Evaluating the Impact of NASA's Strategic and Competed Planetary Missions

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Beckman Center, Irvine, CA

Topics

- Study Goal
- Approach
- Results
- Conclusions

Study Goal

Simply stated:

Evaluate the impact of competed and strategic planetary missions to inform discussion of the roles of these two types of missions in the context of a balanced program comprised of both.

Background: Key attributes of Large Strategic and Small Competed Missions

- **Strategic – Large – Missions**
    1. Their goal is “reconnaissance” and/or the conduct of a broad suite of integrated objectives
    2. They go to the hard-to-reach destinations and/or to challenging environments
    3. They carry large suites of scientific instruments
- **Competed – Small – Missions**
    1. They are focused a single objective or a small number of tightly related objectives
    2. They go to the easier-to-reach destinations and/or to more benign environments
    3. They carry fewer instruments focused on very specific scientific objectives

Ground Rules

- The approach had to be quantitative and applied uniformly across both classes of missions.
- It had to be based on publicly available and clearly identifiable information.
- The study should be conducted by a group of people with diverse viewpoints from across the spectrum of competed and strategic planetary missions.

Approach

- **Scientific impact:** utilize publications, citations and *h-index* assessment using the Web of Science (WOS)
- **Impact on number of scientists directly supported:** assess the total number of scientists directly supported by each named mission
- **Impact on number of mission instruments:** assess the number of science instruments

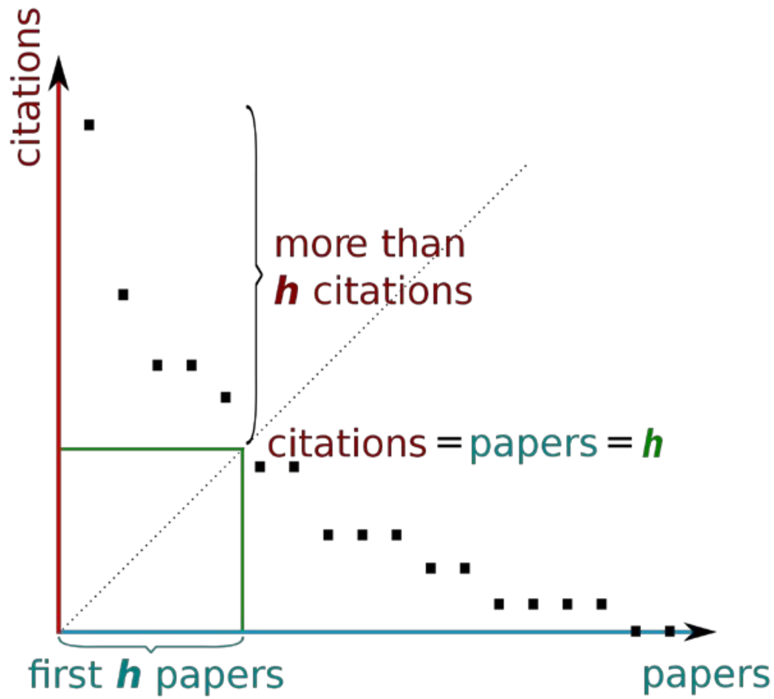
Results: Scientific Impact

The key elements of our approach

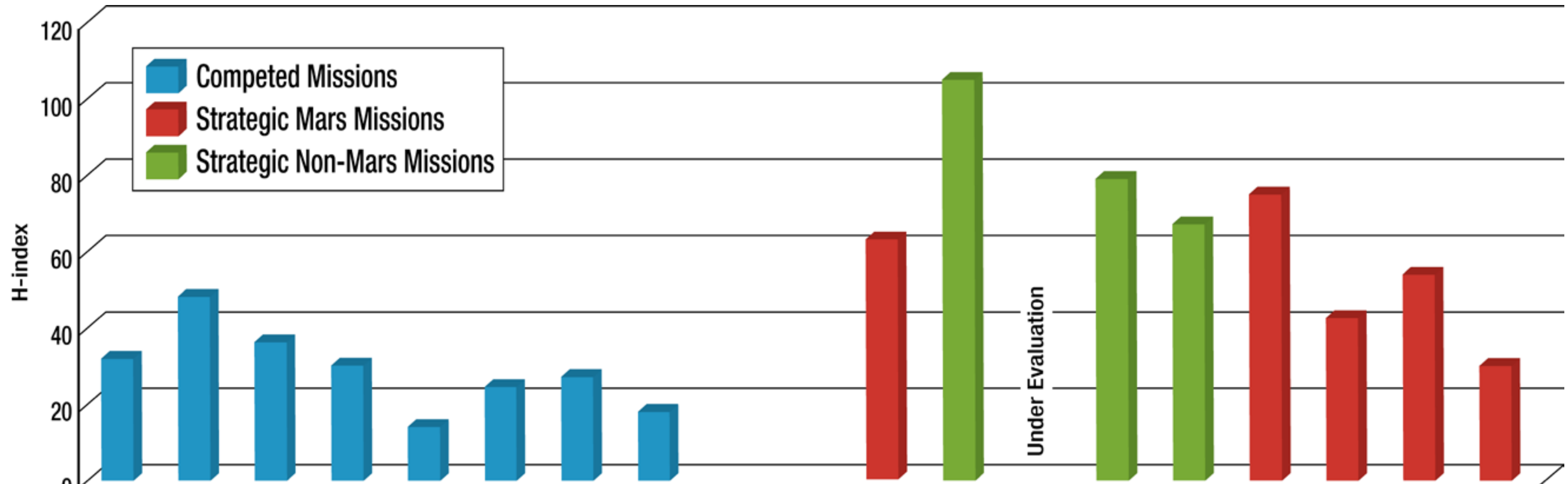
- Utilize publications, citations, and *h-index* as drawn from the Web of Science (WOS) on a mission-by-mission basis for an objective evaluation of scientific impact.
- Include all NASA planetary missions that had completed at least their prime mission phase.
- Apply uniformly: Blind to mission type.

h-index Defined

- *h index* is defined as the number of papers cited at least *h* times each.
- It was created by UCSD physicist Jorge E. Hirsch to evaluate both the productivity and impact of a scientist or group of scientists (*PNAS, 2005).*



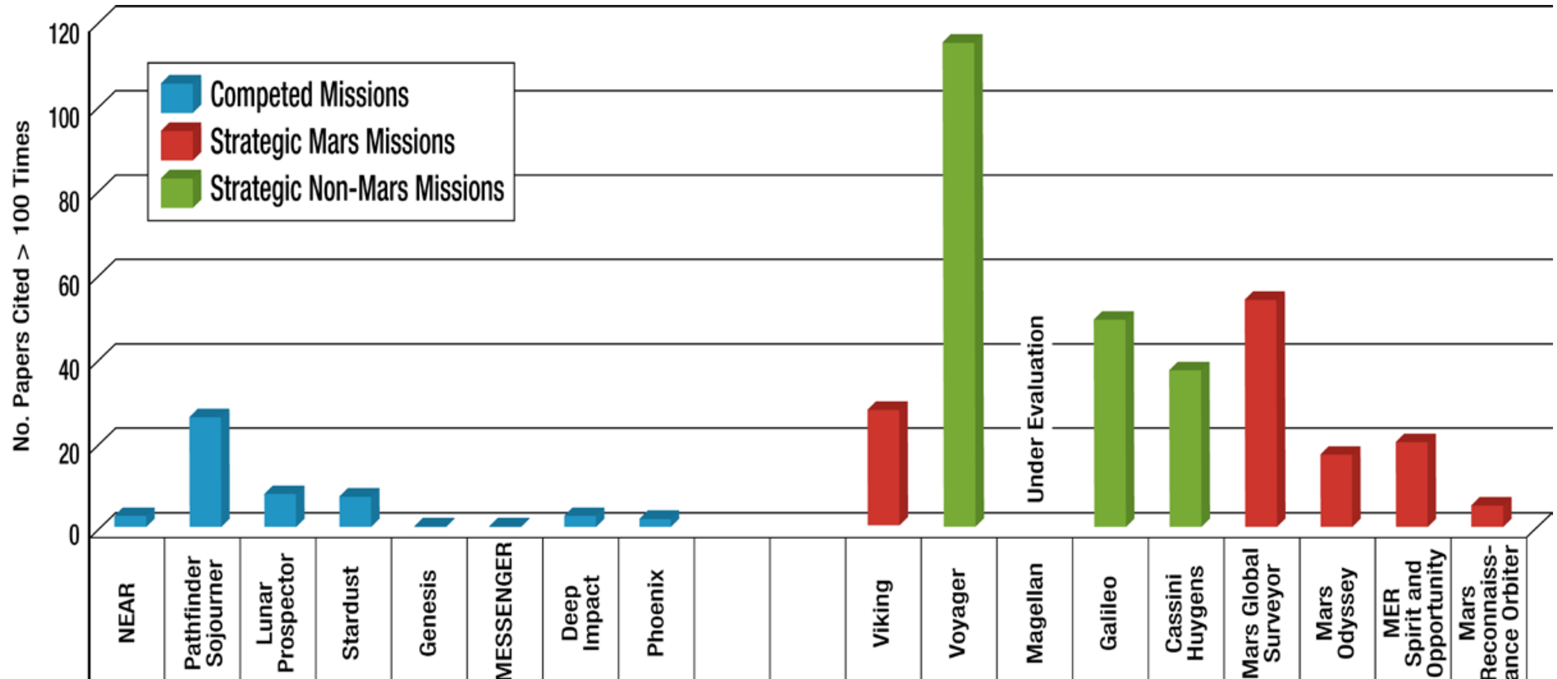
WOS: *h-index (c. 2012)*



	NEAR	Pathfinder Sojourner	Lunar Prospector	Stardust	Genesis	MESSENGER	Deep Impact	Phoenix			Viking	Voyager	Magellan	Galileo	Cassini Huygens	Mars Global Surveyor	Mars Odyssey	MER Spirit and Opportunity	Mars Reconnaiss-ance Orbiter
H-index	32	48	36	30	14	24	27	18			63	105	49	79	67	75	41	54	30
No. Publications	258	541	353	480	110	323	307	189			885	2,931		2,042	2,138	1,056	337	831	355

- Based on *h-index*, *strategic missions are more impactful, but competed missions have substantial scientific impact also.*

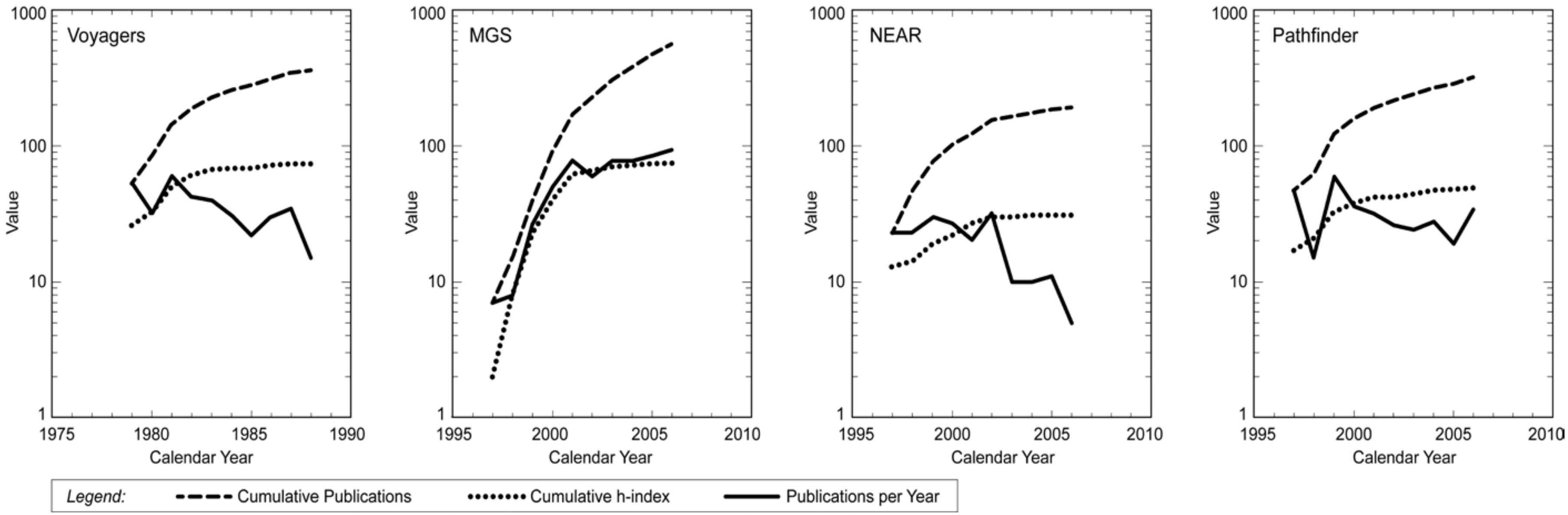
WOS: Number of Papers Cited >100 *(c. 2012)*



	NEAR	Pathfinder Sojourner	Lunar Prospector	Stardust	Genesis	MESSENGER	Deep Impact	Phoenix			Viking	Voyager	Magellan	Galileo	Cassini Huygens	Mars Global Surveyor	Mars Odyssey	MER Spirit and Opportunity	Mars Reconnaiss-ance Orbiter
No. Papers Cited > 100 Times	3	26	8	7	0	0	3	2			28	115	12	49	37	54	17	20	5
No. Citations	3,242	9,814	5,224	4,487	541	2,394	3,171	1,430			19,575	71,992		35,918	31,215	26,195	7,061	11,583	3,991

- Papers cited >100 can be used as one of several *rough surrogates for "paradigm changing."*
- We note that since citation numbers grow with time, up to a point, some of the more recent missions should be expected to show an increase in this parameter with time.

10-year Publication Statistics for Two Strategic and Two Competed Missions



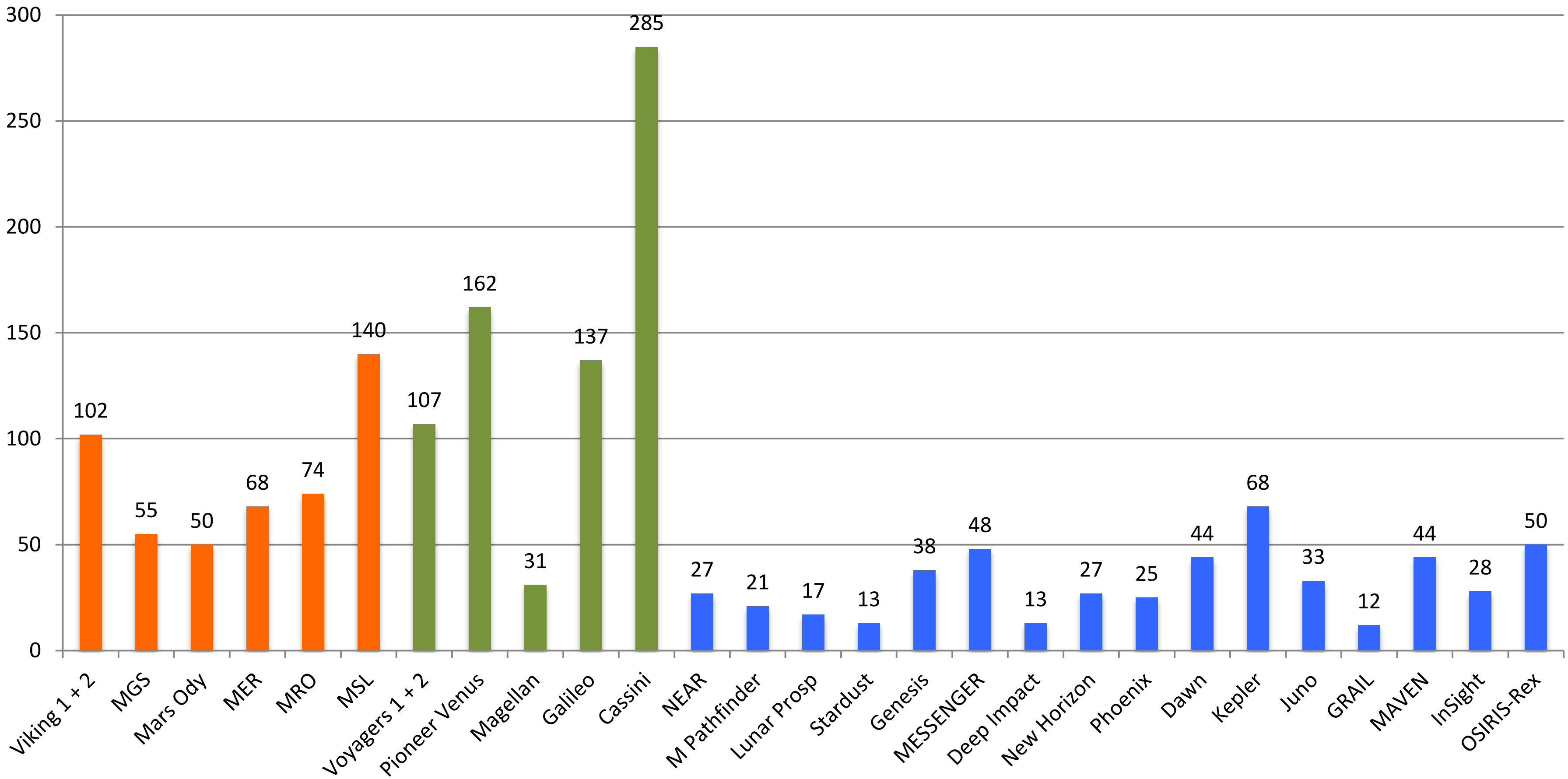
- The results show that rate of publication generally peaks within about five years of return of the initial mission data.
- *More importantly, the h-index comes close to its maximum value within about five to six years of initial mission data return.*

Impact on Scientist Support and Payload Size

Approach and data sources:

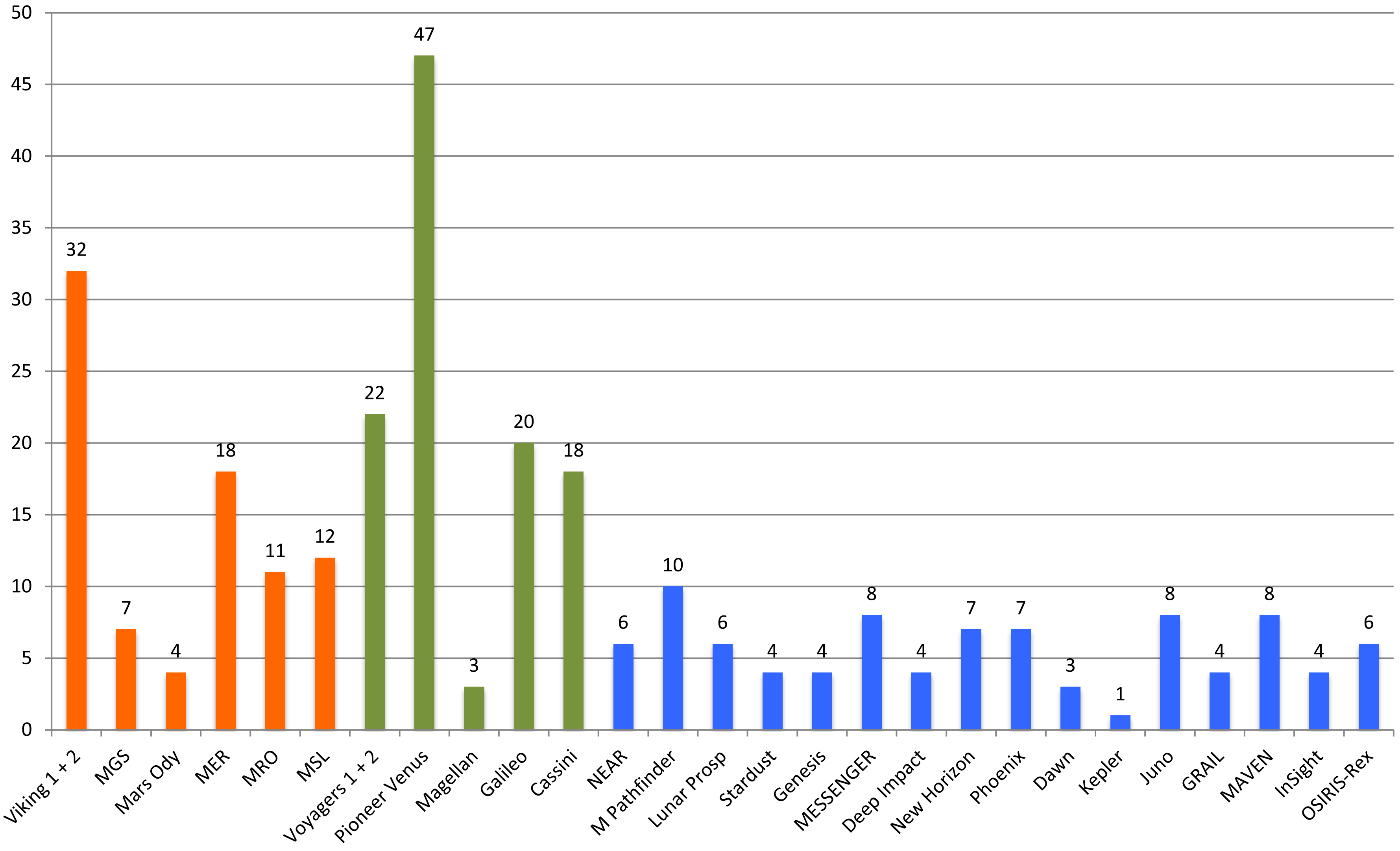
- Include all planetary missions since Viking
  - Past, currently in operations *(c. 2012)*, and in development
- Include every scientist named in official project documents, including IDSs.
  - "Collaborators" not included. These numbers are harder to find and verify. Note that data from four missions indicate collaborators roughly equal the number of named, directly supported scientists.
- Payload elements defined as those that produce data used in peer-reviewed scientific research.
  - Includes, for example, radio science.

Total number of directly supported, named scientists including all US and international scientists



- Were collaborators to be included, the total number of scientists supported by each mission would roughly double.

Number of mission instruments



Conclusion 1
Scientific Impact

- *The h-index and other publication statistics show clearly that both classes of NASA planetary missions have high scientific impact.*

- Loss of either class of mission would have major negative impacts on US planetary science:
  - Loss of strategic missions would end access to the most challenging destinations, and access to integrated, simultaneous, multi-instrument observations at key destinations.
  - Loss of competed missions would end the ability to respond quickly to new discoveries at the easier-to-reach but still high-value scientific destinations.

Conclusion 2
Scientific Community Impact

- *Both classes of missions provide direct support to significant fractions of the science community.*

- Loss of either class of mission would create significant funding gaps for sizeable portions of the community and that would put added strain on a Research and Analysis (R&A) program that is already stretched thin.

  - Entire planetary science disciplines could easily be lost altogether.

Conclusion 3

Engineering Community Impact

- *Strategic and competed planetary missions collectively require unique engineering capabilities not available anywhere else in the domestic or international community.*

- Unique classes of instruments are required for planetary science.

  - While strategic missions have generally larger payloads, the more rapid cadence of competed missions allows for more frequent instrument opportunities.

  - Hence both classes of mission are essential to a successful US program.

- These and other unique and enabling engineering capabilities such as EDL and deep space navigation must be used or they will be lost.

  - The “use it or loose it” principle applies fully. These are capabilities that took decades to develop and that have no application anywhere else.

Conclusion

- *"Vision and Voyages" had it right:*

  "NASA's suite of planetary missions for…2013-2022 should consist of a <u>balanced mix</u> of Discovery [and] New Frontiers [<u>competed</u>] and flagship [<u>strategic</u>] missions [to enable] a steady stream of new discoveries and the ability to address larger challenges…"

  ** Emphasis added*

Back-up Materials

Acknowledgements

- The authors acknowledge and appreciate the support provided by NASA and the authors’ home institutions cited on the title slide.
- We also thank several colleagues who reviewed the work and provided valuable comments and suggestions.

Backup 1

Basic Publication Search Information

The “scientific impact” of sixteen planetary missions was examined in this study by identifying the number of peer-reviewed papers included in the ISI Web of Science database for each mission. Citations in the Web of Science were identified by searching for mission name and including the mission target for missions with common names. The instrument names were included in the searches for the Mars Reconnaissance Orbiter and Mars Exploration Rover missions because of changes in authors referencing missions. The citation report for each mission was reviewed and ‘false drops’ were eliminated manually down through at least twenty-five publications beyond the h-index. Eliminating false drops for publications with zero or very few citations was found not to change the h-index location. False drops are defined as either a totally different subject or just an incidental mention of the mission. Incidental mention includes mention just in the introduction, as the reason for a laboratory or modeling effort, or as background in the discussion of another mission’s results. After the citation reports for a mission were captured, the publications for each year were reviewed to get the Publications By Year numbers. Incidental mentions of mission names were filtered out manually. All the searches were done within the period June 13 through August 22, 2012.

Backup 2 – Data sources for scientists and instrument counts

Competed

NEAR
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1996-008A
http://www.nasa.gov/home/hqnews/presskit/1996/NEAR_Press_Kit/NEARpk.txt

Mars Pathfinder and Microrover
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1996-068A
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=MESURPR

Lunar Prospector
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1998-001A
http://lunar.arc.nasa.gov/resources/LPBckgrn.pdf

Stardust and Sample Return Capsule
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1999-003D
http://www.jpl.nasa.gov/news/press_kits/stardustflyby.pdf

Genesis and Sample Return Capsule
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2001-034A
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2001-034D
http://genesismission.jpl.nasa.gov/gm2/team/scienceteam.htm

Messenger
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2004-030A
http://www.nasa.gov/pdf/525164main_MercuryMOI_PK.pdf

Deep Impact and Impactor
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2005-001D
http://www.jpl.nasa.gov/news/press_kits/deep-impact-launch.pdf

New Horizon Pluto
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=PLUTOKE
http://www.nasa.gov/pdf/139889main_PressKit12_05.pdf

Phoenix
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2007-034A
http://phoenix.lpl.arizona.edu/team01.php

Dawn
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2007-043A
http://www.nasa.gov/pdf/189670main_dawn-launch.pdf
http://dawn.jpl.nasa.gov/team/

Juno
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2011-040A
http://www.jpl.nasa.gov/news/press_kits/JunoLaunch.pdf

Grail (Two Spacecraft)
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2011-046A
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2011-046B
http://www.jpl.nasa.gov/news/press_kits/graiLaunch.pdf

MAVEN
Mars Atmosphere and Volatile EvolutioN (MAVEN), NASA WBS 293945, PPBE
http: lasp.colorado.edu/home/maven/about/teampartners/

InSight
InSight, A mission into the early evolution of terrestrial planets., March 19, 2012
In response to AO NNH10ZDA007O

OSIRIS_REx
http://osiris-rex.lpl.arizona.edu/?q=spacecraftpayload/instruments
http://osiris-rex.lpl.arizona.edu/?q=team

Strategic

Viking (Two Orbiters and Two Landers)
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1975-075A
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1975-075C

Voyager 1 & 2
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1977-084A
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1977-076A

Magellan
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1989-033B

Galileo and Probe
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1989-084B
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1989-084E

Cassini and Huygens Probe
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1997-061A
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1997-061C
http://saturn.jpl.nasa.gov/mission/team/
http://www.csa.com/discoveryguides/cassini/abstracts-f2.php#c07

Mars Global Surveyor
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1996-062A
"Mars Global Surveyor Mars Orbiter Camera,", M. Malin and K. Edgett
http://tes.asu.edu/testeam/index.html
http://tharsis.gsfc.nasa.gov/science.team.html
http://niva.standfors.edu/projects/mgs/mgsmgs-rst,html
http://mgs-mager.gsfc.nasa.gov/mgs_team.html

Mars Odyssey
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2001-014A
http://grs.lpl.arizona.edu/content/about/teammembers
http://www.lpi.usra.edu/meetings/lpsc2003/pdf/1022.pdf
http;//themis.edu/teammembers
http://grs.lpl.arizona.edu/content/about/teammembers
http://www-geodyn.mit.edu/mazarico.odysseyexo.jgr07.pdf
Estimate for the Mars Odyssey science teams for MARIE and Radio Science

Mars Exploration Rover (Two Rovers)
http://athena.cornell.edu/the_mission/scientists.html
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2003-032A
MER Mission Cost and Workforce Data, August 14, 2008, from the JPL Financial System
"Mars Exploration Rover Engineering Cameras", J. N. Maki and others, JPL, American Geophysical Union, 0148-0227, 2003.
Three separate MER IDS scientists listed biographies on various web sites

Mars Reconnaissance Orbiter
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2005-029A
http://marsoweb.nas.nasa.gov/HiRISE/team.html#picture
http://crism.jhuapl.edu/team/teamSub.php
http://www.msss.com/science/mro-marci-ctx-science-team.php
http://starbrite.jpl.nasa.gov/pds/viewInstrumentProfile.jsp?INSTRUMENT_ID=mcs&INSTRUMENT_HOST_ID=MRO
Seven separate MRO IDS scientists listed biographies on various web sites

Mars Science Laboratory
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2011-070A
"MSL Instrument Contact List", JPL, data was from the MSL electronic library, March 2011

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NEAR
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1996-008A
http://www.nasa.gov/home/hqnews/presskit/1996/NEAR_Press_Kit/NEARpk.txt

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http://www.nasa.gov/pdf/525164main_MercuryMOI_PK.pdf

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http://www.jpl.nasa.gov/news/press_kits/deep-impact-launch.pdf

New Horizon Pluto
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=PLUTOKE
http://www.nasa.gov/pdf/139889main_PressKit12_05.pdf

Phoenix
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http://phoenix.lpl.arizona.edu/team01.php

Dawn
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2007-043A
http://www.nasa.gov/pdf/189670main_dawn-launch.pdf
http://dawn.jpl.nasa.gov/team/

Juno
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2011-040A
http://www.jpl.nasa.gov/news/press_kits/JunoLaunch.pdf

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http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2011-046B
http://www.jpl.nasa.gov/news/press_kits/graiLaunch.pdf

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http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1989-084E

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http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1997-061C
http://saturn.jpl.nasa.gov/mission/team/
http://www.csa.com/discoveryguides/cassini/abstracts-f2.php#c07

Mars Global Surveyor
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=1996-062A
"Mars Global Surveyor Mars Orbiter Camera,", M. Malin and K. Edgett
http://tes.asu.edu/testeam/index.html
http://tharsis.gsfc.nasa.gov/science.team.html
http://niva.standfors.edu/projects/mgs/mgsmgs-rst,html
http://mgs-mager.gsfc.nasa.gov/mgs_team.html

Mars Odyssey
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2001-014A
http://grs.lpl.arizona.edu/content/about/teammembers
http://www.lpi.usra.edu/meetings/lpsc2003/pdf/1022.pdf
http;//themis.edu/teammembers
http://grs.lpl.arizona.edu/content/about/teammembers
http://www-geodyn.mit.edu/mazarico.odysseyexo.jgr07.pdf
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http://crism.jhuapl.edu/team/teamSub.php
http://www.msss.com/science/mro-marci-ctx-science-team.php
http://starbrite.jpl.nasa.gov/pds/viewInstrumentProfile.jsp?INSTRUMENT_ID=mcs&INSTRUMENT_HOST_ID=MRO
Seven separate MRO IDS scientists listed biographies on various web sites

Mars Science Laboratory
http://nssdc.gsfc.nasa.gov/nmc/spacecraftDisplay.do?id=2011-070A
"MSL Science Team Email List", from the MSL electronic library, February 12, 2012