The People of GP-B

Seven Near Zeros

And over

Twenty Near-Miracles of Engineering and Science (and Advocacy!)

Apologies for Omissions of People-

Memory is not what it was!

And – we needed you all!

A Sample of the many GP-B Heroes and Heroines – NASA, Lockheed, Stanford, and others

GP-B weathered *Many Storms*

(***1960 to 2011*** *[51 years]* Longest (?) Program in NASA History)

The Anchor and the chain links had to hold in spite of:

- Almost impossible Technical Challenges,
- Complexity of System Engineering

  (Largest Program NASA Delegated to a University?)
- NASA Hq Reluctance to approve Flight Program
- Yearly GP-B Cancellation,

Our Fearless Skipper and Anchor

"On the strength of one link in the cable dependeth the might of the chain; " *Laws of the Navy 1898*

Gravity Probe B Experiment(or GP-B)

1960 --- Conceived by three Stanford Professors While sitting around a swimming pool

Schiff

Always Positi… and always constructive

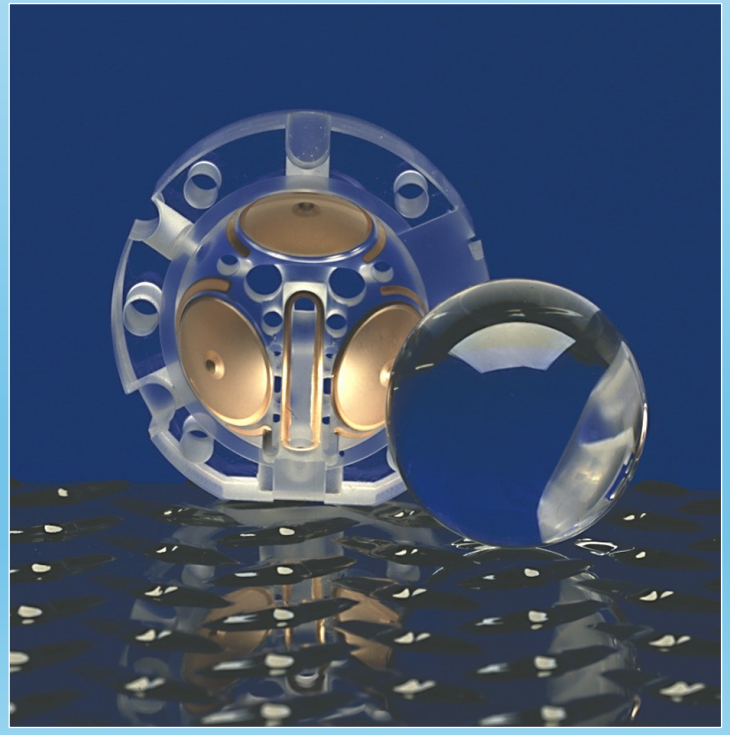
Stanford hired a young PostDoc 1962

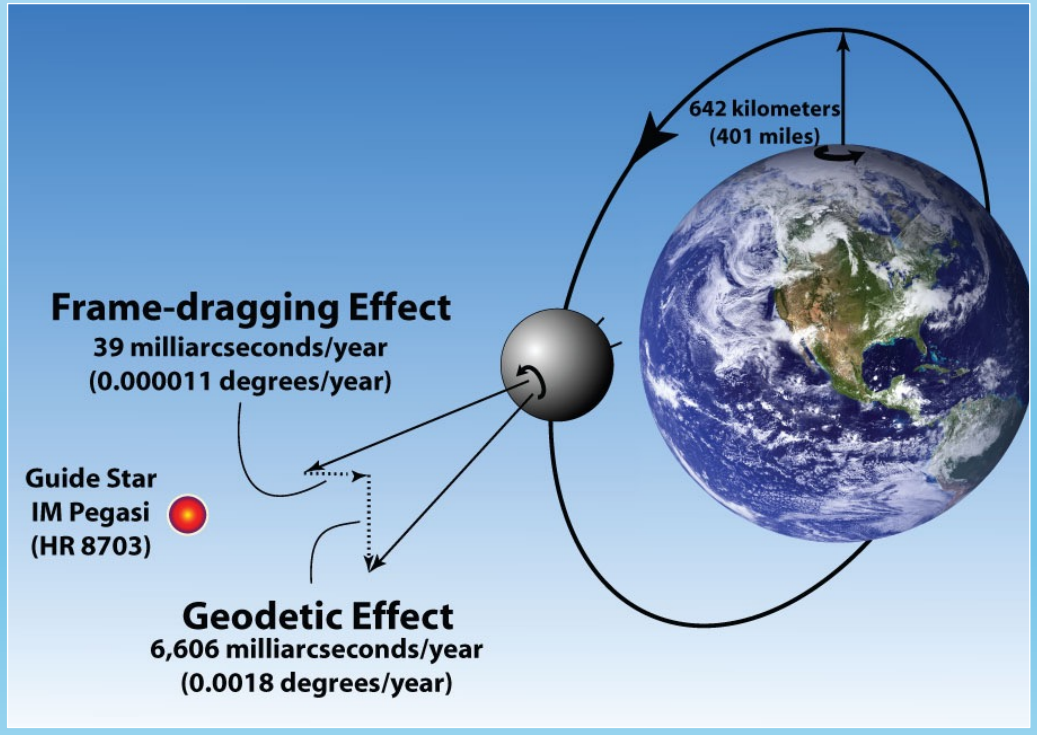
Everitt

Norm Mineta – Our Congressional Godfather

Gravity Probe B - Simple Concept

A near-perfect gyroscope, shielded from torques, will experience two effects of General Relativity





The Seven Near Zeros of GP-B by Francis E.

Experimental Variable	Tolerance Requirements	Tolerances Achieved During Mission
Gyroscope Rotor Near Zeros		
Mechanical Sphericity	50 nanometers (2 micro inches)	<10 nanometers (< 0.4 microinches)
Material Homogeneity	3 parts in 106	3 parts in 107
Electrical Sphericity	5 parts in 107	<5 parts in 107
Probe Environment Near Zeros		
Temperature	1.95 kelvin (-271.2° Celsius or -456.2° Fahrenheit)	1.8 kelvin (-271.4° Celsius or -456.4° Fahrenheit)
Non-Gravitational Residual Acceleration	Less than 10^{-10} g	Less than 5×10^{-12} g
Background Magnetic Field	10^{-6} gauss	Less than 10^{-7} gauss
Probe Pressure	10^{-11} torr	Less than 10^{-11} torr

Back to ***People*** – the critical Links in the GPB Anchor Chain:

The Near Zeros and other requirements needed Near Miracle Solutions by Near-Miracle Workers

A quick review of over twenty of the "Near-Miracles"
Each was a critical link in our essential anchor chain…

The *Near Zeros* required Near Miracle Solutions Miracle Workers

Near Miracle	Technique	A few of our Miracle Workers
Gyro Sphericity and Diameter	Lapping Machine, pH of lapping compound	Initially at MSFC, John Lipa, Dan DeBra, De-Yue Pan, Mac Keiser, Frane Marcelja

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Gyro housing electrodes, lands and ground plane	7-layer Ti-Cu-Ti-Cu-Ti-Cu-Ti electrodes	Ping Zhou, Sasha Buchman
[illegible] the entire mission	testing	[illegible] Buchman

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4 freely spinning gyros for the entire mission	Gyro assembly and > 100,000 hours on ground testing	Rob Brumley, Sasha Buchman

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Measuring Proper Motion – including” Dark Twin” effect	Radio and Optical Star	Irwin Shapiro, Michael Ratner

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The *raw science data* is still active and available on GP-B servers ***Thanks to Jeff Wade –***
20 years after launch.

Stanford's GP-B Managers and Deputy Managers

The LMSC Partners
- Contributed Brilliant Engineering

The MSFC managers and technical personnel were supporters through Thick and Thin!
(And initiated some of the "Near Miracles")

Managerial Continuity for the GP-B Project (1984-2006)

Deputy Program Manager for 22 Years…
Tom Langenstein

The Education Dimension
More Great People…

- *87 PhD's ---*

  (33 Physics; 52 Engineering (A/A, ME, EE); 1 Math, 1 Education)

- *15 Master's Degrees --- 5 Engineer's Degrees*
- *13 PhD's --- at Other Universities*

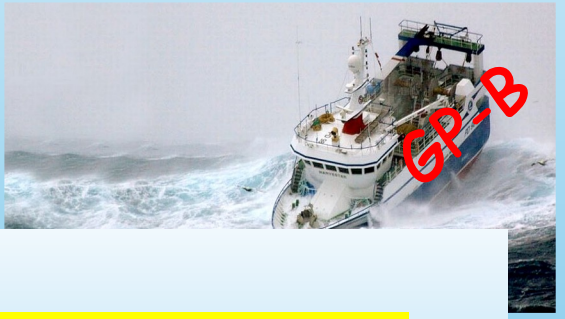
  (University of Alabama - Huntsville, Purdue, Harvard, MIT, University of Wisconsin, University of Aberdeen – Scotland)

- *~ 350 Undergraduates from 11 Departments*
- *--- including Eric Cornell-Nobel Prize 2001*
- *~ 55 High School Summer Students*

Started successful careers for many

GP-B taught:
meeting challenges, team discipline and can do attitude

Our Fearless Skipper and Anchor



Francis is clearly the central figure in our success

- Tenacious
- Grasp of the whole Project
- Superb Technical writer
- Always gave out credit to others
- Skilled at fostering support – NASA/Theoretical Physics Community and, above all, Congress

Would all in the audience, who ***ever*** worked on GP-B, Please standup.

Now give yourselves a round of applause for successfully executing:

"The hardest Program ever attempted by NASA".
(Dr. Frank MacDonald, NASA Chief Scientist)

It only took 51 years!