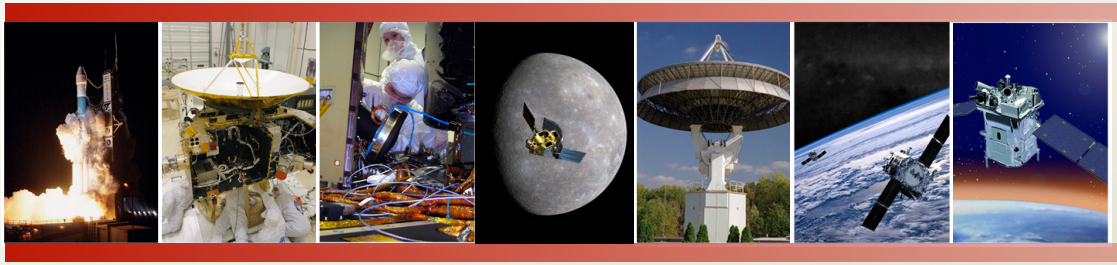


Technology Development at APL

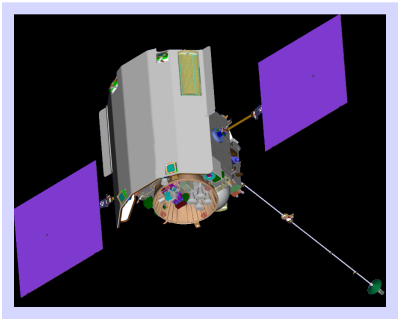
20 May 2010

Robert Gold
240-228-5412

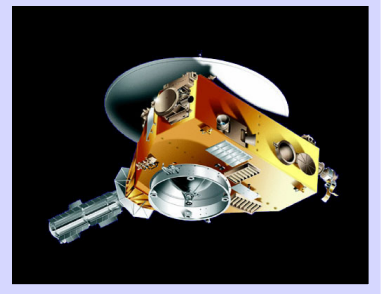
The Johns Hopkins University
APPLIED PHYSICS LABORATORY

APL Advanced Technology Goals

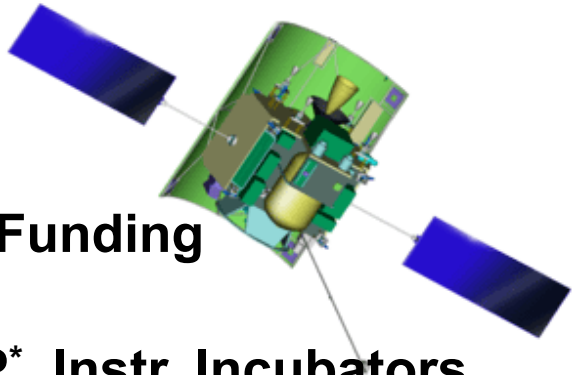
- Develop technologies and capabilities that are enabling for a large class of Civilian and National Security Space missions
- Innovation of instruments, systems, and subsystems
  - Miniaturization to reduce vehicle & propulsion cost
  - Scalability and re-usability simplify future developments
  - Instrument innovations for science, understanding
  - Autonomy to enhance effectiveness & reduce cost
  - Technology transfer *to* and *from* industry to reduce investment



- Use the same staff that work on flight programs
  - Helps ensure that precious technology monies result in useful products
- Effective technology development is a combination of *Push* and *Pull*
  - Ensure that flight project needs are met
  - Don't miss good ideas that can be "game-changing"



Space Technology Development: From an Idea to a Mission



IR&D

Competed Funding

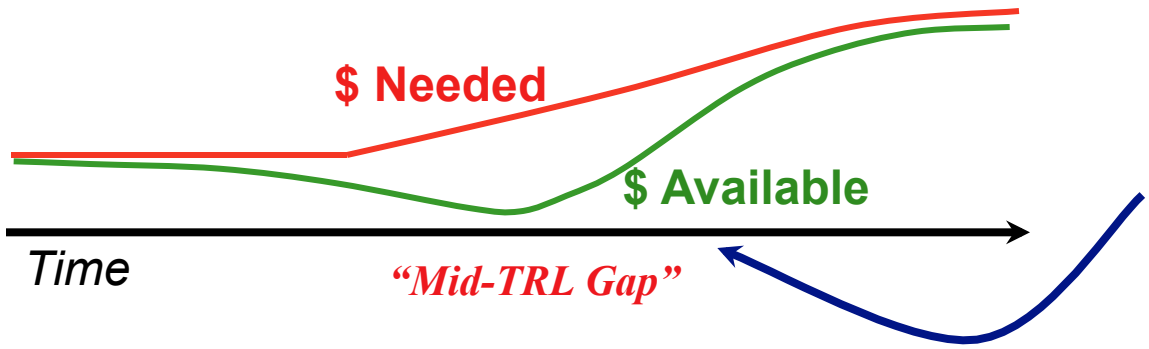
PIDDP*, Instr. Incubators

Flight Program

TRL

Technology Readiness Level 1 2 3 4 5 6 7 8 9

DOD 6.1 6.2 6.3 6.4



Competitive funding sources bridge the Mid-TRL Gap preparing IR&D investments for acceptance into a flight program

*PIDDP = NASA Planetary Instrument Definition and Development Program

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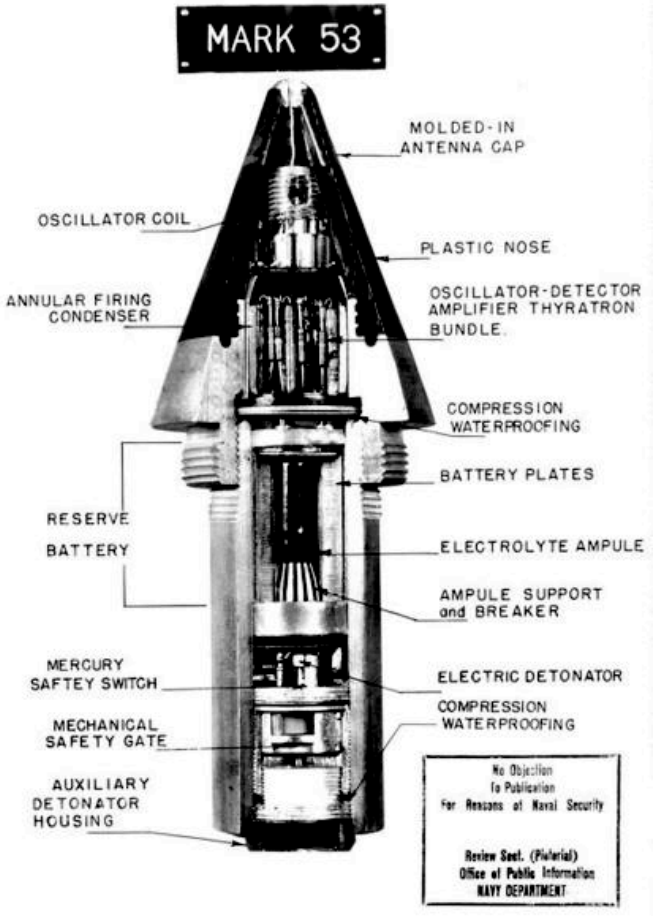
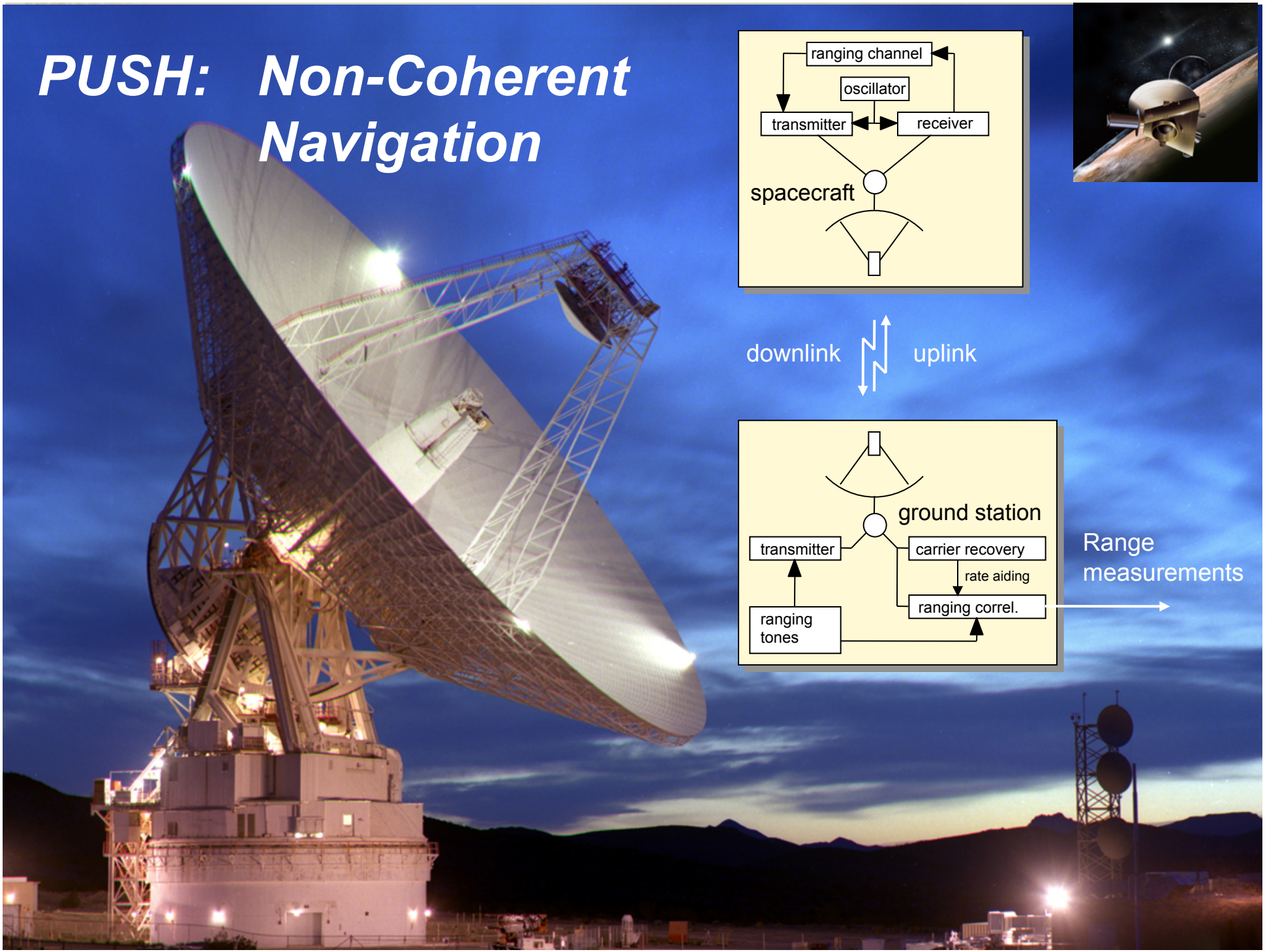
PULL: Radio (VT) Proximity Fuze



PUSH: Non-Coherent Navigation



IR&D Investment Strategies: - Continually Revisited to Refocus Goals

- IR&D funds are very limited and must leverage outside funding
- APL addresses critical challenges
  - Explore the Solar System (both science & exploration motivated)
  - Understand the effect of the Sun on Earth and nearby space
  - Understand the Earth's environment and its effects on humankind
- Identify and develop new mission-centric capabilities
  - Flow-down capabilities to new and needed technologies
  - Increase hardware and software re-use to reduce costs
  - Seek partnering and external support to obviate resource limitations

IR&D Goals (What is our plan?)

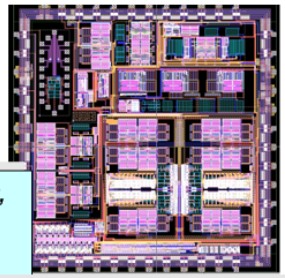
- *Improved spacecraft avionics*
- *Reduced complexity, increased standardization & robust S/C designs*
- *Clean interfaces, design for reuse & simplified system testing*

1-2 yrs **Near-term challenges**

- *Improved in situ & remote sensing*
- *New instruments & S/C control sensors*
- *Miniaturization, enhanced sensors, & power efficiency*

Sensors

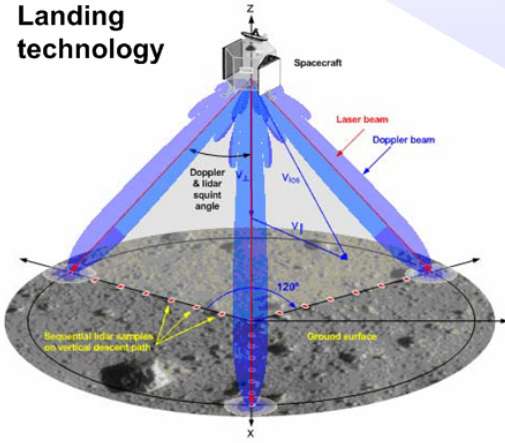
Rad-hard electronics



Intermediate term challenges

- *Enhanced capabilities, power efficiency, expanded design space, rad-hard design w/COTS (microprocessors & ASICs)*

Landing technology



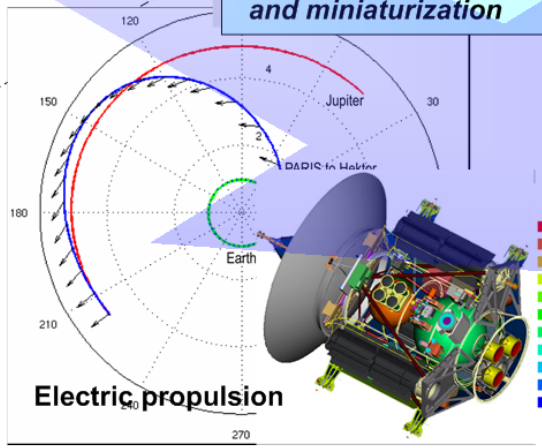
- *Precision guidance to asteroids, comets, & moon*
- *Robust sensors, guidance & control, simulation & planning, & terrain matching navigation*

Sampling technology

- *Sample acquisition, manipulation, analysis, and return*

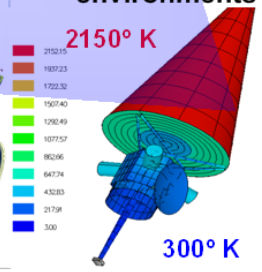
- *Electric propulsion, thermal management, high-temp electronics, and miniaturization*

Beyond 5 yrs **Far-term technologies**



Electric propulsion

Thermal management for extreme environments



Integrated Electronics Module (IEM)

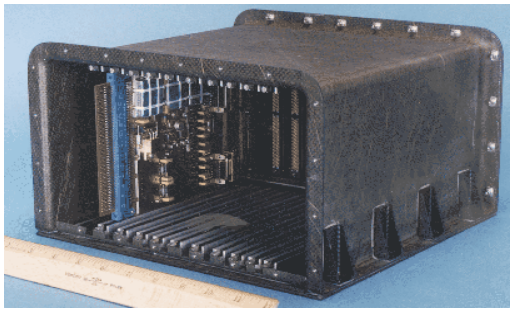
From IR&D To Flight Program

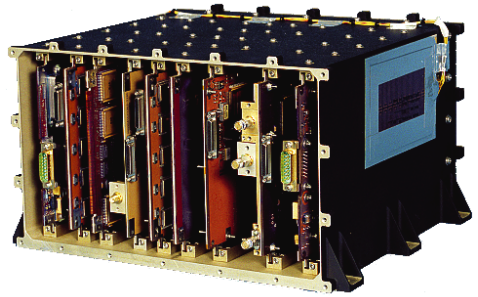
Problem: spacecraft cost too much

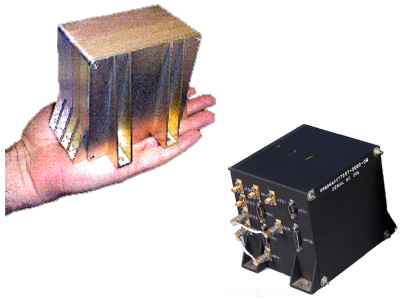
Solution: improve subsystem re-use, eliminate boxes and harnesses

- **Integrated Electronics Module concept (IR&D)**
  - **All S/C avionics - C&DH, G&C, guidance - RF too!**
  - **Refine concept with selected prototypes**
- **1st generation - TIMED, CONTOUR, New Horizons**
- **2nd generation - MESSENGER, STEREO**
- **3rd generation - Instruments & Microsats**
  - **MESSENGER (8 times), MRO, New Horizons, JUNO, MMS, Geospace RBSP Instruments**
  - **AF/NASA-Goddard Cross Link Transceiver (CLT) for the University Nanosat Program**

Result: used in APL's 5 most recent spacecraft & several instruments



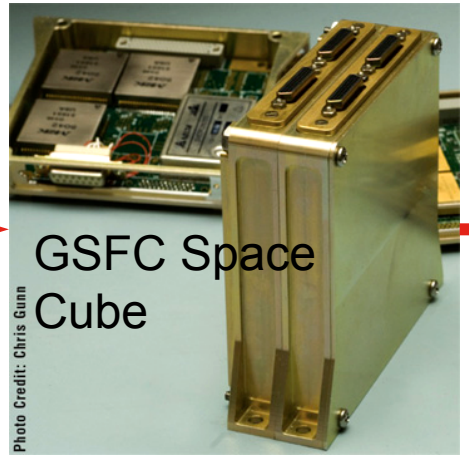




NanoSat CLT

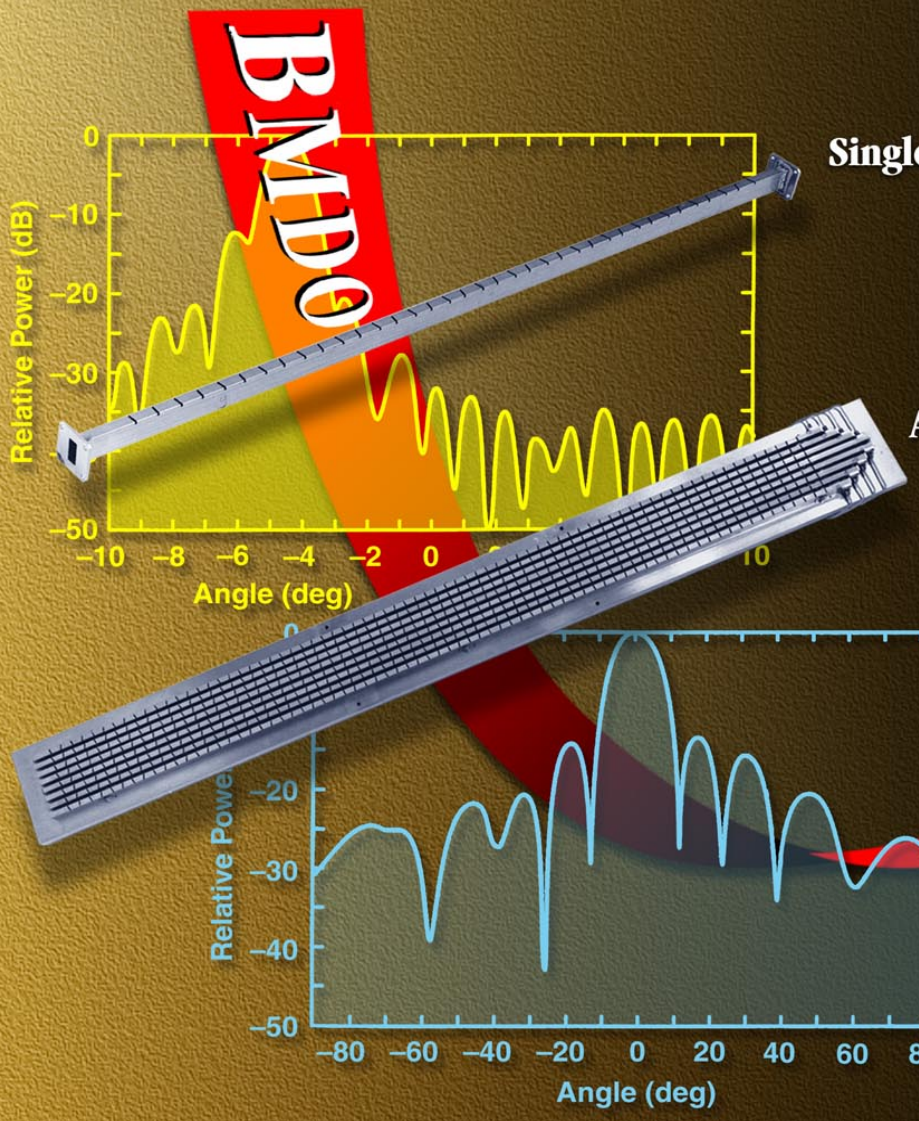
APL

GSFC Creates New Avionics, Adopting APL's Slice Technology



4 Power PC's on 2 boards ("slices")

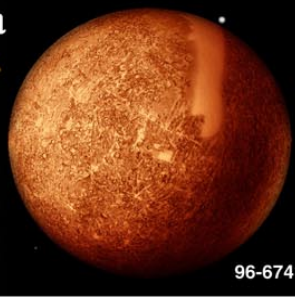
BMDO Radar Antenna Basis for NASA Proposal



NASA

MESSENGER Satellite

Expanded View of Antenna



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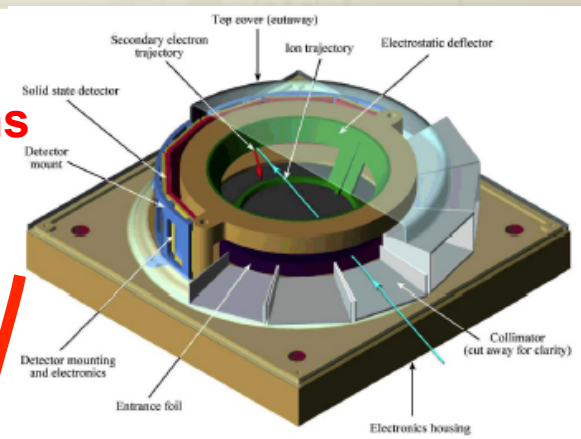
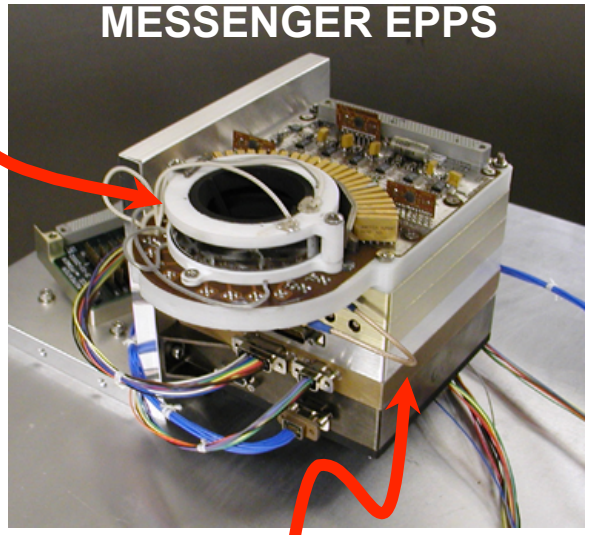
Energetic Particle "Hockey Puck"

Problem: particle instruments are too large and heavy for MESSENGER and New Horizons

Solution: particle steering optics and miniature electronics



- ACE and Cassini instruments were ~ 17 kg
- Hockey Puck concept
  - ~1kg, ~1W, low cost, and re-usable
- FY98 ASIC IR&D
- Won two NASA PIDDPs
- NASA ATD Program
- Adopted for flight
  - MESSENGER EPPS - Energetic Particle and Plasma Spectrometer
  - New Horizons PEPSSI - Pluto Energetic Particle Spectrometer Science Investigation
  - RBSP, Juno, and MMS



3rd Gen IEM 4"x4" Slice Architecture for Electronics

APL

How Can We Improve the Process?

- **Expand the access to the limited technology development funds**
- **A large portion of technology funds are *Pulled* by major missions**
  - **Not awarded in broad competitions**
  - **Limited set of ideas are explored**
- **Very limited assistance for Discovery, New Frontiers concept development**
  - **Mission teams are "on their own" for needed technologies**
- **Instruments are better supported than spacecraft systems**
  - **PIDDP, MIDP, and other programs for instruments**
  - **Almost no programs for comms, nav, software, autonomy, …**

How Can We Improve the Process? (2)

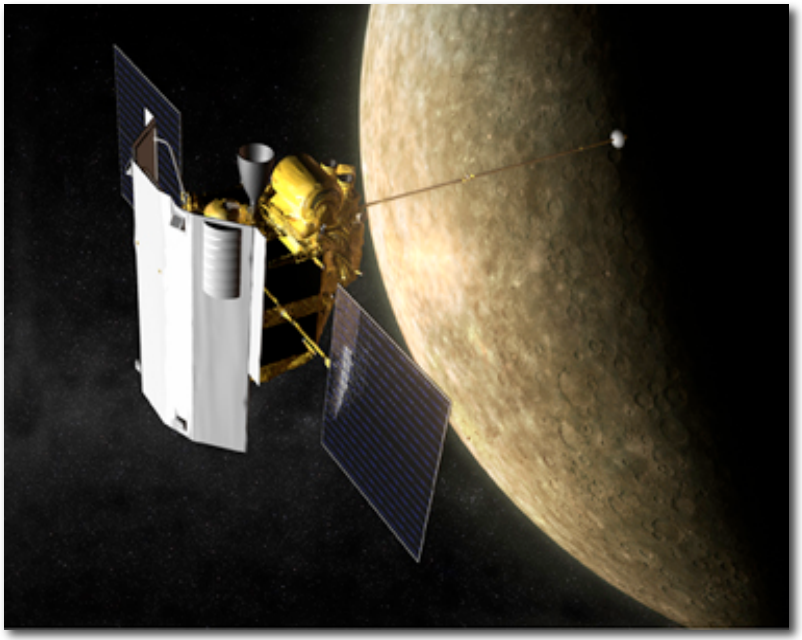
- **Knowledge sharing of government-funded technology developments**
- **It is in the government's interest to make technologies available to the entire NASA community**
  - **Technology developments should be centrally listed and publicized**
    - **Helps avoid duplicate use of scarce technology funds**
  - **Institutions should be required to offer government-funded technologies to all other proposing missions/instruments that would benefit from them**
    - **Technology developers would become part of the new mission team**
    - **This may get some push back by funded developers**

A Good Model: Get Industry involved Early

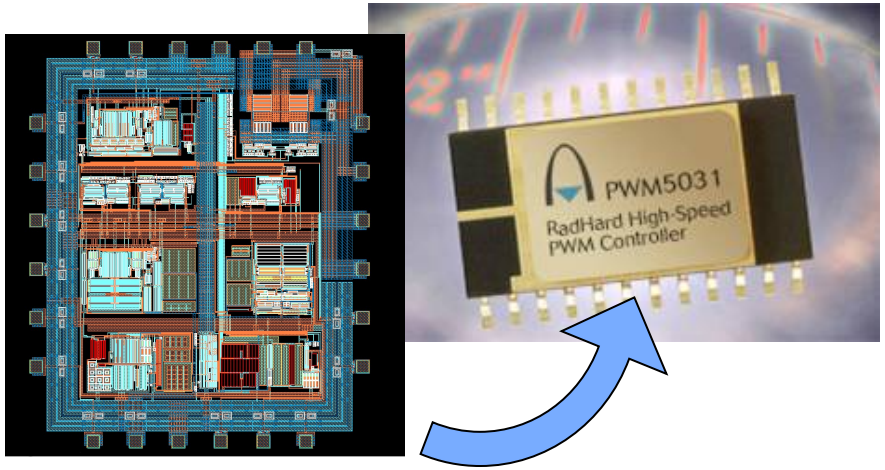
Power Conversion Efficiency for Small Loads

Recent Example:

- **Commercial "brick" DC/DC converters for Instruments and small subsystems lose up to 50% of S/C power**
- **Greatest loss is in pulse-width modulators**
- **NASA funded a rad-hard modulator chip**
- **APL worked with industrial supplier starting at the design phase to make it a commercial product**
- **It is now available to everyone**

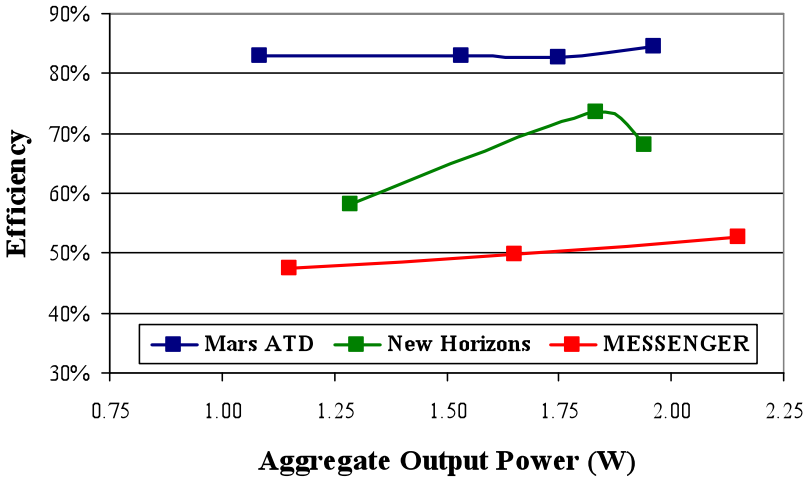


PWM for DC/DC Power Converters



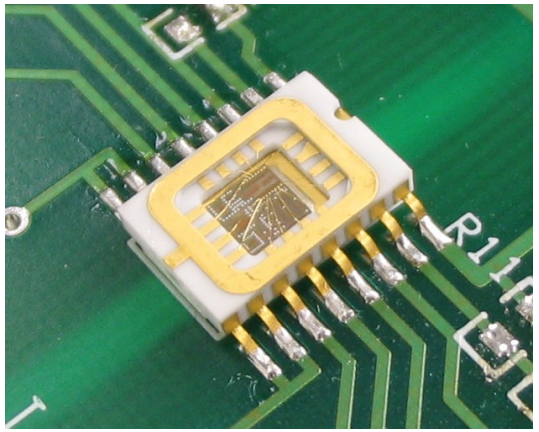
Now a commercial product!

- Reduce DC/DC converter losses 1 order of magnitude while preserving high radiation tolerance
- Partnered with industry to bring the PWM IC to market. Extends benefit to the wider NASA/space community.
- Also developed a digital isolator IC as a rad-hard alternative to optocouplers for power supply control applications.



Digital Isolator Chip:

- Ultra-low power, capacitively coupled, isolation amplifier
  - 100 Mbps, rad-hard



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Summary

- **Fund technologies with wide applicability**
- **Use staff who work on flight programs**
- **Balance technology *Pull* and *Push***
- **Expand the access to technology funds**
- **Publish technology development results**
- **Make technologies available to all NASA programs**

APL


Thank You