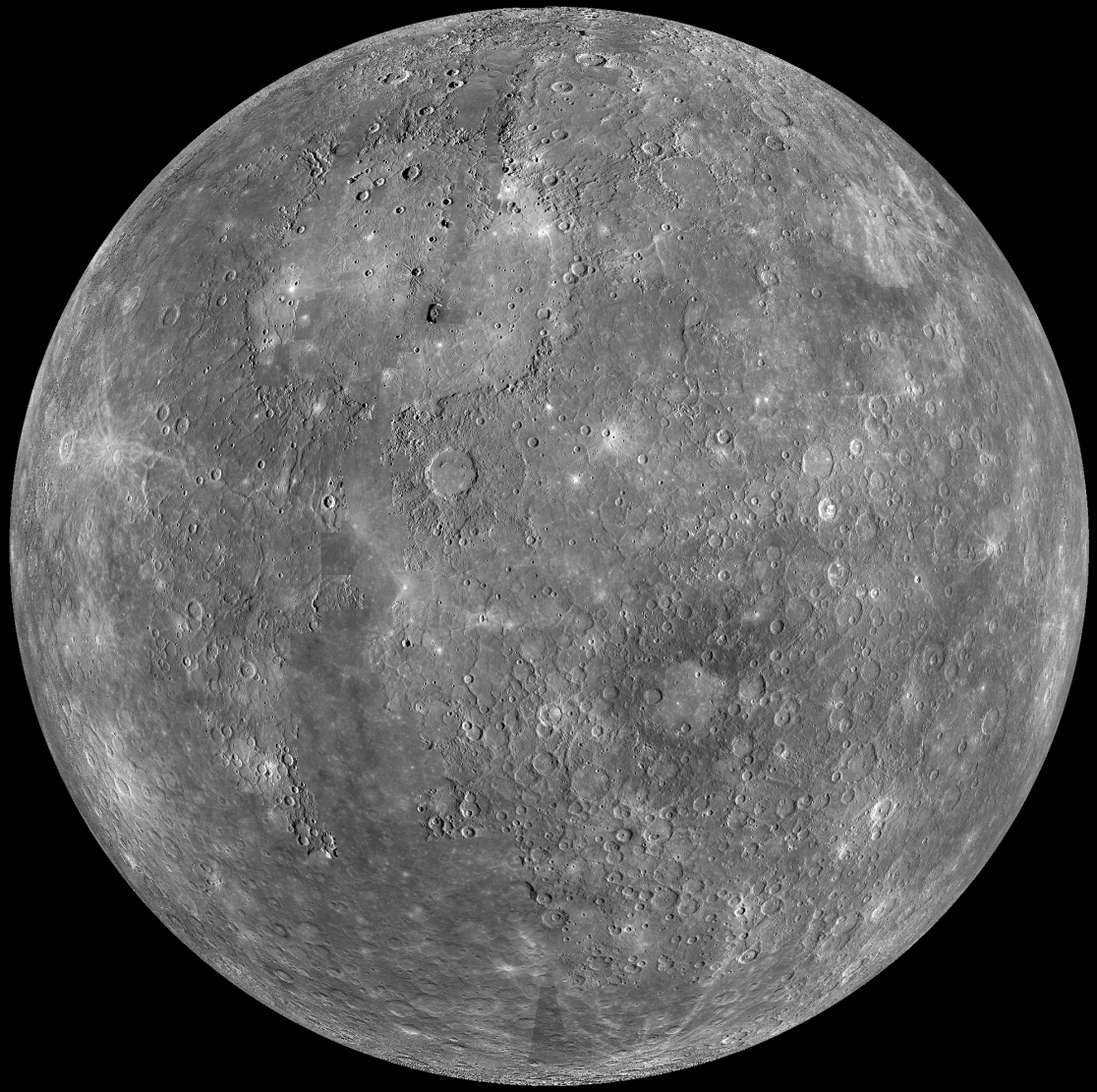
The MESSENGER Mission to Mercury: Some Lessons Learned



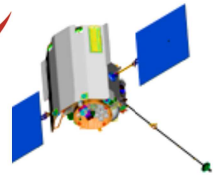
Sean C. Solomon

Lamont-Doherty Earth Observatory

Columbia University

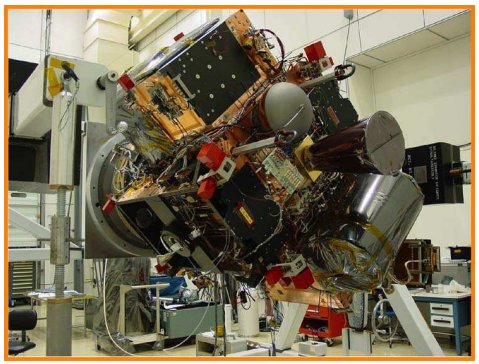
PI Forum #5

16 March 2016



MESSENGER
Mission Milestones

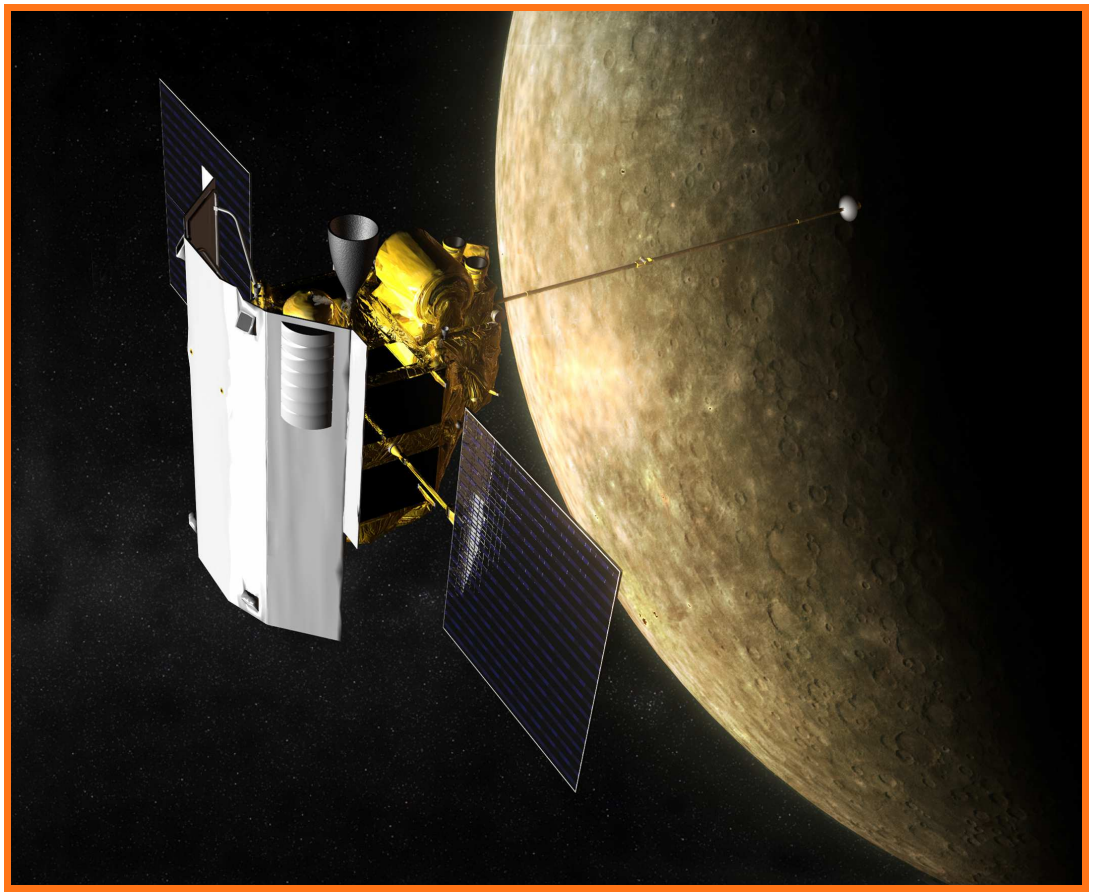
Selection as a Discovery Mission	July 1999
Phase B (detailed design)	January 2000 – June 2001
Phase C/D (fabrication, assembly, & test)	July 2001 – July 2004
Launch	August 2004
Earth flyby	August 2005
Venus flybys	October 2006, June 2007
Mercury flybys	January 2008, October 2008, September 2009
Mercury orbital operations	March 2011 – April 2015



Managed by The Johns Hopkins University Applied Physics Laboratory and the Carnegie Institution of Washington

MESSENGER

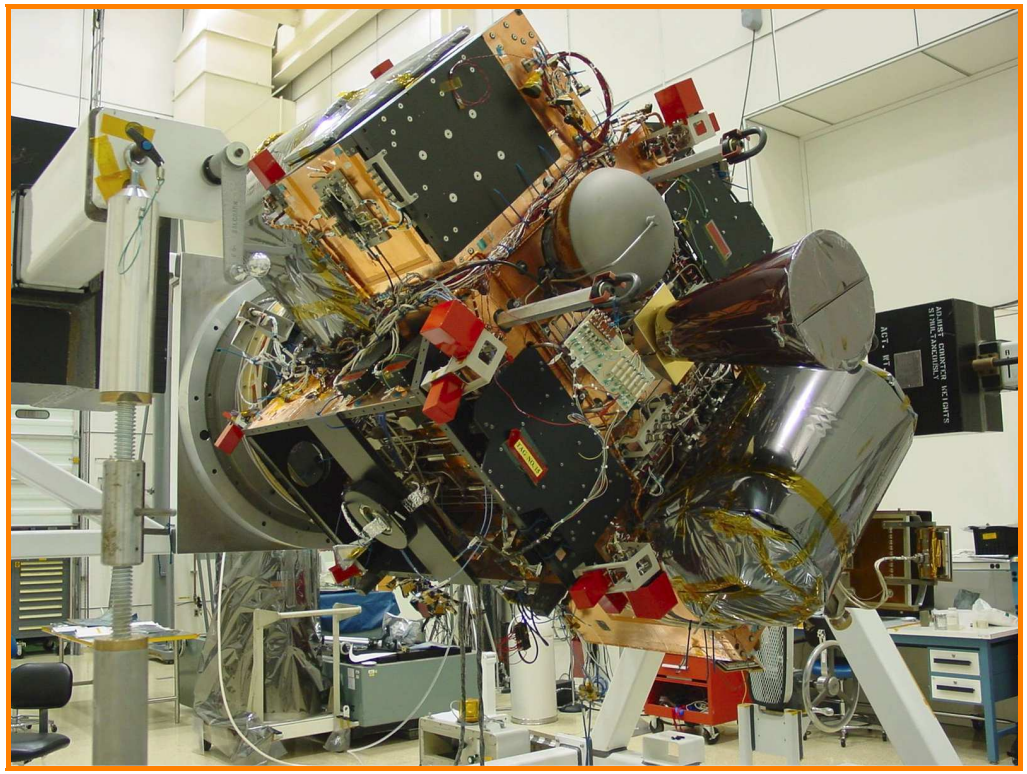
Faced Broad Challenges



- Demanding limits to mass growth
- Hazardous thermal and radiation environment
- Complex mission design with limited launch opportunities and a long cruise phase

MESSENGER

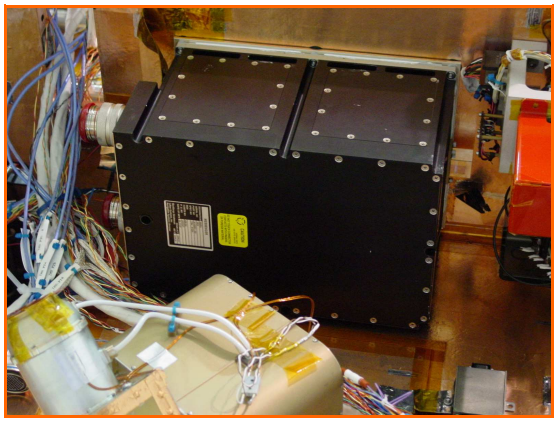
Some Obvious Advice for PIs



- **Budget ample reserves: cost, schedule, mass, power**
- **Learn project management and systems engineering**
- **Assemble the best possible team**
- **Accomplish as much in Phase B as possible**

MESSENGER
Anticipate Technical Challenges

MESSENGER Solar Array



MESSENGER IMU

A challenge anticipated: Solar arrays

- **Multiple vendors engaged**
- **Thorough testing program**
- **Final vendor selection after all prototype testing**

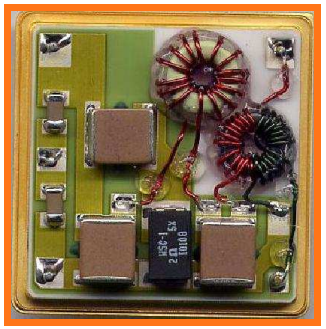
A challenge not anticipated: Inertial Measurement Unit (IMU)

- **Expertise resided with a single vendor**
- **That vendor was bought out by a new vendor, who closed a key facility and had to reinvent expertise**

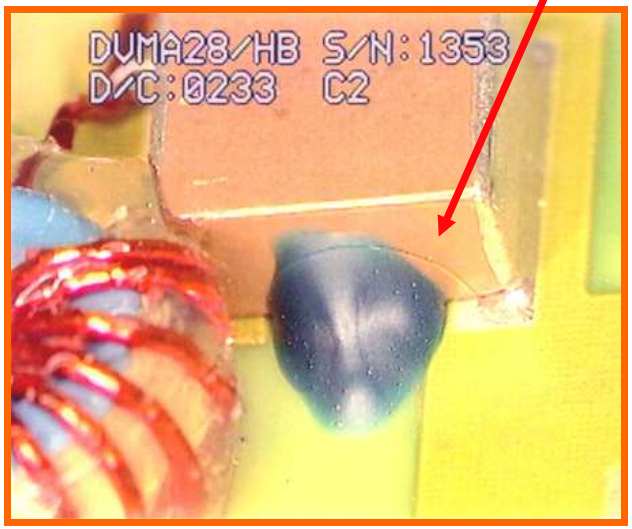
MESSENGER
…and More Technical Challenges

- Manufacturer applied excess epoxy to capacitors on filter boards
- 14 flight filters had to be replaced

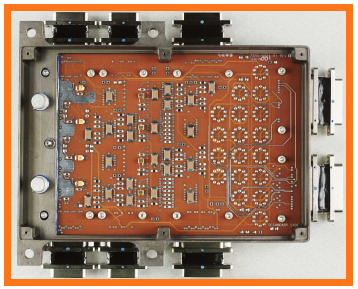
- Delamination (seen as missing copper shadow from inner layers) discovered in multi-layer PC boards
- 13 flight boards had to be replaced



Filter Failures



Board Delamination



MESSENGER

…and Still More

- Spacecraft structure was made of lightweight composite material
- Manufacturer was delayed by late work on MER spacecraft
- Late delivery of structure delayed by 4 months the start of spacecraft integration
- Lessons: engineer for contingencies; schedule generous reserve

MESSENGER

Anticipate Management Challenges

Max Peterson
MESSENGER PM
1998 - Jan 2003

Richard Huebschman
MESSENGER DPM
June 2001 – Oct 2002

Dave Grant
MESSENGER PM
Feb 2003 – Sept 2007

During Phases B and C/D:

- **MESSENGER had two Project Managers and two Deputy Project Managers**
- **The NASA Solar System Exploration Division had four Directors**
- **The Discovery Program had three Program Managers and added the position of Program Director in 2004**
- **Lesson: Pick your own managers wisely**

MESSENGER
Discovery Program Management

Dave Jarrett
Discovery Program Manager
1999 - 2003

Andy Dantzler
Discovery Program
Director
Appointed April 2004

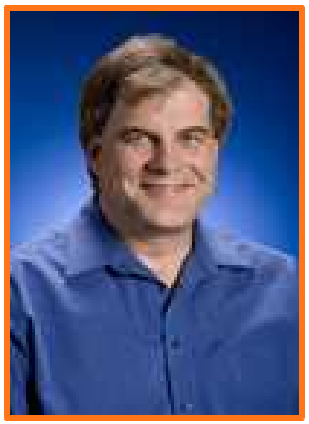
- **Discovery Program was managed for several years out of the NASA Management Office (NMO)**
- **To provide technical oversight of Discovery projects, a Discovery Program Support Office was established at JPL**
- **In July 2003, technical and managerial oversight of Discovery projects was assigned to the Aerospace Corporation**
- **In January 2004, Discovery Program management was assigned to JPL**
- **In August 2004, Discovery Program management was assigned to NASA Marshall**
- **Lesson: Be thankful of MSFC, but be prepared**

MESSENGER

Anticipate Science Team Changes

Maria Zuber
GRAIL PI
2007 – present

Mark Robinson
LROC PI
2006 – present



Scott Murchie
CRISM PI
2001 – present

During Phase E:

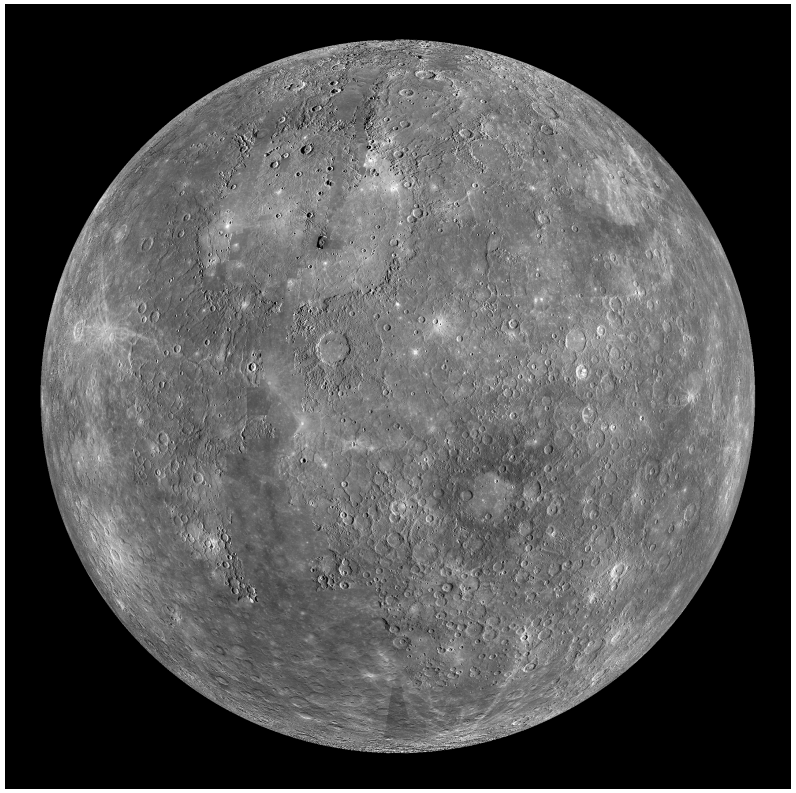
- **One MESSENGER Co-I passed away in 2009**
- **Three MESSENGER Co-Is took on major responsibilities for other NASA missions**
- **NASA added 23 MESSENGER Participating Scientists in November 2007**
- **Lesson: Develop succession plan for key science roles**

This is not the correct ITAR

- **Plan for NASA's tolerance for risk to change between your selection and launch**
- **Plan for more reviews than were initially specified**
  - **View them as learning opportunities**
  - **Learn to assess their cost and negotiate accordingly**
- **Learn about ITAR and its impact on team member access, hardware acquisition, and publication approval procedures**

MESSENGER

Some Final Thoughts



- A Discovery mission can accomplish novel science across a broad spectrum of science disciplines.
- Superb engineering is essential, including software as well as hardware and operations.
- So, too, are open and frequently used lines of communication between the engineering and science teams.
- Thoughtful succession plans for key personnel are required for long-lived missions.
- An openness to changing mission conditions and opportunities can greatly enhance the scientific return.