



National Aeronautics and
Space Administration

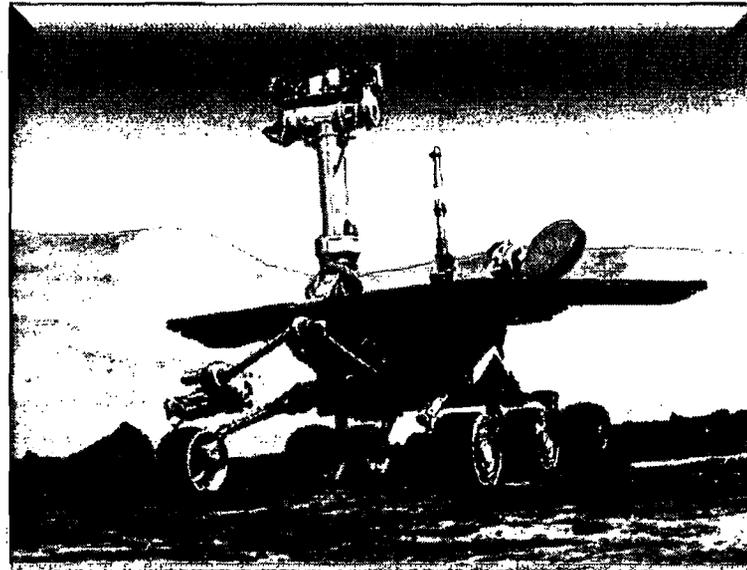
Jet Propulsion Laboratory
California Institute of Technology
Pasadena, California



Collaborative PLM – The Next Generation aka Cars on Mars

**Presentation at the
UGS Analyst Conference**

**By Tom Soderstrom, IT Chief Technology Officer, Office of the CIO, JPL - Caltech
And Mike Stefanini, Senior IT Architect and Technologist, OCIO, JPL - Caltech
June 20, 2007**



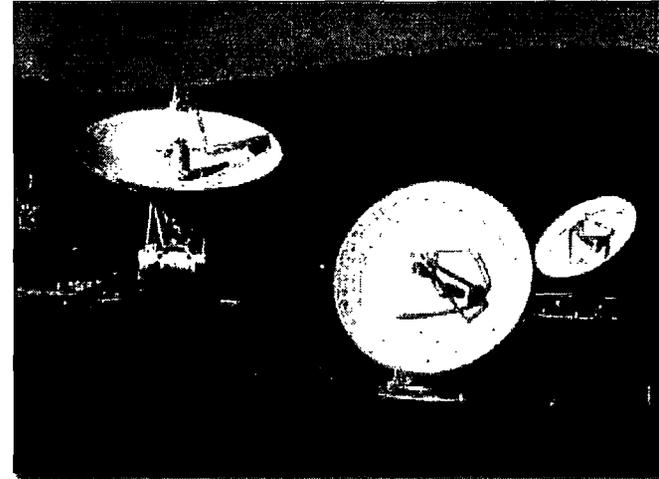
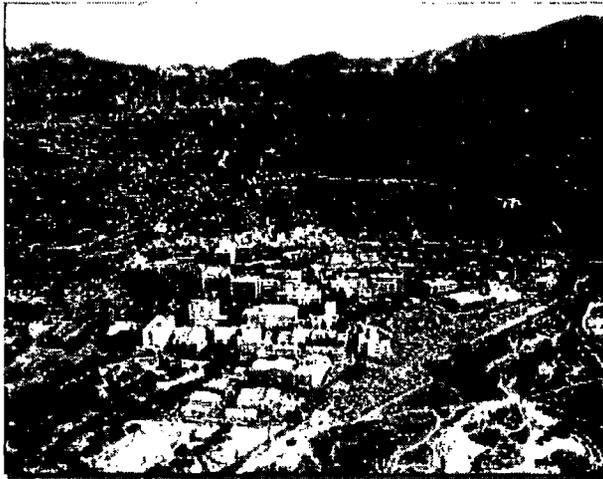




Facts About the Jet Propulsion Laboratory



- **Managed by the California Institute of Technology**
- **NASA's lead center for robotic exploration of the solar system**
- **\$1.6B contract per year, ~ 5,000 employees; 177 acre facility located in Pasadena, CA**

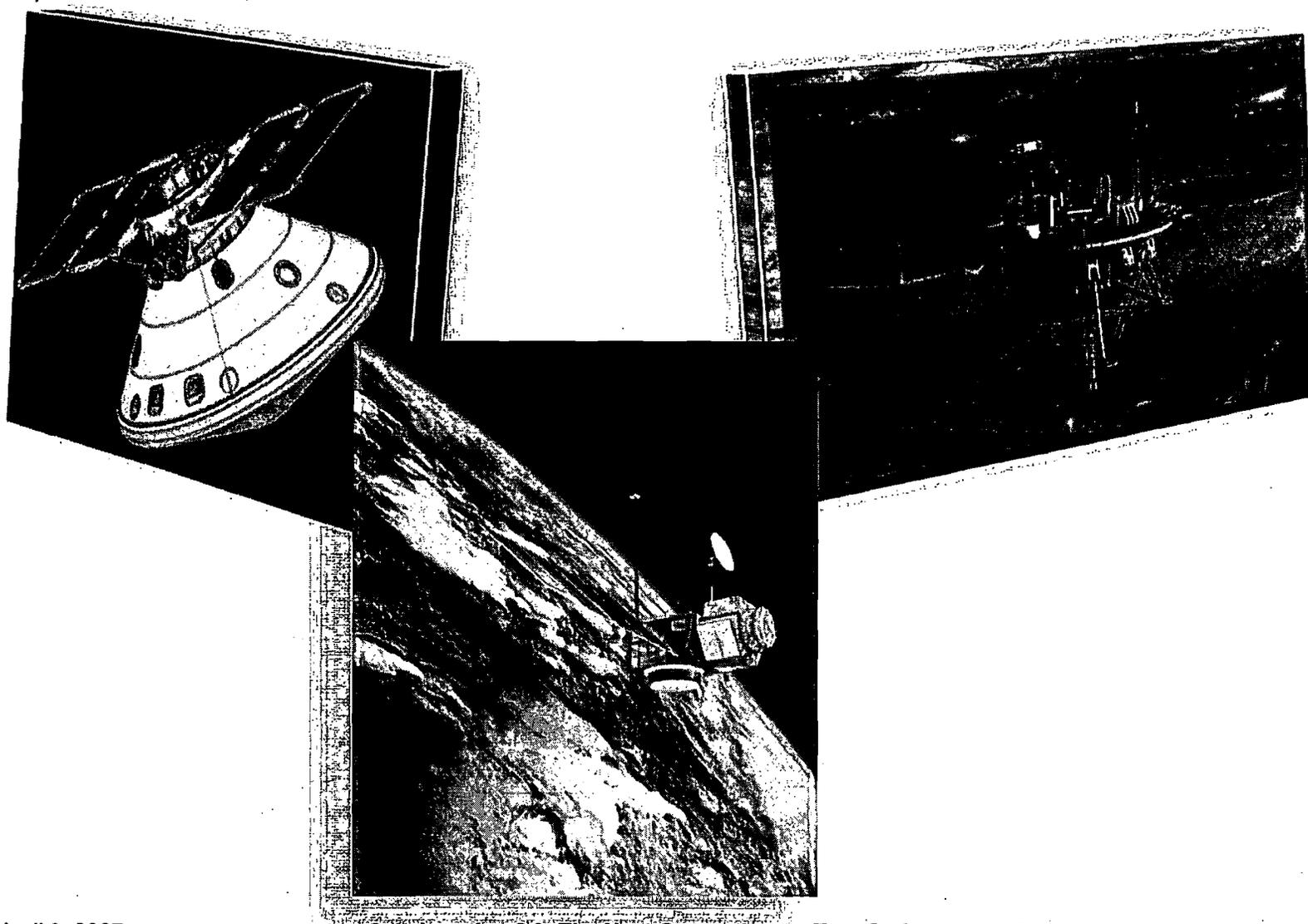


- **Manages worldwide Deep Space Network**
 - **3 Locations - Goldstone CA, Madrid Spain, Canberra Australia**
 - **Spacecraft Command & Control - Recording scientific data**
- **50+ years experience in spacecraft design, production and operation**
- **JPL spacecraft have visited all planets in our solar system except Pluto!**



Video Clips of JPL Efforts

JPL
Jet Propulsion Laboratory
California Institute of Technology



April 9, 2007

Collaboration 2.0: The Next Generation -- Tom Soderstrom, JPL

Innovation Approach: The Right IT Technology at the Right Time

- **Collaborative approach to priorities and solutions**
- **Use emerging trends and industry innovations**
- **Long term view and short term infusion opportunities**
- **Enable effective innovation**
- **Unify enterprise IT...**

• **In short: “Seek – Find – Chew – Bring”**

Some Challenges

- **Intellectual Capital is retiring without passing on the knowledge**
- **Future Intellectual Capital has different expectations**
- **Decreased budget -- as Baby Boomers use up retirement funds; there will be less money for space missions**
- **Decreased margin for error (correctness vs. time factor)**
- **Distrust between USA and other countries**
- **Business Continuity risks (e.g. a pandemic , Asian flu, etc.)**
- **Dealing with information overload**

- **So... how do we improve efficiency and effectiveness of group interaction and knowledge sharing**



Twin Peaks in 360-degree Panorama

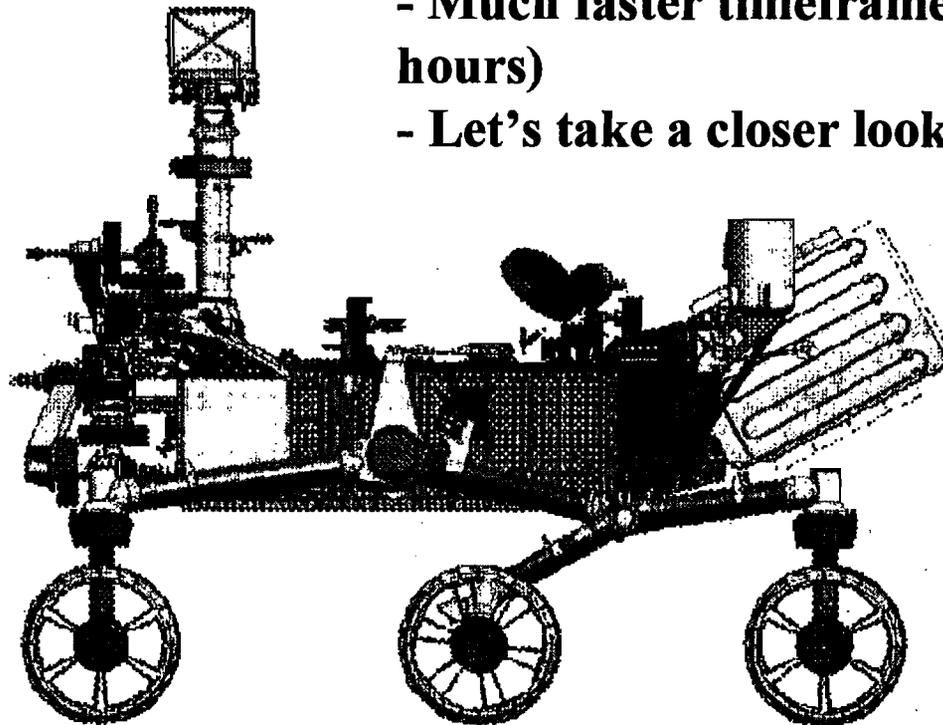


Collaboration Drove Last Year's Model... And Will Drive Next Year's Model Even Faster



- Mars Exploration Rovers success demonstrated collaboration results
- The ante is upped for next year's model (Mars Science Laboratory):
 - Requirement for increased capabilities
 - Much wider international participation
 - Much faster timeframe (everything in 8 hours)
 - Let's take a closer look...

Human Male
1750 mm (5' 9")



April 9, 2007

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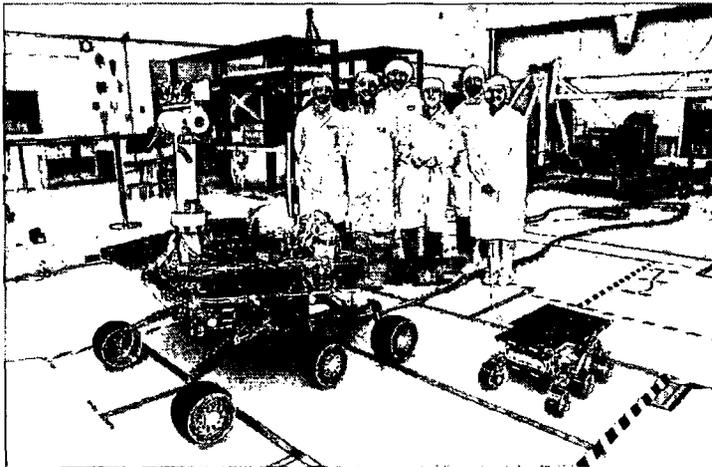
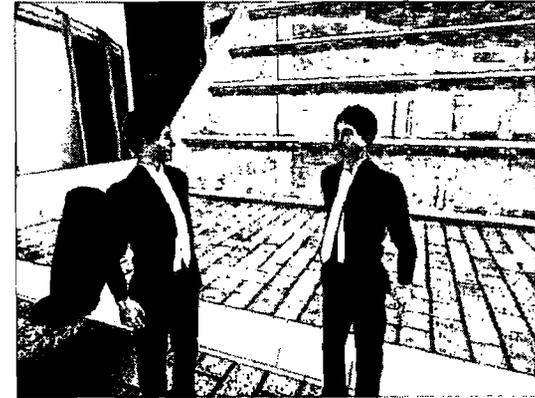
7



It's the easiest of times, it's the hardest of times...



Thirty-one Employees of the JPL All-female Computing Section, 1953



April 9, 2007

Collaboration 2.0: The Next Generation -- Tom Soderstrom, JPL

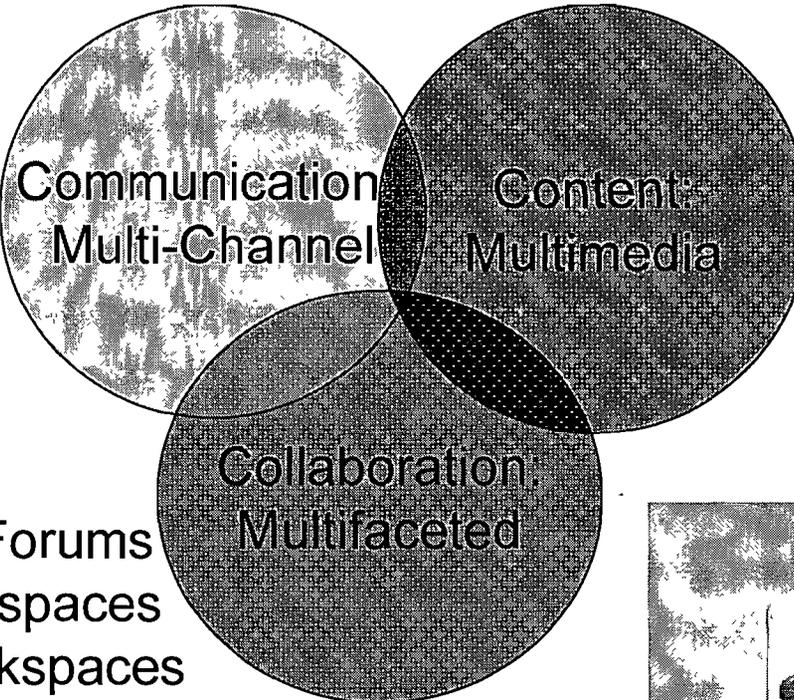




Collaboration Trends: Emerging Communication, Collaboration, and Content Product Categories *



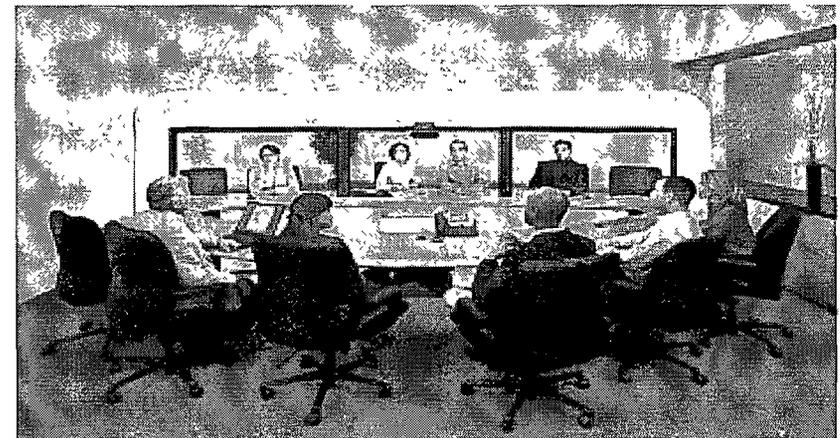
- E-mail
- Telephony
- Mobility
- Instant Msg
- RSS
- ...



- Documents, xCAD
- Databases
- Directories
- Audio/video content
- Recorded events
- ...

- Discussion Forums
- Project workspaces
- Meeting workspaces
- Conferencing
- Shared tools
- Wisdom of Crowds
- Virtual Worlds
- ...

* Ideas from Burton Group



Like Being There
(Cisco TelePresence Mtg)



Year 2010 Model: The Virtual Is The Mainstream



Available Today:

- **HBR: marketing to Avatars**
- **Wharton: Second Life as platform for training / exercises**
- **Masie: Extreme learning (Wikis, gaming, pod casts, ...)**
- **Duke University: classroom**
- **IBM: Virtual town halls, CEO has an avatar**
- **NASA, NOAA, ...**
- **Teaches measured risk taking, multi-tasking, leadership, strategy**



- Meeting in Second Life



Like... On The Way To Mars...

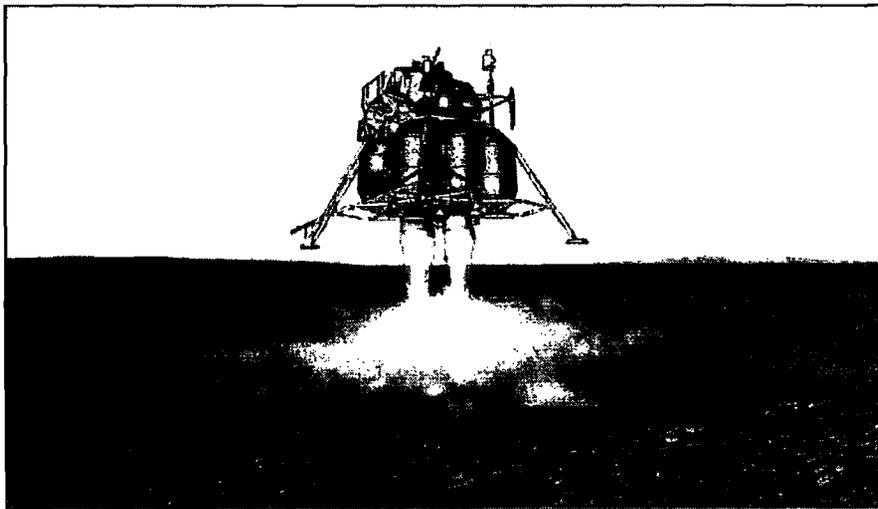
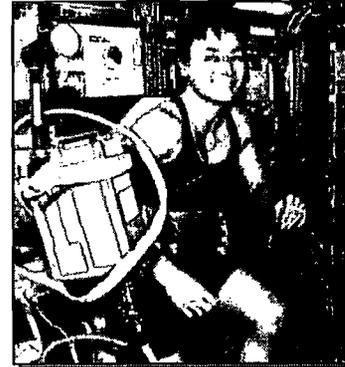
Important Technical Problems To Be Solved



- **Counter measures for human physiological changes**

- Calcium loss from bones
- Atrophy in muscles
- Immune system changes
- Radiation damage

To mention a few



- **Landing 25 metric tons safely**

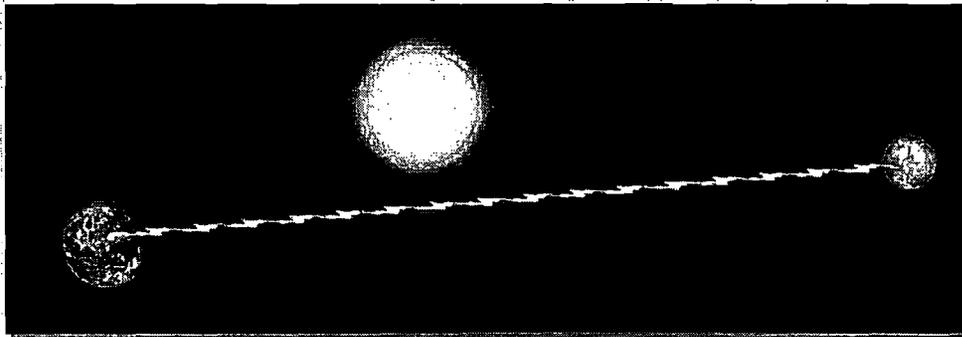
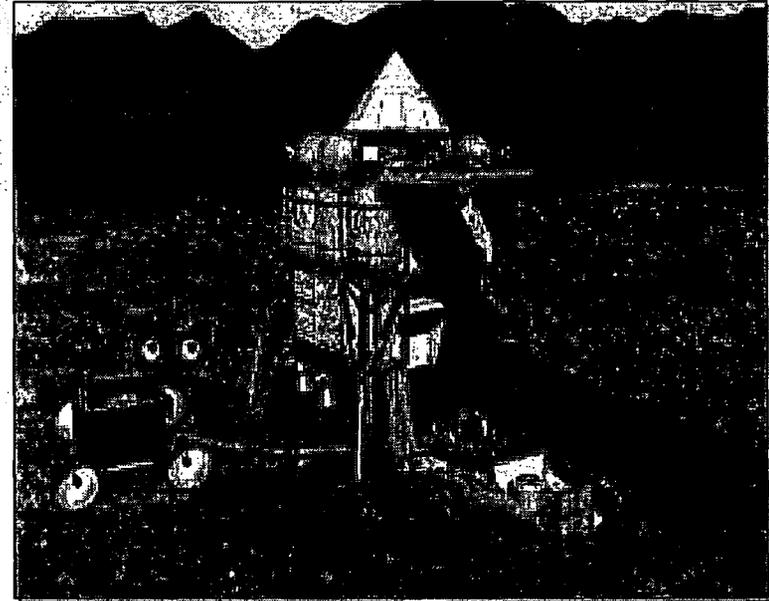
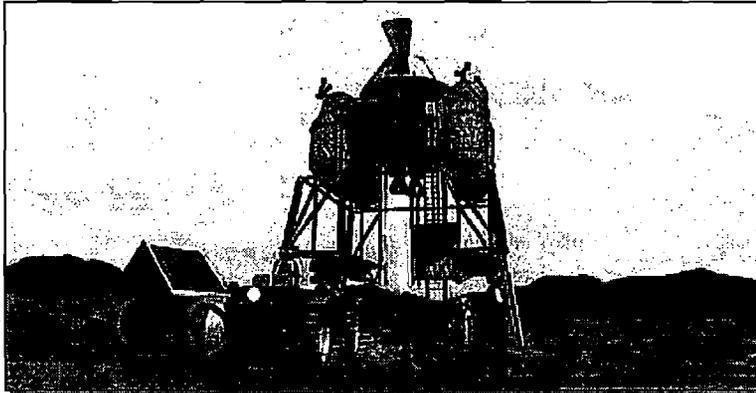


... And When We Arrive On Mars

Important Technical Problems To Be Solved

JPL
Jet Propulsion Laboratory
California Institute of Technology

- **Living off the land – using resources from Mars, don't ship from Earth**

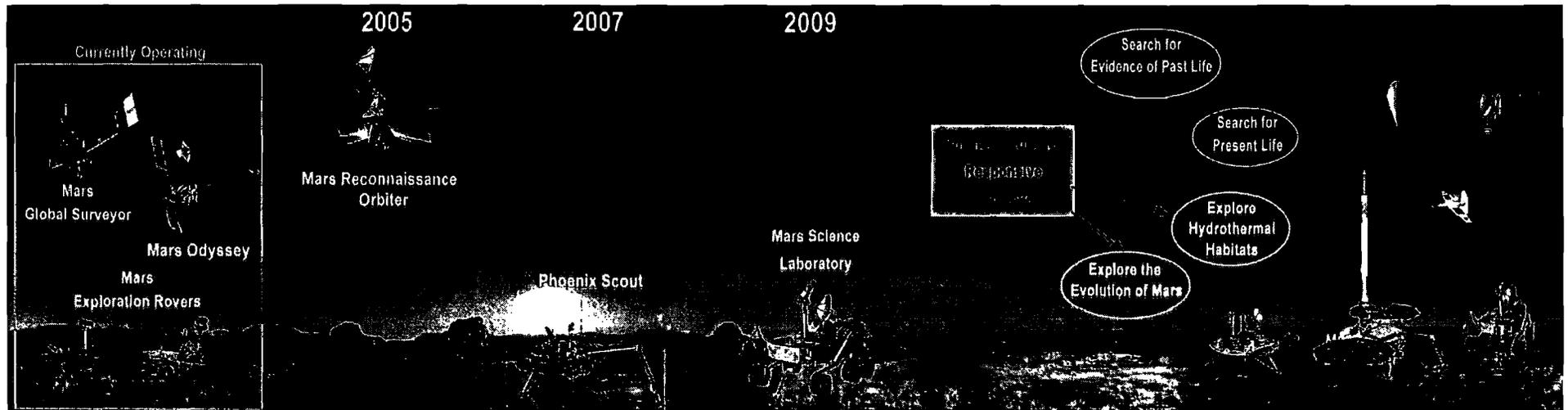


- **Operating 20 minutes (to 30 days) from contact with Earth**



To Reach This Goal...

(2011 and beyond options under study) 2011 2013 2016 2xxx



... We have to overcome

- Time, cultural, and geographical barriers
- Generational gaps
- International disputes
- Budgetary and political challenges

➔ The only solution is consistently evolving collaboration



Anticipated JPL Needs in 2010/2015 Model: Completely working model before any fabrication



- 1. Advancement and implementation of Model Based Engineering**
 - 2. Establishment and embodiment of Re-use culture within IT and Engineering discipline to be used by all projects and domains**
 - 3. Better and scalable cross-discipline/function Product Data Exchange, e.g. Electro-Mechanical also known as Mechatronics**
 - 4. “Anywhere” Engineering, Business, and IT processes (e.g. for Design, Build, Sell)**
 - 5. Long time and reliable archival and retrieval of data**
 - 6. PLM standards enabling multi-disciplinary product integration**
 - 7. Aerospace Ontology and Taxonomy**
 - 8. Managing Change to Speed User Adoption of Technology**
 - 9. Designing Enterprise Architecture to Meet Evolving Business Needs**
- Create and run the entire spacecraft virtually before building anything (including partner models)**



ARCHITECTURE AND IMPLEMENTATION

**A better way to do PLM on Flight Projects
or
PLM in a Rapid Prototyping Environment**



Modeling and Collaboration



iSeries Viewer - Microsoft Internet Explorer

Select a View: ESTO Events

All Events (List Format) | | | Today | View by Day | View by Week | View by Month

Select a date from the list below:	Agenda	Tasks - (Series Items)	Assigned To:
	Subject	Owner Time Title	
7/27/2005	Test of Power Failure Tomorrow	Cross-train UCS Charging mechanisms	DEBBY L CALLAGHAN
8/3/2005	New CIO - James Rinaldi	Set Up CD Caddies	Arthur Estillore
8/10/2005	Prometheus is dead! Long live Prometheus!	Waiver A Process	Kit Ko
8/17/2005	Lab is looking at ~\$150M loss next year	DSMS Gap Analysis	Don Ning
8/24/2005	Return to Flight!	SRS template for TC Requirements	Arthur Estillore
8/31/2005	EC Budget Retreat in Aug	Document Tools for PDMS v3	Moxie Zhang
9/7/2005	Ethics office and ITAR Training - Due by end of September	ECR SRS Document	Stephen B. Sandstrom
9/14/2005	Video Equipment to be moved into Server Room	Waiver B SRS	"THY TRAN"
9/21/2005	Awards & Recognition	Video Complete on Friday	Arthur Estillore
9/28/2005	Section Picnic!	ITAR Wizard	
10/5/2005	Changes in Group	Review tools and process for development and testing	Michael Stefanini
10/12/2005	Sailing Trip Details	Plan for Account Conversion for DocuShare	ANN M BERNATH
10/19/2005	<input type="button" value="Add new item"/>	Doors & Req Gap Analysis	Linda Q. Maleki
10/26/2005		Review TCE 5.0	Moxie Zhang
11/2/2005		<input type="button" value="Add new item"/>	

Meeting Minutes

There are no items to show in this view of the "Meeting Minutes" list. To create a new item, click "Add new item" below.

Running Notes - (Series Items)

There are no items to show in this view of the "Running Notes" list. To create a new item, click "Add new item" below.

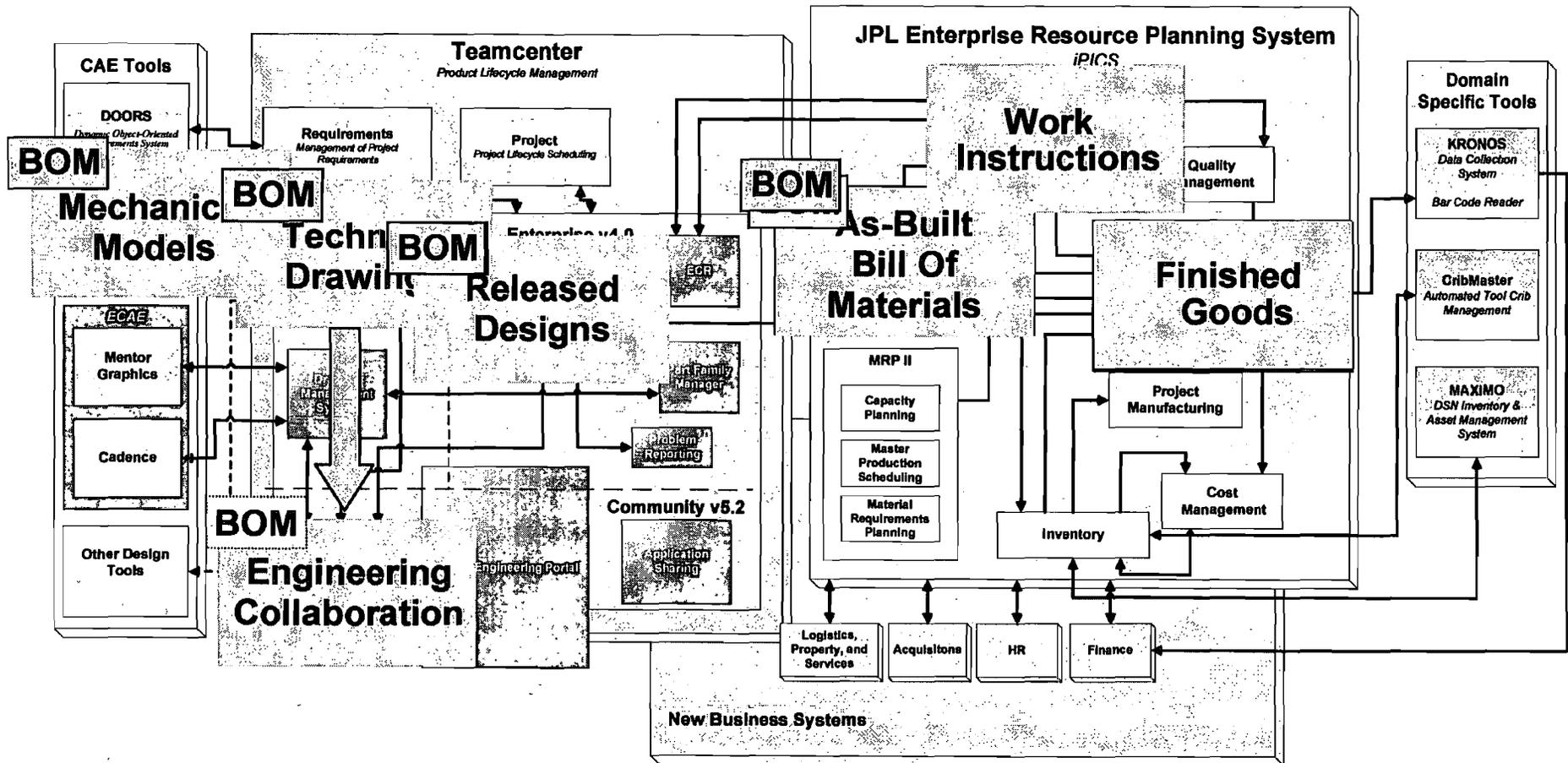
Document Library

Type	Name	Modified By
There are no items to show in this view of the "Document Library" document library. To create a new item, click "Add new document" below.		

Done | My Computer



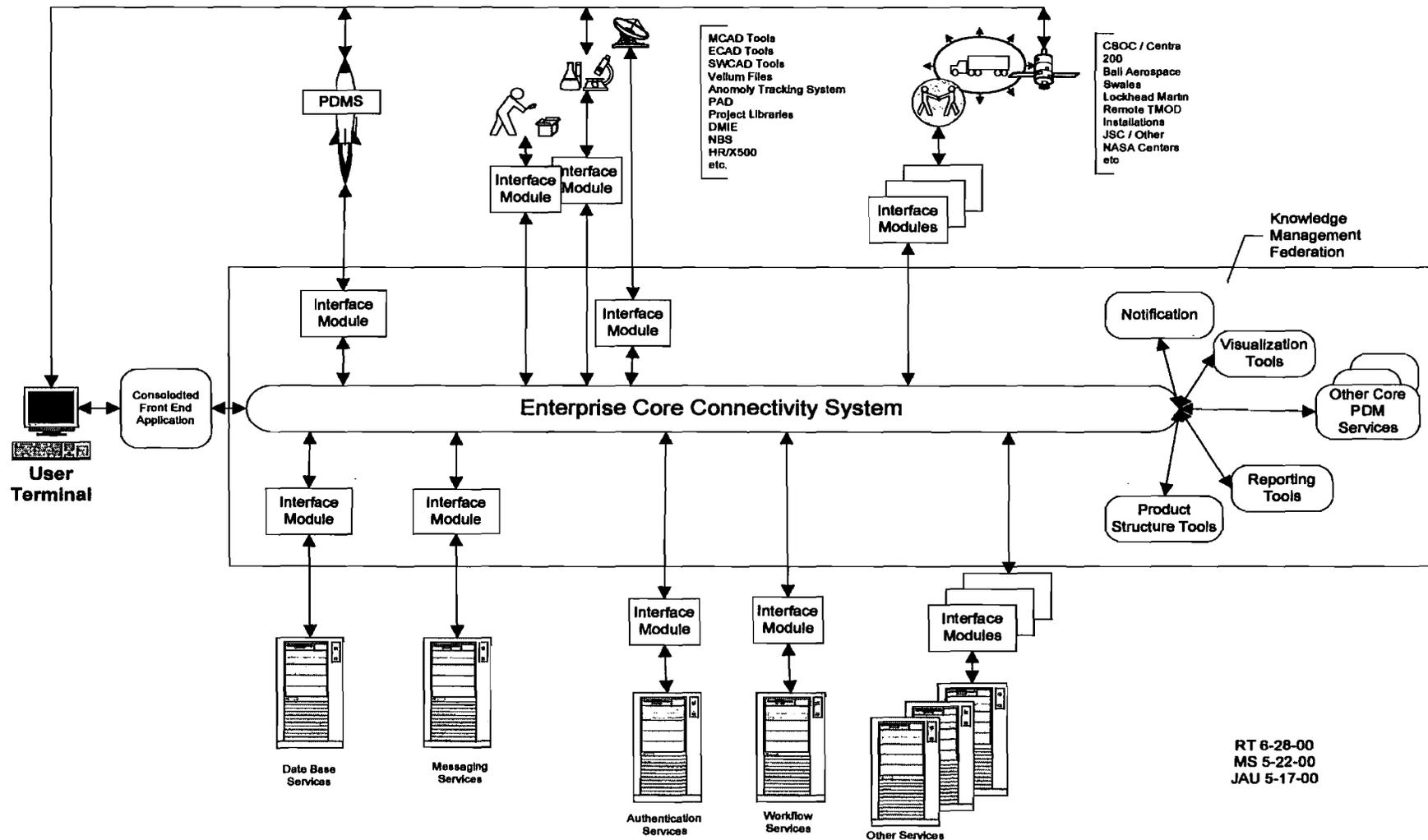
Collaborative Environment System Architecture





Early Architecture Concepts – May 2000

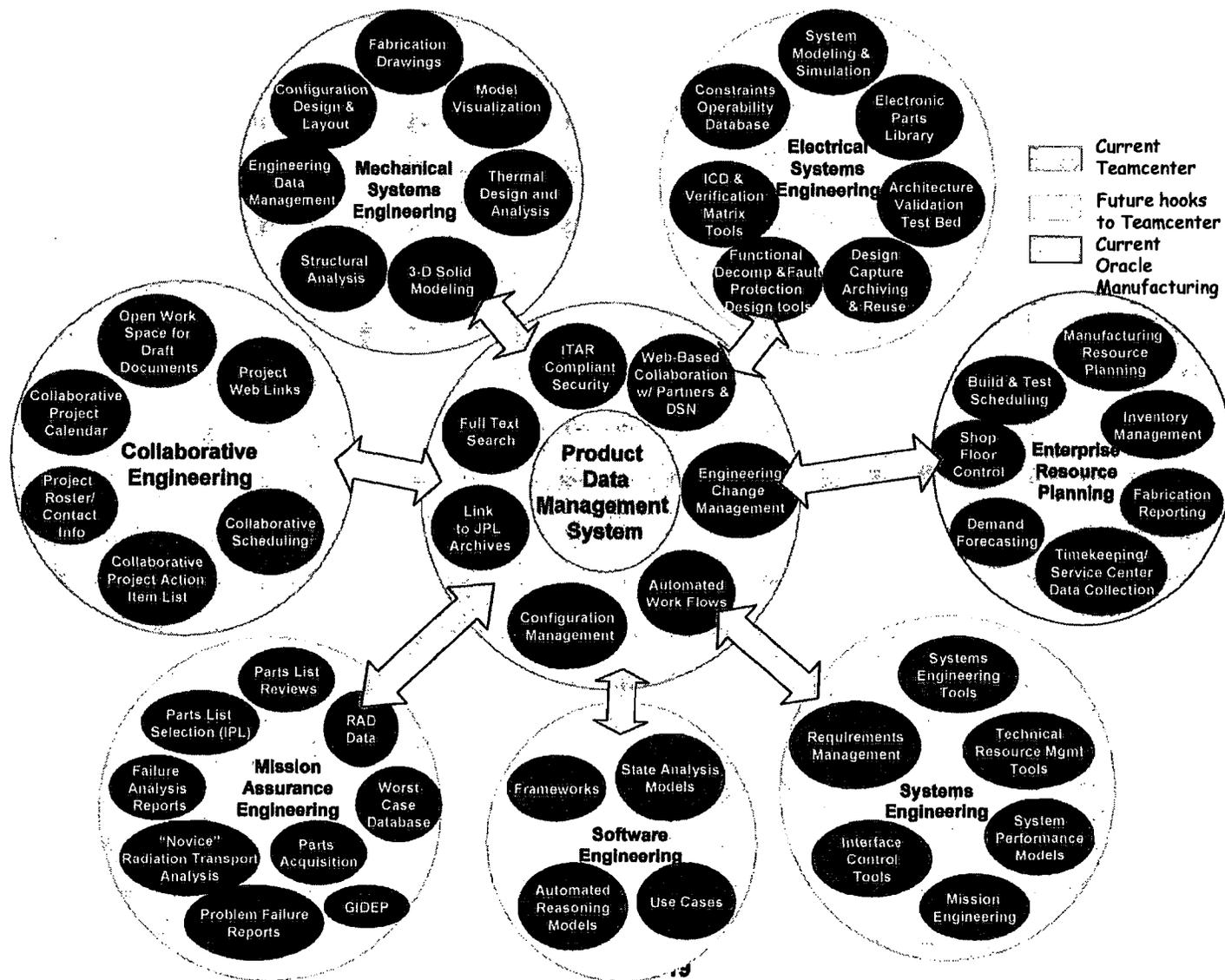
JPL's Enterprise PDM System
High-Level Architecture Diagram



RT 6-28-00
MS 5-22-00
JAU 5-17-00

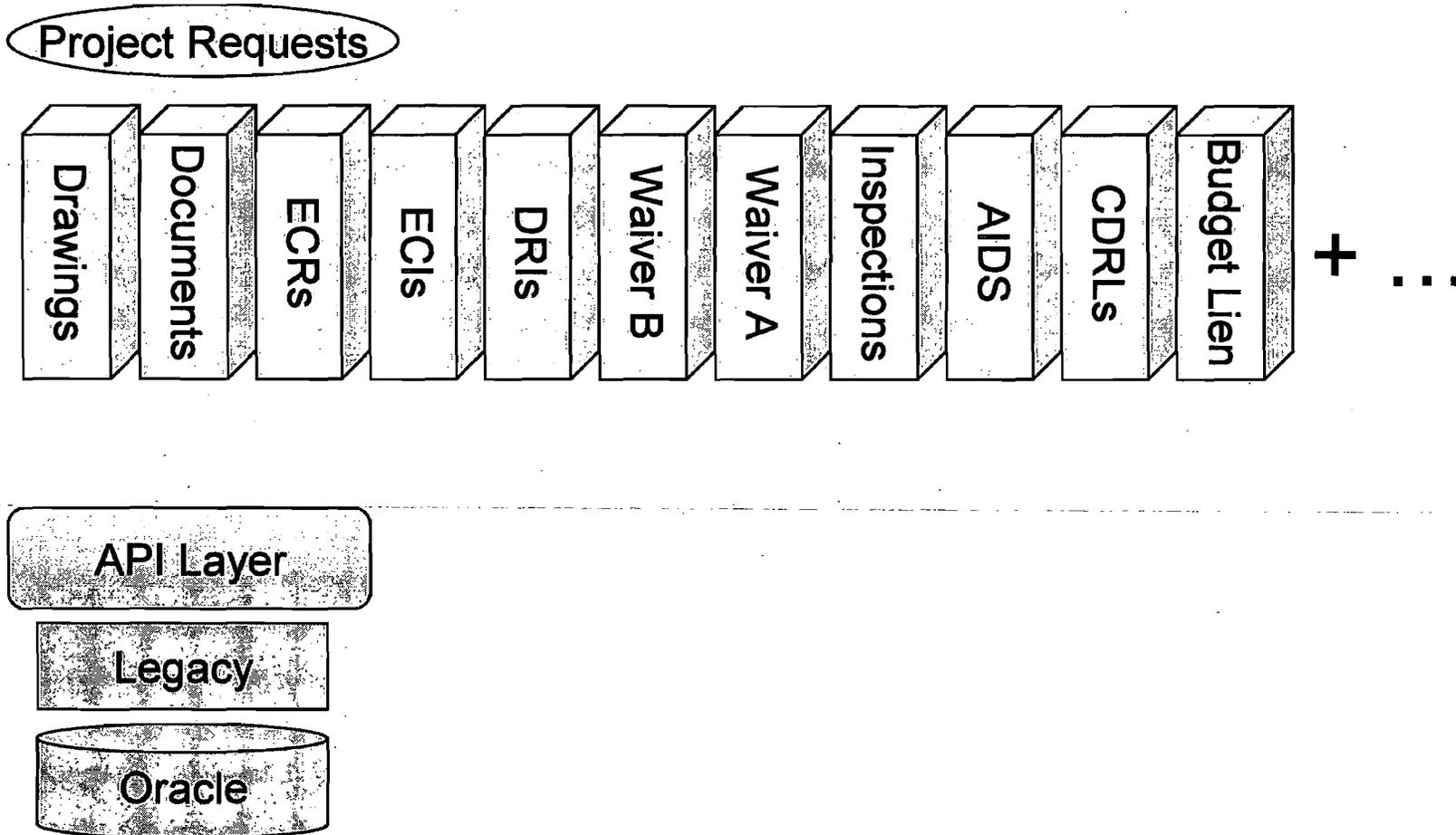


Concept Diagram for Collaborative Environment



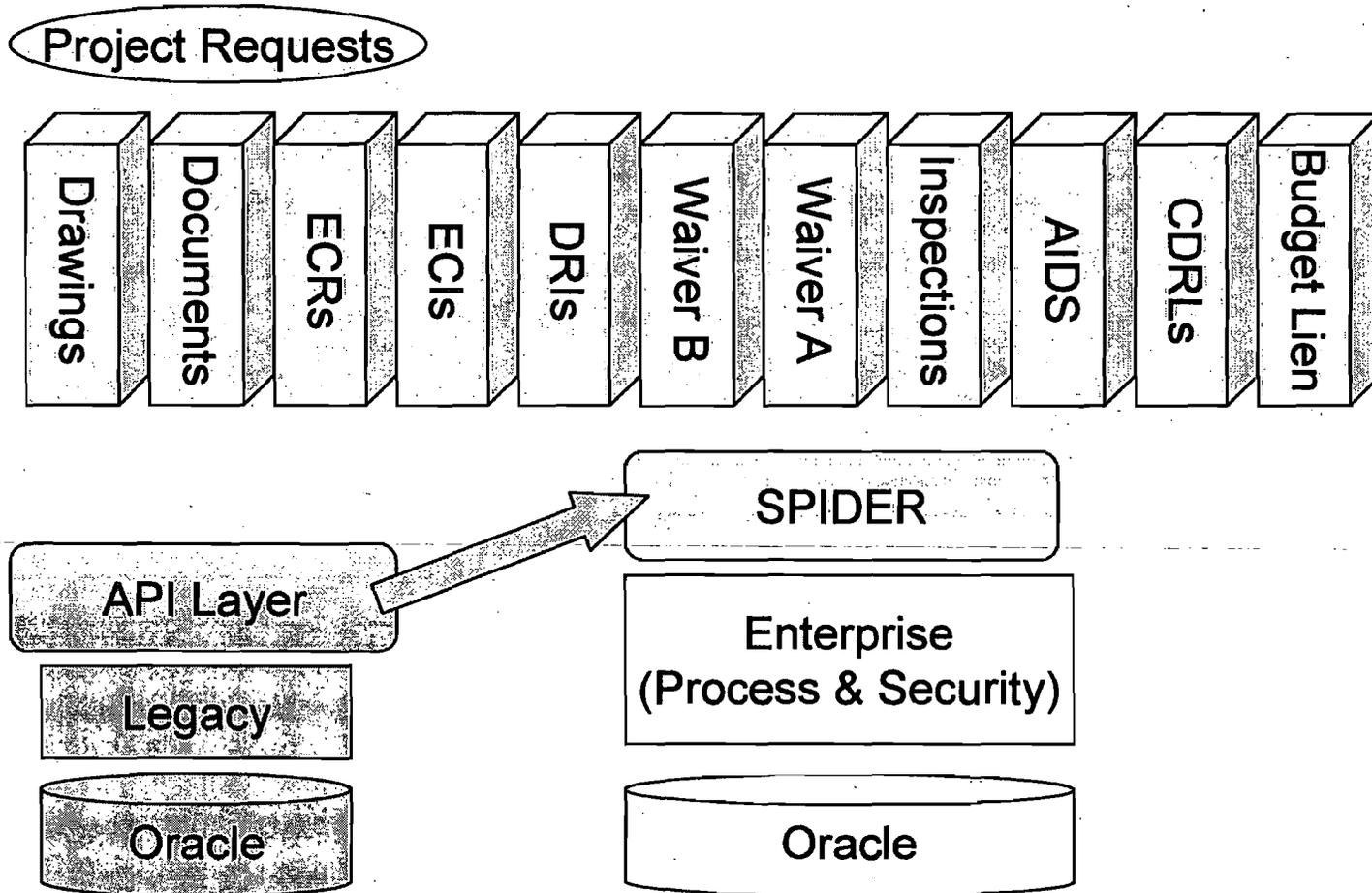


PDMS in 1999



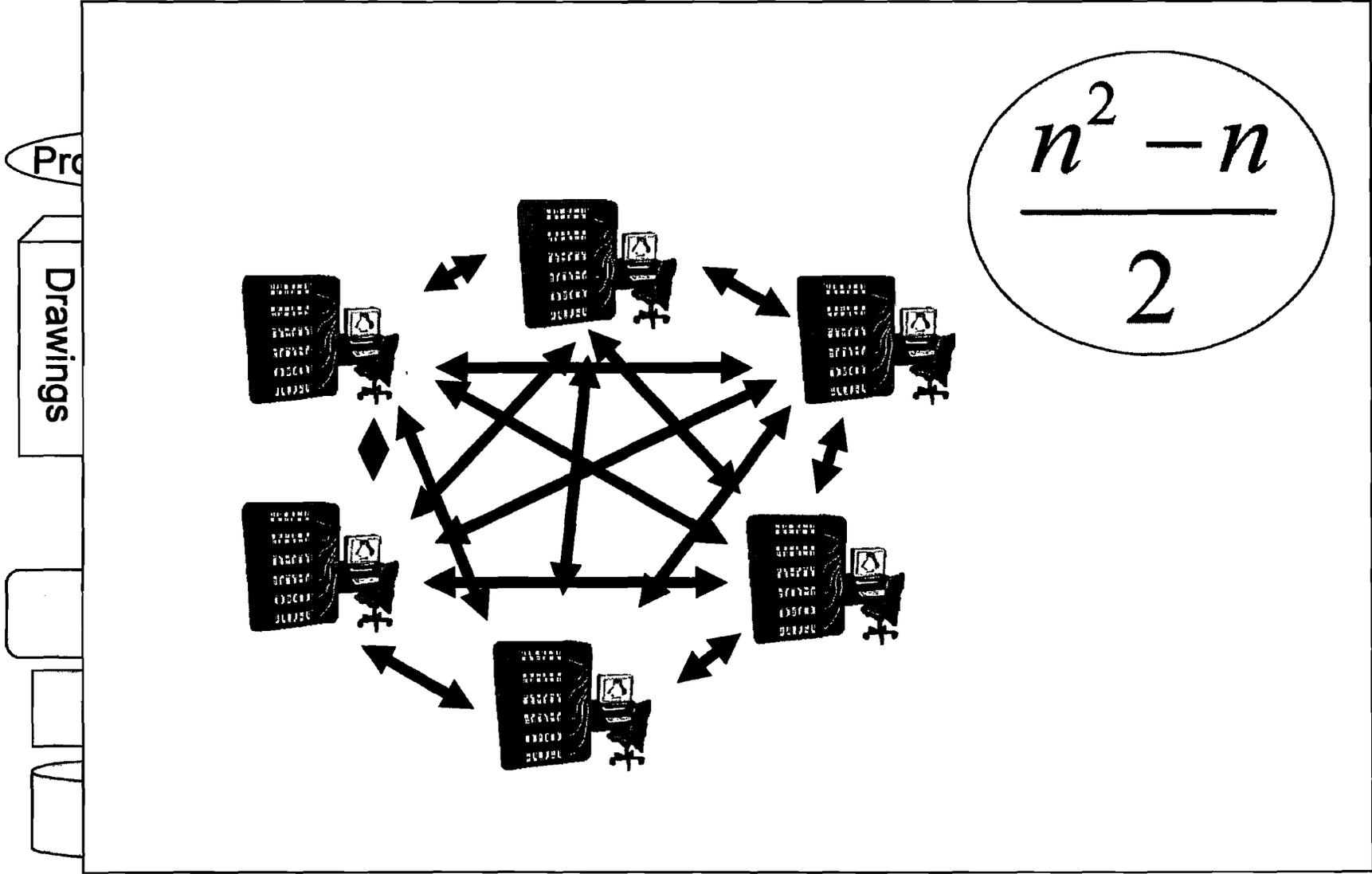


PDMS in 2001





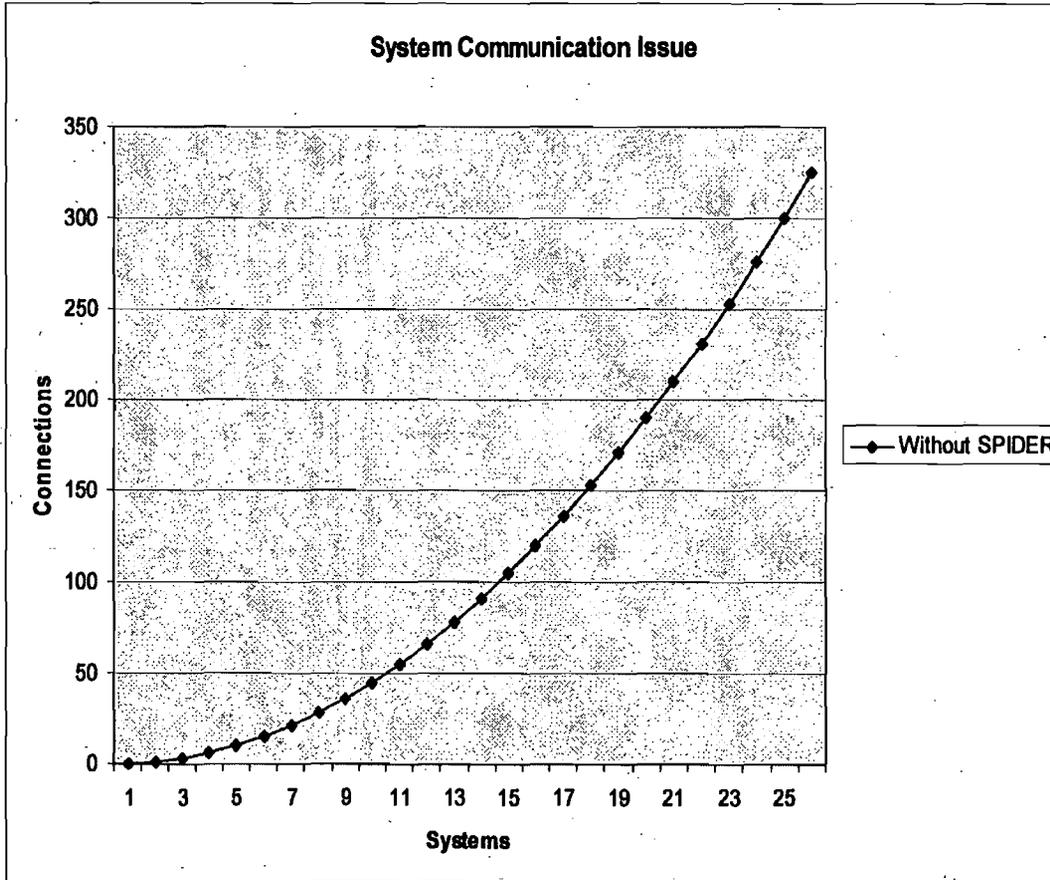
Why Spider?





Why Spider?

Pro
Drawings

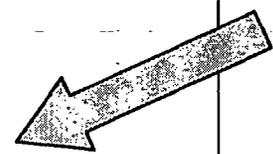
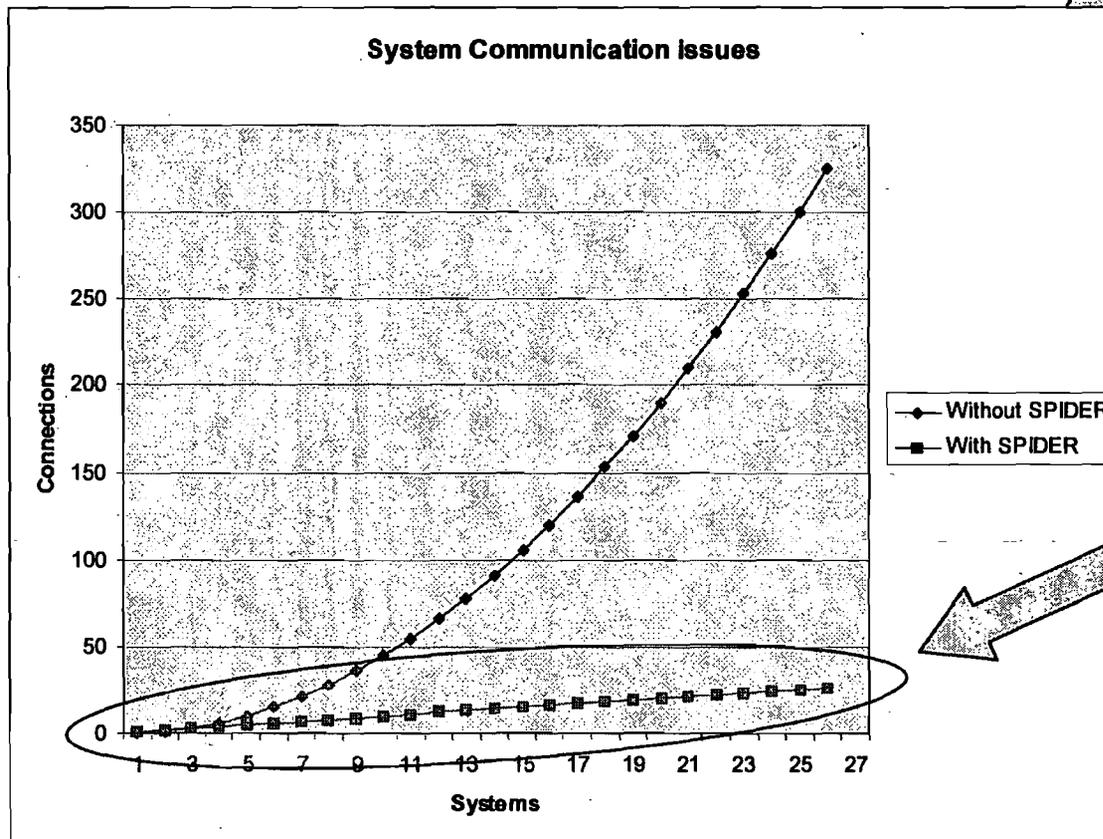
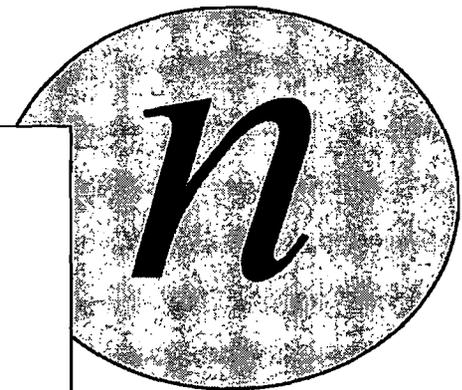


$$\frac{n^2 - n}{2}$$



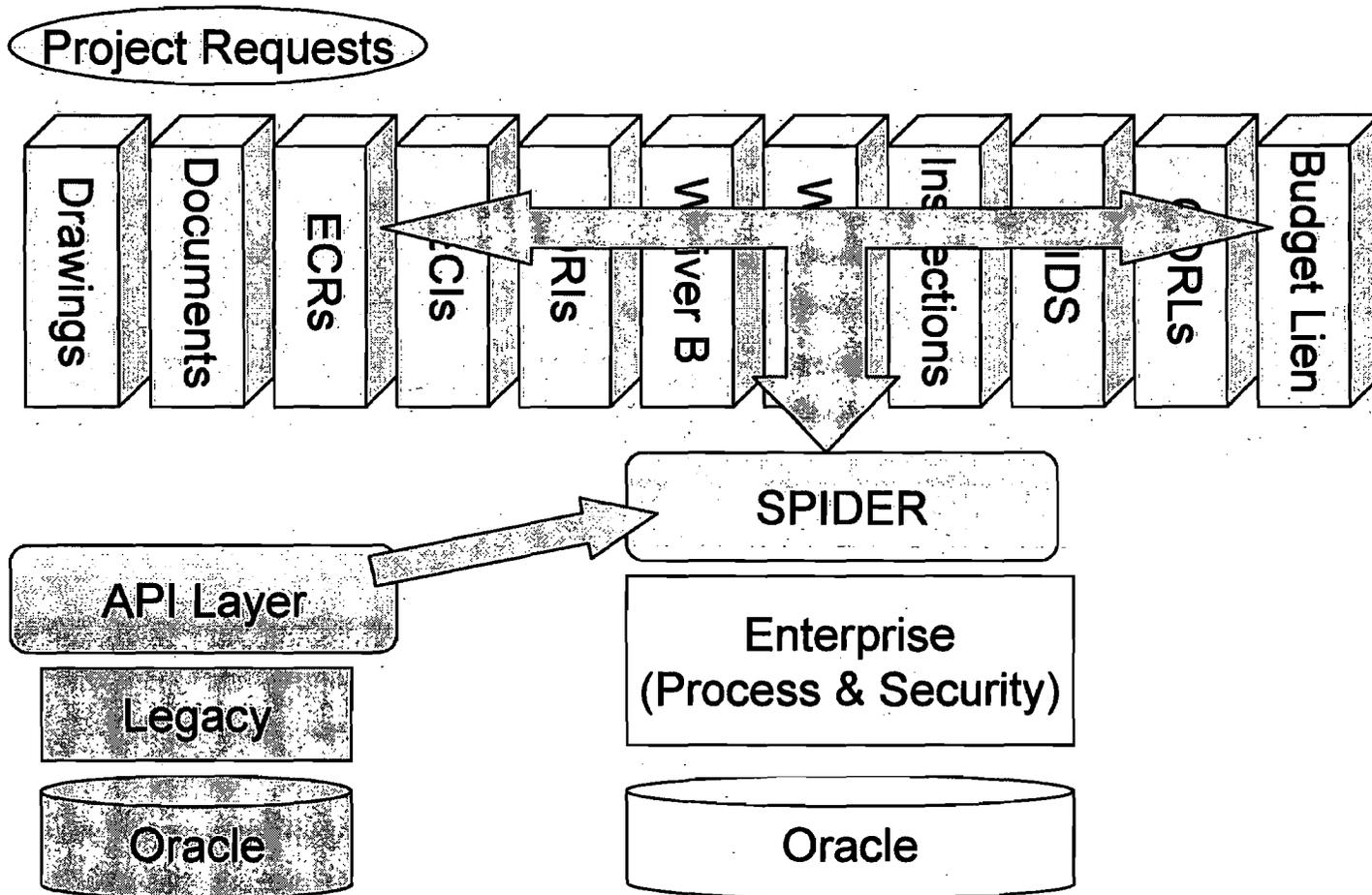
Why Spider?

Pro
Drawings



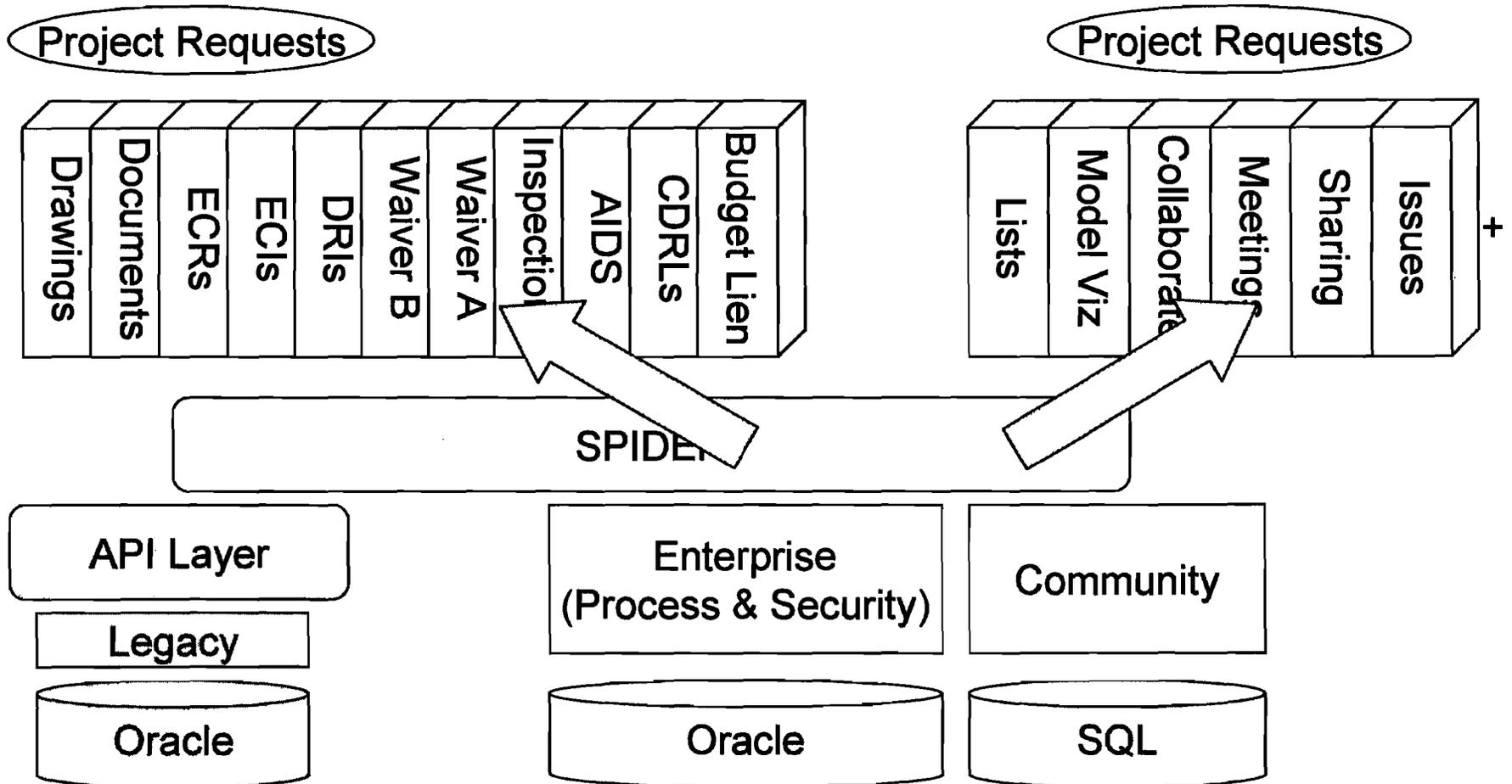


PDMS in 2004



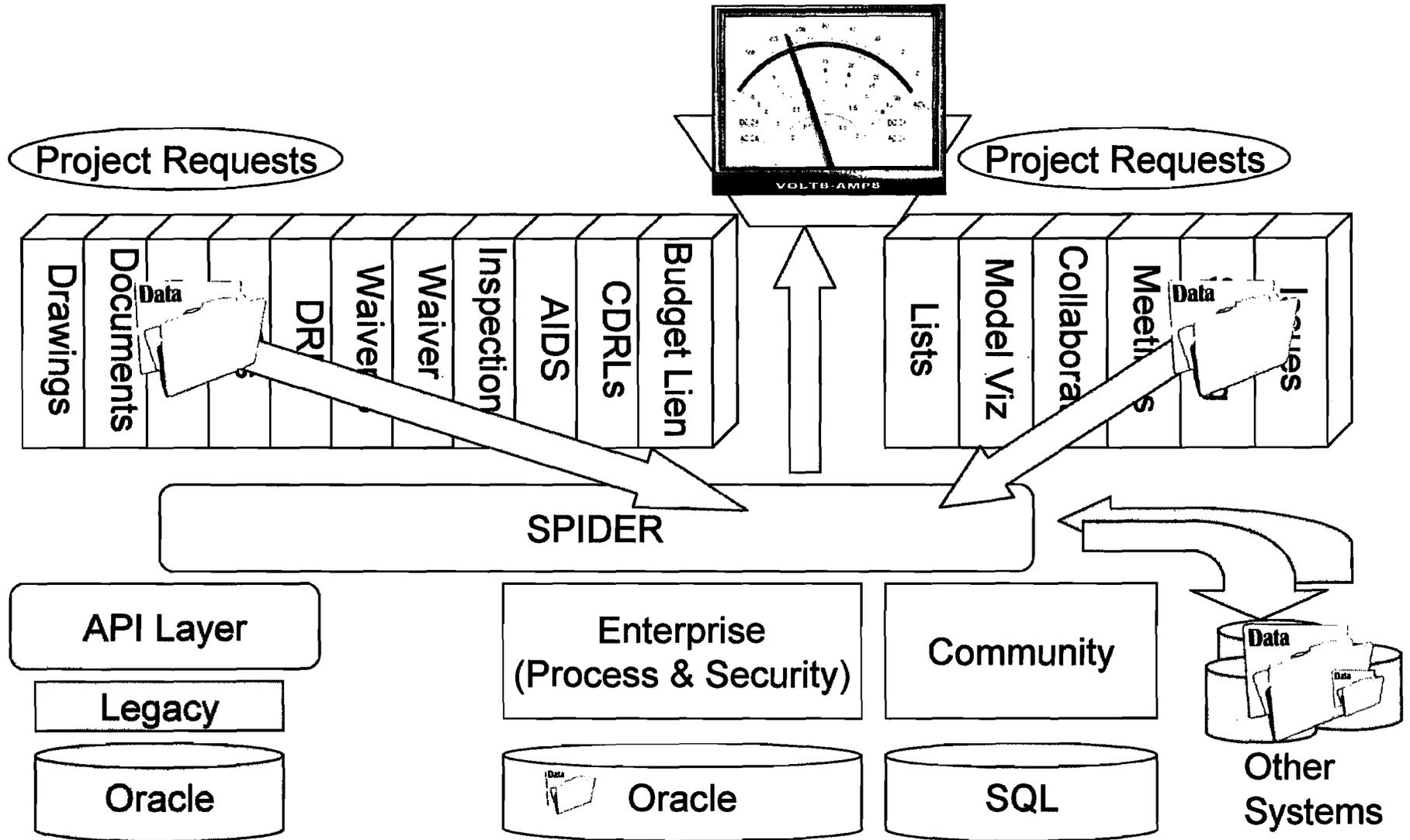


PDMS in 2005



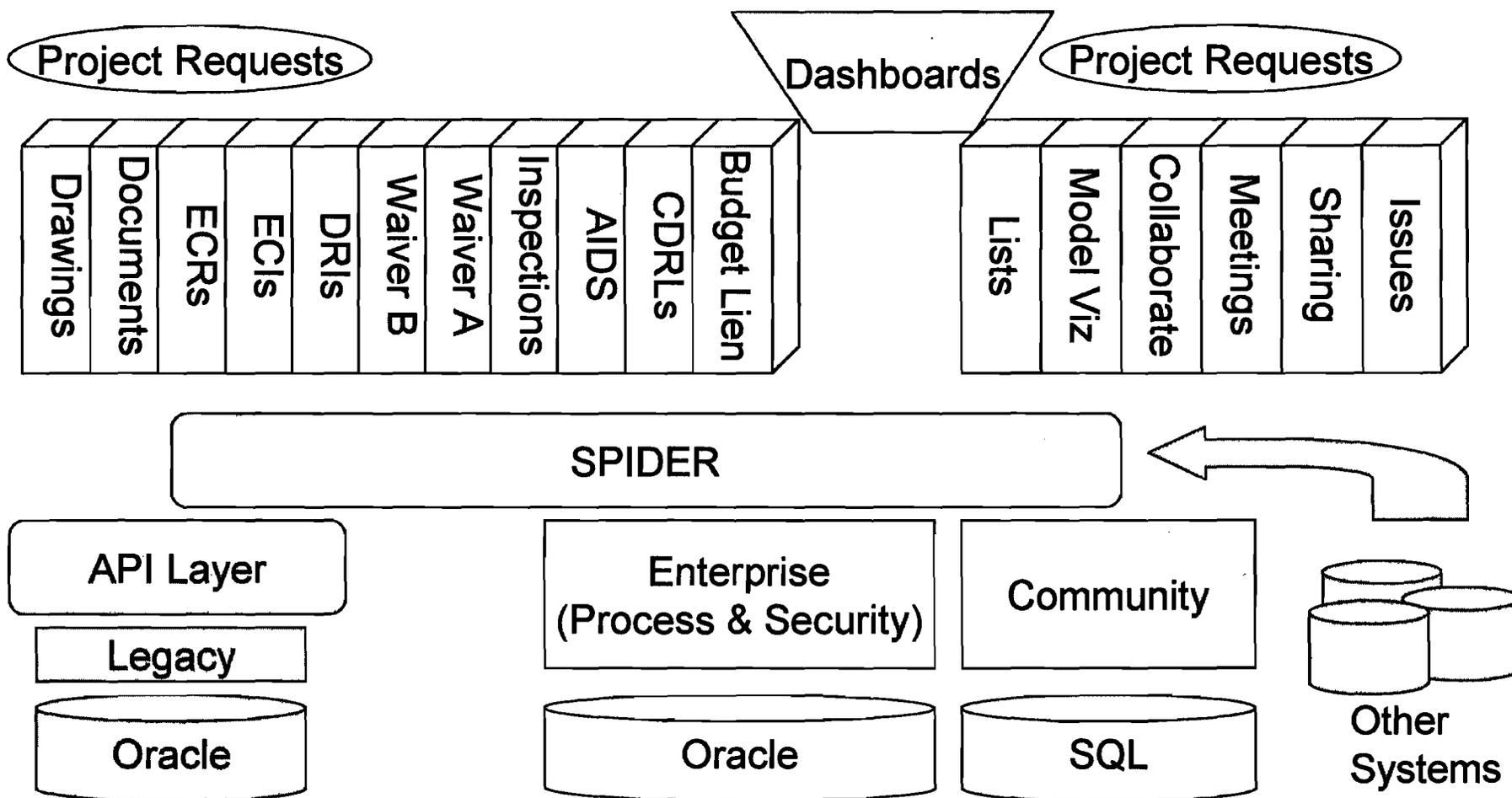


PDMS in 2005





PDMS in 2006





Results

Drawing Print On Demand (POD)

Released Drawing Search Result

Drawing Detail Information

Release Package Queue

Remove Expand Collapse

- ▼ New Release Package
 - ▼ Drawings(0)
 - ▼ Distribution List(0)

Queue item description

Creation Wizard : Step 1 of 5

Status: Create or update the Release Package

Create
Add Drawing
Function
Signature
Distribution

Project # *

Proposed Final Signoff Date *

Project # (Acct. Info) *

Task # (Acct. Info) *

Comment

Release Destination

- Release for Planning
- Release for Build/Buy
- Release for Final

Release for Final is set as default.

Search

2

dated

7

7

7

7

7

7

7

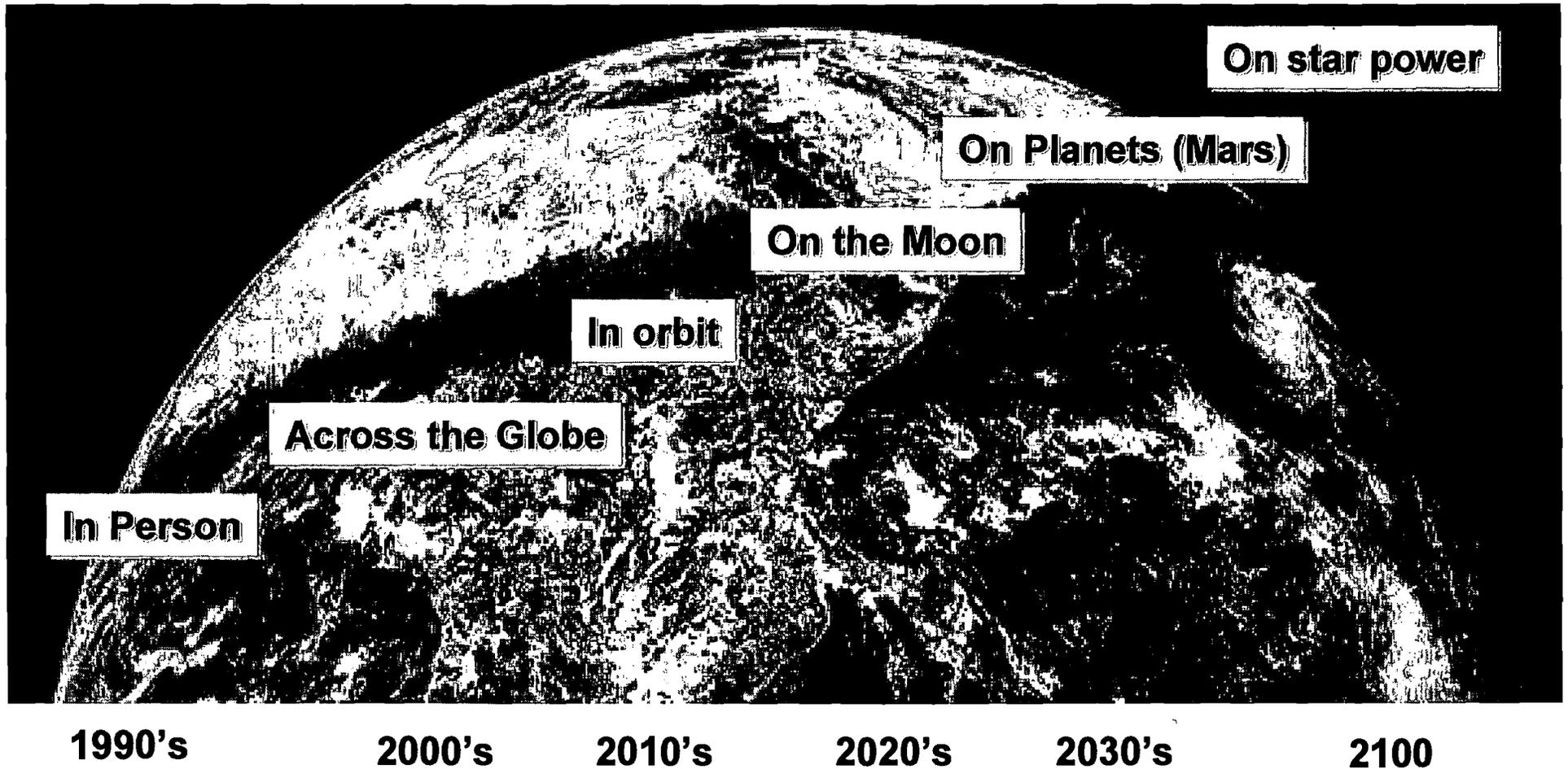
6

Sort by Drawing number

Powered by **PDMS** 2004 (c) Rich Internet Client (RIC) Application Prototype for JPL PDMS Drawing Print On Demand (POD) System



Our Collaboration Needs to Keep Pace With Our Needs



Send an avatar, then a robot, then humans



The Solution is Sustained Interoperable Collaboration



- 1. The vision and needs are astronomical and long term
→ We need an ongoing and long term strategy with sustained buy-in**
- 2. No company or organization can implement the entire solution
→ We must have open, interoperable standards**
- 3. No single country can afford the long term budgetary challenge
→ We need international cooperation and collaboration**
- 4. We will not always know what we need to collaborate on
→ We need to scale in realtime to the needs and available resources**
- 5. There will be political and cost pressure to give up in all countries
→ We need to visibly celebrate successes along the way**

Our Problem Is Large

Our Incentive Is Astronomical

Let's Start the Journey Now

Tom Soderstrom, IT Chief Technology Officer

Tom.Soderstrom@openwave.com

Openwave Systems, Inc. | 10000 Wilshire Blvd. | Los Angeles, CA 90024



Backup Slides



Backup Slides



IT/Web Evolution → Enterprise Computing



Trends

- Accelerating changes
- Perpetual beta
- Faster, cheaper development
- Easier deployment
- Increased standardization
- Wisdom of crowds
- Increased productivity...

Web 4.0 - ?

Web 3.0 - By Enterprise for workers

Web 2.0 - By Consumers for home collaborators

Web 1.0 - By Enterprise for shoppers

Web 0 - By Academia for scientists



Computer-Networks

E-Commerce

Social-Networks

Application-Nets

PDA-Nets

1960s/70s

- Packet switching
- ARPANET

1992

- Netscape public
- Smart Developers

~2004

- Google
- "Web 2.0"
- Smart Users

~2008

- Semantic Web
- Smart Data

~2010

- Mobile Web / Always On
- Smart mobile devices

Definition of “Collaboration” Is Becoming Over Complicated

Google search for Collaboration generated 161M hits

From Wikipedia:

“Collaboration refers abstractly to all processes wherein people work together —applying both to the work of individuals as well as larger collectives and societies.

Blah blah blah

... the nature of collaboration is coming under more intensive study.”

Analysis Paralysis → Watch what the kids do

Successful Collaboration Incorporates Six Key Characteristics

1. Flexible Time

- Synchronous (We're having a conversation) vs.
- Asynchronous (How do we get out "living in the In-box") vs.
- Historical (We're reusing the best of breed information)

2. Any Distance

- Collocated → In same company → in same country → on the same planet

3. Bridges Culture

- E.g. Science vs. Engineering; IT vs. Finance; Government vs. Commercial
- Corporate culture and international differences

4. Considers Different Ages

- Knowledge transfer from retiring Baby Boomers to new generation is hard
- Rapid changes in collaboration practices creates communication challenges
- New generation with new work patterns and new tools

5. Security is Built-in

- Reactive → Proactive → Built-in and automatic

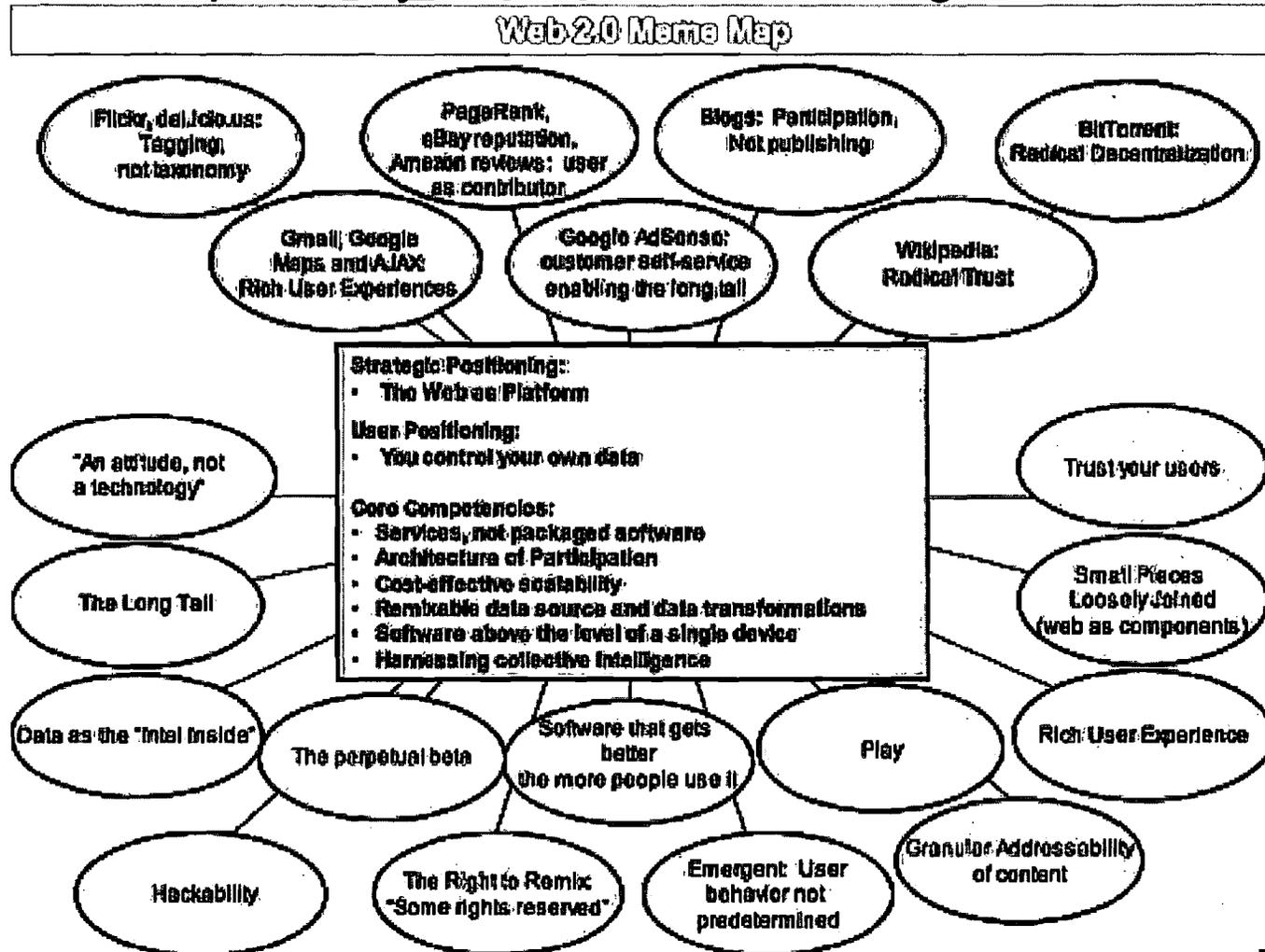
6. Most Effective Mix of Resources

- Facilitating standards, network, tools, and people determine specific solution



Web 2.0 – A Collaboration Step Ladder

<http://www.youtube.com/watch?v=6gmP4nk0EOE&eurl>



...
 Blogs,
 Social networking,
 Folksonomies,
 Wikis,
 Podcasts,
 RSS feeds,
 AJAX,
 SOAP,
 REST,
 Mashups,
 Web Svcs,
 Flickr,
 Del.ici.ous,
 YouTube,
 Google
 ...

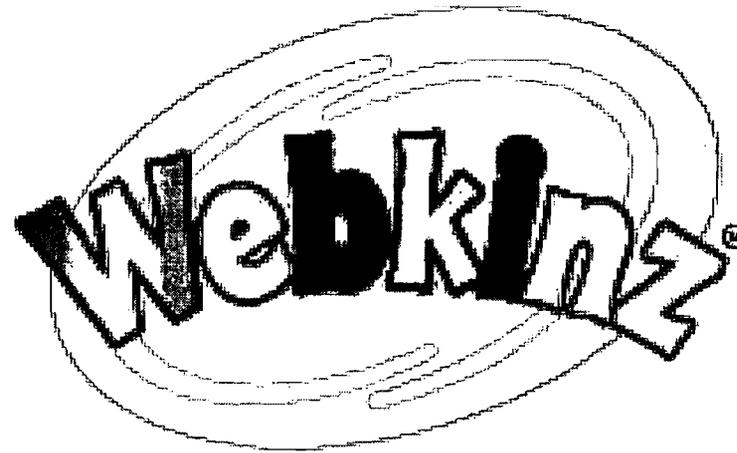
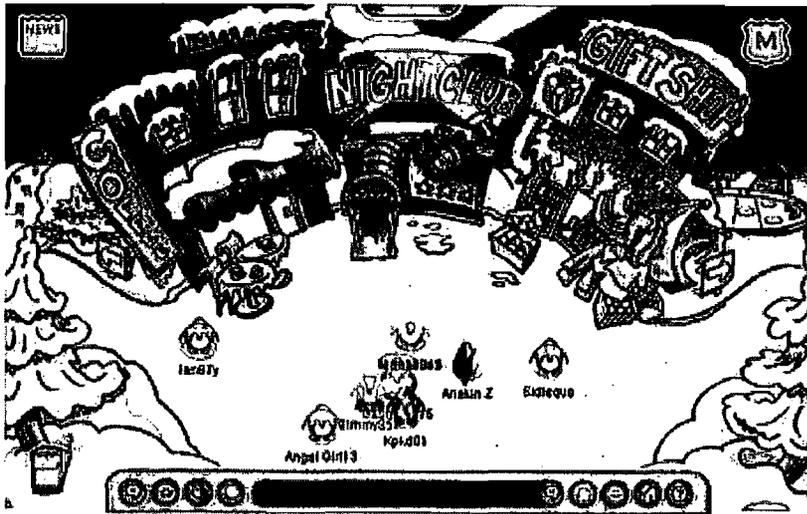
- From O'Reilly



The Next Generation Workforce Is Training... What can we learn from Cheeky Monkey and Love Puppy?



There are 29M US kids 8-14 years old with annual purchasing power of \$40B. 90% are online.



www.clubpenguin.com/

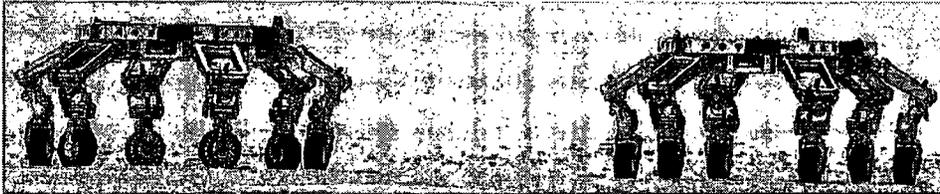
1.6M unique visitors/month (2.9M in Jan.)
Free access to virtual penguins; pay to decorate
Worldwide, simultaneous parties. “Snow Days”
2 years to reach 1M users (SL took 3).
4x stickier than YouTube.

www.webkinz.com

900K unique visitors/month (1.6M in Dec)
Access to purchased virtual pets.
Hold virtual jobs to upgrade lifestyle.
2 years to reach 1M users
4x stickier than YouTube.



Expanded Definition of Collaboration: So, How Do You Motivate A Robot?

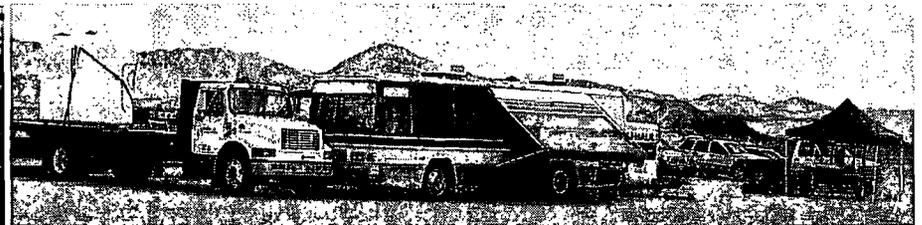


ATHLETE Robots

- Sustained simultaneous operations of two robots for multiple days
- Drove vehicles on flat terrain and on sand dunes
- Performed basic walking



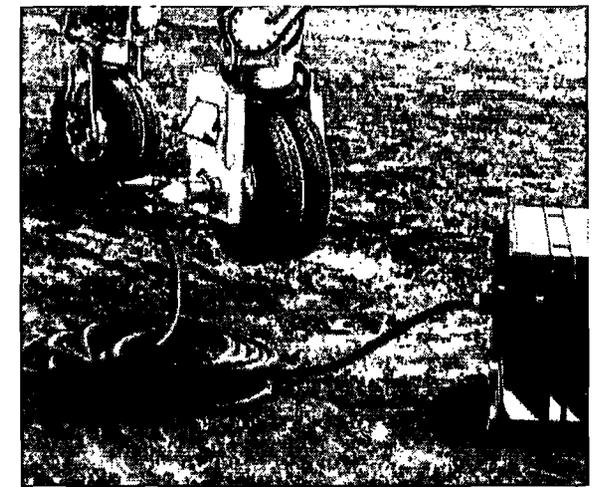
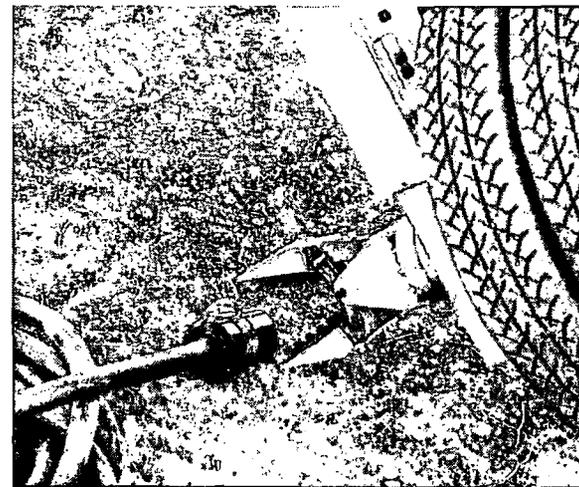
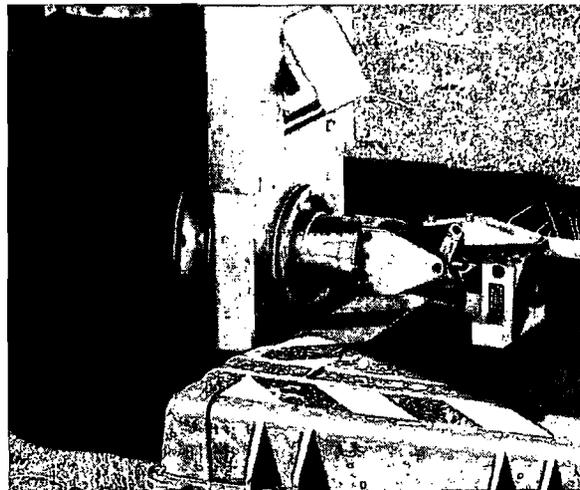
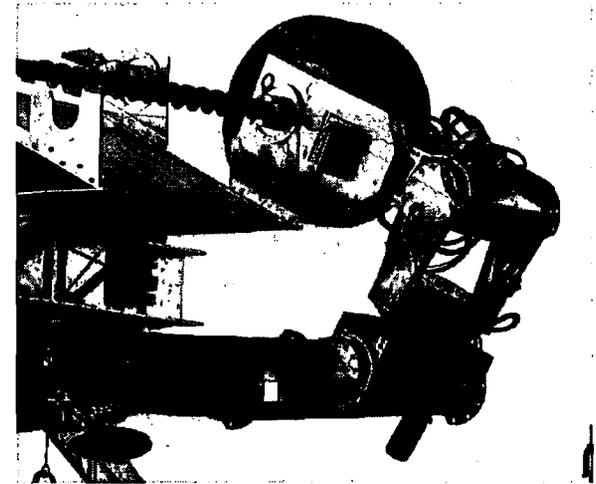
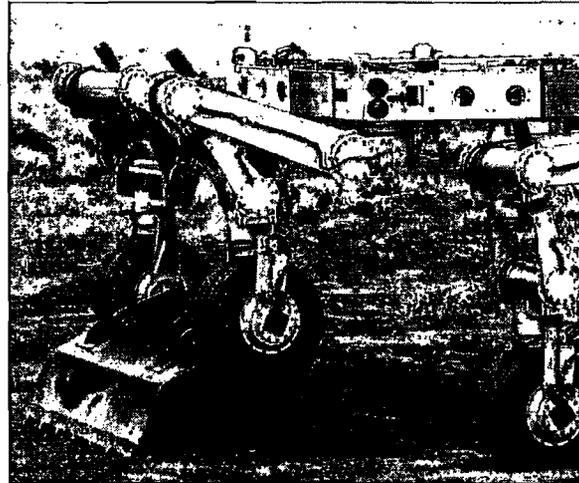
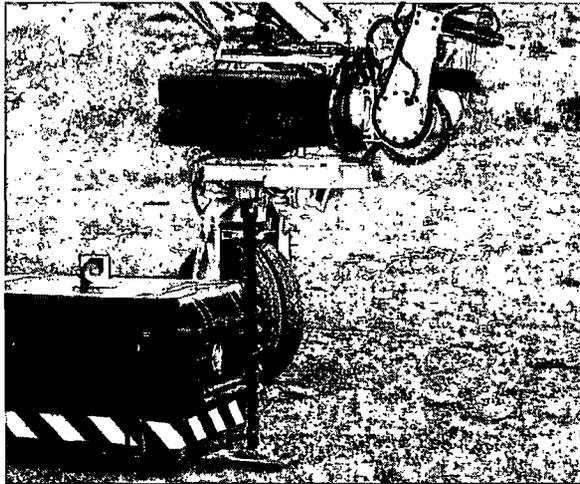
COACH configured for dual-robot operations



COACH in field camp

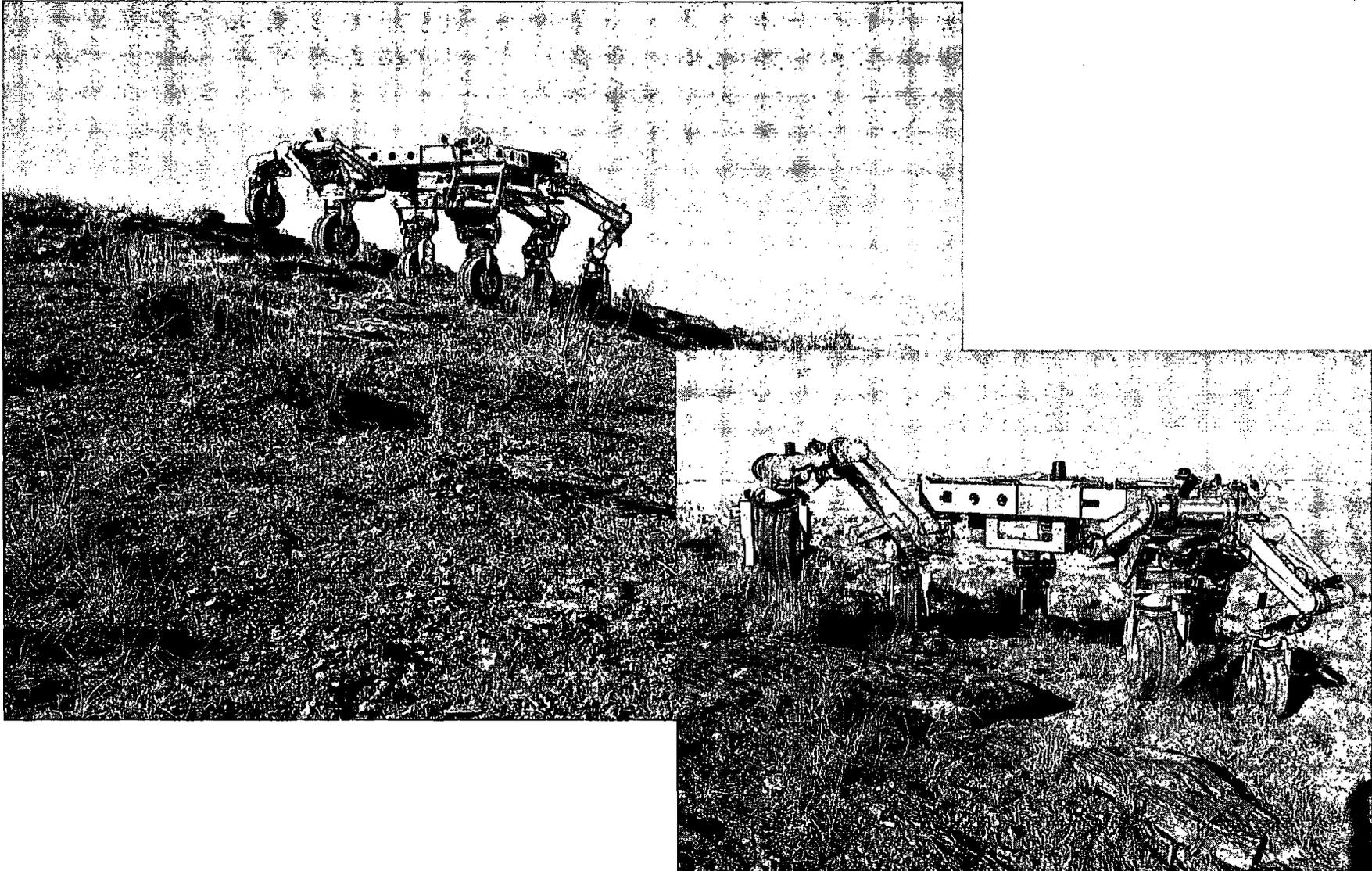


Well, You Let it Play With Teleoperated Tools...





Give it Exercise...

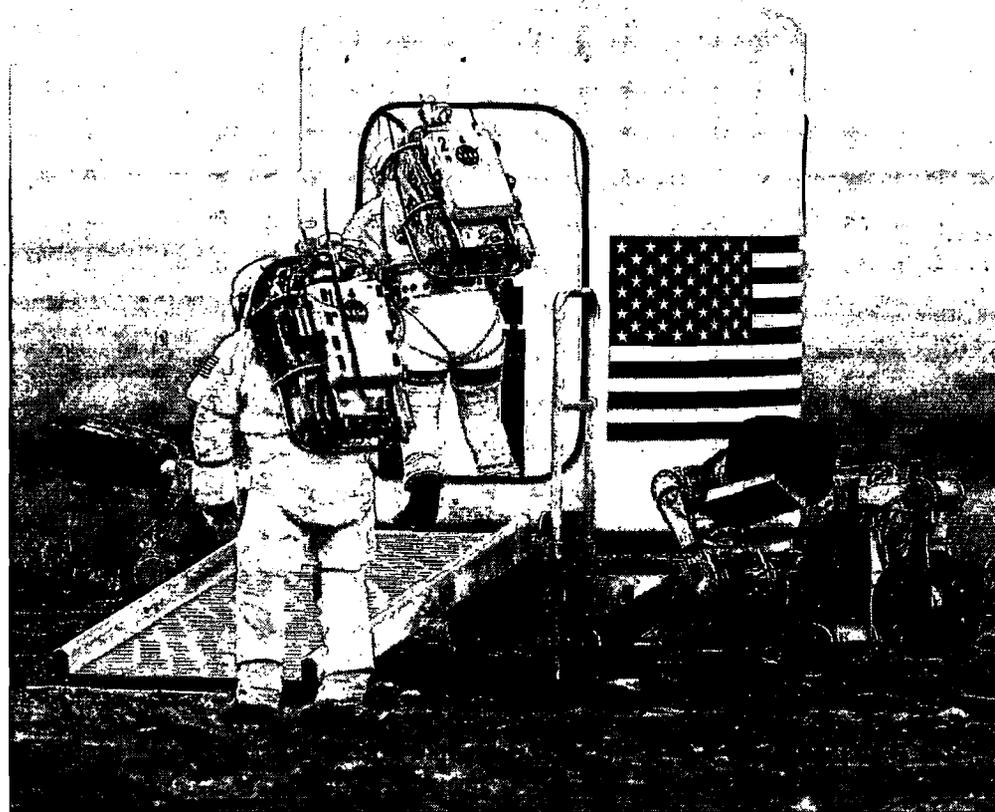
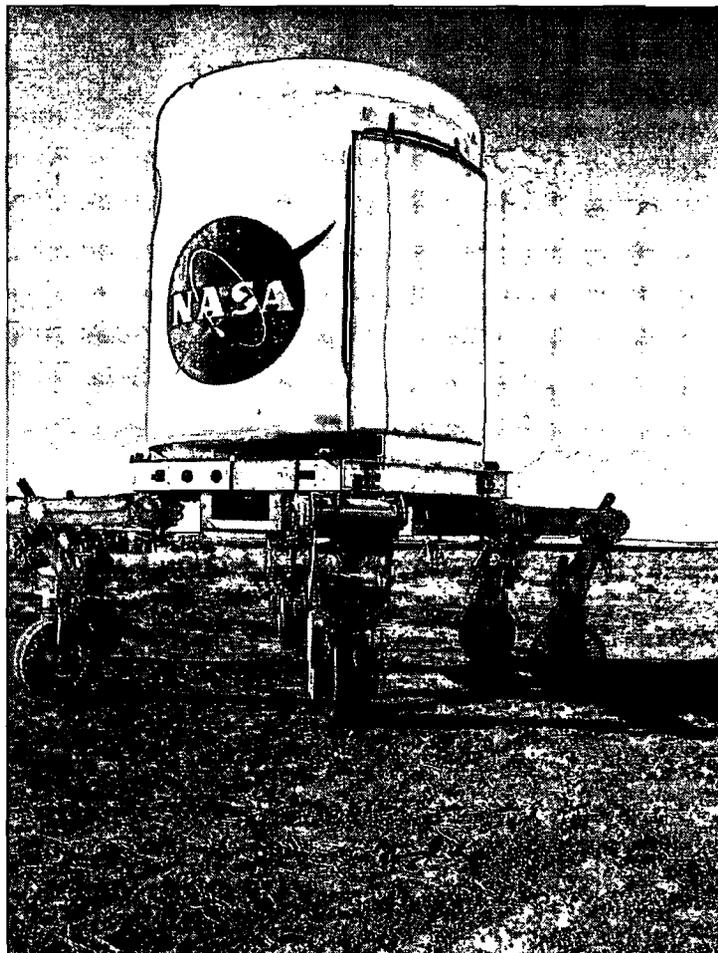


April 9, 2007

Collaboration 2.0: The Next Generation -- Tom Soderstrom, JPL



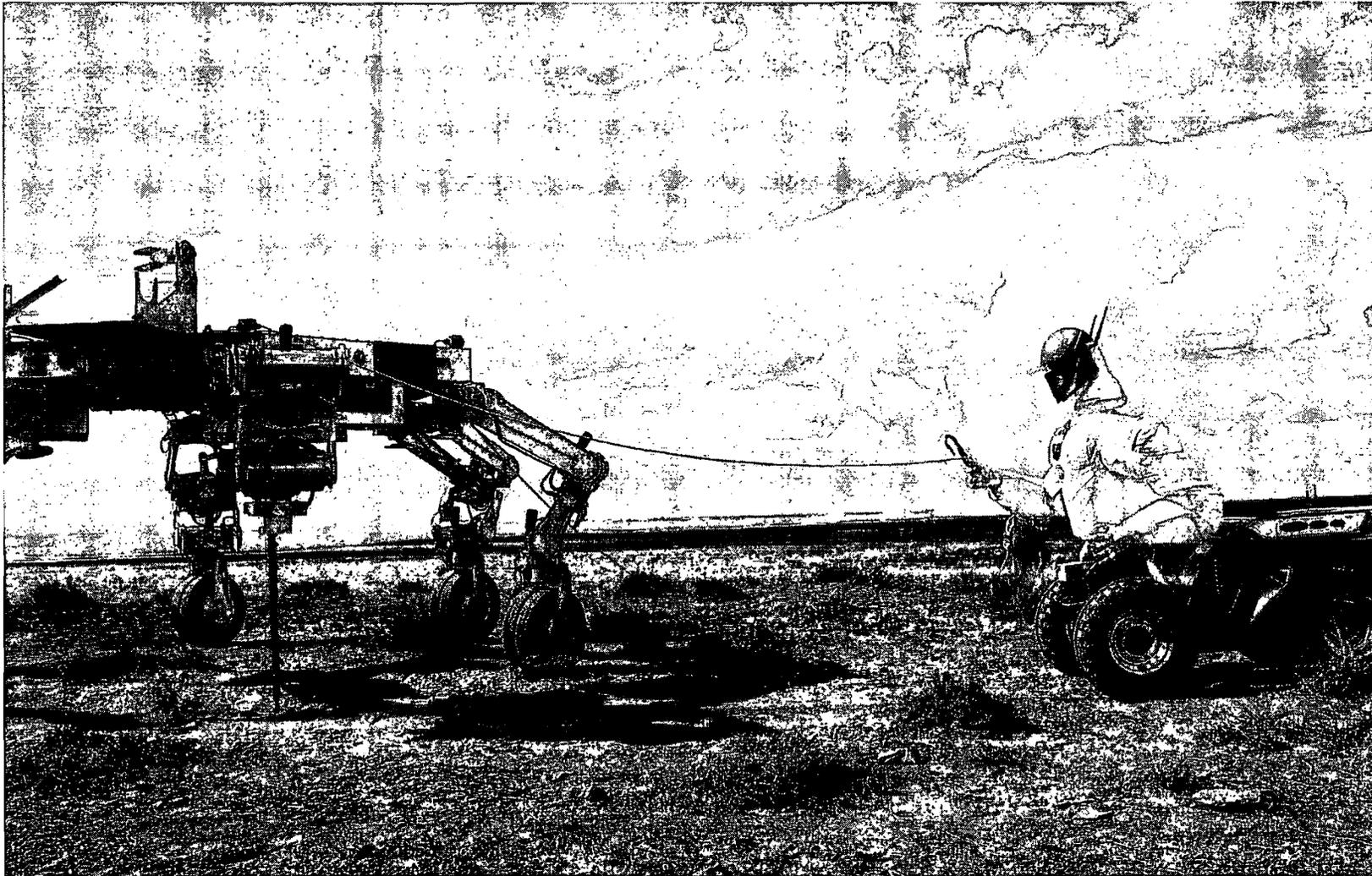
Give It A Purpose ...





... And Let it Play With Other Robots

JPL
Jet Propulsion Laboratory
California Institute of Technology



April 9, 2007

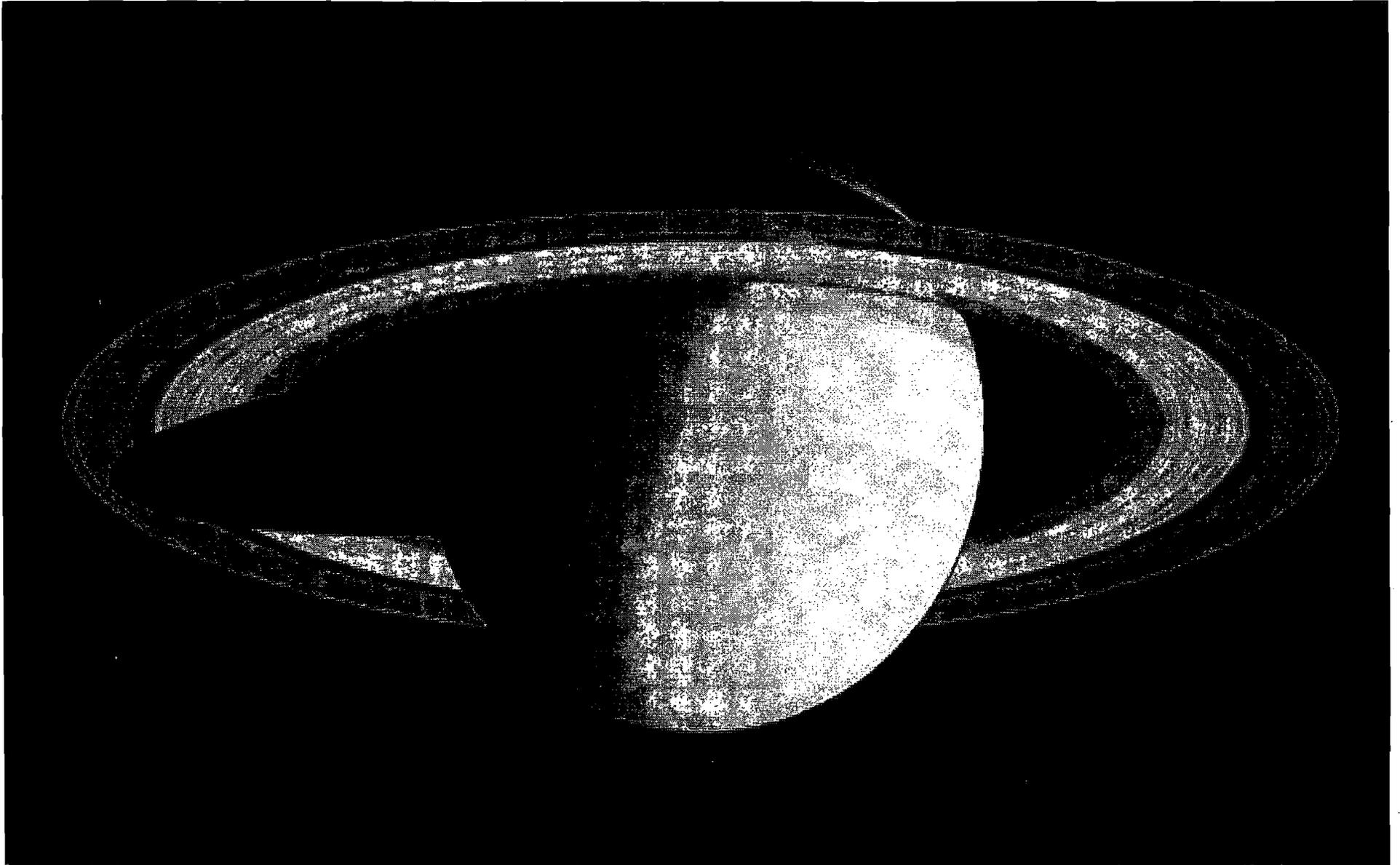
Collaboration 2.0: The Next Generation -- Tom Soderstrom, JPL

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Q&A

JPL
Jet Propulsion Laboratory
California Institute of Technology



for Year 2010 Model

- Be prepared
- Be organized more easily
- Be part of counter culture
- Be part of the coming generation

“Always on”,

Active

in an organized manner

(blogs, podcasts,

forums, ...)

Life cycle of a Space Project:

Commercialization

1. Build up the (Enterprise) House – Determine and document
2. Watch the major vendors
3. Experiment with/ use innovative tools and ideas
4. Adopt experimental successes into the Enterprise Architecture and work processes
5. Get an Avatar... it'll really impress you
6. Get small successes, then push

Don't build the house



Web 2.0 Patterns *



Harnessing Collective Intelligence

www.mashable.com, www.readwriteweb.com

Data is the Next “Intel Inside”

<http://microformats.org>

Innovation in Assembly

www.programmableweb.com, <http://blogs.zdnet.com/SAAS>

Rich User Experiences

<http://ajaxpatterns.org>; www.ajaxworldsexpo.com

Perpetual Beta

Software Above the Level of Single Device

www.gigaom.com; <http://opengardensblog.futuretext.com>

Leveraging the Long Tail

www.longtail.com

Lightweight Business and Cost-Effective Scalability

<http://gettingreal.37signals.com>; www.37signals.com/svn

Enterprise 2.0

<http://blog.hbs.edu/faculty/amcafee>

* From O'Reilly Radar



Web 2.0 -- How should we use it?

- **Purpose:** Adopt innovative and widely used technologies/methods
- **Benefits:** Allows individual contributors to make a visible difference and participate directly in the organization's mission. Technologies are proven, massively scaleable, inexpensive, and comfortable to users. Adoption allows standardization, improves productivity, and provides a competitive advantage
- **Challenges:** (1) They are seen by many as “toys that will never work in a serious IT environment” and (2) they were invented by consumers, not corporate IT
- **Roadmap:** (1) Canvas our environments for current users; (2) Identify new uses and use cases; (3) Discuss them in an open forum; (4) Form Positions and collaboratively prioritize them into a roadmap; (5) Encourage and sponsor experimentation; (6) Adopt them via standard Governance Process; (7) Continuously communicate the Position on these technologies



Peers' Web 2.0 Plans



- **Dip a foot in the river**
- **Fit it into the culture – create a participatory Web**
- **Fully implement Wikis, Instant Messaging**
- **Implement SharePoint 2007 collaborative work spaces, Blogs**
- **Explore and implement Mashups, AJAX, Folksonomies, Service Oriented Architecture**
- **Collaborate and learn via Web conferencing and RSS**
- **Measure and move forward**



Numbers in the Web 2.0 Landscape

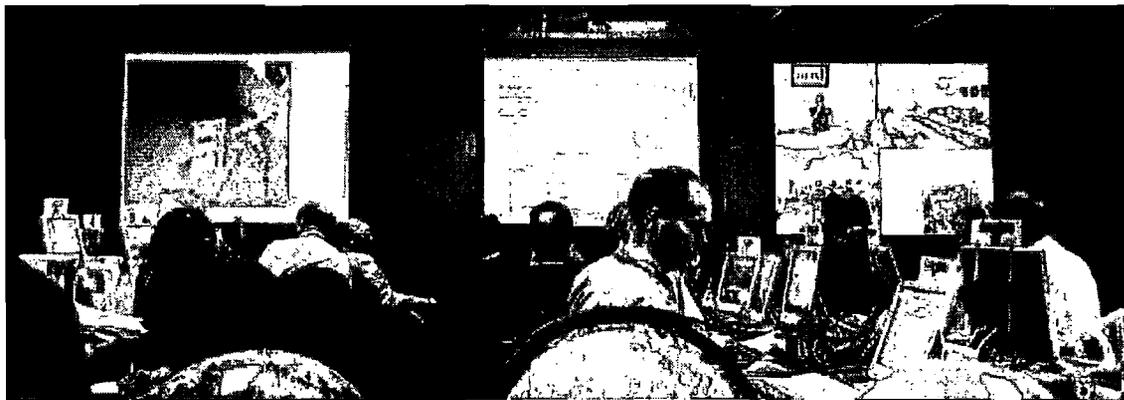
- **1 new blog per second (1.5M posts/day)**
- **21% of blogs are active (15M in March'07)**
- **3,200 hits on Wikipedia to 1 on Encarta**
- **Growing Photobucket.com, Kodakgallery, Flickr**
- **4% of visits edit Wikipedia (the older generation)**
- **75% of visitors to Wikipedia and YouTube are male**
- **YouTube passes Yahoo and Google in video searches**



“Typical” Project



- **JPL provides system management for a team of:**
 - **Project Scientists from around the world**
 - **Multiple JPL design teams with some in-house production**
 - **One or more NASA centers doing trade studies and perhaps developing instruments**
 - **One or more space agencies from outside the US also developing instruments**
 - **Industry Partners and vendors assisting with design and production of spacecraft, large assemblies, or components**



April 9, 2007

Collaboration 2.0: The Next Generation -- Tom Soderstrom, JPL

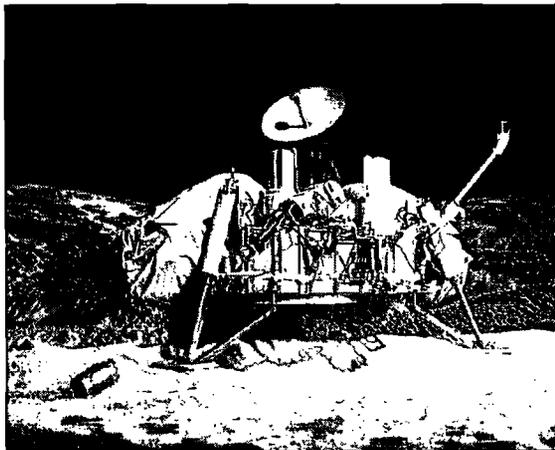
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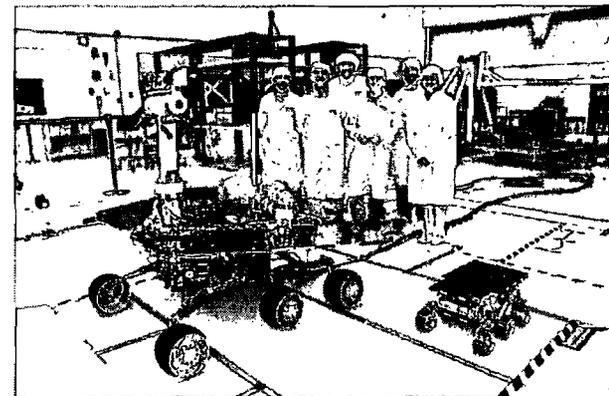
Flying Prototypes



- **JPL Projects are all (well, almost all) One-of-a-Kind endeavors**
- **No Mass Production**
- **No Significant Heritage from previous missions**
- **Fresh teams**
- **Very Rapid development cycles**
- **Finding relevant Lessons Learned, Design Information, or other previous knowledge is a challenge**
- **Releasing Designs must be a Rapid – but Controlled affair**



April 9, 2007



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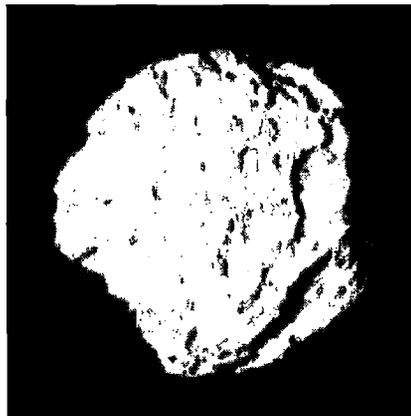
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Future View



- **Mechatronics**
 - **Support for mechanical and electrical systems**
 - **Full life cycle support for engineering, fabrication, and operations**
 - **“Drive” the models through a simulated environment**
 - **Collaborate on the master model with partners over Internet**



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