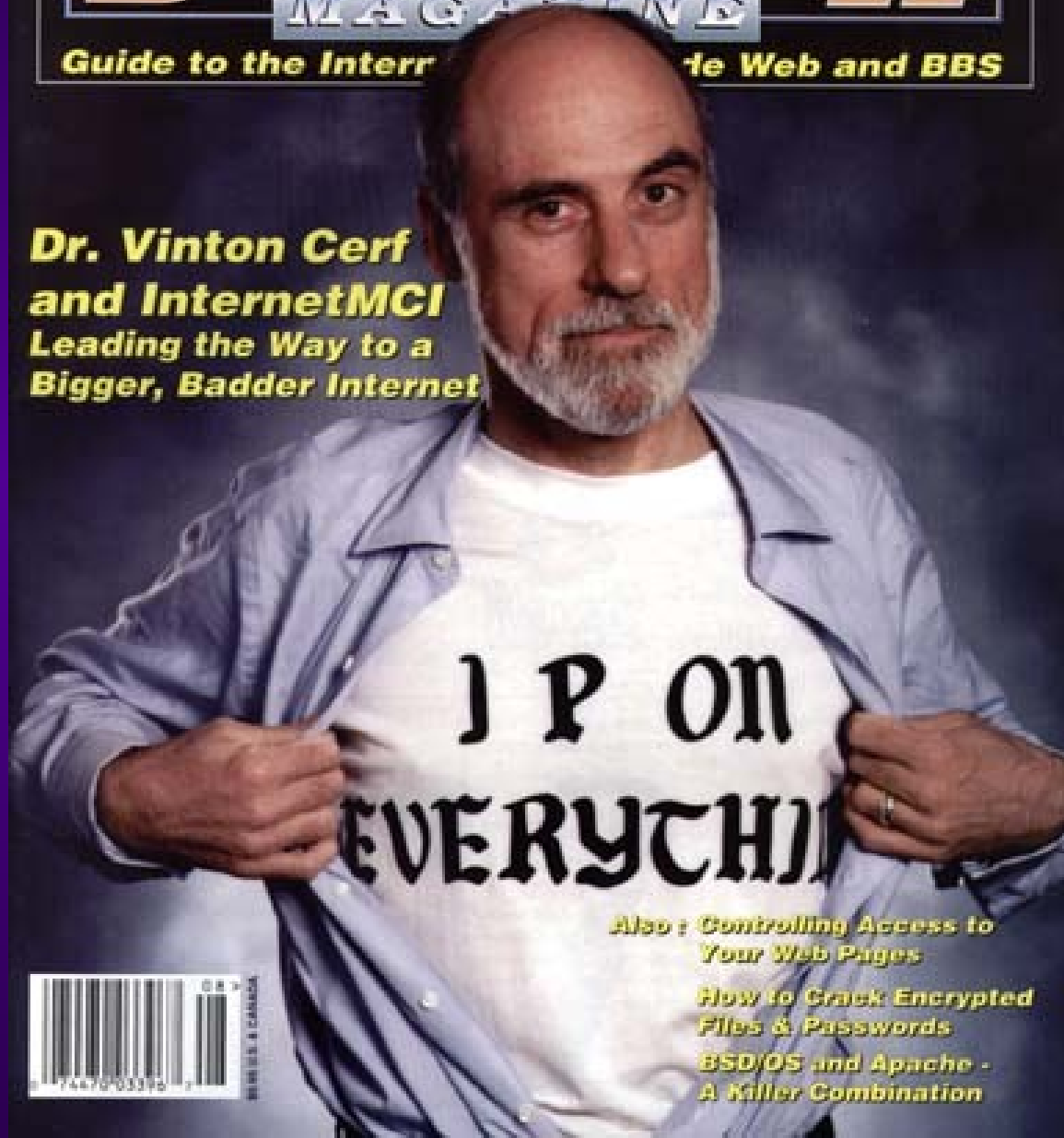
Uses TCP/IP protocols and packet
switching .

Runs on any communi-
cations substrate.

BOARDWATCH MAGAZINE

Guide to the Internet, the Web and BBS

**Dr. Vinton Cerf
and InternetMCI**
Leading the Way to a
Bigger, Badder Internet



**Also : Controlling Access to
Your Web Pages**

**How to Crack Encrypted
Files & Passwords**

**BSD/OS and Apache -
A Killer Combination**



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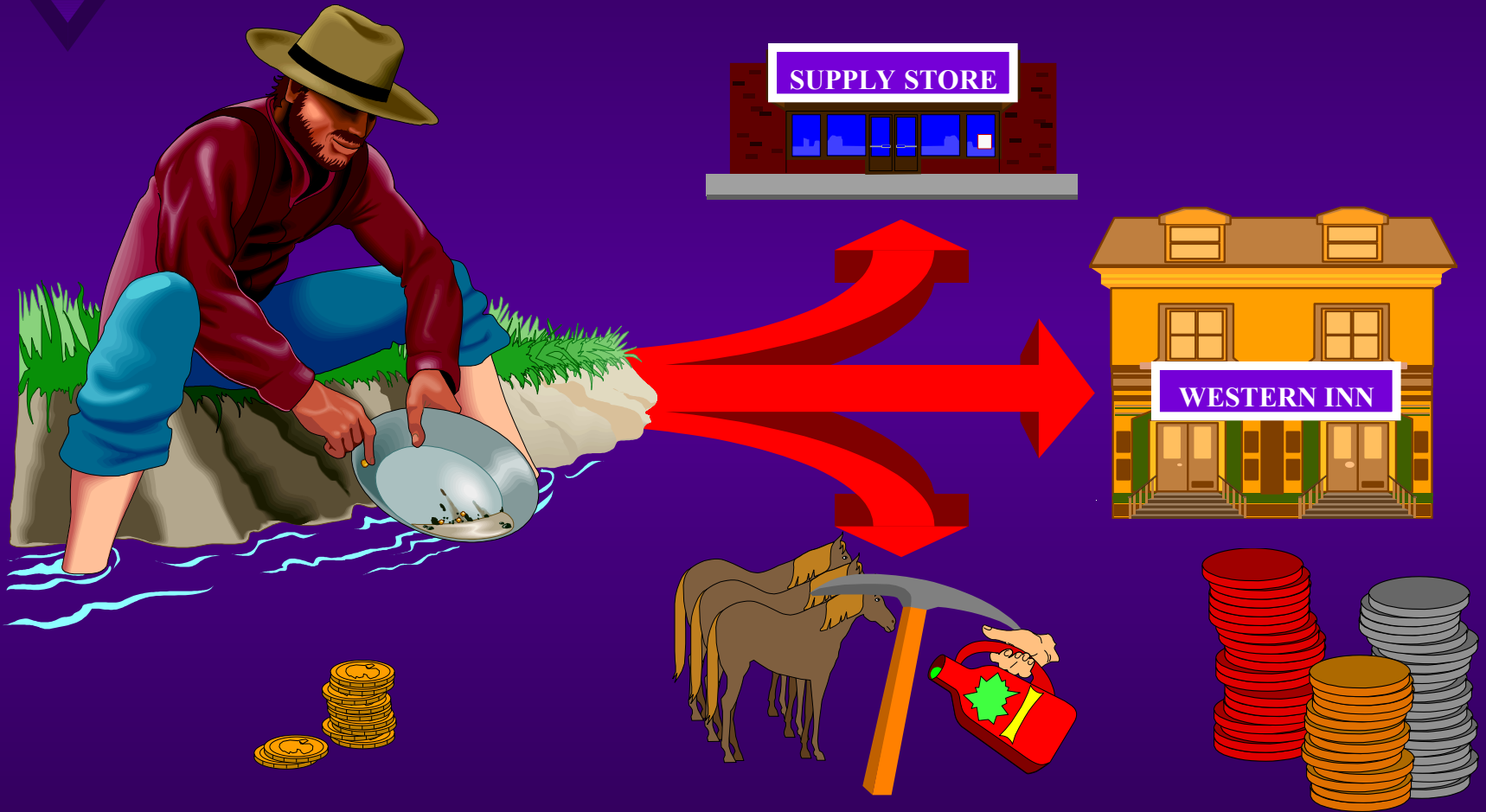


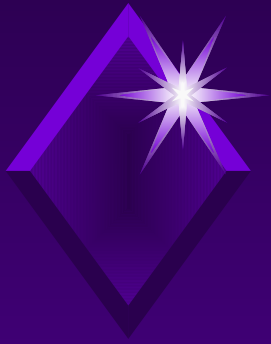
Some philosophical analogies

- ◆ Electrical Power and fractional horsepower motors - doing work for us 24 hours/day.
- ◆ Internet and computers (processing power) doing work for us - distributing and processing information, performing logical tasks 24 hours/day

INTERNET "GOLDRUSH"

[California: 1848. It was gold.
150 years later...it's Internet and the stock market]





Internet - Recent Statistics

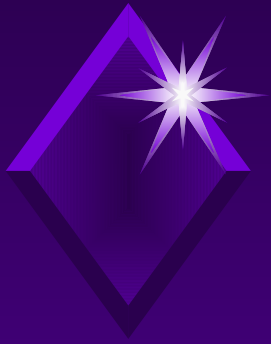
6 M Level 2 Domains (NSI Nov 1999)

75 Million Hosts (VC est. Jan 2000)

212/246 IP countries (NW June 1999)

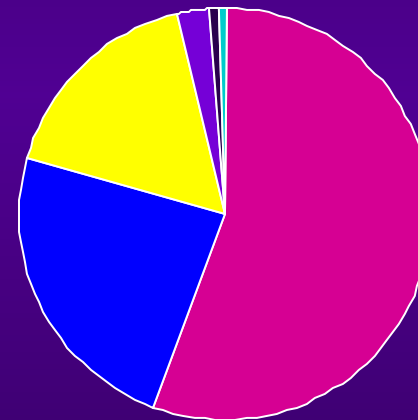
201 Million Users (NUA Nov 1999)

(950 Million Telephone Terminations)

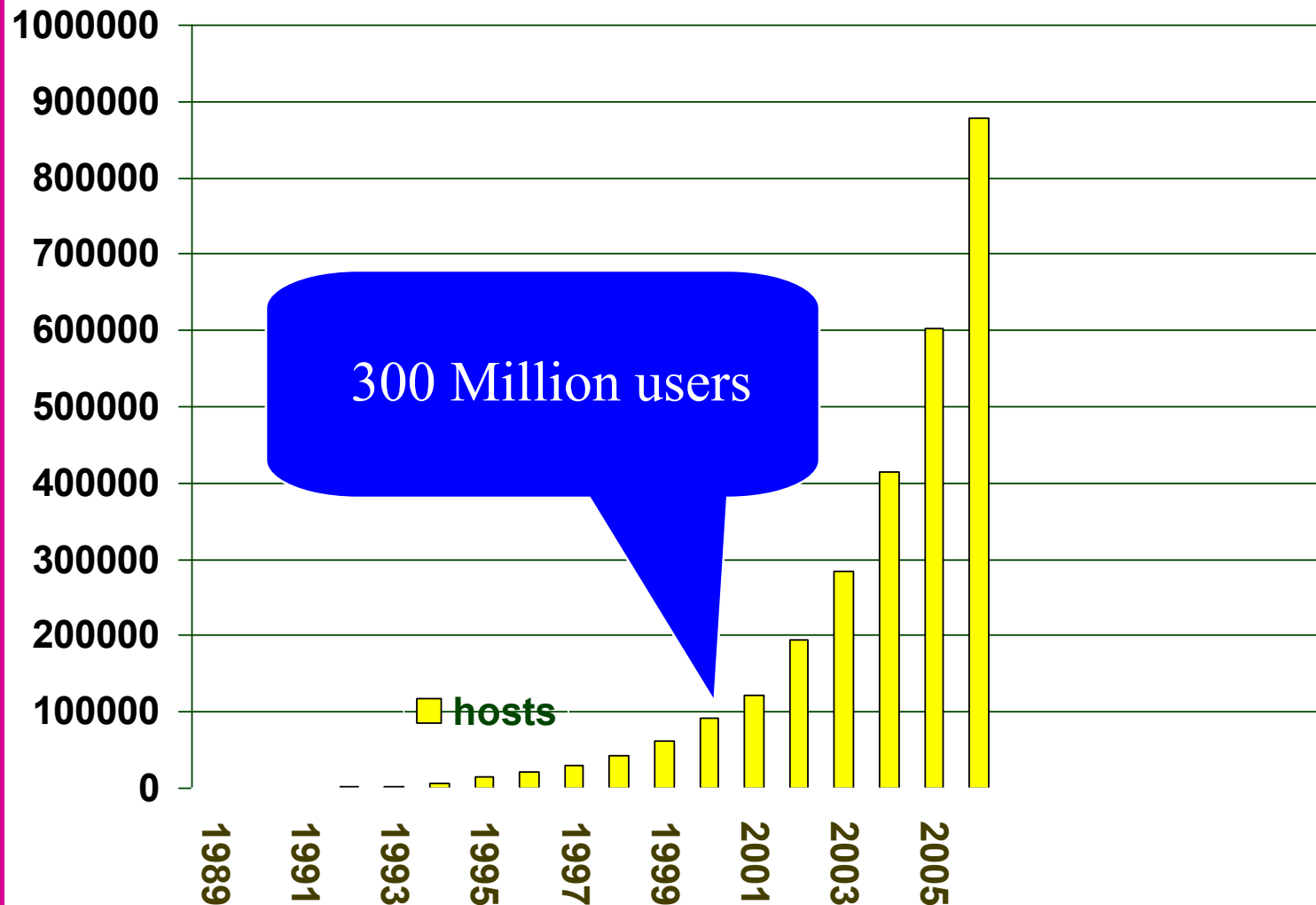


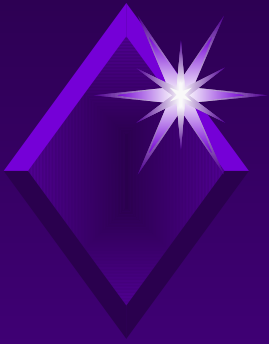
Users on the Internet - Nov 1999

- ◆ CAN/US - 112.4M
 - ◆ Europe - 47.15M
 - ◆ Asia/Pac - 33.61M
 - ◆ Latin Am - 5.29M
 - ◆ Africa - 1.72M
 - ◆ Mid-east - 0.88 M
-
- ◆ Total - 201.05M

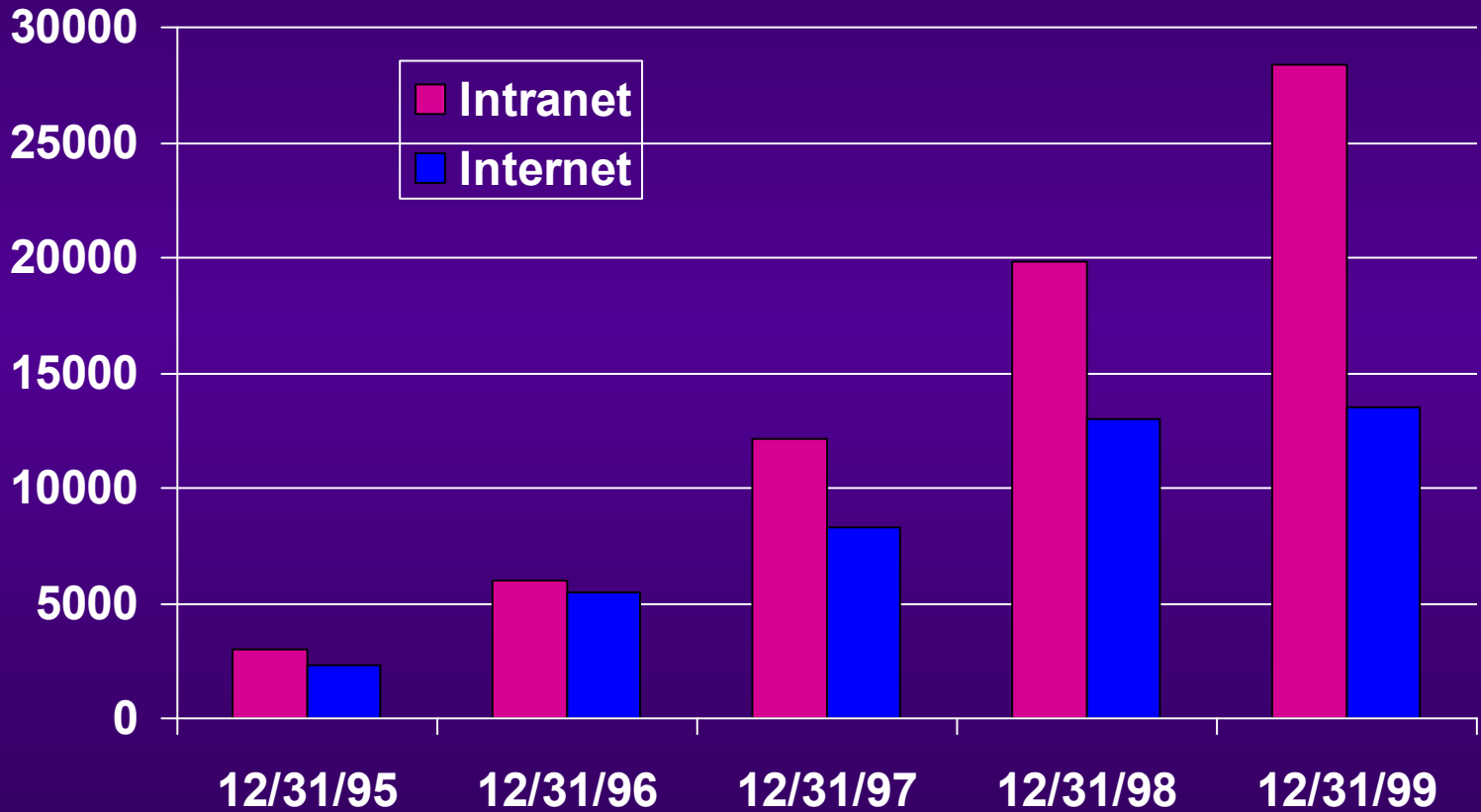


Internet Hosts (000s) 1989-2006

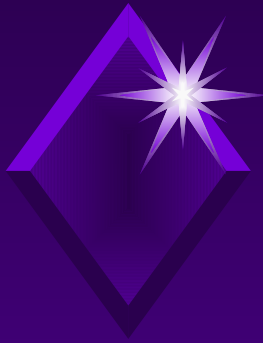




Intranet/Internet Market

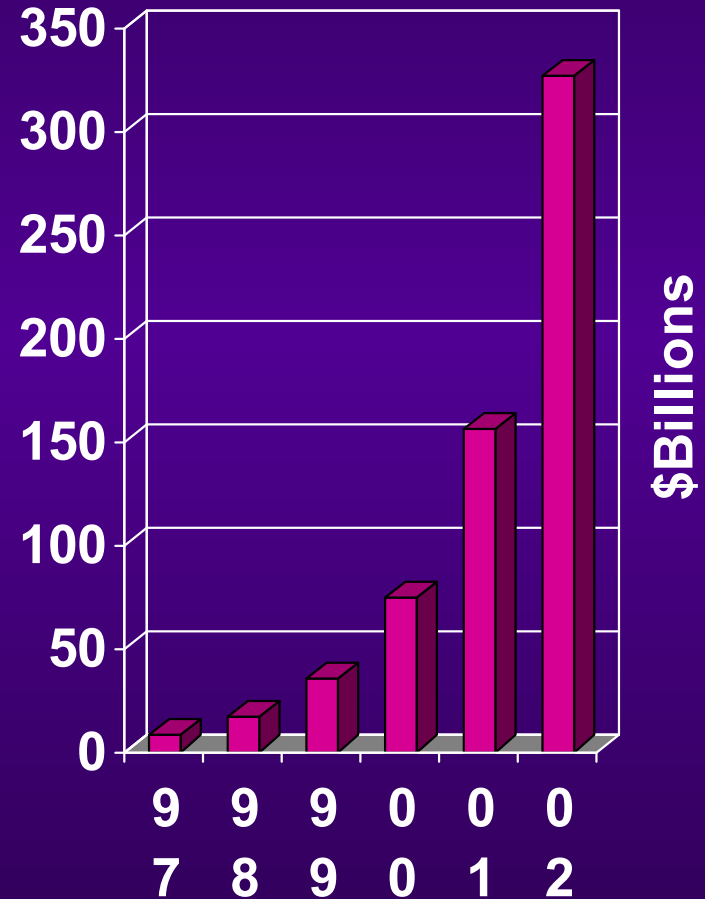


Source: Zona Research

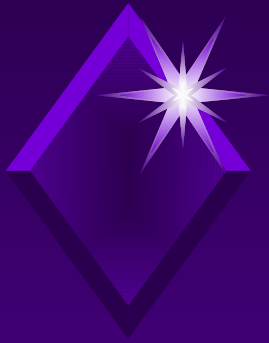


Internet Transactions (\$Billions)

- ◆ Goods and services traded between companies from \$8 billion this year to \$327 billion in 2002



Source: Forrester Research



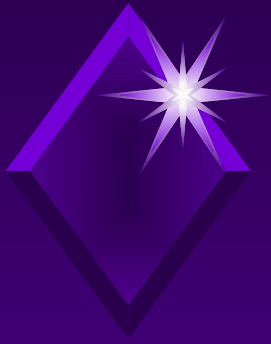
iCommerce in 2003

- ◆ Commerce sales will be between \$1.8 trillion and \$3.2 trillion in 2003.
- ◆ Estimates include business-to-business and business-to-consumer sales and EDI orders placed on the Internet, but exclude the value of financial transactions.



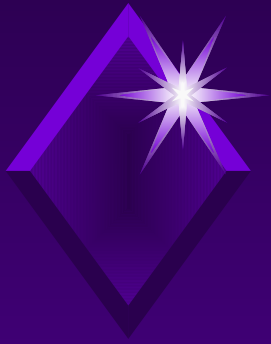
Internet and MultiMedia

- ◆ Internet multicast “video”, telephony and “radio”
- ◆ Transport of Internet traffic on cable, direct broadcast satellite, radio and broadcast TV
- ◆ Real-time quality of service support, VOIP e.g. MCI WorldCom’s “Click ‘n Connect”



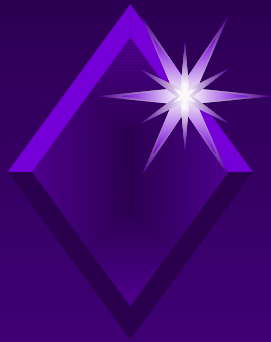
High Performance Networking

- ◆ DWDM Backbone - Electro-optical or all-optical switching (lamdas now, packets maybe)
- ◆ Core BFRs (Juniper M160, Cisco 12000, Avici, Lucent, ...) w/MPLS traffic engineering
- ◆ Edge-derived QOS



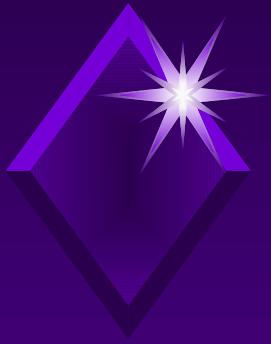
Internet Backbone Architectures

- ◆ Router (IP layer)
- ◆ ATM/Frame Relay (traffic engineering)
- ◆ SONET
- ◆ WDM (DWDM, Solitons), Radio, Satellite
- ◆ ATM/FR and SONET may be eliminated



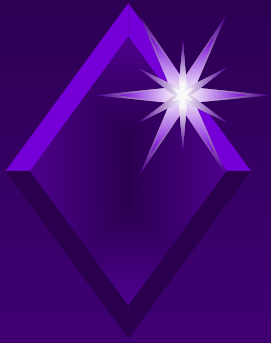
Newer Service Features

- ◆ Multicast
- ◆ Encryption
- ◆ Authentication
- ◆ IPv6
- ◆ Classes of Service
- ◆ Roaming, Dynamic DNS?



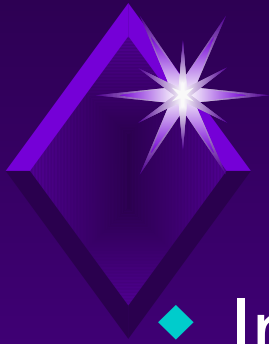
Higher Performance Last Hop

- ◆ Digital Subscriber Loops: 0.5 -25 Mb/s
- ◆ Cable Modems: 0.5 -10 Mb/s
- ◆ Fixed Radio links (blimps?, ground link)
- ◆ IR or Radio LANs: 0.2 - 10 Mb/s



Wireless Internet

- ◆ e.g. Internet cell phones, cameras
- ◆ “always on” networking
 - ◆ increasing demand for IP address space
- ◆ “Bluetooth”, Wireless LANs, LMDS and MMDS, Digital Broadcast Satellite
- ◆ Mobile Radio -
 - ◆ Ricochet (128 kb/s), 3G cellular (2 Mb/s)



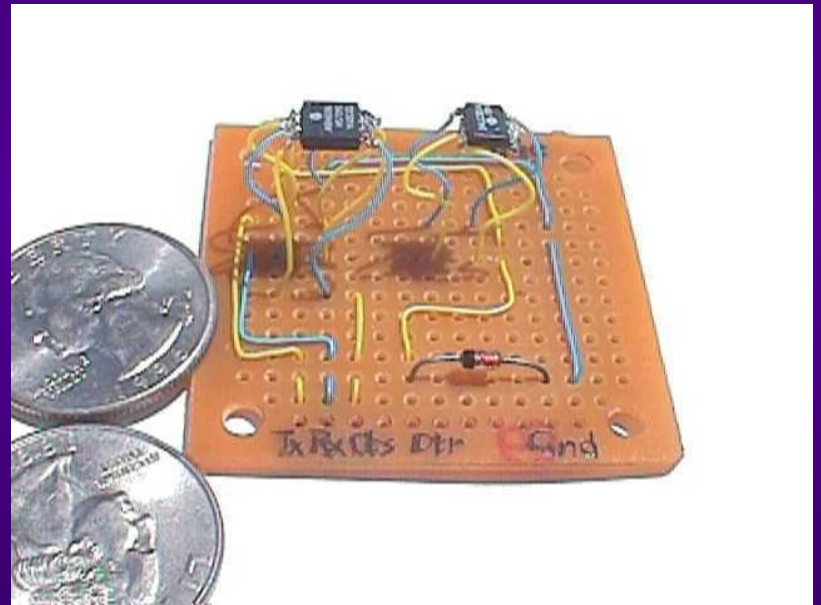
Internet-enabled Devices

- ◆ Information appliances
 - ◆ 1997 - 3 M, 1998 - 6 M, 2002 - 56 M (IDC)
- ◆ WebTV, Palm-Pilot, Nokia 9000, Sony, Nintendo, Sega games (video conf)
- ◆ Refrigerator (and the bathroom scales)
- ◆ Automobiles, household appliances (turning a box of soap into a service)
- ◆ “Reading” glasses
- ◆ Web-server on a chip (see next slide)

UMASS Web server on a chip

born 10 AM, 14 July 1999

- ◆ TCP/IP code itself fits in about 256 bytes (12-bit)
- ◆ PIC 12C509A, running at 4MHz
- ◆ 24LC256 i2c EEPROM
- ◆ HTTP 1.0 and RFC 1122 compliant
- ◆ eternity.cs.umass.edu:9080/index0.html

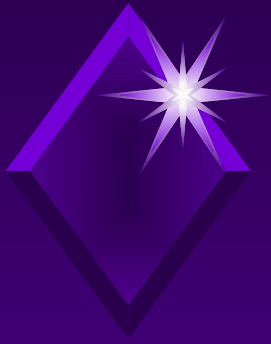




Internet-enabled Refrigerator

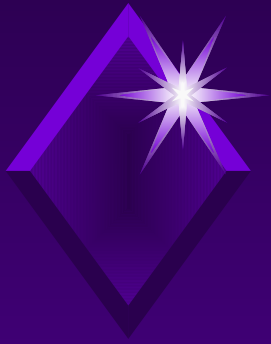
- *News, Radio*
- *Email*
- *Video Messages*
- *Recipes*
- *Shopping Lists*





Security

- ◆ Public Network infrastructure
- ◆ Corporate networks
- ◆ Laptop to remote VPN communication
- ◆ Servers (public, corporate)
- ◆ Downloadable software



Protective Measures

- ◆ Active Monitoring (patterns of attack, rule-based traffic analysis)
- ◆ Strong authentication for command and control infrastructure, network management, information integrity
- ◆ Paranoid applet hotels (“just because I am paranoid doesn’t mean they aren’t out to get me...”)



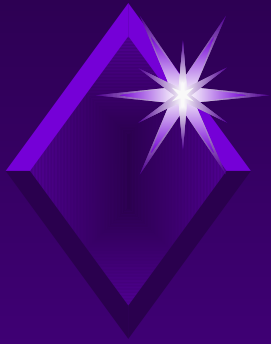
Protective Measures (2)

- ◆ Network infrastructure
 - ◆ Digital Signatures on control traffic
- ◆ End Application Systems
 - ◆ Firewalls are not sufficient
 - ◆ The enemy within: inside attacks likely
 - ◆ MAC registration w/DHCP
- ◆ End user to server: encrypted tunnels allow users on foreign LANS to gain safe access (Guest Ports)



Protective Measures (3)

- ◆ DARPA-sponsored R&D at Lincoln Labs (Communications Department) -
 - ◆ false alarm filters
 - ◆ critical Operating System state transition analysis - not just pattern recognition
- ◆ Constant probing of internal systems for known weaknesses
- ◆ Firewall configuration consistency checking



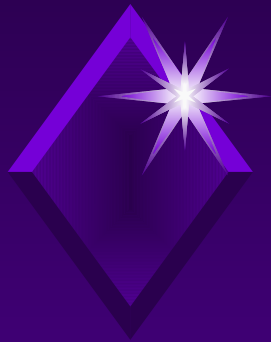
Scenes in 5+ years

- ◆ IPv6 well established w/IPSEC
- ◆ NAT boxes still around
- ◆ More flexible firewalls (they are not enough)
- ◆ end/end security measures
 - ◆ SSL/IPSEC
 - ◆ Application level
- ◆ network level security



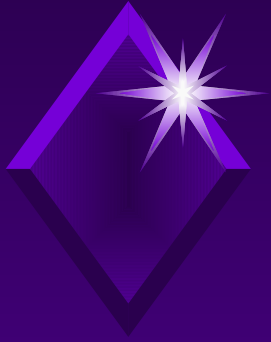
Some Security and Authentication Scenarios

- ◆ The Smart Card Scenario starting with ATM smart cards
- ◆ The appliance scenario
- ◆ The wireless scenario (home, mobile, international roaming...satellite?)



Policy Issues

- ◆ Cryptography and export
- ◆ Digital Signatures/Certificate issuance
- ◆ Taxation
- ◆ Trademarks and Copyright
- ◆ Liability and Dispute Resolution
- ◆ Convergence (TV, Radio, Telephony)
- ◆ Regulatory Framework
- ◆ Censorship/Voluntary Filtering



Future

look



Space: the final frontier

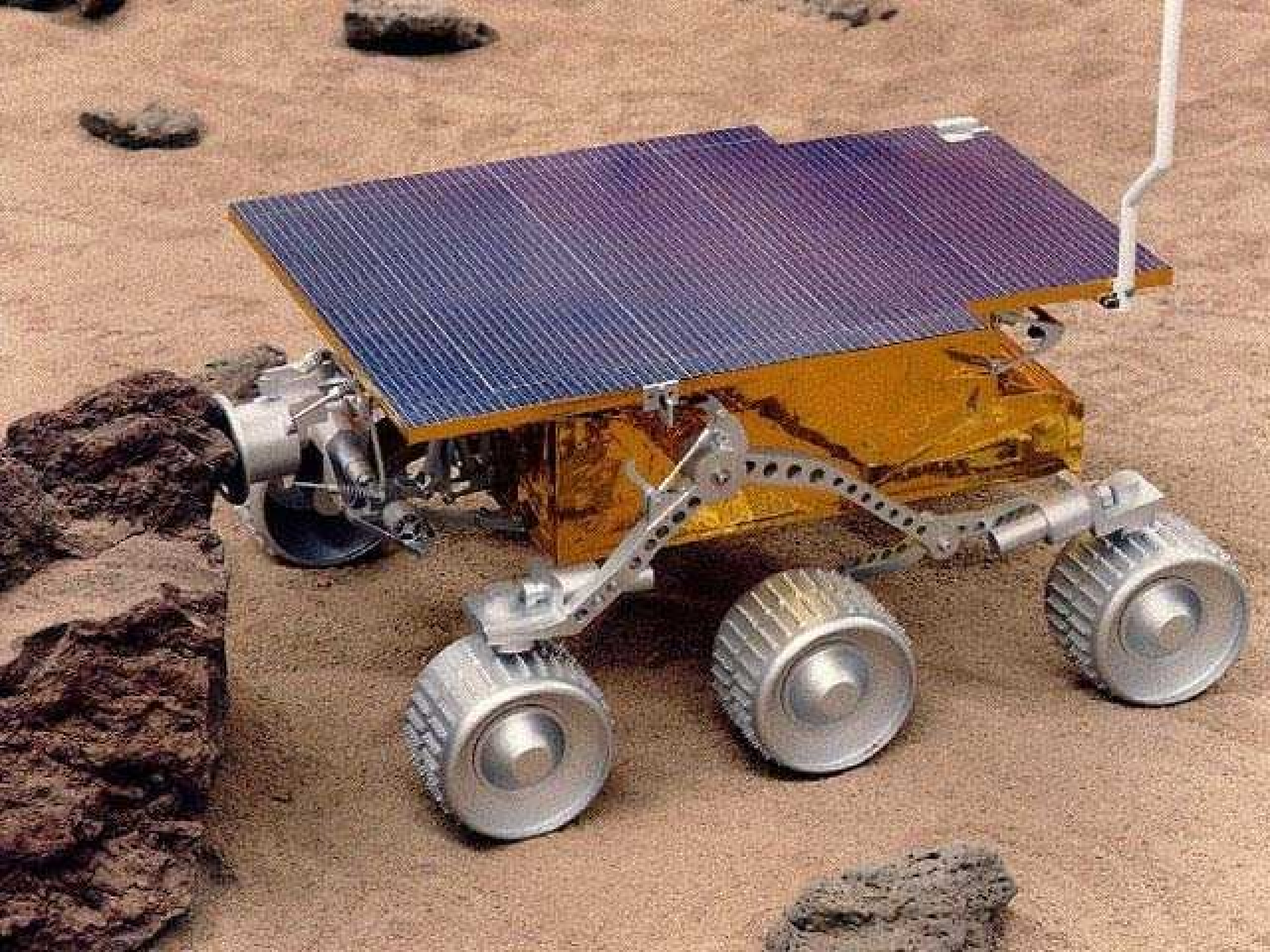
**Our 25 year mission: to go where
no network has gone before!**



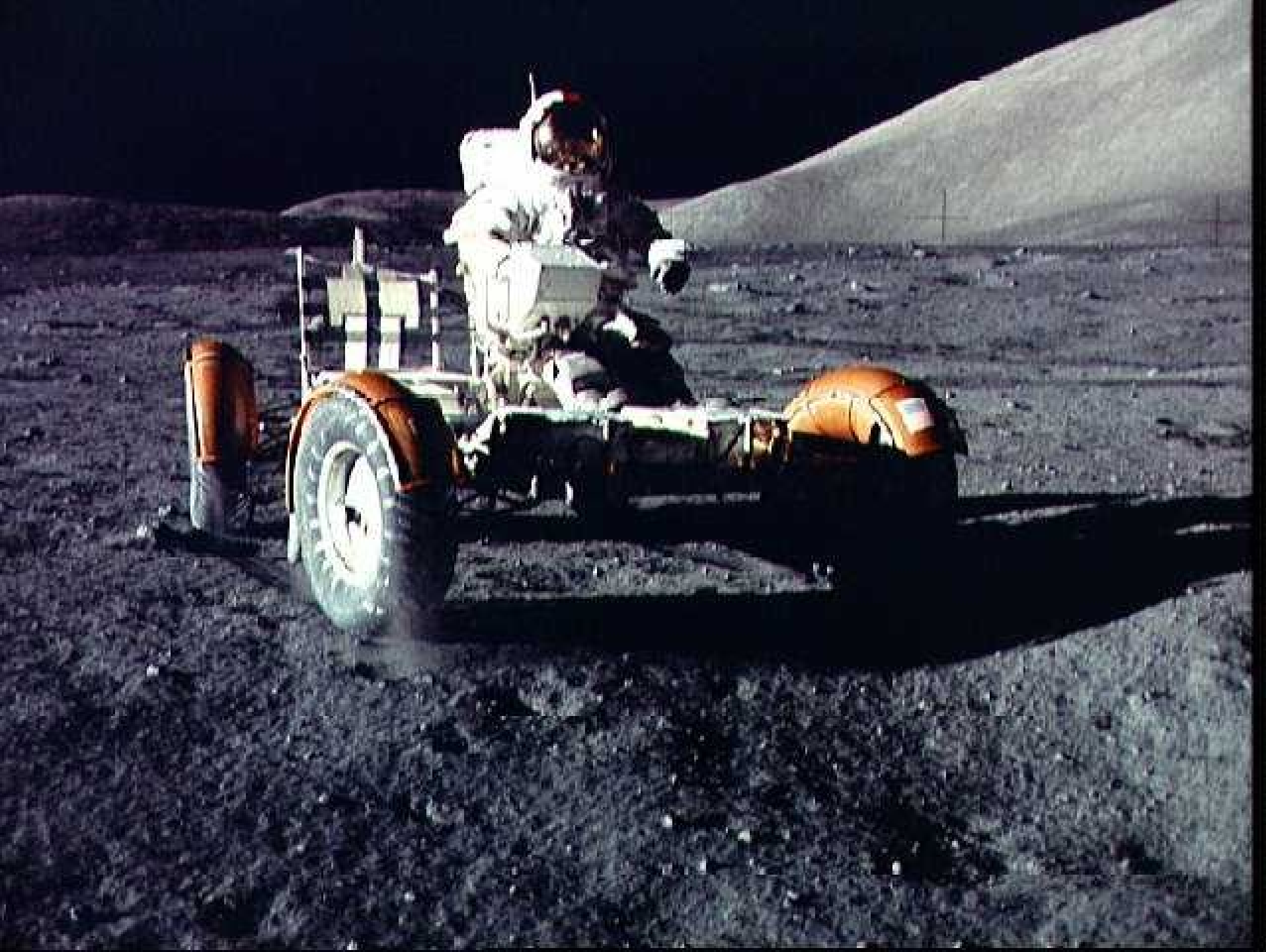




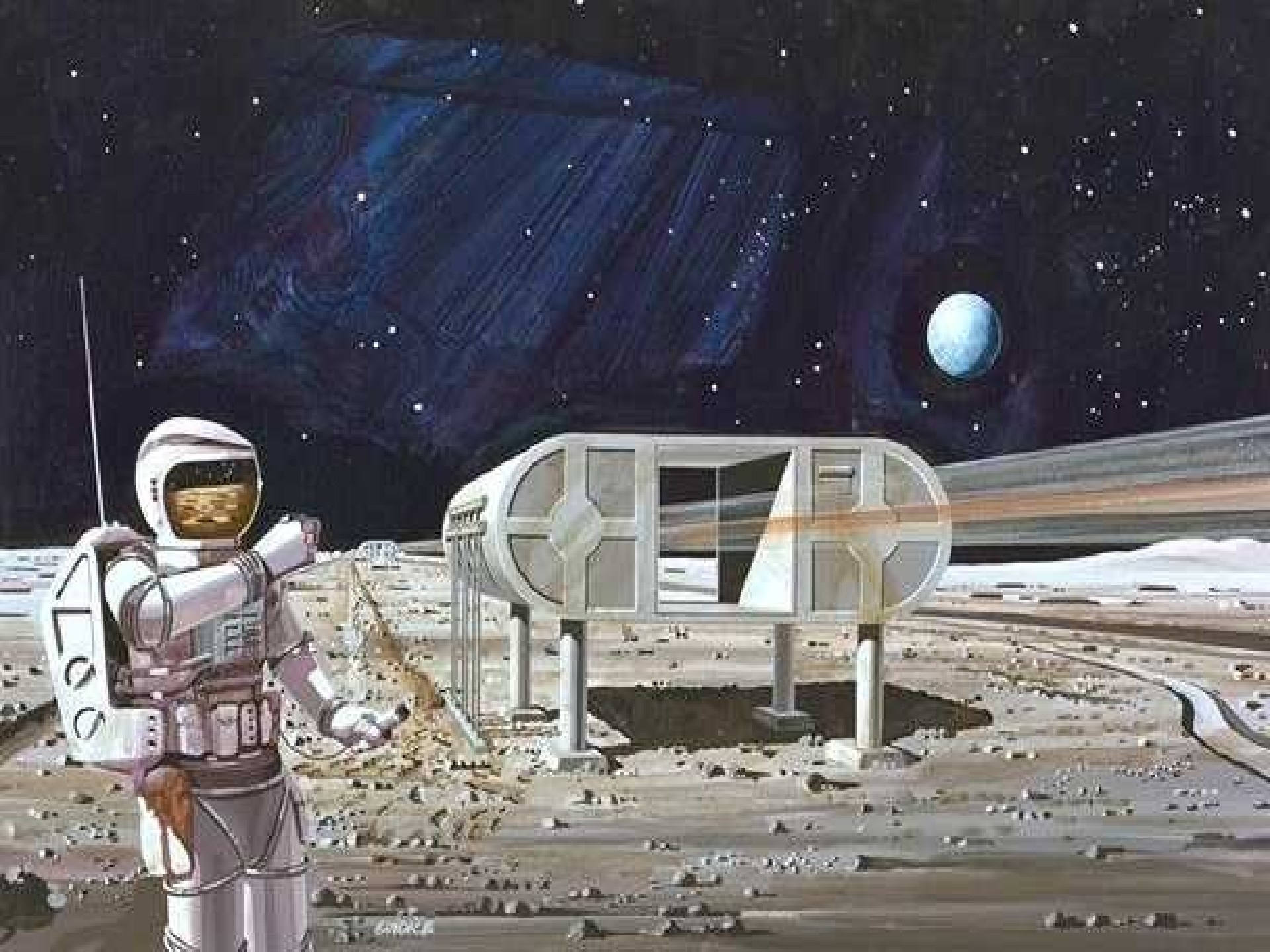














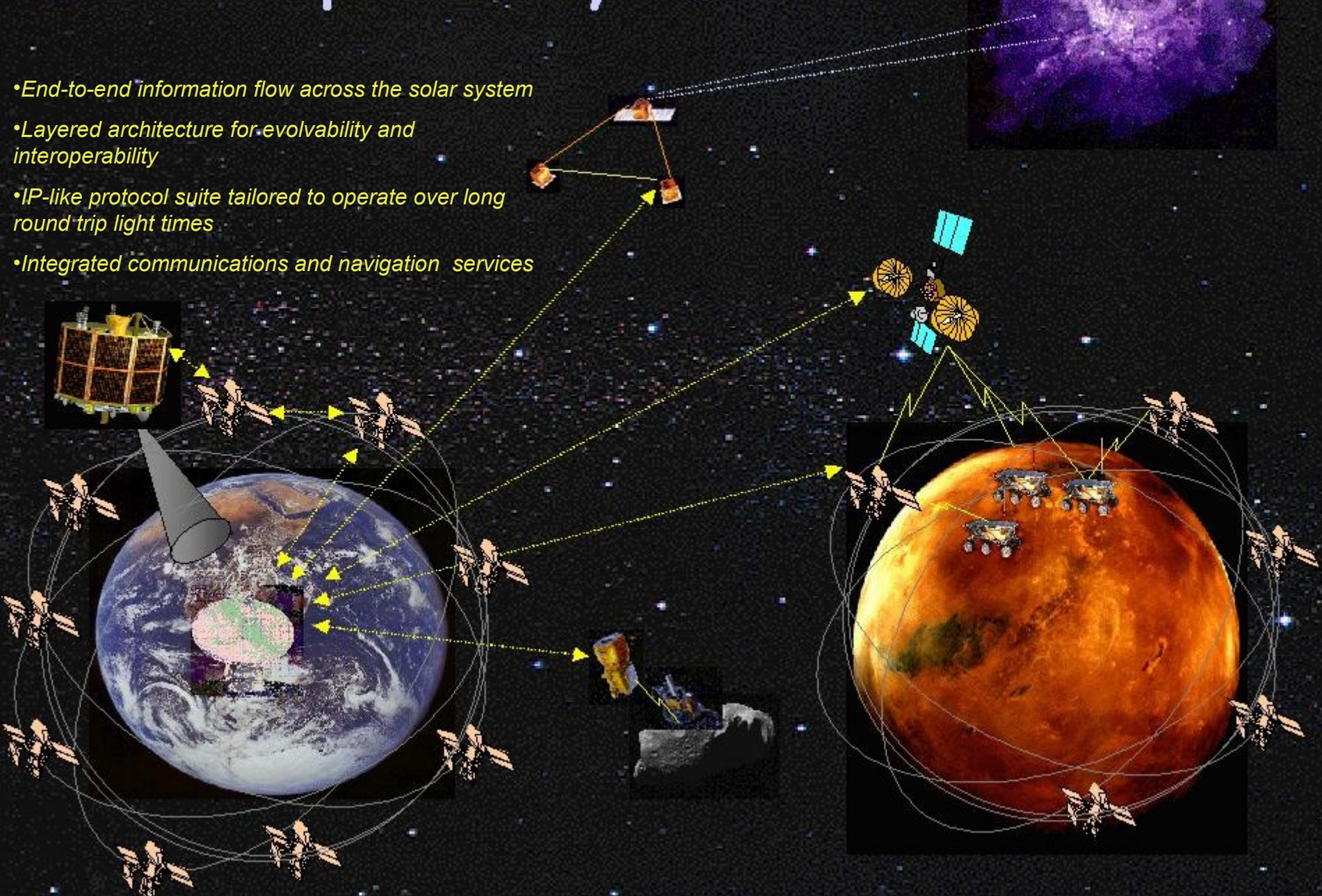
GUIDE



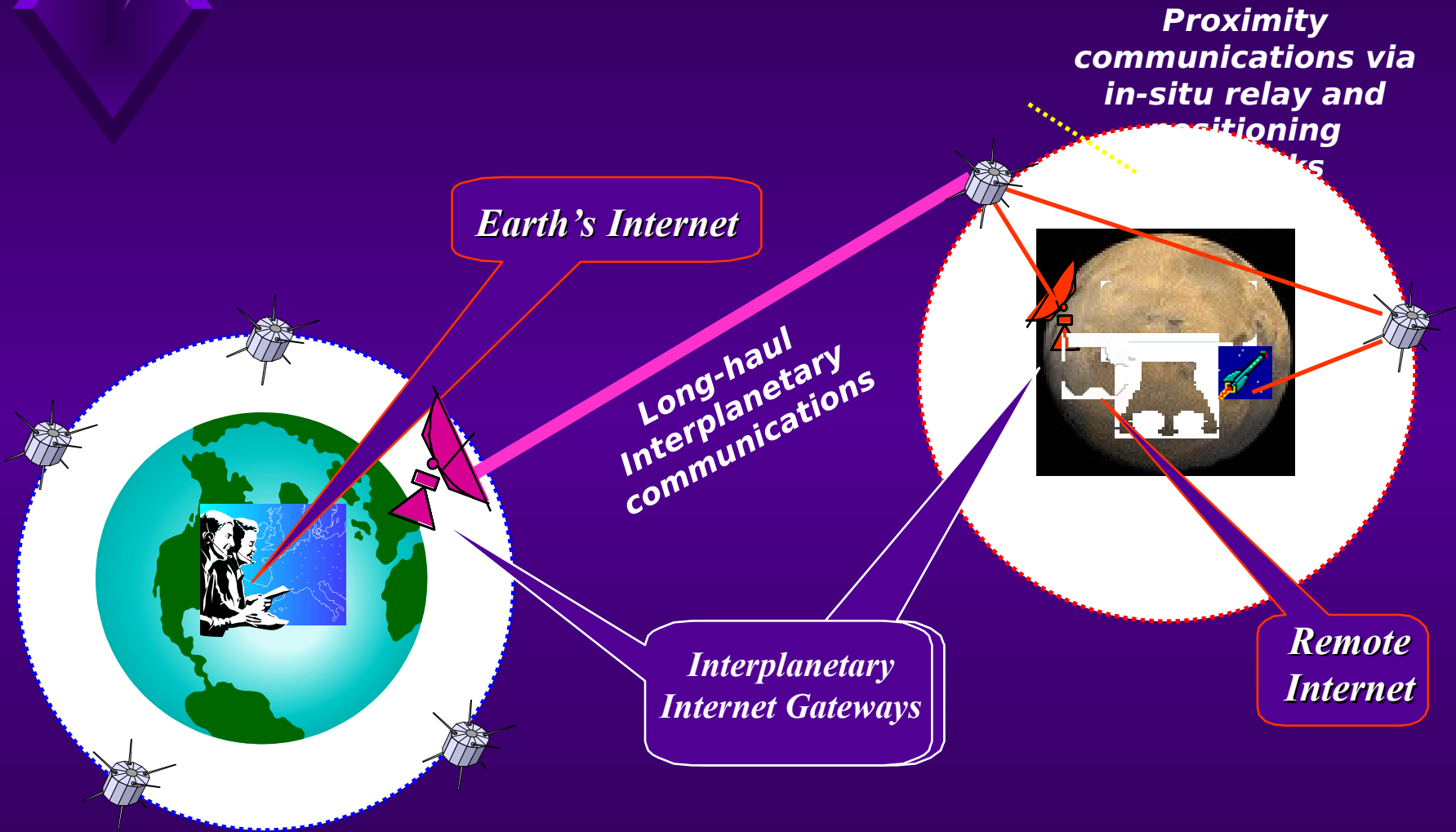
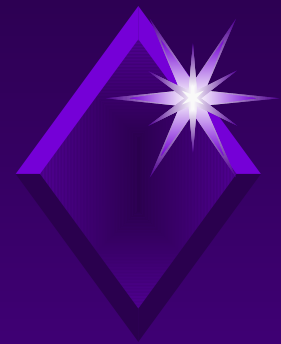
Interplanetary Internet

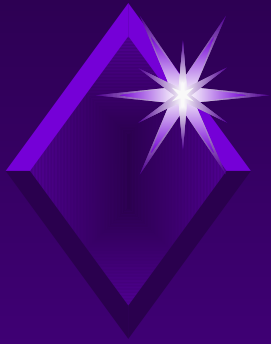


- End-to-end information flow across the solar system
- Layered architecture for evolvability and interoperability
- IP-like protocol suite tailored to operate over long round trip light times
- Integrated communications and navigation services



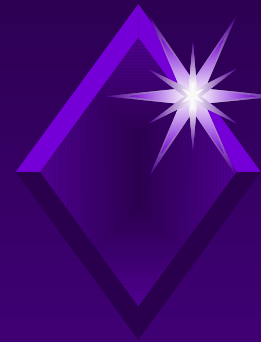
Components of the Interplanetary Internet





Interplanetary Internet Status

- ◆ Part of the Mars Mission Plan
- ◆ Low Mars Orbit and Areosynchronous satellites by 2008
- ◆ Access control & confidentiality!
- ◆ Mars Outposts by 2010
- ◆ Possible Manned Mars station 2030??
- ◆ Stable Interplanetary backbone 2040?



Cerf's Slides and other
information are found at:

www.wcom.com/cerfsup

www.isoc.org/internet

Also see:

www.gip.org

www.nua.org

www.idc.com/telb/projectatlas.html