Horizons

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The American Institute of Aeronautics and Astronautics

March / April 2013
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The 44th Lunar and Planetary Science Conference (LPSC)

Dr. Larry Jay Friesen, Wes Kelly and Shen Ge

Also, Continuing in this Issue! Part 5 of 8

Man Will Conquer Space Soon!

(Collier's 1952-54)

Near the top of every page is an invisible link to return to this page.
The link is in located here (the blue bar), but not all pages display this bar.

March / April 2013
Horizons, Newsletter of AIAA Houston Section

Horizons is a bimonthly publication of the Houston Section of The American Institute of Aeronautics and Astronautics.
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Cover: Two photographs of speakers at the 44th Lunar and Planetary Science Conference of March 18-22, 2013, at the Woodlands near Houston, Texas. Left: Dr. Lindy Elkins-Tanton delivering the Masursky lecture. Right: R. Aileen Yingst. Image credits: Douglas Yazell. Table of contents page: part of Vincent van Gogh's 1889 painting The Starry Night.

Upcoming Annual Awards Banquet Featuring a Talk on the NASA Warp Drive!

DANIEL NOBLES, CHAIR

On the evening of June 13th, the Houston Section will hold our Annual Awards Banquet in memory of Mr. James C McLane, Jr. (1923-2012). Mr. McLane held the position of AIAA Houston Section Chair from 1971-1972, during which the Johnson Space Center flew Apollo Mission 15 and 16. He was the second person in South Carolina to build a gasoline-powered model airplane, and attended Clemson University. He joined the Army Air Corps, and flew as a combat pilot over Germany as a member of the 357th fighter group. From there, he worked for the National Advisory Committee for Aeronautics in Langley, VA, and then designed wind tunnels in Tullahoma, TN. He also led the design of the Lunar Receiving Laboratory, and was a Division Chief for the Space Environmental Simulation Lab. On a more personal note, Mr. McLane was a dear friend to many of us here in the Houston Section, and still regularly attended dinner meetings whenever possible, and we looked forward to speaking with him. His passing has been felt by many of us, and we will be holding this year's Awards Banquet in his memory.

Dr. Sonny White holds a Ph.D. in physics from Rice University, and a vast amount of experience in engineering here at the NASA Johnson Space Center, where many of us best remember his meritorious service to the Engineering Robotics Division. He has been awarded a Silver Snoopy and a NASA Spaceflight Awareness Award, both of which are prestigious awards. Currently, he holds a post as the Advanced Propulsion Theme Lead for the NASA Engineering Directorate and is the JSC representative to the Nuclear Systems Working Group. I cannot wait to hear his perspective of how we can achieve faster than light travel. For more information, check out this link at Space.com: "Warp Drive May Be More Feasible Than Thought, Scientists Say."

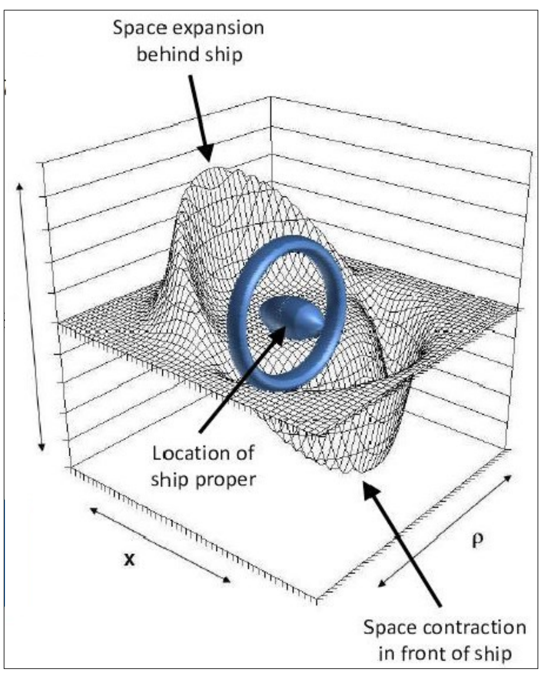
We will also present various awards and introduce our executive council for next year.

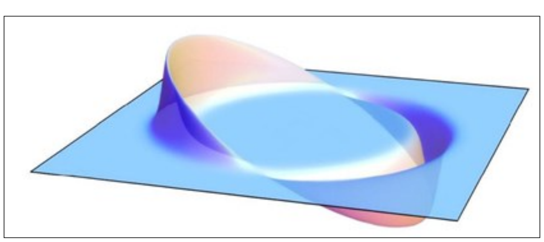
chair2012@aiaahouston.org
(Daniel A. Nobles)
Links:
https://people.nasa.gov

I hope to see you there.

For more information about this dinner meeting, visit our website's event page via this link or email Jennifer Wells at: honors2012@aiaahouston.org

Thank you for your continued support of the AIAA Houston Section.





Above: Photo from a 1972 Section meeting in the Holiday Inn on NASA Road 1. Chairman James C. McLane, Jr. (standing) is introducing the speaker, Major General Douglas T. Nelson, Program Director for the B-1 supersonic bomber. The guest on the right (seated) is Gemini/Apollo astronaut and Air Force test pilot James A. McDivitt. Image credit: James C. McLane III.

Above right: Sheriff Foster B. McLane, Abbeville, South Carolina, circa 1900.

Left: Images from the January / February 2012 issue of Horizons from an article starting on page 26 reporting on our Section's lunch-and-learn by Dr. Harold "Sonny" White. Image credits: Harold White.

From the Editor

Aerospace Alligator News, LPSC 2013 & More

DOUGLAS YAZELL, EDITOR

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An archive for Horizons on a national AIAA web site is here.

Submissions deadline: June 9, 2013, for the May / June 2013 issue, to be online by June 30, 2013.

Advertising
Please contact the editor about rates.

There are two alligators in the Bay Area Blvd ditch, one at Boeing Way and one at Park Shadows Trail! Neighbors say both alligators have been there for years. Both are small and about five feet in length. Illegal acts include feeding alligators (A $75 ticket is part of the penalty, though I met a couple feeding both alligators. The penalty discourages people from teaching alligators to associate people with food.) and moving alligators. Also, unauthorized killing of an alligator results in arrest and a large monetary penalty.

A neighbor reported that someone told her about a TV news report saying that the Boeing Way alligator was killed on Middlebrook Drive after police found it in the middle of the road. That led us to the internet where we found two TV news reports (ABC and NBC) about an alligator killed by a Texas Parks and Wildlife Department (TPWD) game warden in our Houston Clear Lake area, but it was a different alligator. This reptile was almost ten feet long and it was found on Clear Lake City Blvd. It was not dangerous, but moving it would been dangerous for the people doing the work of moving the alligator.

Heavy rains and the mating season cause the alligators to move away from their favorite homes.

A photograph taken on May 29, 2013, shows the Park Shadows Trail alligator with a very full stomach. It seems to be a sudden change, so a meal of an egret or a large turtle is more likely than a pregnancy.

I have not seen the Boeing Way alligator for a week or two. I hope it is safe in its home in this ditch on both sides of Boeing Way.

The NBC news report stated that TPWD discourages people from complaining to them about alligators unless someone is in danger.

Dr. Larry Jay Friesen is an excellent writer whose work for this issue's cover story is appreciated. He covered the Lunar and Planetary Science Conference in the Woodlands with Horizons reporters Wes Kelly and Shen Ge. Wes did a great job of combining the writing of all three of those journalists.

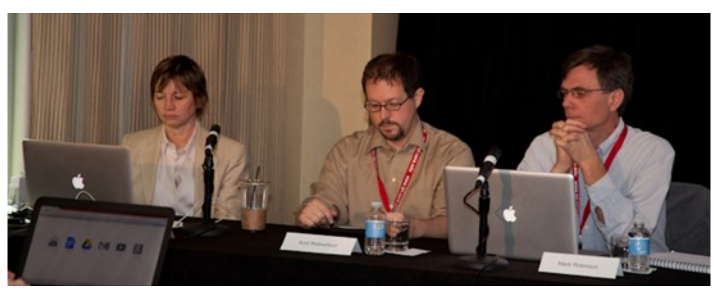
Daniel R. Adamo provides three excellent astrodynamics articles for this issue. Additional contributors include Philippe Mairet and James C. McLane III. The Horizons Collier's series continues its great run in this issue, too.

I am late with the formatting work for this issue, so we missed our deadline to publish this March / April 2013 issue by April 30. We now aim for publication by May 31. Among other reasons for this delay are my back surgery in November of 2012 and a business trip to Oregon.

When time permits, we will return to listing AIAA conference papers by local authors.

The January / February 2013 issue can now be downloaded in its low resolution format article by article. By using these smaller PDF files, the user need not download an entire 72-page issue. That was a successful experiment.

Top: The Park Shadows Trail (PST) alligator after a meal, it seems. Middle: The PST alligator. Bottom: The Boeing Way alligator and large Red-eared Slider turtles. Image credits: Douglas Yazell.



Above: GRAIL and LRO press briefing. Image credit: LPSC 2013 royalty-free images.

Right: Astronauts for Hire (www.astronauts4hire.org) published their fourth quarterly newsletter.

The 44th Lunar & Planetary Science Conference

Cover Story

Dr. Larry Jay Friesen, Wes Kelly and Shen Ge

Where should one begin discussion of a multi-world trade fair, the 44th Lunar and Planetary Science Conference (LPSC), held in the Houston-area Woodlands Marriott Convention Center 18-22 March 2013? Let's start with the first day plenary session featuring the Masursky memorial lecture, "On Building an Earth-Like Planet," by Dr. Lindy Elkins-Tanton, Director of the Department of Terrestrial Magnetism at the Carnegie Institute for Science.

The conference guide to oral and poster presentations provides one or two sentences for each of 2,000 papers. All are available online as two-page abstracts (www.lpi.usra.edu/meetings/lpsc2013).

Elkins-Tanton's new paper **[#1408]** says, "Magma ocean processes on planetesimals and planets control the earliest compositional and volatile content of the terrestrial planets." Listening to Elkins-Tanton at this year's plenary session, we observe the timeline of events close to the Earth's formation are noted to three decimal point precision in the period from 4 to 4.6 billion years ago. Yet, the role of cometary collisions with Earth in the Late Heavy Bombardment period (LHB – see Glossary) is greatly reduced or revised to explain the supply of "volatile" materials such as water and carbon compounds. Hydrogen and carbon within the earth's interior and magma ocean, it is reasoned, were eventually released as the early heated atmosphere; this, in part, precipitated into early oceans and lakes.

This thesis could mean giving up a popular idea for supplying water to early Earth, the idea of late addition of water to Earth by comets, because comets are not a good match for Earth's deuterium-to-hydrogen isotopic abundance ratio, nor do comets match Earth's ratio of nitrogen isotopes. For this late addition argument to hold, we need asteroids made of rocky materials, plus retention of enough water and other volatiles during accretion impacts. In principle, a water ocean could have been produced with very little initial water (Compare the depth of Earth's oceans with the thickness of the mantle.), but there is not full understanding of what happens to water in a magma ocean (a layer of molten rock thought to have covered early Earth). The take-home message is that any terrestrial planet should start with a water ocean early in its formation.

Whether this is a majority consensus, we hesitate to say, except that evidence or argument for this scenario appears throughout papers presented in LPSC 44, some in collaboration with Elkins-Tanton. But there are arguments and data sets causing one to wonder where the matter will finally rest. Also, there are findings in sessions about planetary formation processes in other star systems. These findings place the formation of Earth and our other solar system's planets in a larger context with other possible outcomes. Thus, an increasingly clear picture of planetary formation processes emerges. That picture is based on

- Field findings from planets, meteorites and asteroids,
- Better instrumentation in labs, and
- Data from and modeling of solar system and extrasolar planets.

This picture is made even clearer by exhaustive debate that frequently revises much of this never-to-be-finished mosaic.

Magma (from Greek word for "mixture") is a mixture of molten or semi-molten rock, volatiles and solids found beneath the surface of the Earth. Clearly, its presence and composition across space and time beneath planetary, lunar and asteroid surfaces are features of much debate, as session paper abstracts show. Separation of the magma into layers of rock rich in silicates, metals, carbonates or water is discussed in detail by geologists.

After decades of conferences since the lunar landings, there is now increased concern with volatiles: compositions of atmospheres and fluid reservoirs, and origins of water.

We identified lakes, oceans and glaciers on several planets and moons in our solar system, and we find traces and inferred histories of lakes, oceans and glaciers on planets and moons beyond our solar system. All lakes, oceans and glaciers disappeared on Mars and Venus. Current research interests are often

- The origins of life on this world,
- Habitability (perhaps for astronauts) earlier or now on other solar system bod-

(Continued on page 6)

Above: The help desk on Sunday, March 17, 2013. Image credit: LPSC royalty-free images.

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(Continued from page 5)

ies, and

- The prospect that extrasolar planets could provide parallel-Earth examples (such as Thursday's session, **Planetary Atmospheres: Exoplanets [R452]**).

This is not to say that the conference is unconcerned with many other aerospace issues. Descriptions of planetary and lunar environments affect the design of future spacecraft. The conference is also a treasure trough of data on existing spacecraft performance, operations, payload sets and proposals for new spacecraft missions. Whether proposals are presented in oral or poster format, it is clear that the submissions were already connected to a legacy of previous conferences. It is also clear that future proposals will be shaped by this year's scientific and operational reports.

Historical Notes

The March 18, 2013, afternoon lecture **[M151]** is named for pioneer space geologist and astronomer Dr. Harold Masursky (1922-1990). In the NASA Apollo program years, Masursky led lunar and planetary surface survey teams and landing site selection groups. He helped monitor and guide the 1969 Moon landing and analyzed the data afterwards. Looking to Mars, he led the1971 Mariner 9 Mars observing team and the selection of the 1976 Mars Viking lander sites. Masursky regularly visited Houston during his career. Many here remember him from work, conferences, or his sharing of scientific findings with television audiences. One of us (Wes Kelly) last saw him with students and coworkers at a Houston Clear Lake area Indian restaurant on Upper Bay Road during a late 1980s LPSC.

The first of these conferences took place in 1970. It was called the Lunar Science Conference (LSC). The eighth conference was the first to use the new name, the Lunar and Planetary Science Conference (LPSC). The 1970 LSC took place at NASA Johnson Space Center (JSC) and the newly formed Lunar Science Institute (LSI) in the former James Marion West plantation house east of JSC on the NASA Parkway. Some of those earliest conferences (1971 and others) took place in a downtown Houston convention center which no longer exists.

As scope of lunar and planetary science studies increased, with more varied missions and international participation, the gatherings grew from hundreds to thousands of presenters and participants. New and larger venues near JSC subsequently served as hosts, including a hotel in South Shore Harbor.

LPSC proceedings were once three-volume sets resembling Houston's yellow pages. A compact disk (CD) version arrived in 2005. The memory stick issued to 2013 attendees contains 2,087 abstracts and 750 megabytes of data. Abstracts are also available online at the Houston Clear Lake area Lunar and Planetary Science Institute (LPI) web site. This report will mention and link to some of those abstracts. The author list, though not all were in attendance, exceeds 7,000 names. Among "non-attendees," as Table 1 indicates, is the extensive fleet of robotic spacecraft exploring planets, moons, comets and asteroids. These spacecraft made this flurry of Woodlands activities possible.

Early Sessions and Papers

To illustrate the structure and depth of LPSC 44, Monday morning's first-day (March 18, 2013) sessions began with four simultaneous sessions of oral presentations prior to Dr. Elkins-Tanton's talk:

- **Planetary Differentiation across the Solar System [M101]**; the first of several special sessions devoted to

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Table-1 Lunar and Planetary Science Mission Sources for 44th LPSC Papers

Spacecraft	Target(s)	Activity Period
Cassini	Saturn, Titan, Enceladus & other satellites	Current
Curiosity / Mars Science Lab	Mars	Current
Messenger	Mercury	Ongoing
Bepi-Columbo	Mercury	Preparation
Dawn	Asteroid Vesta (en route to Ceres)	Current
LRO (Lunar Reconnaissance Orbiter)	Moon	Complete*
GRAIL (Gravity Recovery and Interior Laboratory)	Moon	Complete**
Selene	Moon	Complete
Chang'e 1	Moon	Complete
Chane'e 2	Moon, Asteroid 4172 Toutatis***	Current
Selene / Kaguya	Moon	Complete
Hayabusa-1	Asteroid Itokawa	Complete
Phoenix	Mars	Complete
Mars Exploration Rover (Opportunity)	Mars	Current (at Endeavour Crater)
Stardust	Comet Wild	Complete
Genesis	Solar wind	Complete

* Apollo mission data contributed to many reports.
** Vehicles guided to crash on lunar surface
*** Earth-Sun L2 Lagrangian point, also

(Continued from page 6)

the Mars Science Laboratory (MSL) Curiosity rover results,

- **Geology and Environment [M102]**,
- **Lunar Remote Sensing [M103]**, devoted to results from several recent lunar orbiters, and
- **Early Solar System Chronology [M104]**, derived from isotopic ratios obtained from geological field sites and meteorites. The afternoon sessions were devoted to planetary characterization:
- **Cartography [M152]**,
- **Volcanism in the Solar System [M154]**,
- **Dynamics and Tectonics [M155]**,
- **From Dust to Planetary Disks [M156]** (early formation stages) and
- **Soils and Rocks [M153]**, more about the MSL results.

The evening included a NASA briefing on future plans. Press briefings highlighted particular discoveries or reports.

Starting with the Monday morning MSL session Project Scientist Dr. John Grotzinger presented a broad survey of Curiosity's activities with instruments for the first 100 Martian days, or sols (about 24.5 hours per sol), since the landing of August 5, 2012. The vehicle has an expected drive capability of 20 kilometers with a payload of 11 cameras, spectrometers, and digging tools as chemical analyzers. The names of the principal instruments are listed below. Session papers providing more detailed discussions of their 100-sol findings are indicated by catalog number.

- SAM: a gas chromatograph -mass spectrometer to search for carbon in rock
- CheMin: an X-ray diffraction meter to identify mineral type (#1365, #2781)
- Mastcam & MAHLI cameras (#1617)
- APXS: an alpha particle X-ray spectrometer for in situ soil chemical analysis
- ChemCam: a laser breakdown spectrometer (#1267) for rock and mineral chemical composition
- DAN: an active neutron spectrometer
- REMS: the Mars "weather station" (#1548, #1625)
- RAD: background solar radiation monitor

Amid this summary of 100-sol findings Grotzinger declared that geological evidence of ancient water (clays) indicated relatively neutral pH levels, low salinity and some carbon, present in crystalline forms.

Contemporary Martian surface features are the main concern of the session described above. Elsewhere, at the **Differentiation session [M101]**, planetary theoretical models dig deeper, searching sometimes for "magma." Work of the morning's first presenter William Bottke (#1672) was reported in Horizons last year. This and subsequent papers concentrate on

- The asteroid belt as observed,
- The asteroid belt's composition inferred from meteorites, and
- Models of interior processes, such as convection and differentiation into different mineral layers.

Here there is a close link between

- What Elkins-Tanton presents about planetesimals coalescing into Earth-like planets in a sequence of collisions and mergers, and
- What can be determined from examining asteroid remains of such a process.

Differentiation session papers **[M101]**, at the very least, show that the asteroid belt composition is not uniform and that formation processes were influenced by initial distance from the Sun (as in "Asteroid Partial Melting at the Solar System's Snow Line," #2481), and then by the sizes of the bodies after surfaces and interiors cooled. Subsequent collisions scattered remains into the heterogeneous asteroid belt composition we observe today, and scattered remains into meteorites collected here on Earth, where we attempt to trace them back to their parent bodies.

The solar-electric powered NASA Dawn mission to asteroids Vesta and Ceres is another spacecraft star of the LPSC 44 show. Wednesday's special session, **Dawn: Vesta from the Inside Out [W301]**, naturally links with **Differentiation session** papers **[M101]**, and links with results discussed later in the conference, **Dawn at Vesta [Session 802]**, with its one paper, **[#1136]**. T. H. Burbine's paper **[#2637]** begins by stating, "The asteroid class best linked to a meteor type are the V-types." In this case, V indicates Vesta or similar asteroids that have one-micron bands similar to the spectra of howardite, eucrite and diogenite (HED) meteorites. For decades prior to the Dawn mission, Vesta had already been identified as a source for meteorites with volcanic features not attributed to Mars or the Moon. This led to speculation that Vesta would be rich in volatiles or a differentiated surface, perhaps even

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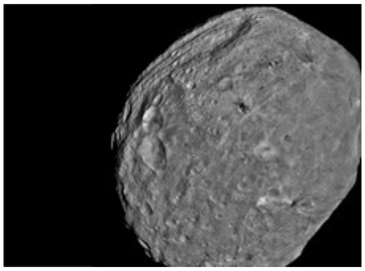
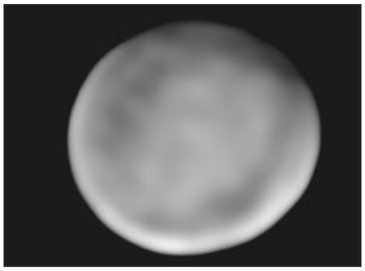


Above: Vesta image by NASA's Dawn spacecraft. Vesta is the second largest asteroid in the main asteroid belt. Image credit: NASA.

Above: Vesta image by the Hubble Space Telescope. Image credit: NASA.



Above: Image of Ceres, the largest asteroid in the main asteroid belt, taken by the Keck Telescope. Image credit: Keck Observatory by C. Dumas.

Above: An artist's version of the NASA Dawn spacecraft leaving Earth. Dawn completed the Vesta portion of its mission and is now on its way to Ceres. Image credit: NASA/JPL-Caltech/UCLA/McTech

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Above: An image from the NASA Mars Science Lander (MSL) press briefing. Image credit: LPSC royalty-free images.

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carbonates and water. From remote sensing it certainly appeared to differ from other larger asteroids such as Ceres. It now appears that Vesta has a deep basaltic crust about ten kilometers thick. Other V type asteroids are perhaps crustal remains with diameters of that order. As for large quantities of volatiles, as paper **[#2767]** argues, if not at Vesta, there is still good prospects for their presence at Ceres, the largest asteroid and a body connected with carbonaceous chondritic meteorites. Ceres is the next stop on Dawn's excursion.

It was Monday afternoon (Session **From Dust to Planets in the Protoplanetary Disk [M156]**) that the authors of paper **[#1403]** ("Effects of Refractory Carbon Grains on Exoplanet Planetesimal Composition") addressed variations of magma composition on the interstellar vs. interplanetary scale. Torrence Johnson and colleagues "calculated the planetesimal composition for exoplanet systems with different carbon-oxygen ratios (C/O)." This was done since, "Given the observed range in stellar carbon to oxygen ratios in exoplanet host stars, condensates might range from more water and volatile rich than solar system objects to volatile poor and silicate/metal rich. [And] for more carbon-rich stars (C/O greater than about 0.8) refractory material in the inner part of the systems might be dominated by carbides rather than silicates."

Volatile ice composition would depend on availability of oxygen for formation of H_2 ice condensations. Systems with less than the solar value for C/O of 0.55 would have very ice rich planetesimals. A number of stars with photospheric abundances greater than the solar ratio were examined with the chemical abundance applied to the complex coalescence processes within the presumed protoplanetary disks surrounding the stars early in their life histories.

Atmospheric Studies of Solar System and Extrasolar Planets

Findings, of course, rest on assuming that circumstellar and stellar photosphere elemental abundances are similar. But are they? Inquiring of several attendees about this problem, one suggested verification could come through continued study of solar system abundances preserved in meteorites, asteroids or comets. This brings us back to examining isotopic ratios to determine ages and original abundances of both refractory and volatile materials. We note reports in 22 March 2013 *Science* [**References 1 & 2**], discussing the same issue of extrasolar planet compositions and volatiles, but using ground-based Keck II Observatory results. The introduction notes that abundances of elements heavier than helium (C, N, S) in the atmospheres of Jupiter and Saturn exceed solar abundances by factors of 3 and 7 respectively; and that "enhancements of specific elements provides a fingerprint of the planet formation process." Infrared spectrum results for three exoplanets exceeding Jovian mass shape the discussion.

An intriguing extrasolar planet situation is that of an Earth-like world located near enough to a red dwarf star to experience heating similar to the solar constant (1,380 Watts per square meter), but also experience low rotation rates due to increased tidal effects from the star. The authors of paper **[#2787]**, within limits of their models that included a variable reflectance, identified thermal saturation conditions leading to runaway greenhouse effects if the night side of the planet could not radiate off into space stellar heat at a rate to match the buildup on its permanently illuminated side (1,640 Watts per square meter maximum stellar heat flux constant). With rotational rates increased to values approaching Earth's angular rate, the boundary dropped to 1,550. There's something to ponder here for Earth's future as well.

Isotope Abundance Ratios, Age Estimations and Points of Origin

In the fourth session of the first morning, **Early Solar System Chronology [M104]**, a paper by Y. Amelin and others provided an interesting introduction to isotopic evidence trails in meteorites. Though cryptically titled, "U-Th-Pb Systematics of CAIs from CV Chondrite Northwest Africa 4502," **[#2690]**, it had links to other presented papers that would resonate outside the conference halls. Still, the program lead did not yield information easily: "Four CAIs from CV chondrite NWA 4502 have Pb [lead] isotopic age of 4,567.40 ± 0.27 [million years], and uniform $^{238}U/^{235}U$ of 137.808 ± 0.019." In translation we conclude that a meteorite from West Africa is under examination for age through a process known as Pb-Pb isotopic dating, and that the age is found to be similar to other CAIs (calcium aluminum rich inclu-

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sions). Toward lunchtime, paper **[#1841]** reported about tests on another chondrite, NWA 6704. Based on $^{238}U/^{235}U$ ratio of 137.88, an age of 4.56334 billion years with +/-300,000 years uncertainty was reported.

In the two-page abstract of another paper examining other NW African meteorites (7388 and 7605), similar age but far different composition and origin conclusions are drawn; and for a similarly ancient NWA 7325, investigator Anthony Irving, speaking Wednesday morning in a session devoted to science results from the Messenger spacecraft, suggests a quite extraordinary explanation of origin **[#2164]**. While we note that some NWA meteorites have been traced to Mars by investigations (e.g., NWA 7034 and 6162 in several papers of session **[W302]**; 7034 is discussed as well in **Reference 3**), Irving argues that 7325 could have originated on Mercury!

Beta decays are attributed to weak force interactions within the nuclei of atomic isotopes, the source of much natural radioactivity. Each isotopic configuration of the nucleus has its characteristic rate of decay which we associate with an isotopic level of instability or stability. As a result we can determine the age of ancient cave camp fires or the formations of the oldest rocks from atomic remains. In broad terms, radio carbon dating tracks from nitrogen-15 decay to carbon-14 (^{14}C) and back to stable ^{14}N for the cave, reckoning over thousands of years; and planetary geophysics tracks deposits of slower decays over billions of years, for example, assessing uranium-to-lead abundance ratios when a molten mix might have settled out into a solid ore (Table 2).

Not all isotopic abundance ratios are assessed to determine a decay rate, however. Comparing deuterium-to-hydrogen ratios in the atmospheres of Earth, Mars and Jupiter might give an estimate of how much hydrogen might have escaped from each world over eons, with the heavier of the two atoms (^2H) less frequently reaching escape velocity. As mentioned,

- There are abundance ratios in the solar photosphere which have been altered by solar nuclear reactions,
- There are abundances in the giant planets which might reflect the original abundance ratios of the clouds from which they formed, and
- In the terrestrial planets there are atmospheric abundance ratios for nitrogen, oxygen, carbon and the inert gases such as argon, plus the abundance ratios of many stable and unstable isotopes of elements in rocks and ores extracted from their interiors or obtained on Earth as meteorites.

More Monday Reports

In the **MSL Geology and Environment** session **[M102]** by Palucis and others **[#1259]** discussed the Peace Vallis fan system that drains into the Curiosity landing area. Its similarity to other fan systems in the Martian southern highlands suggests a period in Mars' history of widespread fluvial activity [related to rivers or streams]. The authors propose snowfall as the water source. They estimate the source regions to be too high in elevation for it to be ground water. If the water source were rainfall, based on terrestrial experience, they would expect more fine scale branching of the tributaries.

In **Lunar Remote Sensing [M103],** Hayne and others **[#3003]** find evidence or the effectiveness of relative regolith thickness as a dating tool. Regolith is the upper layer of finely divided material - dust and small rocks - that covers the Moon. They think they will be able to use thermal inertia as a measure of upper regolith thickness. Braden and co-authors **[#2843]** reported small-scale volcanic units in many maria; some smooth, some rough. [The singular of

Cover Story

maria, Latin for seas, is mare; maria are large, dark plains of volcanic origin on the Moon, according to Wikipedia, which explains that astronomers initially mistook them for seas.] They estimate ages for smooth volcanic units between 18 and 50 million years, fantastically young for the Moon. They ask the question, "What kept these areas active for so long?" Greenhagen and co-authors **[#2987]** report that Tsiolkovsky crater, on the far side of the Moon, is weird in a number of respects. For one thing, it contains lots of rocky blocks, which is not expected for a crater thought to be about 3.2 billion years old, based on crater counts in mare-filled areas.

Monday afternoon at the session called **Planetary Dynamics and Plate Tectonics [M155]**: Leone and co-authors **[#1089]** offered a new idea for the cause of the Martian hemispheric dichotomy, where the southern hemisphere of Mars is at very much higher elevation than the northern, and the boundary between them is in many

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Table-2 *Radioactive Decays for Planetary Science

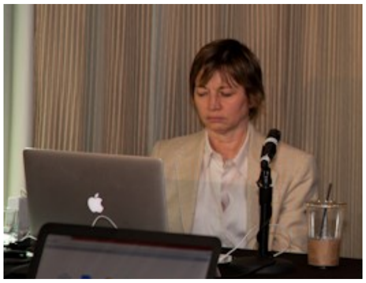
Process	Symbol	Half-Life (Years)	Stable End Product
Thorium	^{232}Th	$1.39x10^{10}$	^{208}Pb (lead)
Neptunium	^{237}Np	$2.25x\ 10^6$	^{209} Bi
Uranium	^{238}U	$4.51x10^9$	^{206}Pb
Actinium	^{235}U	$7.07x10^8$	^{207}Pb
Carbon-14	^{14}C	$5.73x10^3$	^{14}N

*Adapted from *Principles of Modern Physics*, Robert Leighton, McGraw-Hill, 1959. The text notes a terrestrial $^{238}U/^{235}U$ abundance = 138.5.

$N(t)/\ N_0 = 2^{-t/T_{HL}}$ Half Life Decay Formula or

$N(t)/N_0 = \exp(-\lambda\ t)$ where $\lambda = \ln(2)/T_{HL}$

Cover Story



Above: Dr. Maria Zuber from the NASA GRAIL mission at the GRAIL/LRO press briefing. Image credit: LPSC royalty-free images.

Above: Kurt Retherford, Principal Investigator for the NASA Lunar Reconnaissance Orbiter (LRO) mission at the GRAIL/LRO press briefing. Image credit: LPSC royalty-free images.

(Continued from page 9)

places relatively sharp and steep. They propose a giant southern impact with impactor radius around 1,600 kilometers. The planet's response to the impact is volcanism, crustal production, and crustal thickening. This contrasts with an existing idea for a giant northern impact, which would make the northern lowlands the floor of a gigantic impact basin. There are other models not involving impacts.

At the session called **Planetary Volcanism in the Solar System [M154]**, Huang and co-authors **[#2288]** offered evidence for explosive volcanism on early Mars. They identified 75 ancient volcanoes in the southern part of Mars, and found a new type of knobby terrain. Their evidence tells them that explosive eruption was a dominant volcanic style on early Mars.

Tuesday

Morning at **Terrestrial Planetary Differentiation [T201]:** James M. D. Day **[#1835]** reported a ubiquity of late-accretion signals on terrestrial planets. Material was added to the planets after they had differentiated and their main core growth was over. In the **MSL** at **The Rockness Sand Dune [T202],** Archer and co-authors **[#2168]** offered reasons for thinking perchlorates may be widespread on Mars. Found already by the Phoenix lander, they are relatively stable in Mars conditions and do not react readily with organic matter. Some terrestrial organisms use them as an energy source. They can suck up water and form brines. When heated, they readily decompose, releasing oxygen, so they could be destroyed, rather than discovered, by lander instruments that heat samples.

At **Origin and Evolution of the Moon [T204]**, Nakajima and Stevenson discussed two variations on the giant impact model for the origin of the Moon

- Impact into a fast-spinning proto-Earth, and
- Collision between two "sub-Earths" of similar size.

Most giant impact models consider a Mars-size object colliding with a much larger proto-Earth. Visscher and Fegley **[#1546]** discussed chemistry in the debris disk from which the Moon formed. How much water is retained in the eventual Moon depends on the initial water inventory and the solubility of water in melt lavas. Lanueville and co-authors **[#1594]** noted that there is a strong enrichment of heat sources (radioactive uranium, thorium, and potassium) on the near side of the Moon. Nearly 90% of the Moon's volcanism occurred on the near side. They estimate that near side volcanism stopped roughly one billion years ago, and that far side volcanism stopped around three billion years ago. Joliffe and co-authors **[#2655]** report that re-interpretation of Apollo seismic data points to a thinner crust on the Moon than previously thought, with an average thickness between 34 and 43 kilometers. This is in accord with GRAIL mission gravity data, which also indicates a thinner crust.

Tuesday's Wholly GRAIL

GRAIL is familiar to most of our readers, NASA's recent and successful Gravity Recovery and Interior Laboratory (GRAIL) mission to use high-quality gravitational field mapping of the Moon in order to determine the Moon's interior structure (Wikipedia). In the session **GRAIL Explores the Moon's Interior [T255]**, Zuber and co-authors **[#1777]** described their lunar gravity model of degree and order 660. This represents block sizes of 8.3 kilometers on the lunar surface. Work on a model of degree and order 900 is in process. Plans for models beyond degree 1,000 are also in work, making the team the largest current users of NASA supercomputer time. They are currently limited by Lunar Orbiter Laser Altimeter (LOLA) topography data from the Lunar Reconnaissance Orbiter (LRO). As map comparisons show, at short wavelengths on the Moon, gravity closely follows topography.

Williams and co-authors **[#3092]** worked on the Moon's J_2 and C_{22} gravitational terms from GRAIL data, and the Love number K_2, measuring lunar elastic response to tidal forces. They cannot get the Love number to make sense if the Moon's core is entirely solid; some part of it must be liquid. They give lunar radius as 1,737.15 kilometers, a slight difference from the current standard value. Inner solid core radius equals 240 kilometers. The outer fluid core starts at 240 kilometers, with its top at 330 kilometers. Mean lunar density is 3,345.6 kilograms per cubic meter. Taylor and co-authors **[#1783]** report that some far side locations have crusts up to 50 to 60 kilometers thick. GRAIL data imply less aluminum in the Moon than previously thought. This means the Moon is probably not enriched in refractory abundance when compared with Earth.

Wieczorek and co-authors **[#1914]** find that the Moon is highly fractured by cratering,

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which leads to a higher porosity of the upper several tens of kilometers of the Moon than previously thought, ranging from 5 to 20%. Many craters have a lower porosity interior, with higher porosity just outside. This results from crustal thinning inside, and dumping excavated ejecta outside. Similar patterns have been observed for terrestrial craters.

Kiefer and co-authors **[#2030]** report buried high density material near Aristarchus, the Marius Hills, and the Cauchy-Gardner area. South of Aristarchus may lie a buried mass concentration (mascon) crater, although that's not the only possibility. North of Aristarchus, there must be basaltic intrusions. The Marius Hills must have at least 12 kilometers thickness of intruded material. Sori and co-authors **[#2755]** pointed out that we don't know how much mare area there originally was. Some may be buried under later highlands ejecta. They used GRAIL data to look for buried denser material, and they found some.

Neumann and co-authors **[#2379]** used GRAIL data to take inventory of impact basins and search for previously hidden ones. They provided a list of confirmed new basins. One or two very large "megabasins" are still under assessment. Miljkovic and co-authors **[#1926]** report that GRAIL data shows evidence of a hemispheric asymmetry in basin sizes. Eight basins larger than 300 kilometers in diameter are on the near side of the Moon, and one such basin is on the Moon's far side. The crust is thinner, on average, on the near side of the Moon than on the far side. At the time of the impacts, there was also a thermal difference between these hemispheres, due to the near side concentration of radioactive heat sources mentioned earlier. Their modeling shows that the differences in target materials and temperature would have resulted in the same impactor producing a far larger crater on the near side than on the far side of the Moon. This new lesson learned contradicts the idea that a collection of larger impactors struck the near side of the Moon, as compared to smaller impactors striking the far side of the Moon. The new lesson learned is: the Moon responded differently to impacts on the near side, as compared to impacts on the far side.

Wednesday's Vesta Dawn Celebration, Plus Mars and Mercury

In Wednesday morning's session on NASA's Dawn asteroid mission, **Vesta from the Inside Out [W301]**, Russell and co-authors **[#1200]** compare Vesta spectra with spectra from the HED (Howardite, Eucrite, Diogenite) meteorites, thought to come from Vesta. Euchrite (crustal) spectra dominate in the north, Diogenite (interior) spectra dominate in the south, and Howardite (a mixture) spectra dominate overall. This implies that more crust has been removed from the south part, which is what one would expect from the two giant overlapping impact basins at Vesta's south pole. Vesta is very dry, though there is evidence for water in the mineral apatite, and perhaps in some craters.

Fu and co-authors **[#2115]** point out that Vesta's equatorial bulge is far larger than expected for its current spin rate. They wonder if there could have been a roughly 6% late de-spinning. Raymond and co-authors **[#2882]** report that Vestatia Terra, located on the rim of the giant south pole impact basin Rheasilvia, is the highest terrain on Vesta. It is ancient and dense; perhaps it is a surviving plutonic (defined as: formed by solidification of magma deep within the earth and crystalline throughout <*plutonic* rock>) complex. Bowling and co-authors **[#1673]** conclude that Vesta's equatorial troughs were likely generated by the Rheasilvia impact. The maximum extension during this proposed impact event is near the equator.

In the Fluids on Mars [W305] session, Hauber and co-authors **[#2513]** find that Martian deltas previously studied are younger than Noachian (less than 3.7 billion years old) and not all the same age. They think some deltas could form in single, short-duration events with limited water supply, but not necessarily by a regionally connected water table. Older deltas have longer feeder valleys; perhaps episodic surface runoff could be responsible. Not finding water-altered minerals suggests short term activity.

In the **Messenger Results from Mercury [W303]** session, Ernstand co-authors **[#2364]** report the volcanic plains interior to the Caloris basin to be at least 2.5 kilometers thick. Selvans and co-authors **[#2773]** report more scarps (defined by Google as very steep banks or slopes) in the south of Mercury than the north. They are oriented more east-west near the poles, and oriented more north-south near the equator. The researchers ask if this could be connected with mantle convection.

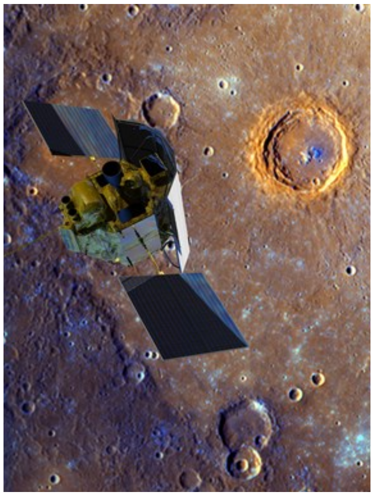
In the **Volatiles at Mercury [W353] session**, Chabot and co-authors were able to use

(Continued on page 12)

Cover Story

Above: Mark Robinson of the NASA Lunar Reconnaissance Orbiter (LRO) at the GRAIL/ LRO press briefing. Image credit: LPSC royalty-free images.

Cover Story



Above: NASA's Messenger robotic spacecraft over Calvino Crater. A depiction of the MESSENGER spacecraft is shown flying over Mercury's surface displayed in enhanced color. The crater ringed by bright orange is Calvino crater. The enhanced color imagery of Mercury was obtained during the mission's second Mercury flyby in 2008. Visit this page to learn more about this high resolution sequence of color imagery from Mercury flyby 2. Image credit: NASA/Johns Hopkins University Applied Physics Laboratory/ Carnegie Institution of Washington.

(Continued from page 11)

indirect scattered sunlight to image within permanently shadowed areas in craters Prokofiev and Kaninski near Mercury's poles. Permanently shadowed areas match areas that appear radar-bright from Earth. They also show high reflectivity to the laser altimeter, which is interpreted as water ice at the surface. Those areas also look bright in wide-angle camera (WAC) clear-filter images. Two research groups proposed that mysterious hollows on Mercury, which look like neither impact craters nor volcanoes, are formed by volatization of subsurface materials, followed by collapse of material above.

During noon break between sessions, we heard from the **Lunar Exploration Analysis Group (LEAG)**, a group of scientists who advise NASA about science related to lunar exploration. The next full meeting of LEAG will take place Oct. 14-16 of this year in Laurel, Maryland, at the Applied Physics Laboratory (APL). Michael Wargo made a presentation where he explained that the NASA Lunar Science Institute (NLSI) is being replaced by the NASA Solar System Exploration Virtual Institute (SSERVI). Basically, the institute is being renamed and its mission is being expanded. Lunar science is not being excluded; rather, other topics are being added.

Thursday

In the morning at **Mineralogy of Martian Aqueous Environments [R402]**, Carter and co-authors **[#1755]** show evidence that surface weathering was widespread on early Mars. This implies early Mars was warmer and wetter than today. The deeper the spectral analysis, the more aluminum clays they see. These clays require weathering and water to form. They conclude ages for these materials are from 3.65 to 3.80 billion years, similar to ages of valley networks. In the related **Ice, Glaciers and Polar Processes on Mars [R451]**, Bibring and Forget **[#2161]** claims that Mars preserved a record, with stratigraphy, from before the late heavy bombardment times. *[The Late Heavy Bombardment (LHB) took place from 4.1 to 3.8 billion years ago, according to the Wikipedia article.]* They wondered how this was possible, and considered the possibility that studied areas may have been covered by ice. Clifford and co-authors **[#2881]** investigate the water inventory in the middle of Martian history. They show the presence of massive ground ice in the northern hemisphere.

In **Lunar Samples and Experiments [R404]**, Borg and co-authors **[#1563]** find a lot of ages around 4.35 billion years. This implies either (1) a widespread magmatic event 4.35 billion years ago, or (2) the primordial solidification of the Moon taking place at that time. Wilson and Head **[#1169]** report that most magmas erupted onto the lunar surface and had high volume rates, at least in their early stages.

In the **Impact Mechanics [R405]**, Schultz and Hermalyn **[#2589]** report from their experiments that only 1/3 to 1/2 of the mass displaced during an impact actually gets out of the crater. Crater depth and diameter grow differently with impactor size. For oblique impacts into strength controlled targets, results seem more controlled by projectile momentum than energy. In some cases, crater diameter continues to grow after depth growth stops. Targets with layers of different materials also affect things.

Friday

At **Lunar Volatiles [F505]**, Thomas-Keprta and co-authors **[#2103]** report carbon-rich material on Apollo black glasses that was clearly indigenous to the Moon. The carbon was in an amorphous phase which could have been kerogen-like material; its source it not yet known. *[Google provides this definition of kerogen: a complex fossilized organic material, found in oil shale and other sedimentary rock.]* Armand and co-authors **[#1957]** report that apatite is the main water-bearing or hydroxyl-bearing phase in mare basalts. *[Google provides this definition of hydroxyl: of or denoting the radical -OH, present in alcohols and many other organic compounds.]* The water in the lunar interior seems to show a common origin with water in Earth's interior.

Session **Lunar Imact and Cratering [F555]** began with a tribute by Everett Gibson to the late Dr. David McKay. Both Gibson and McKay trained the Apollo astronauts in geology. Dr. McKay had been a leader in lunar and planetary science ever since. There followed a paper by the Kickapoo Lunar Research Team and G. Y. Kramer **[#1426]**, students at Kickapoo High School, Springfield, Missouri. They looked at LRO Narrow Angle Camera (NAC) images of layered boulders around Aristarchus Crater, in Mare Undarum. They presented arguments that these layers came from layering within an

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intrusive igneous body, a "pluton." Kalynn and co-authors **[#1309]** confirmed that at a given diameter, highland craters are deeper than mare craters. Highland craters are deeper than previous results indicated. It is now easier to distinguish between fresh and modified craters. Central peak heights, on average, increase with crater diameter at least up to diameters of 100 kilometers, though there remains variability in this, influenced by impact parameters and/or target properties.

Spacecraft and Mission Proposals

Both Tuesday and Thursday evenings had poster sessions dedicated to future missions and instrumentation and some new missions were discussed in oral presentations as well. In the Thursday session, for example, on **Planetary Atmospheres [R453]**, J. N. Goswami of the Indian space agency describes plans for a Mars mission launch this year to examine atmospheric composition and to detect methane. Both science objectives and engineering approach were described in remarkably comprehensive detail **[#2760]**, given the limited briefing time.

Tuesday provided the majority of new missions or instrumentation poster presentations. **Planetary Mission Concepts [T638]** and **Instrument and Payload Concepts [T641]** provided 37 and 72 poster slots respectively. The four posters in **Current and Future Mars Landing Sites [T640]** group implied the need for a few more missions. Thursday, the mainstay was **Asteroid Analysis: Missions and Tools [R735]**, with eight more presentations. This last session split between ground-based analysis systems, a Hayabusa 2 mission and some small spacecraft comet exploration proposals. The designs and proposals ranged from discussions of capabilities for exploration, such as the NASA Space Launch System (SLS), overall orbiter and lander designs, and individual payload instruments or packages. In the final element, the instrumentation, we could say that our loop is closed, taking us back to the environments and surfaces we are exploring currently and how we intend to continue the process.

Horizons Reporters Among the Posters Tuesday and Thursday Nights

Tuesday Poster Session

Arkani-Hamed and Roberts examined how a giant impact on Mars could stifle core convection. It might not come back full strength for 900 million years and perhaps never. If core convection stops, the planet's magnetic field disappears with it. This could explain how Mars lost its early magnetic field. A poster by Dietrich and co-authors presented topographic evidence for multiple lake levels in Gale crater (the Curiosity landing site) **[#1844].** Lakes stood at different heights at different times.

J. Berk, a Space Studies U. of North Dakota, graduate presented "Space Station 2.0: A Transformational Architecture for Space Development" [#**1861**]. To place spacecraft around the Moon at an affordable price using NASAS's Commercial Orbital Transportation System (COTS), a multipurpose module is proposed to be delivered from Low Earth Orbit (LEO) via solar electric propulsion. Citing the NASA Air Force Cost Model (NAFCOM), lower cost and higher mission performance were projected.

P.E. Clark and co-authors of Lunar Cubes **[#1233]** explain how a constellation of CubeSats can be sent to the Moon for science missions via low-thrust trajectories, citing CubeSat success in reducing space missions costs. More information is available at http://www.lunarcubes.com/purpose-scope.

J. Straub, also working on CubeSats for the University of North Dakota (UND) as the Director of the Open Orbiter Small Satellite Development Initiative presents, "Open Orbiter: A Platform for Enabling Planetary Science" [#**1424**]. Open Orbiter is to be North Dakota's first student-designed satellite. Currently, CubeSats cost between $15,000 and $100,000, but Straub aims to reduce the costs to $5,000. Building from scratch, CubeSat hobbyists and engineers will only need three to six months to build them. Straub estimates that with the approximately 300 students and faculty members at UND working on this project, it will take the team eighteen months to two years to develop. Following an open source approach, all CAD files and design instructions with video will be online. A list of suppliers will be available with many options presented for those interested in constructing their CubeSat.

Thursday Poster Session

In side-by-side Thursday posters, Bland and co-authors **[#1655],** and Dombard and Schenk **[#1798]** in poster session **[R721],** presented argu-

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Cover Story

Above: An image from one of the LPSC poster sessions. Image credit: LPSC royalty-free images.

Cover Story

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ments that if Ceres is differentiated, with ice at the top and rocky materials below, it should retain few impact craters over geologic time, except at the poles, due to viscous relaxation. Lemmon and co-authors reported Curiosity's MastCam observing two transits of Phobos across the Sun and one transit of Deimos **[#1787, R715].** We were especially impressed by posters with high school student authors. At poster session **[R721, #1613]** E. E. Burgess and H. V. Frey discuss improving the crater retention age estimate for the Moon's South Pole-Aitken impact basin. Because Ms. Burgess is a high school student in Maryland, her schedule did not permit her to be at the LPSC in person. Her advisor, Dr. Frey, well known in the lunar science community, was present to discuss the poster.

E. B. Patmore and co-authors reported on, "Video Analysis of High Speed Asteroid Impact Simulations" **[#2982]**. The team tested shooting small aluminum bullets at pieces of rock at the NASA Ames Vertical Gun Range (AVGR) to simulate asteroid impacts. The bullets traveled at five kilometers per second and cameras recorded the effects of the impacts. They are not sure if the rocks match the asteroid type, but in the future they will use more asteroid-like rocks.

T. Hirabayashi of the University of Colorado at Boulder worked on "Constraints on the Size of Asteroid 216 Kleopatra Using Internal Stresses" **[#1592]**. A spinning asteroid such as Kleopatra can disintegrate if it spins too rapidly. Hirabayashi looked at central asteroid segments most prone to stress failure assuming a uniform density derived from constraints placed on asteroid physical properties. Minimum friction angles were derived from three different computations.

Similarly D. Cotto-Figueroa and co-authors at Ohio University researched "Radiation Recoil Effects on the Dynamical Evolution of Asteroids" **[#2945]**. Thermal re-emission from irregularly shaped bodies results in a torque that can change the rotation rate and the orientation of the spin axis. This force is known as the YORP effect. In a classic simulation scenario, an asteroid spins up to a certain point before it slows down and changes its spin again. The rotation rate of asteroids suggests that most asteroids are rubble piles. Since the YORP effect has a strong sensitivity to the shape of the asteroid, any deformation to the asteroid itself will cause a change in the YORP effect. The team revised the model by allowing the asteroid to change its shape due to the YORP effect; this in turn caused change in spin and more YORP effect, resulting in a significantly different spin rate than the classical rigid body simulation.

Geologists at Lund University, Sweden addressed the "Mass, Morphology and Internal Structure of Three Particles from the Hayabusa Sample Return Mission" **[#1937]**. They used synchrotron radiation X-ray tomographic microscopy (SRXTM) to precisely determine the masses of three grains.

J. B. Adler from UCLA examined the "Diurnal Yarkovsky Drift Rate for a Shape Model" **[#2527]** with asteroid Itokawa as a test case. A triangular mesh and a thermal model were used to extract the momentum vectors from each of the 49,152 triangular surface sectional areas of the modeled asteroid surface. Indirect photon momentum from thermal radiation forces ejected from one surface and absorbed by another was also examined. The decay rate of the semi-major axis was plotted for several starting locations of a test sphere and an Itokawa shaped model.

A. Venkataramanasastry from the University of North Dakota presented "A Space Debris-Enhanced Intervention Mission to a Near Earth Asteroid" **[#2449]**. The mission approach is a spacecraft rendezvous a with an existing space debris collection and transfer of the debris collector to the intervention spacecraft, which is then dispatched to strike the asteroid or orbit the asteroid as a gravity tractor.

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References

1. Marley, M. S., "Probing and Extrasolar Planet", *Science*, Volume 389, March 22, 2013, pages 1393-1394.
2. Konopacky, Q. M. and co-authors, "Detection of a CO and Water Lines in an Exoplanet Atmosphere", *Science*, Volume 389, pages 1398-1401.
3. Humayun, M., "A Unique Piece of Mars", *Science*, Volume 389, February 15, 2013, pages 771-772.

Links for LPSC program notes and abstracts for oral and poster presentations can be obtained as follows, for example, abstract **[#2449]**:

http://www.lpi.usra.edu/meetings/lpsc2013/pdf/2449.pdf

and a Thursday session **[R721]**:

http://www.lpi.usra.edu/meetings/lpsc2013/pdf/sess721.pdf

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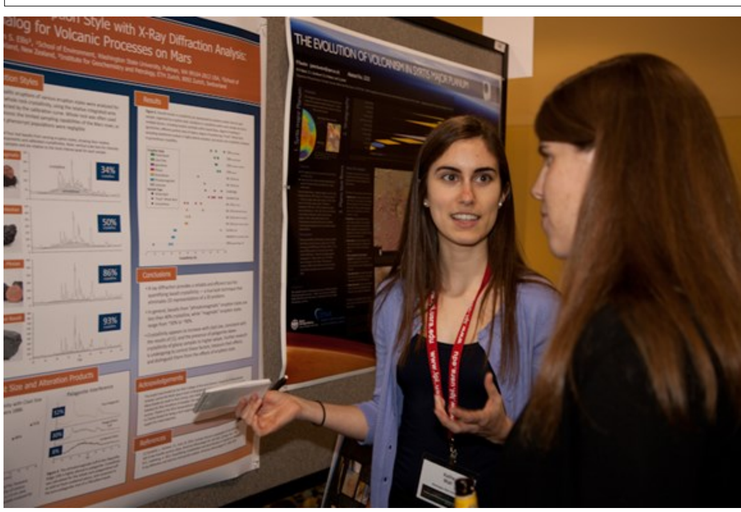
Glossary

- CAIs: small calcium and aluminum rich inclusions found in carbonaceous chondrite meteorites, among the first solids condensed from the cooling protoplanetary disk.
- Dark halo craters: possibly volcanic in origin, surrounded by ejecta blankets darker than the adjacent area.
- GEMS: glass with embedded metal and sulfides. These are tiny spheroids in cosmic dust particles that are the building blocks of anhydrous interplanetary dust particles (IDP).
- Grand Tack: Jupiter's path in the early solar system. According to theory, due to multi-body dynamics, it migrated toward the sun, stopped, and then migrated back outward. See an earlier **Horizons** discussion of Nice Model. That is in the November / December 2011 issue of Horizons starting on page 18.
- HEDs: Howardite, Euchrite and Diogenite meteorites associated with Vesta and similar asteroid parent bodies.
- Late Heavy Bombardment: An interval between approximately 4.1 and 3.8 billion years ago, when many planetary scientists believe that a pulse of substantially increased cratering from asteroids and/or comets took place in at least the inner (and possibly the entire) solar system.
- Late Veneer Hypothesis: water and iron-loving elements added to the Earth late in its formation by impact with icy comets and meteorites.
- Noachian: Martian geological epoch from planet formation to about 3.7 billion years ago.
- NWA: a collection of numbered meteorite finds from Northwest Africa, varied origins, ages and composition.
- Regolith: the upper layer of finely divided material - dust and small rocks - that covers the Moon.
- SNCs: meteorites traced to Mars of three geographic groups, shergottites, nakhalites and chassignites.
- Volatiles: in planetary and satellite environments, sometime solids that transform to fluids liquid or gas.
- YORP effect: Yarkovsky–O'Keefe–Radzievskii–Paddack effect, a second-order variation on the Yarkovsky effect which changes the rotation rate of a small body (such as an asteroid). The term was coined by David P. Rubincam in 2000. In the 19th century, Yarkovsky realized that the infrared radiation escaping from a body warmed by the Sun carries off momentum as well as heat. Translated into modern physics, each photon escaping carries away a momentum p = E/c where E is its energy and c is the speed of light. Radzievskii applied the idea to rotation based on changes in albedo and Paddack and O'Keefe realised that shape was a much more effective means of altering a body's spin rate. Paddack and Rhee suggested that the YORP effect may be the cause of rotational bursting and eventual elimination from the solar system of small asymmetric objects [Wikipedia].



Left: An Image from one of the LPSC poster sessions. Image credit: LPSC royalty-free images.

Cover Story

Above: An image from the exhibit opening. Image credit: LPSC royalty-free images.

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Cover Story

Above: Media images from the Golden Spike web site including Alan Stern and Gerry Griffin, former Director of NASA/JSC.

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Golden Spike

By Dr. Larry Jay Friesen

At noon on Monday, Alan Stern made a presentation about Golden Spike, a company he founded for the purpose of getting human missions to the Moon. Dr. Stern is a former head of the NASA Science Mission Directorate. His is now the principal scientist for the NASA New Frontiers mission, on its way to investigate Pluto and the Kuiper Belt. Stern is CEO and President of Golden Spike. Gerry Griffin, who is well known in the NASA / JSC community, is Chairman of the Board. The company includes employees with science, media and government expertise.

Stern believes he can get people back to the Moon for six to eight billion dollars for the first mission, with repeat trips costing about 1.5 billion dollars each, about the cost of a major NASA robotic planetary mission like Cassini. The company will use a commercial business model, relying on advance flight and media sales, and not relying on billionaires.

The reason for the low development cost is that they plan to use existing hardware wherever possible, including existing launch vehicles. That means much of the development cost has already been paid. Rather than develop a heavy-lift launch vehicle, they plan to use multiple launches of existing vehicles to get everything they need launched into orbit and launched to the Moon. They will require two or four launches, depending on what launch vehicle they select. They plan not to develop but to buy vehicles. Atlas and Falcon Heavy were two possible launch vehicles discussed.

They aim to put in place an affordable turnkey Earth-to-Moon transportation system to enable human lunar expeditions for science, commerce, etc. They envision two people being sent to the Moon per mission. They foresee a major market in what they call "mid-level" countries. These are countries which would like to take part in human spaceflight to the Moon. They have the scientific and technical abilities to take part, but they lack the budget to develop a lunar transportation system on their own. They have identified 25 to 30 candidate countries of this type. Corporations may be another market.

They are in the process of a crewed lunar lander system study. In this area, they probably will find it necessary to develop their own vehicle. They expect to be able to bring back a minimum of 50 kilograms of lunar samples per flight. They also plan to have lunar surface experiment packages to deploy at each landing site. They call them GoldSEPs, a reference to the Apollo Lunar Surface Experiments Packages (ALSEPs). They will offer a suite of scientific instruments from which customers can choose. If a customer wishes to supply an instrument of their own, that's fine, as long as it is compatible with the GoldSEP interface requirements.

This is a *sortie* mission mode. This is terrific for lunar science; not so great for those who want to put long term human settlements on the Moon. However (Larry Friesen's personal opinion here), I imagine that once this transportation system is up and running, would-be settlers can figure out ways to piggy-back off it.

Golden Spike is planning a workshop at the Houston Clear Lake area's Lunar and Planetary Institute (LPI), October 3-4, 2013. Information about that workshop can be found on the LPI web site.

Near-Earth Objects in Earth-Like Orbits

DANIEL R. ADAMO, ASTRODYNAMICS CONSULTANT

A useful situational awareness exercise is to occasionally survey all known near-Earth objects (NEOs) in orbits similar to Earth's as catalogued by the Jet Propulsion Laboratory's (JPL's) Small Bodies Database (SBDB). Orbits with osculating semi-major axis a near 1 AU, osculating eccentricity e near zero, and osculating ecliptic inclination i also near zero tend to be the most accessible for human space flight (HSF) over time intervals of years to decades. Such accessibility is at a premium if a small NEO (or part of a larger one) is to be successfully retrieved into the Earth-Moon system by a future robotic asteroid redirection mission. Highly accessible NEO orbits also tend to pose the greatest threat of Earth impact, particularly if the NEO is sufficiently large or monolithic.

Results from the present survey of Earthlike NEO orbits are plotted in Figure 1 as points in (a, e) coordinates, generally for $i < 5°$. Many of these points are annotated with NEO HSF Accessible Targets Study (NHATS, pronounced "gnats") rankings. The metric for these rankings is n, a tally of NHATS-compliant missions with launch dates in years 2015 through 2040. The NEO ranked #1 in Figure 1 is 2000 SG_{344} at (a, e) coordinates (0.978 AU, 0.067) with n = 3,302,718. Criteria for NHATS-compliant missions are as follows.

1) Total change-in-velocity $\Delta v_{TOT} \leq 12$ km/s. In NHATS software, Δv_{TOT} is

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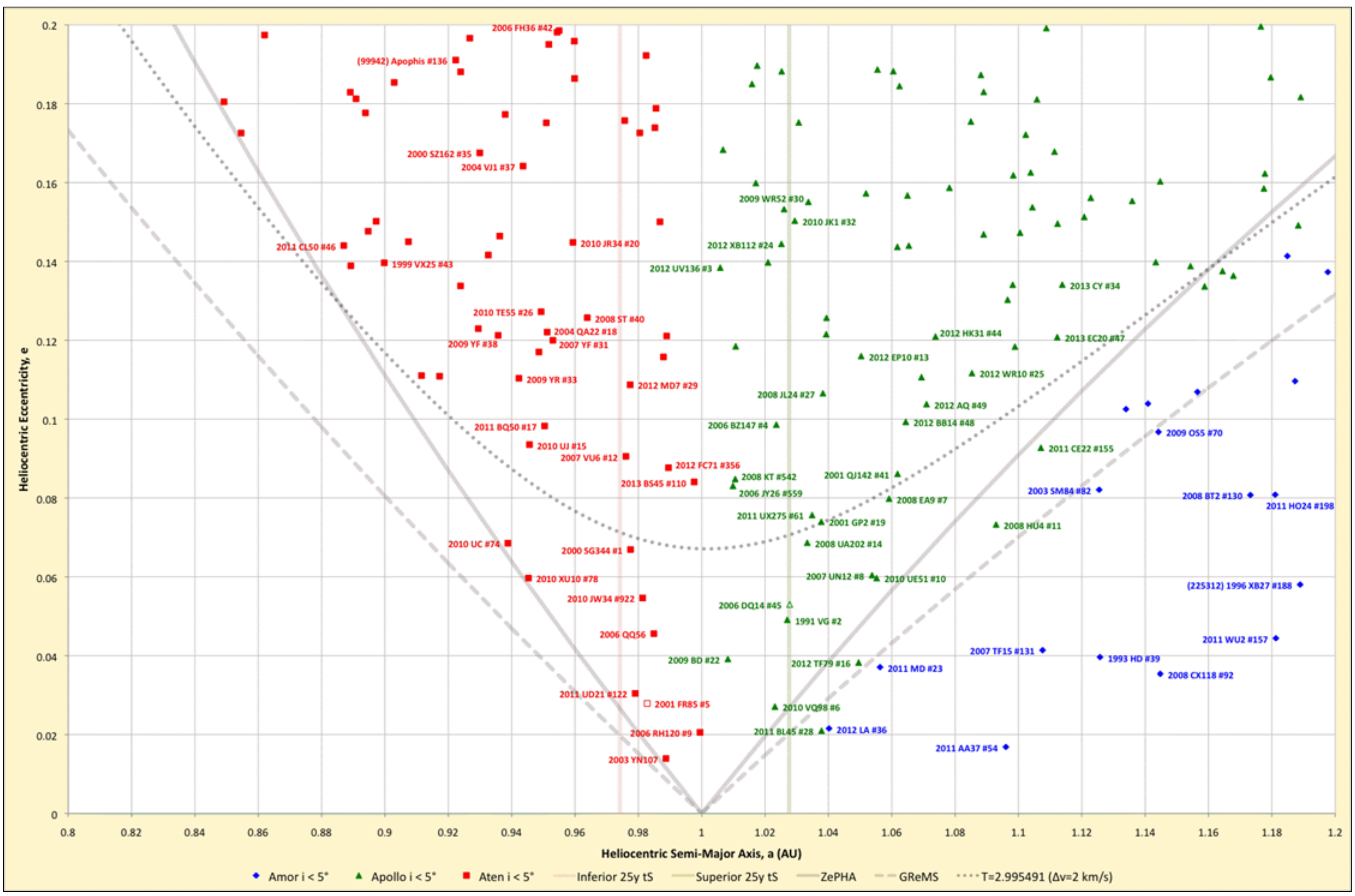

Figure 1. All NEOs catalogued in the SBDB with 0.8 AU < *a* < 1.2 AU, *e* < 0.2, and *i* < 5° are plotted according to their (*a*, *e*) coordinates. Those NEOs ranking in the top 50 according to the NHATS metric *n* are annotated with their SBDB designation, followed by their #*m* rank. Exceptions to these plotting and annotation rules are noted in the foregoing narrative along with the significance of loci plotted in gray. Supporting SBDB and NHATS data are time-sensitive and reflect downloads on 11 March 2013 UT.

Astrodynamics

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computed as the sum of impulses required to depart a circular Earth orbit at 400 km height targeting NEO intercept, achieve NEO rendezvous, perform NEO departure targeting Earth return, and ensure Earth's atmosphere is entered at a speed of 12.0 km/s if this value would otherwise be exceeded.

2) Roundtrip mission duration ≤ 450 d.

3) Post-rendezvous NEO loiter time ≥ 8 d.

Additional NHATS viability criteria optionally exclude any NEO whose absolute magnitude is too faint or whose orbit prediction uncertainty is too great. These optional criteria are not applied in computing NHATS rankings to annotate Figure 1.

Osculating orbit elements in the SBDB are dynamic on occasion due to NEO planetary encounters. These elements also change to reflect updates from new observations. Rankings under the NHATS *n* metric can change as these new observations are incorporated into the SBDB and as additional NEOs are discovered. Data and annotations in Figure 1 reflect downloads from the SBDB browser at this link and from the interactive NHATS table at this link performed on 11 March 2013 UT.

Each (a, e) marker plotted in Figure 1 has an appearance indicating the corresponding NEO's membership in one of four possible orbit groups. Blue diamond markers correspond to the Amor group, whose members have orbits completely exterior to Earth's. Green triangles indicate members of the Apollo group, whose orbits cross Earth's (in the sense perihelion is less than Earth's aphelion) and have periods exceeding Earth's. Red squares correspond to members of the Aten group, whose orbits cross Earth's (in the sense aphelion is greater than Earth's perihelion) and have periods less than Earth's. Atira group members have orbits completely interior to Earth's. No cataloged Atira has (a, e) coordinates within Figure 1 limits.

As noted in the Figure 1 legend, multiple loci are coplotted with NEO (a, e) points. Two vertical "25y tS" lines are plotted, one "inferior" (interior) to Earth's orbit at $a = 0.974$ AU, and one "superior" (exterior) to Earth's orbit at $a = 1.028$ AU. Together, these lines denote a rectangular region in Figure 1 within which a plotted NEO (a, e) point is associated with a synodic period exceeding 25 years. Thus, it is possible for a NEO in this region to be on the other side of the solar system from Earth during years 2015 through 2040 and not tally a single NHATS-compliant mission. Notable examples of this outcome are 2003 YN_{107}, at the most Earthlike (a, e) = (0.989 AU, 0.014) catalogued, and 2006 QQ_{56} at (a, e) = (0.985 AU, 0.046). These are the only NEO annotations in Figure 1 not accompanied by #*m* suffixes indicating their NHATS *n* rankings.

The "ZePHA" locus referenced in Figure 1's legend is a mnemonic for <u>Ze</u>ro <u>P</u>erigee <u>H</u>eliocentric <u>A</u>psis. The shape of this locus gives Figure 1 its informal "V-plot" moniker, and it contains (a, e) points capable of very close Earth encounters near perihelion (for NEO members of the Apollo orbit group) or near aphelion (for NEO members of the Aten orbit group). Such close approaches possess low heliocentric radial velocity enhancing NHATS-compliant mission opportunities and *n*. The ZePHA locus also sets a minimum *e* limit on any orbit capable of crossing Earth's (in the sense perihelion is less than 1 AU and aphelion is greater than 1 AU) at an arbitrary *a*. Thus, trajectories between Earth and a NEO can be made short in distance and time only when that NEO is positioned near or above the ZePHA locus in a V-plot.

At a given *e* coordinate, note Figure 1 plots no NEO inferior to the inferior ZePHA branch (locus points with $a < 1$ AU). This dearth of NEOs at the left of Figure 1 is almost certainly a consequence of always observing these relatively small and faint objects from locations close to Earth's surface, where members of the Aten and Atira orbit groups never stray far from the Sun's glare.

A second V-shaped locus appearing in Figure 1 is dubbed "GReMS", a mnemonic for <u>G</u>eocentric <u>Re</u>lative <u>M</u>otion <u>S</u>tall conditions. Any (a, e) point on this locus corresponds to an orbit whose speed with respect to Earth would fall to nearly zero around perihelion (for NEO members of the Apollo orbit group) or around aphelion (for NEO members of the

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Aten orbit group). If a GReMS condition were to develop at a location near the Sun-Earth line, favorable mission opportunities and enhanced n could be expected for the associated NEO in that timeframe.

Although the ZePHA locus sets a minimum e limit on accessible orbits closely approaching Earth, it fails to constrain geocentric speed at approach. But achieving a NEO rendezvous within spacecraft performance limits is critically dependent on sufficiently constrained geocentric position *and* velocity. Selecting an appropriate value of Tisserand's parameter T to map onto the V-plot while assuming $i = 0$ imposes a maximum e accessibility constraint with a U-shaped locus. Furthermore, the value of T to be plotted can be selected based on a maximum acceptable geocentric speed at Earth intercept Δv equivalent to asymptotic Earth departure or arrival speed v_∞ (also equivalent to the square root of asymptotic energy). In Figure 1, the $T = 2.995491$ value plotted is equivalent to $\Delta v = 2$ km/s, as noted in the legend. On a V-plot, the ZePHA and T loci together bound a roughly triangular region of high accessibility. Orbits whose (a, e) coordinates lie within this region offer close Earth approaches with acceptably low speeds for NEO missions at times whose programmatic desirability can be further assessed.

Within Figure 1 (a, e) limits, the general intent is to annotate every NEO whose n ranking is #50 or less. Notes and exceptions relating to this intent are as follows.

1) Two members of the Aten orbit group meet the n ranking ≤ #50 criterion, but their e coordinates exceed the V-plot maximum of 0.2 and therefore do not appear in Figure 1. These exceptions are 2009 HE_{60} at (a, e) = (0.996 AU, 0.266) with n ranking #21 and 2011 CF_{66} at (a, e) = (0.997 AU, 0.270) with n ranking #50.

2) Two NEOs meet the n ranking ≤ #50 criterion and fall within Figure 1 axis limits, but they exceed the $i < 5°$ V-plot criterion by a small amount. These exceptions are 2001 FR_{85} at (a, e, i) = (0.983 AU, 0.028, 5.245°) with n ranking #5 and 2006 DQ_{14} at (a, e, i) = (1.028 AU, 0.053, 6.296°) with n ranking #45. Both of these NEOs are plotted in Figure 1 with unfilled markers.

3) Every NEO with $e < 0.1$ is annotated, even if its n ranking exceeds 50.

4) Due to perennial interest in its Earth collision possibilities, (99942) Apophis is annotated at (a, e) = (0.922 AU, 0.191) with n ranking #136.

On inspection, Figure 1's V-plot conveys a good deal of situational awareness regarding NEOs in Earthlike orbits and their relative accessibility under NHATS criteria. First, it appears orbits completely interior to Earth's (those of NEOs in the Atira group) within Figure 1 plotting limits cannot be found. This is likely due to these orbits' apparent proximity to the Sun when observed from Earth or its vicinity. Second, NEOs in more Earthlike orbits are generally more accessible under NHATS criteria, but there are exceptions. Most notably, a NEO whose synodic period exceeds 25 years may fail to achieve any degree of NHATS compliancy because it is too distant from Earth during years 2015 through 2040. Thus, the most Earthlike NEO orbit known, that of 2003 YN_{107}, has zero NHATS compliancy. Third, the ZePHA and T loci on a V-plot enclose a region of high accessibility defining NEO destination orbits for missions requiring acceptably low propulsion and duration. The "upper" boundary of this region can be selected based on the maximum acceptable speed at which a mission's NEO destination may approach Earth's vicinity.

At heliocentric (a, e) coordinates (0.998 AU, 0.084) on the V-plot of the first page of this article is the newly discovered NEO 2013 BS_{45}. The following article describes its unusual orbit.

Astrodynamics

The “Horseshoe” Orbit of Near-Earth Object 2013 BS_{45}

Daniel R. Adamo, Astrodynamics Consultant

Figure 1. The 1.8 m Spacewatch telescope is pictured inside its protective dome at Kitt Peak, Arizona (photograph by Robert S. McMillan).

1. Earth-Based Discovery

Discovered by the Spacewatch 1.8 m telescope (see Figure 1) on 20 January 2013, near-Earth object (NEO) 2013 BS_{45} closely encountered Earth at a range of 0.0126 AU (4.9 lunar distances or 1.88 million km) on 12 February 2013.

As is typical among NEO discoveries made in the night sky prior to closest Earth approach with observations of our planet’s night sky, 2013 BS_{45} crosses Earth’s orbit inbound towards the Sun. It reaches perihelion on 29 April 2013 at 0.92 AU or 92% of Earth’s mean distance from the Sun. Figure 2 is a plot of 2013 BS_{45}, Earth, and Mars as they orbit the Sun during 2013.

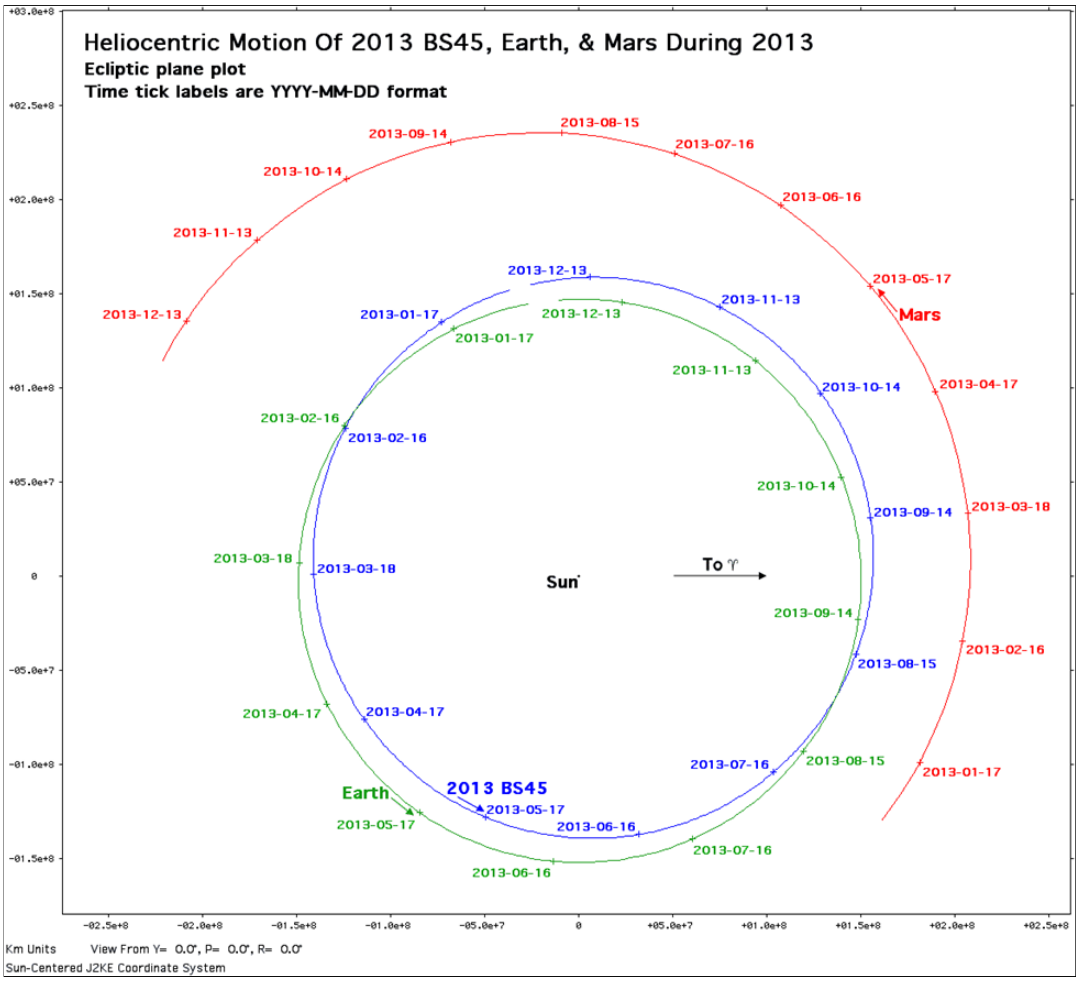

Figure 2. Orbits of 2013 BS_{45} (blue), Earth (green), and Mars (red) are plotted during year 2013 in a non-rotating (inertial) Sun-centered (heliocentric) coordinate system. The plot plane coincides with that of Earth’s orbit, the ecliptic, and 2013 BS_{45}’s orbit is inclined to the ecliptic by less than 1°.

Before moving into Earth’s daytime sky circa 9 February 2013, about 80 optical observations were being processed by the Jet Propulsion Laboratory (JPL) to produce 2013 BS_{45} ephemerides with maximum position uncertainties equivalent to hundreds of minutes in heliocentric motion a century in the past or future. During mid-February, planetary radar observations conducted at Goldstone, CA had reduced this uncertainty to the order of 10 minutes.

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2. Accessibility for Human Spaceflight

Since the orbits of Earth and 2013 BS_{45} are so similar, this NEO should be highly accessible for human spaceflight (HSF) whenever it closely approaches Earth. Close approaches are a necessary condition for HSF accessibility because of the trade between speed and distance in this context. Unless distance between Earth and NEO is small, spacecraft speed must be increased to impractical levels in order to complete a roundtrip within the time limits of human exposure to confinement, galactic cosmic radiation, and microgravity. This trade, along with many others, is made by NEO HSF Accessible Targets Study (NHATS, pronounced "gnats") software. The Goddard Space Flight Center, in cooperation with JPL, generates and posts NHATS data to http://neo.jpl.nasa.gov/nhats/ on a daily basis.

Three-dimensional pork chop charts (PCCs) succinctly summarize mission viability under NHATS criteria. In a PCC plotted by NHATS software, the horizontal axis is Earth departure date, and the vertical axis is roundtrip flight time in days. Each pixel in a PCC's domain is colored according to total mission change-in-velocity Δv_{TOT} in km/s[1]. White pixels violate one or more NHATS mission viability criteria. Excessive Δv_{TOT} or mission duration will generally result from attempting to cover an excessive roundtrip distance. The PCC for 2013 BS_{45} appears in Figure 3.

[1] In NHATS software, Δv_{TOT} is computed as the sum of impulses required to depart a circular Earth orbit at 400 km height targeting NEO intercept, achieve NEO rendezvous, perform NEO departure targeting Earth return, and ensure Earth's atmosphere is entered at a speed of 12.0 km/s if this value would otherwise be exceeded.

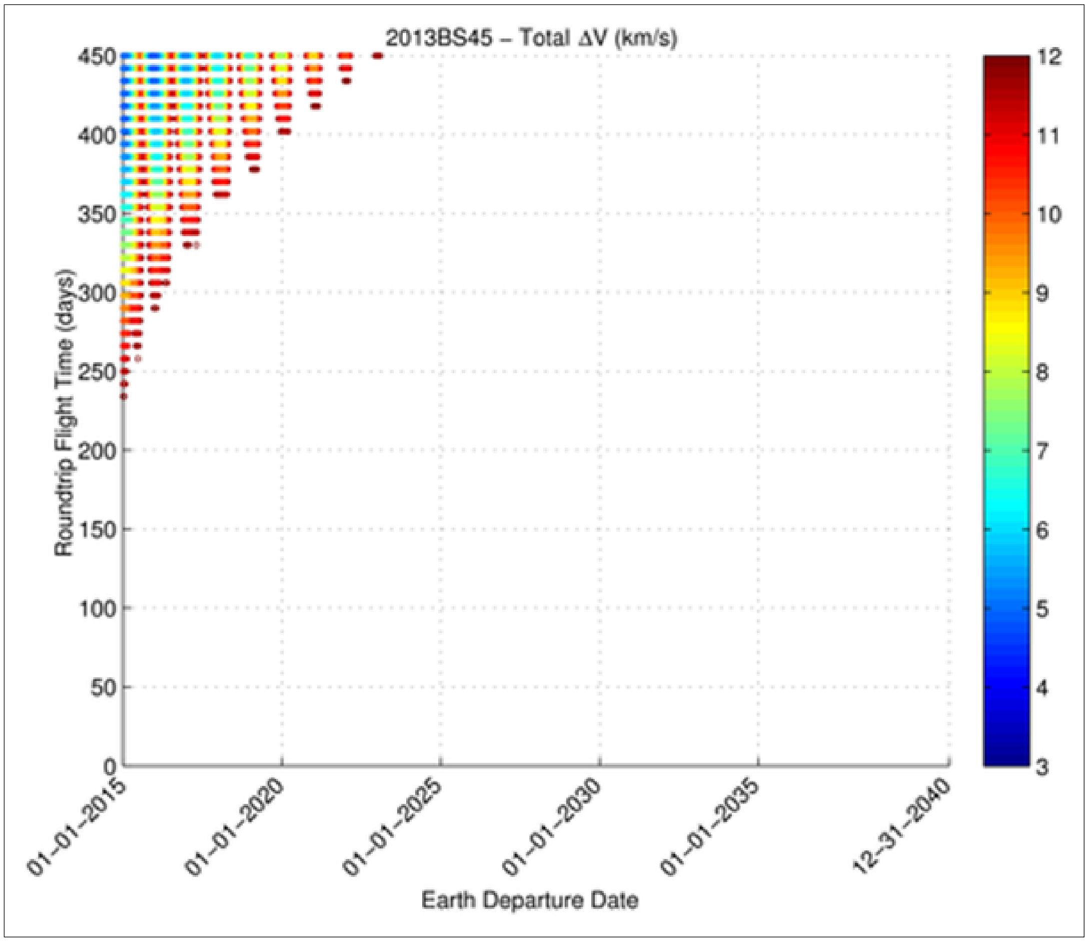

Figure 3. The 2013 BS_{45} PCC posted 20 February 2013 at the NHATS website shows viable mission opportunities on the wane at the earliest NHATS-compliant Earth departure dates during year 2015. In accord with the Δv_{TOT} color legend at right, a NEO with ideal HSF

If NHATS mission viability criteria included Earth departure dates circa year 2013, a PCC for 2013 BS_{45} would be filled with deep blue pixels at relatively short roundtrip flight times for those dates. Unfortunately, about half of these nearly ideal HSF mission opportunities would have been history by the time 2013 BS_{45} was discovered. As matters stand in early 2013, only about 3 or 4 years would remain to plan, assemble, and depart Earth before a HSF mission to 2013 BS_{45} became impractical due to excessive duration and/or excessive Δv_{TOT}.

3. Horseshoe Motion With Respect To The Sun-Earth Line

How long will it be before 2013 BS_{45} again makes close approaches to Earth and NHATS-viable mission opportunities resume? Although

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this NEO's orbit requires some refinement before long-duration predictions can be made with high confidence, the answer appears to be "about 80 years". This interval between successive clusters of close Earth approaches is equivalent to a NEO's *synodic period*. Figure 4 plots motion of 2013 BS_{45} in the ecliptic plane with respect to a rotating Sun-centered coordinate system in which the Sun-Earth line is fixed. This plot accounts for all manner of perturbations to 2013 BS_{45}'s heliocentric motion, chief among these being Earth's gravity. Figure 4 motion spans one synodic period, extending from year 1932, when 2013 BS_{45} last began a series of close Earth approaches, through year 2015, when the current series of close Earth approaches ends.

Kepler's third law is often used to compute the heliocentric angular rate ω of a NEO's orbit using the following formula, in which a is the NEO orbit's heliocentric semi-major axis and μ is the Sun's reduced mass.

$$\omega = \sqrt{\frac{\mu}{a^3}}$$

With Earth's heliocentric angular rate ω_E well determined, the NEO's synodic period T_S is the time required for the difference in angular rate between NEO and Earth to ac-

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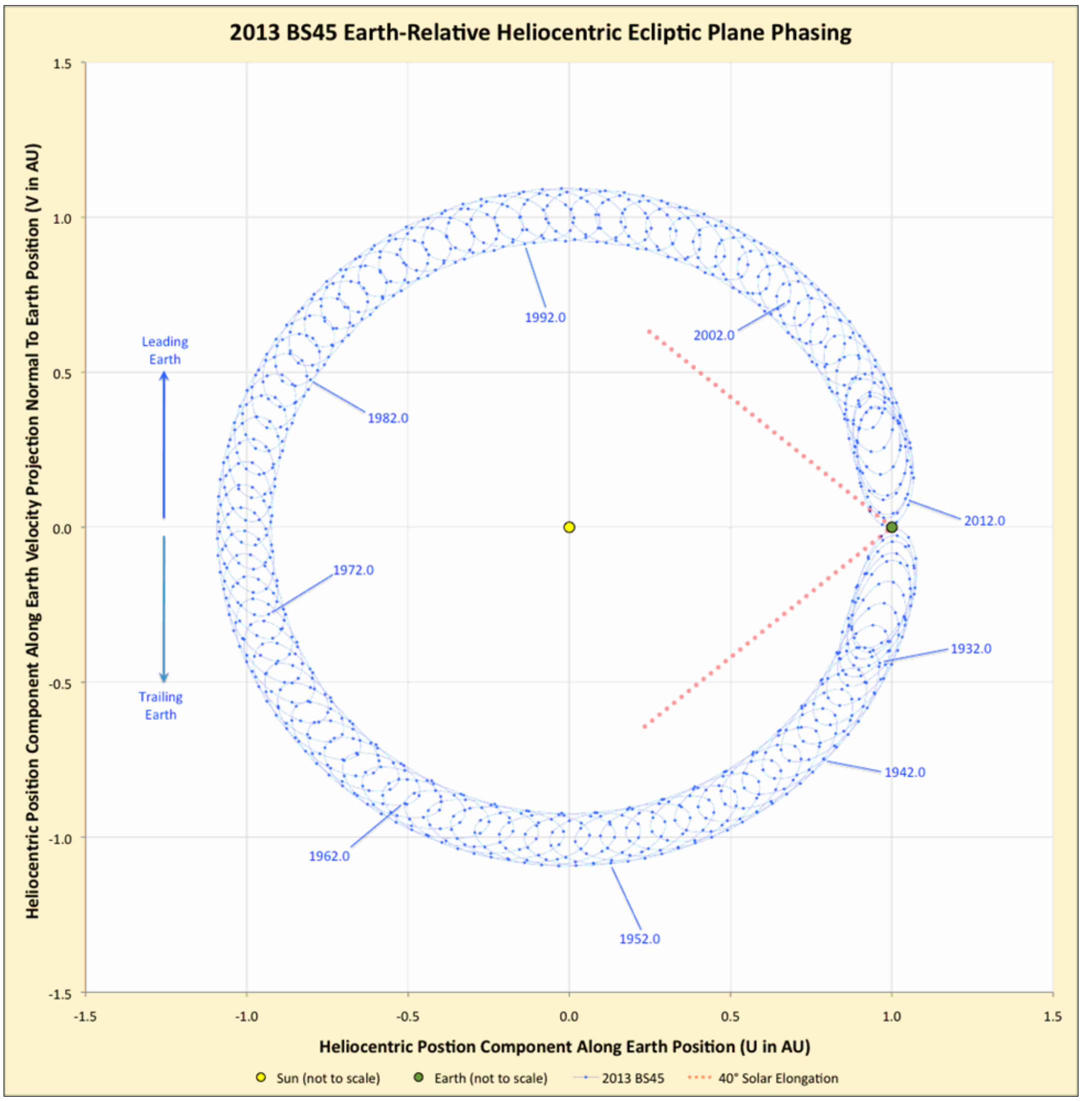

Figure 4. Heliocentric motion of 2013 BS_{45}, beginning with close Earth approaches in year 1932 and ending with other close approaches in year 2015, is plotted in the ecliptic plane with respect to a fixed Sun-Earth line.

[2] In this context, "Earth's vicinity" refers to observations made at Earth's surface and at contemplated space-based locations ranging out to Sun-Earth libration points about 1.5 million km from Earth along the Sun-Earth line. These libration points are commonly referred to as SEL1 (lying between Earth and the Sun) and SEL2 (lying beyond Earth from the Sun).

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cumulate a full revolution. Therefore, $T_S = 2\pi / (\omega - \omega_E)$.

All NEO orbits crossing that of Earth are grouped into two families. Those Earth-crossers with $\omega < \omega_E$ are assigned to the Apollo family, and those with $\omega > \omega_E$ are assigned to the Aten family. A sign convention is embedded in the T_S formula whereby Aten family orbits produce a positive value, and Apollo family orbits produce a negative value. Table 1 presents examples of T_S computations for 2013 BS$_{45}$ during early 2013 as it undergoes an Apollo-to-Aten transition.

Table 1. When Kepler's third law is used to compute tabulated 2013 BS$_{45}$ synodic period T_S values in early 2013, wildly varying results are obtained as the NEO's heliocentric angular rate transitions from less than Earth's to greater than Earth's. If Earth gravity perturbations are included when modeling 2013 BS$_{45}$'s orbit, a T_S value near 80 years is inferred.

2013 UT	T_S (years)
05.0 Jan	-201.283
15.0 Jan	-209.741
25.0 Jan	-226.579
04.0 Feb	-283.056
14.0 Feb	-3873.767
24.0 Feb	+477.737
06.0 Mar	+355.733
16.0 Mar	+316.713
26.0 Mar	+297.532
05.0 Apr	+286.492

From Table 1's example, it is evident T_S computations ignoring Earth gravity perturbations on a heliocentric NEO orbit cannot produce consistent or meaningful results at times when those perturbations are significant. In such instances, a thorough analysis of the perturbed orbit must be conducted from one set of close Earth approaches through the next set to infer the actual T_S.

As annotated in Figure 4, the plot's vertical "V" coordinate signifies whether 2013 BS$_{45}$ leads (positive V) or trails (negative V) Earth as they orbit the Sun. Position of 2013 BS$_{45}$ in Figure 4 is annotated for the new year at 10-year intervals, beginning with the initial point at "1932.0". Proceeding chronologically from this initial point, 2013 BS$_{45}$ trails Earth until the mid -1970s when it lies across the solar system from our planet and is highly inaccessible for HSF. Thereafter, 2013 BS$_{45}$ grows progressively closer to Earth from positions leading it in orbit about the Sun.

The dotted red "v" whose apex coincides with Earth in Figure 4 denotes a *solar exclusion zone* (SEZ) in which a NEO cannot be observed from Earth's vicinity because its apparent solar elongation is less than 40°[2]. Although this zone has infinite extent along Figure 4's -U axis, its boundary is only drawn out to a geocentric range of 1 AU in Figure 4 because NEOs are typically so small and intrinsically faint they cannot be detected very far from Earth. Indeed, 2013 BS$_{45}$ was discovered only after it had closed within 0.044 AU or 6.6 million km from Earth. From its apparent brightness and known distance from Earth, NHATS software estimates 2013 BS$_{45}$ is 12 to 53 m in diameter assuming a reflectivity range spanning most NEOs of known size. The SEZ rules out observing an appreciable percentage of close Earth approach points in Figure 4. A small NEO with shorter T_S than 2013 BS$_{45}$'s might have flown past Earth too quickly and evaded discovery during the brief interval it was close enough to observe.

A close examination of yearly "loops" made by 2013 BS$_{45}$ in Figure 4 shows they tend to bunch-up when nearest to Earth. This is the graphic manifestation of variations in ω previously noted and arises from Earth gravity perturbations to 2013 BS$_{45}$'s heliocentric orbit. Circa year 1932, when 2013 BS$_{45}$ closely trails Earth, these perturbations decrease ω from slightly more than ω_E to slightly less than ω_E. In terms of NEO orbit families, 2013 BS$_{45}$ transitions from an Aten to an Apollo and is never able to overtake Earth. During year 2013, similar Earth perturbations are at work to increase 2013 BS$_{45}$'s ω just before Earth would otherwise overtake it. In this scenario, 2013 BS$_{45}$ is transformed from an Apollo back to an Aten. Because of the gap surrounding Earth in Figure 4, 2013 BS$_{45}$

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is said to be in a "horseshoe" orbit. Figure 5 illustrates 2013 BS_{45}'s Apollo-to-Aten transition in detail from year 2011 into year 2016.

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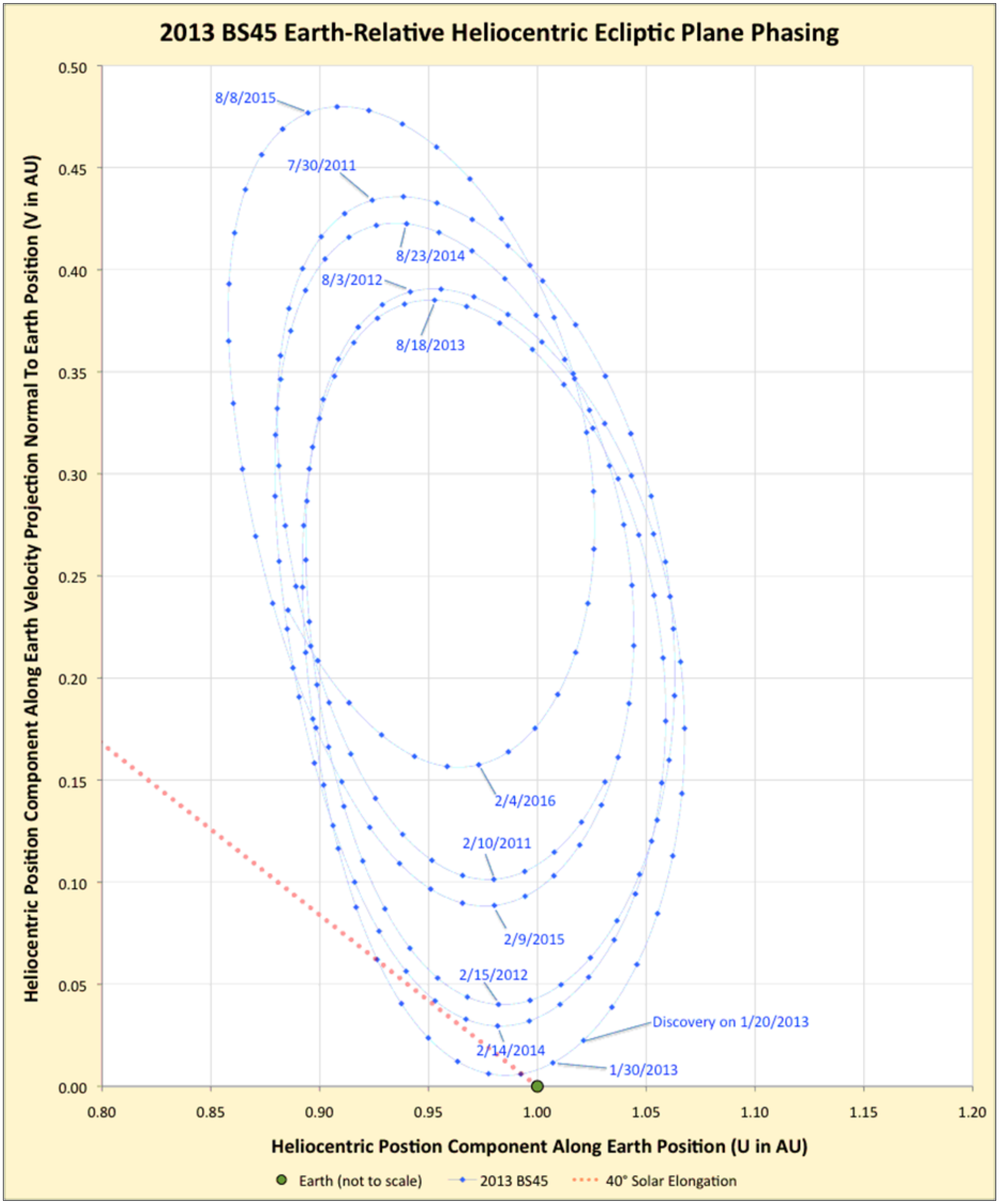

Figure 5. The "horseshoe" orbit turnaround is plotted with respect to the Sun-Earth line as 2013 BS_{45} transitions from the Apollo to the Aten orbit family during years 2011 to 2016. This is a highly magnified segment of Figure 4's domain.

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Trajectory markers in the Figure 5 plot are placed at 10-day intervals. Along the trajectory arc passing closest to Earth at the bottom of this plot, note only 20 days following 2013 BS_{45} discovery are available in which to observe this NEO from Earth before it drifts into the SEZ. By the time 2013 BS_{45} departs the SEZ in early April 2013, 70 days after discovery, it is likely too far from Earth to detect. It will hopefully be recovered during its next close approach during early 2014, when uncertainties in its orbit could then be appreciably reduced.

It is also useful to consult Figure 5 with HSF accessibility in mind. A necessary condition among all NEO round-trip mission designs boasting relatively short duration and low Δv_{TOT} is Earth-NEO distance less than 0.1 AU at some point during the mission timeline. This criterion applied to Figure 5 corroborates the best mission opportunities are ending in 2015 just as the Figure 3 PCC's time domain opens under NHATS criteria.

4. Discovering NEOs Well In Advance Of Their Close Earth Approaches

The NEOCam concept presented by JPL/Dr. Amy Mainzer in 2009 (ref. link) proposes a NEO survey conducted from SEL1 at solar elongations from 40° to 125°. Assume this instrument is capable of detecting objects as faint as apparent visual magnitude m = +24. With this assumed sensitivity and deployment sufficiently far in the past, NEOCam would have discovered 2013 BS_{45} as early as January 2011 at a solar elongation near 106° and geocentric distance near 0.14 AU. It should be noted that NEOCam is designed to observe infrared emissions quite distinct from reflected visible light simulations leading to this January 2011 estimate. Nevertheless, a 2013 BS_{45} discovery two years before the actual event could have allowed sufficient time to mount a viable HSF mission. A "launch on need" capability, placing the mission in a high state of readiness before its destination is known, might be necessary to visit serendipitously discovered NEOs offering mission opportunities whose Earth departure dates are imminent.

As a means to observe NEOs in the SEZ and all around Earth's orbit during reasonable time intervals, consider a NEO survey telescope operating in interplanetary space with perihelion at 0.700 AU (near the distance of Venus from the Sun) and aphelion at 0.882 AU (near 2013 BS_{45}'s perihelion distance). Such an instrument would have a T_S of only 2.37 years. Because it remains well inside Earth's orbit, nearby NEOs observed by the telescope in proximity to Earth's orbit always have solar elongations greater than 90°. As such, each observation tends to be of a well-illuminated NEO surface near its maximum possible brightness from a given distance.

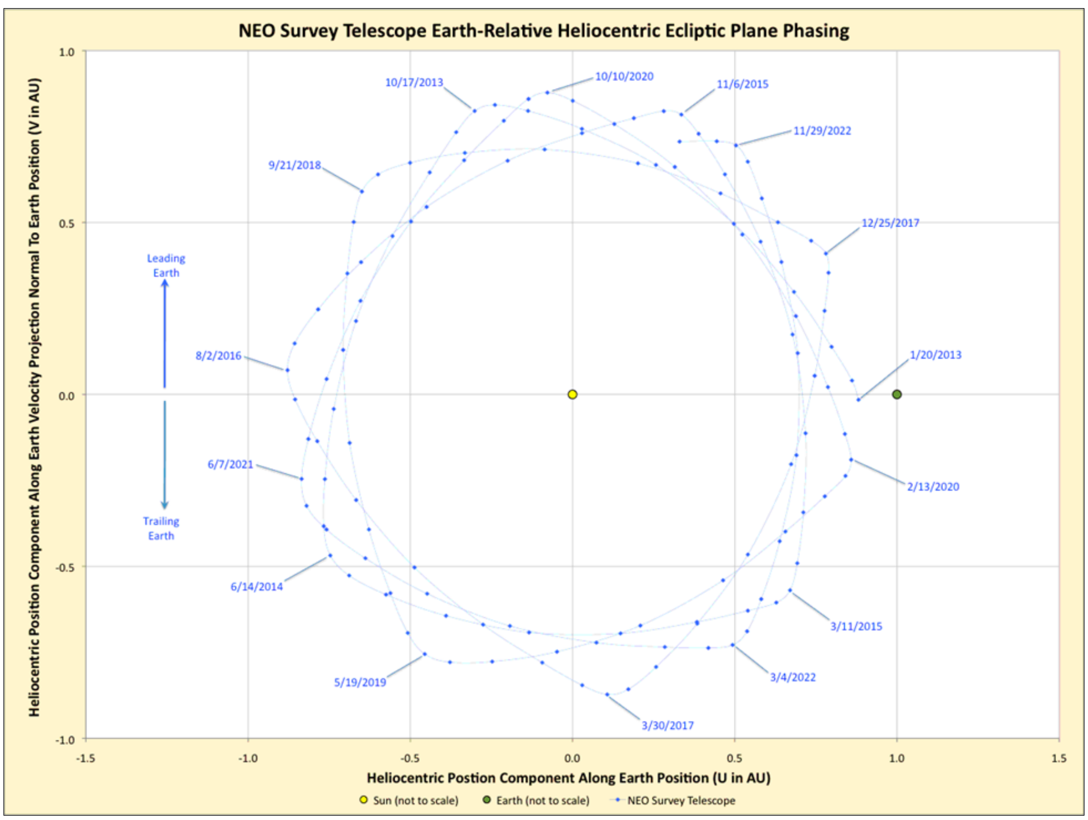

Figure 6. Motion of a notional NEO survey telescope operating between the orbits of Venus and Earth is plotted with respect to a fixed Sun-Earth line in the ecliptic plane. The 10-year interval of this plot spans 4.2 synodic periods for the telescope, ensuring all sectors of interplanetary space near Earth's orbit are observed on multiple occasions.

Figure 6 plots motion of this hypothetical telescope for 10 years using a coordinate system identical to that of Figure 4. This plot begins with the telescope arbitrarily at aphelion near the +U axis on the date 2013 BS_{45} was discovered. It then extends 10 years into the future. A point near each telescope aphelion is annotated with the corresponding date in Figure 6 as 4.2 synodic periods convolve around Earth's orbit. A telescope in this orbit with m = +24 sensitivity could detect a NEO like 2013 BS_{45} years or decades before viable HSF mission opportunities would arise.

5. Summary

The orbit of 2013 BS_{45} serves as a specific example supporting four important precepts associated with NEOs of high HSF accessibility. First, the most accessible NEO orbits tend to be the most Earthlike.

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Such orbits have protracted HSF launch opportunities several years in duration, but these accessibility seasons may be separated by intervals from decades to a century.

Second, close NEO approaches to Earth associated with HSF mission opportunities are also the only occasions permitting Earthbound observers to detect small ones ~100 m in diameter or less. This leaves little time to prepare and dispatch a HSF mission during an accessibility season.

Third, by conducting a NEO survey from the SEL1 libration point or from interplanetary space between the orbits of Venus and Earth, a potential HSF destination such as 2013 BS_{45} can be observed years or decades in advance of a close Earth approach. These observations will likely leave adequate time to prepare for and utilize the most practical HSF mission opportunities.

Fourth, some Earthlike NEO orbits display a horseshoe character in which close approaches leading and trailing Earth are achieved with regularity, but the Sun-Earth line is never crossed. Earth gravity perturbations during these close approaches impart turnarounds in the heliocentric rate at which the NEO is chasing Earth or vice-versa. Because NEOs in horseshoe orbits possess extremely long synodic periods and have only been observed for the past decade or two, little is certain about the long-term dynamical stability of such orbits.

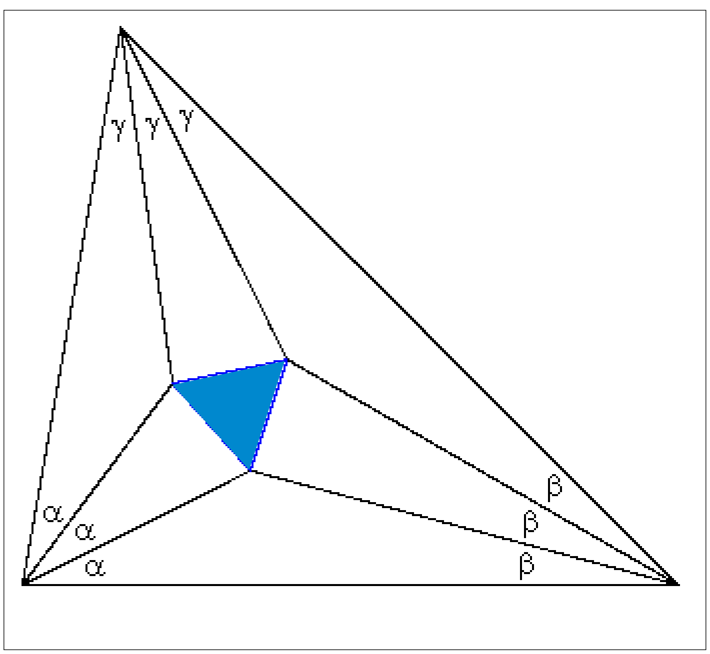
Acknowledgments

The author gratefully acknowledges editorial and technical input from NASA-HQ/Lindley Johnson, NASA-HQ/Rob Landis, NASA-GSFC/Brent Barbee, and JPL/Jon Giorgini. All orbit-related data appearing in this paper, including the simulated 2013 BS_{45} discovery date from observations at SEL1, are traceable to JPL's *Horizons* online solar system data and ephemeris computation service accessible at this link.

Cranium Cruncher

Prove this Triangle is Equilateral

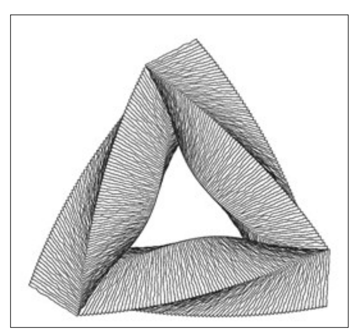
DOUGLAS YAZELL, EDITOR, FILLING IN FOR DR. STEVEN E. EVERETT



Above: A web site called MathPages by Kevin Brown (author) includes Morley's trisection theorem. Image credit: Kevin Brown.

My great friend Jean-Marie Lemaitre showed me this brain teaser about two years ago. He showed me a quick sketch like the figure at left. On May 29, 2013, I was able to find the question and answer thanks to a Google search which found an unusual web site. The web site, MathPages, seems to be the creation of author Kevin Brown. The question and answer appear here on his web site, along with excellent history notes. By the way, Jean-Marie teaches mathematics in Hong Kong at the moment. He is no relation to Georges Lemaitre. The fifth Automated Transfer Vehicle (ATV) from the European Space Agency is named after Georges Lemaitre. Based in part on that excellent ATV program success, NASA's first Orion crew capsule spacecraft will have an ESA Service Module.

MathPages includes animated GIFs. My iPad 1 news aggregator application Flipboard showed me a web site with excellent animated GIFs created by PATAKK. Below is a screen capture image of one of those animated GIFs.



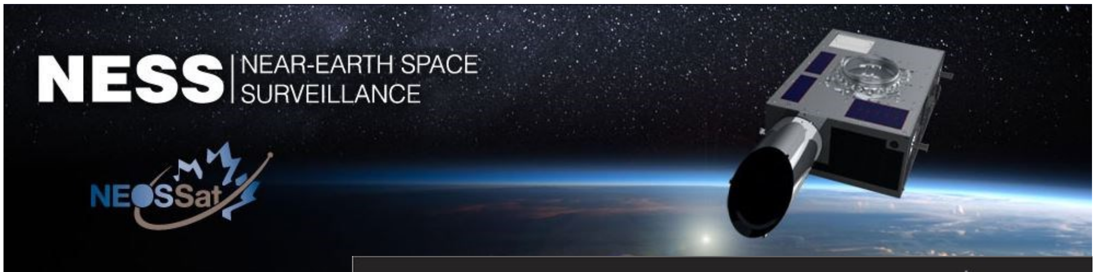
A 3AF MP Editorial, 1st Published:La Gazette #26

PHILIPPE MAIRET, 3AF MP, OUR FRENCH SISTER SECTION

Let's wish Gerard Depardieu, our talented French actor, good luck with the Russians. After all, his change of citizenship from French to Russian (mostly a search for a reasonable tax rate) does not concern us! Being French, members of an old Gallic culture, we wish him no harm, no sky falling on his head. Speaking of falling skies in Russia, an unforeseen meteor exploded over Chelyabinsk in the southern Urals recently, injuring more than 1,000 people, some seriously.

One can sympathize with the Russians after this 2013 meteorite disaster, since it is the biggest such example since the Tunguska event of 1908, also in Russia. While on the subject of Near-Earth Object (NEO)-Earth impacts, it is worth noting a new discovery described by scientist Andrew Glikson and others (Telegraph, February 2013). He describes an impact zone (shocked terrain) in southern Australia that is about the third biggest in the world. This probable asteroid impact zone is more than three hundred million years old. Contrary to the Chelyabinsk event, the effects of this Australian event were global.

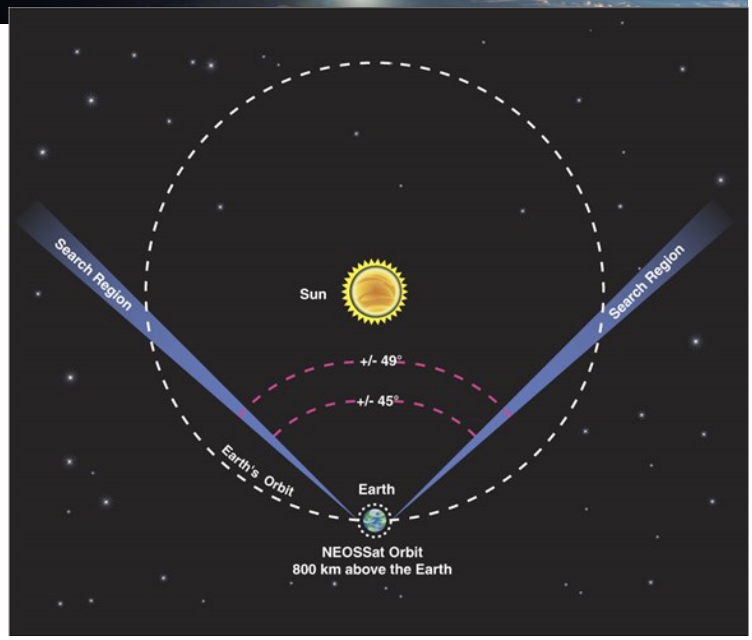
The European Space Agency (ESA) is planning research into ways to better detect such dangers and provide timely warnings. Overseas, others are also planning this kind of research. A new Canadian program is a NEO-hunting satellite. It was placed into orbit with other satellites by an Indian rocket. Some nations have studied deflection and destruction of such NEO-Earth impact threats.



The first test flight of the NASA Orion crew capsule is now planned for 2017 with no crew onboard. The planned launch rocket is the NASA Space Launch System (SLS). This first Orion spacecraft will include an ESA Service Module, a big step in international partnering. Subsequent Orion flights will be crewed. Stay tuned to see how long this ESA-NASA partnership lasts: the longer, the better. Norman Augustine once said (at Rice University in Houston, where the 2011 video remains online) that international partnerships can be very difficult to manage, but can also bring huge benefits. One of those benefits is cost sharing, no doubt. Another benefit might be increased difficulty in cancellation of a project.

The year 2013 is the 100th anniversary of the Marcel Leyat propeller car, the Hélica. This is now a popular subject for car collectors and those who work in aeronautics. It even appears in the current issue of the magazine Le Point.

Leyat's Hélica was a perfect combination of airplane and car. Jean-Luc Chanel is the 3AF MP Chair of our technical committee, "Light Aviation and Derived Machines." He participated in a Leyat-dedicated booth mounted by the association "Friends of the Hélica" at the 2013 Rétromobile event in Paris. He highlighted the features of many early 20th-century cars. From the Chernobyl cloud to the Chelyabinsk meteor, things do not respect international borders. The laws of aerodynamics apply to both airplanes and automobiles. Chanel plans a follow-on to Leyat's work. Chanel is organizing a conference devoted to his Project Leyel, exactly 100 years after Leyat unveiled his 1913 Hélicocycle.



Above: The Near-Earth Space Surveillance (NESS) project uses the Near-Earth Object Surveillance Satellite's (NEOSSat's) space telescope to discover asteroids of the inner solar system. NESS is contributing to the international science community's efforts to find and track near-Earth asteroids and comets. Image credit: CSA.

Above: Map showing Chelyabinsk in Russia. Image source: Wikipedia. Image credit: Uwe Dedering.

Above: Leyat's 1921 Hélica. Image source: Wikipedia. Image credit: PHGCOM.

Astrodynamics

Chelyabinsk Bolide Trajectory Reconstruction

DANIEL R. ADAMO, ASTRODYNAMICS CONSULTANT

A bolide explosion above the Russian city of Chelyabinsk on 15 February 2013 at 3:20:26 UT is the most powerful event of its kind since 1908 (reference JPL's report at this link). According to a report filed 16 February and posted at this link, the resulting shock wave injured over 1100 people. Coincidentally, the near-Earth object (NEO) 2012 DA_{14} reached perigee about 16 hours later at 19:25:49 UT[1].

With preliminary bolide position data now available from video imagery of the event, reasonably accurate reconstructions of the bolide's terminal trajectory can be made. Such a reconstruction has been performed using the earliest two positions from IAU Telegram #3423 as reproduced in Table 1.

Table 1. Phase Elapsed Time (PET) associated with the following two positions reported in IAU Telegram #3423 is assumed to be zero on 15 February 2013 at 3:20:14.800 UT. This assumption places bolide explosion near the 3:20:26 UT epoch reported by JPL at +11.20 s PET. "Height" in the telegram is assumed to be geodetic altitude.

PET (s)	Latitude (°N)	Longitude (°E)	Height (km)
0.00	54.508	64.266	91.83
+9.18	54.788	61.913	41.02

The two Table 1 positions serve as boundary values defining a perturbed Lambert problem solution accounting for Earth gravity, including its J_{20} "oblateness" harmonic, together with gravity from the Sun and Moon. Ballistic atmospheric drag is also modeled using bolide mass = 10 million kg and a spherical radius of 8.5 m per the referenced JPL report. These physical data are equivalent to a bolide mean density of 3.9 g/cm^3.

The Lambert solution, expressed as a geocentric initial position and velocity at zero PET, has a speed of 17.673 km/s, a heading of 282.666° E of N, and a flight path angle of -18.823° relative to the local horizontal plane. Standard Small Bodies Database (SBDB) elements for this solution coasted backward to a geocentric range of 1.365 million km appear in Table 2.

Table 2. Heliocentric ecliptic elements in standard SBDB format at UT epoch 14.0 February 2013 are documented for the bolide reconstruction based on Table 1 data.

SBDB Element	Value
JED EPOCH	2456337.500777605255
EC	0.525941229805981
AU QR	0.760370788517564
JED TP	2456292.279850039662
° OM	326.461152943781
° W	109.362847047727
° IN	4.06570147976527

A bolide trajectory reconstruction by Zuluaga and Ferrin (reference the paper downloadable at http://arxiv.org/abs/1302.5377) was published on 22 February 2013. It contains mean heliocentric ecliptic elements at an undisclosed epoch, together with standard deviation uncertainties (1σ) in these elements from a Monte Carlo simulation of 50 reconstruction cases. These data are compared in Table 3 with corresponding values arising from Table 2 elements at UT epoch 00:01:07.1851 on 14 February 2013 (14.0 February 2013 CT).

(Continued on page 29)

Table 3. Bolide heliocentric ecliptic elements from a Monte Carlo analysis by Zuluaga and Ferrin are compared to those arising from the Table 2 reconstruction. Elements related to Table 2 falling more than ±1σ from the corresponding mean value are underlined.

Element	Zuluaga and Ferrin (mean ± 1σ)	Adamo (best estimate)
Semi-major axis *a* (AU)	1.73 ± 0.23	1.60
Eccentricity *e*	0.51 ± 0.08	0.53
Inclination *i* (deg)	3.45 ± 2.02	4.07
Arg. of perihelion *ω* (deg)	120.62 ± 2.77	<u>109.36</u>
Lon. of asc. node *Ω* (deg)	326.70 ± 0.79	326.46
Perihelion dist. *q* (AU)	0.82 ± 0.03	<u>0.76</u>
Aphelion dist. *Q* (AU)	2.64 ± 0.49	2.45

[1] This epoch and other trajectory information relating to 2012 DA_{14} appearing in this paper are obtained from JPL's *Horizons* on-line solar system data and ephemeris computation service accessible at http://ssd.jpl.nasa.gov/?horizons.

(Continued from page 28)

A geocentric plot of the bolide reconstruction arising from Table 1 data, along with a geocentric plot from 2012 DA_{14}'s JPL#65 ephemeris, appear in Figure 1. Although both Earth encounters fall on the same day, their geocentric approach velocities are distinctly different.

Radar measurements of 2012 DA_{14} on 15/16 February 2013 indicate its major (long) axis is 40 m (reference JPL's report at this link), more than twice the bolide's estimated size. Along with its larger size and intrinsic brightness, 2012 DA_{14} spends much of its time in Earth's night sky when close enough to detect with ground-based telescopes. These factors enabled 2012 DA_{14}'s discovery nearly a year before its 15 February 2013 Earth encounter.

As is evident from Figure 1, the Chelyabinsk bolide approached from Earth's Sun-facing hemisphere and could not be observed by ground-based telescopes. This approach geometry has been termed a "Red Baron scenario" after Snoopy's dogfighting escapades in the comic strip *Peanuts*. Such approaches can only be observed with a telescope placed a sufficient distance from Earth in the Sun's direction.

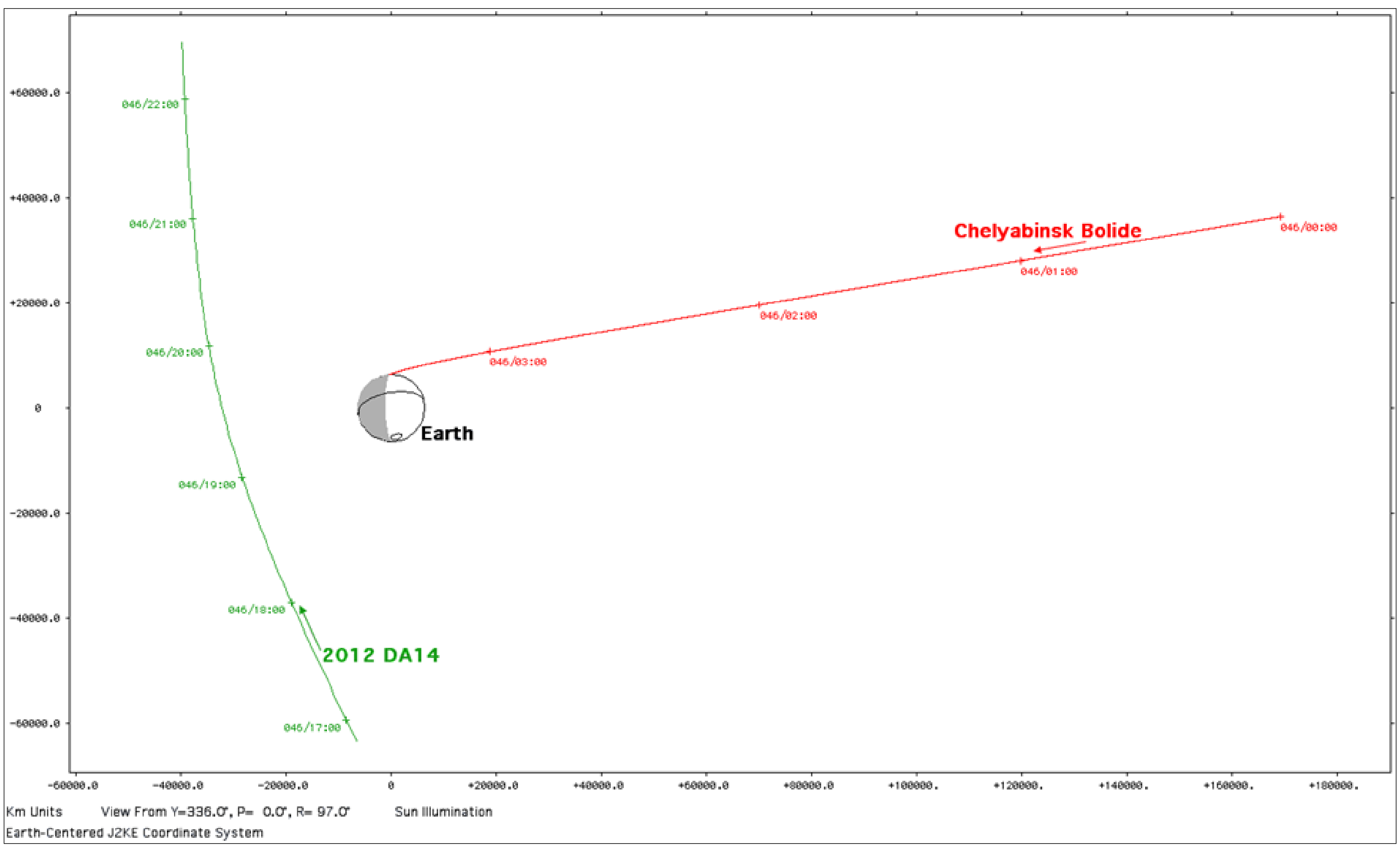


Figure 1. This geocentric inertial plot of the Chelyabinsk bolide's terminal approach to Earth (red) is viewed from a direction very nearly perpendicular to its plane of motion. Earth's nightside is shaded gray, and the subsequent flyby of NEO 2012 DA_{14} is co-plotted (green) to illustrate its distinctly differing speed and direction. Time ticks accompanying both trajectories are at one-hour intervals and annotated with 15 February 2013 UT in day-of-year/hour:minute format.

Clear Creek High School & NASA's HUNCH

Douglas Yazell, Editor

Above: Master of Ceremonies Alan Sisson at a Section dinner meeting at NASA / JSC.

The acronym is High school students United with NASA to Create Hardware (HUNCH). Our local Clear Creek High School in the Houston Clear Lake area was the first to participate. That was back in 2003.

Alan Sisson was a great help for our Section's AIAA work in recent months and years. He is volunteering once a week at this high school and this NASA project. Alan is a graduate systems engineering student at the University of Houston at Clear Lake (UHCL). Alan earned his bachelor of science in aerospace engineering degree from the University of Texas at Austin. He put me in touch with Robin Merrit, the engineering teacher at Clear Creek High School.

It is surprising to see engineering taught in high schools, and it is a surprise to know that this school has about fifty students enrolled in engineering with Mr. Merritt. He started work at this school in 2004, so he missed the first HUNCH activities.

The most recent HUNCH project at Clear Creek High School is for the International Space Station (ISS): a Cupola Astronaut Restraining System (CARS). It holds the astronaut in place while operating the ISS robotic arm. The astronaut stands on it. It can help with spacecraft docking with ISS, but CARS can also help with any ISS robotic arm task. CARS is adjustable and can be removed from the cupola in less than seven seconds. CARS was delivered to NASA in 2012. NASA might not use the entire design. The Clear Creek High School CARS team was not working with any other high schools on that project. Students do

(Continued on page 31)

Above: Clear Creek High School engineering students wearing the uniform (shirt) of those enrolled in the engineering curriculum. These students participate in High school students United with NASA to Create Hardware (HUNCH) program. Their teacher Mr. Robin Merritt is shown at right. Image credit: Supplied to Horizons by Mr. Robin Merritt.

(Continued from page 30)

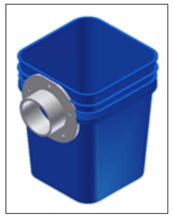
quite a lot (maybe all) of the design work on their own. This team has a NASA-sponsored machine shop in the school, the only such machine shop in the area.

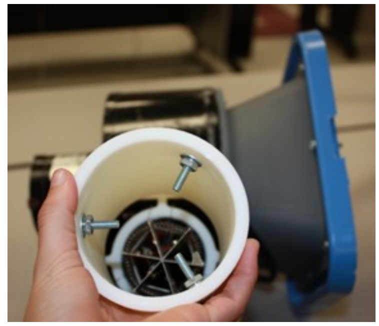
Their current project is a space station shower and washer system. The shower has four components:

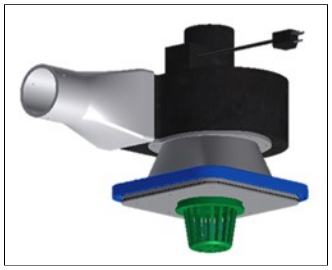
- Capsule: collapsible, lightweight, with a waterproof liner
- Vacuum system
  - Creates a circular flow of air throughout the shower system
  - Provides air flow to move water through the shower
  - Provides air/water movement for filter function
  - Facilitates clothes drying in dryer component
- Filter system
  - Allows the passage of air but not water
  - Enables air to be recirculated into the capsule
  - Retains water within the bucket
- Heating
  - Air is heated in fan unit
  - Provides some home-like amenity to the shower
  - Facilitates drying of clothes in washer component

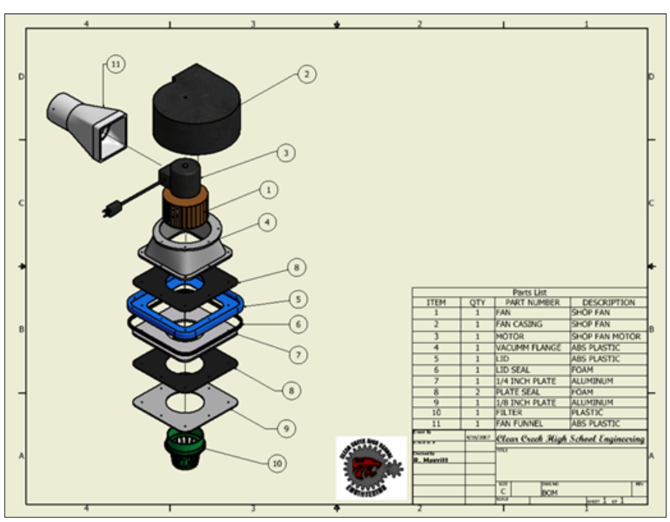
The washer has three components:

- Integrates into shower system
- Uses vacuum from shower to remove water
- Clothes are washed by depositing clothes and washing detergent in bag and agitating with hands









Parts List			
ITEM	QTY	PART NUMBER	DESCRIPTION
1	1	FAN	SHOP FAN
2	1	FAN CASING	SHOP FAN
3	1	MOTOR	SHOP FAN MOTOR
4	1	VACUMM FLANGE	ABS PLASTIC
5	1	LID	ABS PLASTIC
6	1	LID SEAL	FOAM
7	1	1/4 INCH PLATE	ALUMINUM
8	2	PLATE SEAL	FOAM
9	1	1/8 INCH PLATE	ALUMINUM
10	1	FILTER	PLASTIC
11	1	FAN FUNNEL	ABS PLASTIC

Above: The space station shower and washer system designed by the Clear Creek High School HUNCH. Image credits: Mr. Robin Merritt, Engineering Instructor, Clear Creek High School.

Current Events

Planetary Defense Conference

A. A. JACKSON, PH.D., LUNAR AND PLANETARY INSTITUTE

The third International Academy of Astronautics (IAA) Planetary Defense Conference took place April 15-19, 2013, in Flagstaff, Arizona:

- Current state of knowledge on Near Earth Objects (how many, physical characteristics, orbits, current limitations, current risk.
- Consequences of an impact (tsunami, NEO size vs. consequence, economic impact, past events).
- Techniques for deflecting or mitigating a threatening NEO (kinetic impact, gravity tractor, explosive devices, others).
- NEO deflection mission and campaign design (launch requirements, cost, timelines, new tools).
- Political, policy, legal framework for planetary defense creasing public awareness.
- Current national and international activities supporting planetary defense.

Above: Gathering for Impact. Credit: IAA.

NASA MSL Curiosity Update

DR. DOROTHY Z. OEHLER, MSL PARTICIPATING SCIENTIST

June 4, 2013.

The Mars Science Laboratory (MSL) science team is analyzing the data from our first hole drilled in Gale crater, which was located at the John Klein site in Yellowknife Bay (YKB). Results indicate that this site was a habitable environment where microbes could have existed at one time. That is, it was a site with liquid water, a supply of carbon in CO_2, and potential energy sources in chemical gradients provided in pairings of oxidized and reduced chemical species (such as sulfate and sulfide pairs). In addition, the early results suggest that this environment was only weakly saline, not harshly oxidizing, and near neutral in pH – all characteristics of mild, habitable environments. Specifically:

- The regional geology and fine-grained rock suggest that the John Klein site was at the end of an ancient river system or within an intermittently wet lake bed.
- The mineralogy indicates sustained interaction with liquid water that was not too acidic or alkaline, and low in salinity. Further, conditions were not strongly oxidizing (Figures 1-2).
- Key chemical ingredients for life are present, such as carbon, hydrogen, nitrogen, oxygen, phosphorus, and sulfur.
- The presence of chemical species in various states of oxidation would provide a source of energy for primitive organisms.

Mars entered solar conjunction on April 4, an approximately four-week period where the sun is between the Earth and Mars. During this period, no commands were sent to the rover, as a precaution against potential interference of the sun that could corrupt a command. The rover is back in communication now that conjunction is over and plans are being made to visit two key outcrops on the way to Mt. Sharp. These outcrops (called Point Lake and Shaler) were first encountered on the way to YKB. The science team felt that additional analyses of these particular deposits on the way out of YKB could be of value in understanding the history of the area. When the new analyses of these outcrops have been acquired, Curiosity will begin the long traverse to Mt. Sharp.

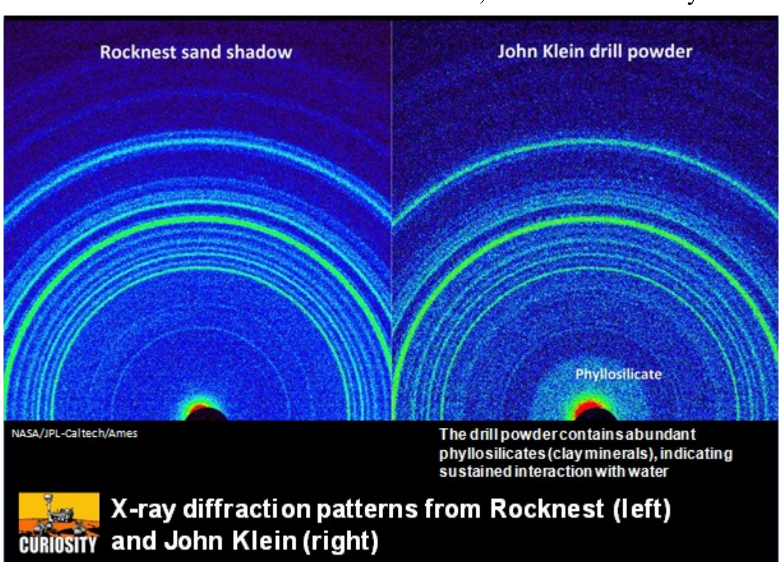


Figure 1. Comparative results from the Chemistry & Mineralogy instrument (CheMin) on Curiosity.

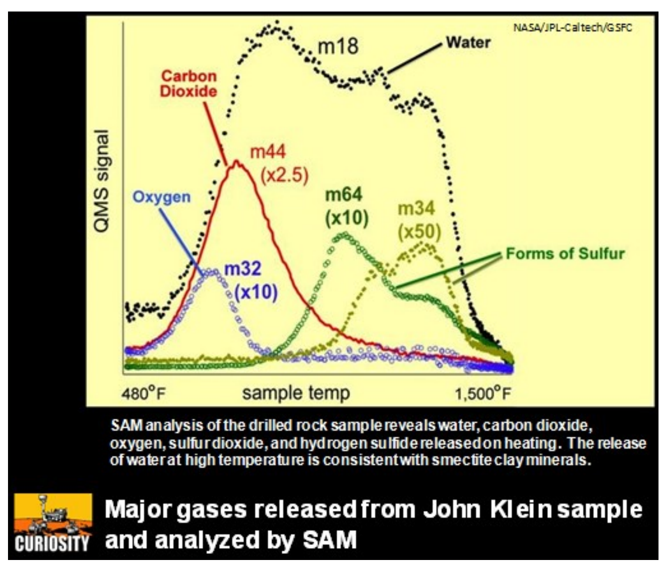


Figure 2. Recent results from the Sample Analysis at Mars instrument (SAM) on Curiosity.

Times are Tough!

PHILIPPE MAIRET, 3AF MP

In this year 2013, for the 50th Paris-Le Bourget Air Show, NASA probably will not be in attendance, because of the sequester. "Times are tough!" everyone says. But what about this woman? Will she be in attendance? This is Valentina Tereshkova, the first woman in space.

She celebrated her 75th birthday on March 6, 2012. She is that pioneer who showed the path to the stars to women who came to this profession since her historic flight of June 16-19, 1963. She holds the record as the youngest cosmonaut, and she is the only woman who flew alone in the cosmos!

Her journey in space was not routine, even though she was ordered not to speak of the in-flight anomalies. At the time, Soviet propaganda dominated such communication.

On the way back from Earth orbit, her Vostok-6 spacecraft exhibited anomalous operation from its automatic vehicle orientation program. Initially her spacecraft was going farther away from Earth instead of getting closer to Earth, Finally, the atmospheric re-entry took place without problems. Soviet engineers and technicians eventually found solutions for this incident. It has not happened again, but Valentina Tereshkova found it necessary to keep quiet about those problems, at the request of Sergei Korolev.

References:

- An article on the Futura Sciences web site
- Sergei Pavlovich Korolev, also transliterated as Sergey Pavlovich Korolyov (12 January 1907 [30 December 1906 when using old style calendars] – 14 January 1966) was the lead Soviet rocket engineer and spacecraft designer in the space race between the United States of America and the Soviet Union during the 1950s and 1960s. He is considered by many as the father of practical astronautics. (Wikipedia)

Our French sister section is 3AF MP, l'Association Aéronautique et Astronautique de France, Midi-Pyrénées chapter, www.3af-mp.fr. See the Section News pages for the 3AF MP organization chart. More information is soon to be placed on our web site at www.aiaahouston.org, but that has not yet been transferred from our former web site, www.aiaa-houston.org.

The relevant committee is in the technical branch of AIAA Houston Section, the International Space Activities Committee (ISAC), as shown on our organization chart. The ISAC is chaired by Ludmila Dmitriev-Odier.

Above: Valentina Tereshkova and NASA astronaut Catherine Coleman at the Gagarin Cosmonaut Training Center (GCTC) in December 2010. Image source: Wikipedia. Image credit: NASA / Mike Fossum.

Above: A 1969 Soviet Union Sergei Korolev stamp. The face value of the stamp is ten kopeks. Image source: Wikipedia. Image credit: Eugene Zelenko.

Museum

1940 AIR TERMINAL MUSEUM

This is a bimonthly column about the 1940 Air Terminal Museum, a 2008 addition to the list of AIAA Historic Aerospace Sites. The museum is restored and operated by the non-profit Houston Aeronautical Heritage Society.

1940 Air Terminal Museum
8325 Travelair Street
Houston, Texas 77061
(713) 454-1940

1940 Air Terminal Museum at Hobby Airport An AIAA Historic Aerospace Site

DOUGLAS YAZELL, EDITOR

We have sad news to report. Captain A.J. High, one of the leaders of the museum volunteers, died recently. The Houston Chronicle mentioned his passing with great respect. Captain High died April 3, 2013, just short of his 90th birthday.

I first got to know A.J. when he spoke to our AIAA visitors on a Saturday lunch visit to the museum, a Wings & Wheels event. I later learned from his memoir, *Meant to Fly*, that the initials A.J. stood for nothing, just "A.J.!" As I recall from the book, when he joined the military, someone got angry at him during the sign-up phase, thinking A.J. was joking about his name. That name almost kept him out of the military.

The museum web site presents an amazing Houston aviation timeline from 1900 to 2000. I am guessing Captain High wrote all or most of it. I used that timeline for most of the nomination report when the museum was successfully nominated as an AIAA Historic Aerospace Site. (Chester Vaughan helped greatly with the review phase for that nomination report. Drew Coats suggested to me that we nominate the museum for that honor.)

One of the museum displays is devoted to Caption High. He generously donated family photographs, his Captain's wings and other items.

Horizons reviewed High's memoir starting on page 30 of our April 2009 issue.

Wings & Wheels

The third Saturday of most months is reserved for this great lunchtime-centered activity. For about $7 for adults, it is a bargain visit with aircraft out back and cars or motorcycles our front. The museum itself is quite a visit, too! Lunch is usually available from the gourmet truck Flaming Patties.

Saturday, March 16, 2013

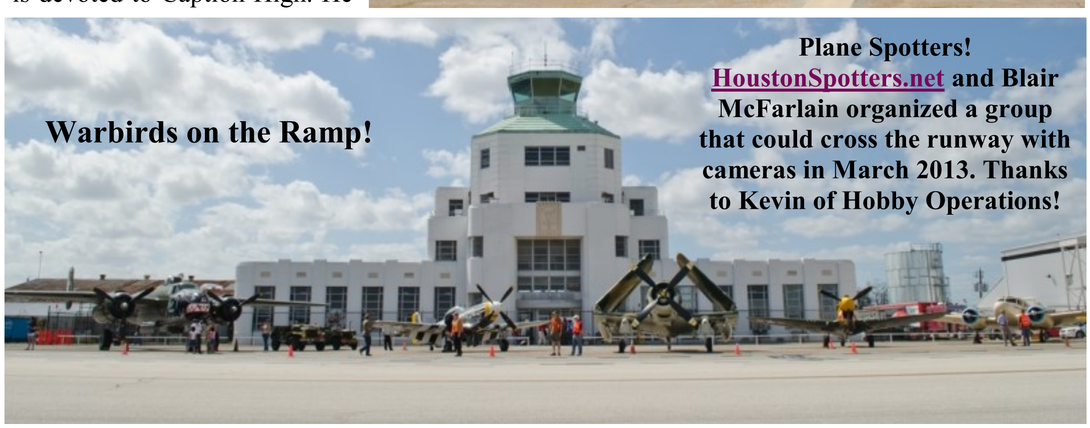
Red Tails Exhibit!

"We had beautiful weather for this month's Wings & Wheels, as well as all week for the Red Tails exhibit. This month, the Commemorative Air Force (CAF) Red Tail Squadron hosted visitors at its RISE ABOVE Traveling Exhibit. Also joining the exhibit on Saturday CAF Gulf Coast Wing's B-17 "Texas Raiders", along with a P-51, B-25, and P-40 from the **Texas Flying Legends Museum**

"We also had two planes from the **Vietnam War Flight Museum**, a Skyraider, as well as a T-34.

"The B-17 sold rides and had two flights in the afternoon."

Image credits: Museum web site. Art credit: Jonathan Frank: book cover art for memoir, "Meant to Fly."



Warbirds on the Ramp!

Plane Spotters! HoustonSpotters.net and Blair McFarlain organized a group that could cross the runway with cameras in March 2013. Thanks to Kevin of Hobby Operations!

The Experimental Aircraft Association (EAA) Chapter 12 (Houston)

Mission

The EAA's Chapter 12, located at Ellington Field in Houston, Texas, is an organization that promotes all forms of recreational aviation. The organization includes interest in homebuilt, experimental, antique and classic, warbirds, aerobatic aircraft, ultra lights, helicopters and commercially manufactured aircraft and the associated technologies.

This organization brings people together with an interest in recreational aviation, facilitating social interaction and information sharing between aviation enthusiasts. Many of the services that EAA offers provide valuable support resources for those that wish to develop and improve various skills related to aircraft construction and restoration, piloting, aviation safety and aviation education.

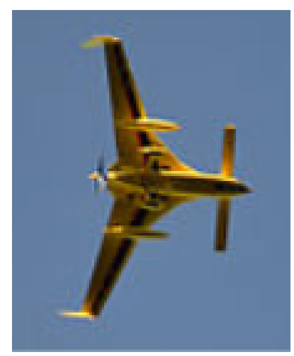
Every individual and organization with an interest in aviation and aviation technology is encouraged to participate. (EAA membership is not required, but encouraged.) Meetings are generally from 6:30 PM to 9:00 PM at Ellington Field in Houston Texas. We welcome everyone. Come as you are and bring a guest; we are an all-aviation friendly organization!

In our May 2011 issue we started our series "EAA/AIAA profiles in general and experimental aviation" with Lance Borden, who is rebuilding his Inland Sport airplane, an aircraft manufactured by his grandfather's 1929 - 1932 company. The second in this series was a profile of Paul F. Dye. The third profile will appear as soon as possible. This series was suggested by Richard Sessions of EAA Chapter 12.

Ideas for a meeting? Contact Richard at rtsessions[at]earthlink.net, Chapter 12 web site: www.eaa12.org. Another email contact: eaachapt12[at]gmail.com. As of April 13, 2012, EAA Chapter 12 is meeting on the first Tuesday of month, based on the calendar on the web site. Experimental Aircraft Association (EAA) web site: www.eaa.org

Scheduled/Preliminary Chapter 12 Event/Meeting Ideas and Recurring Events:

1st Saturday of each month – La Grange TX BBQ Fly-In, Fayette Regional (3T5)
1st Saturdays – Waco/Macgregor TX (KPWG), Far East Side of Field, Chap 59, Pancake Breakfast with all the goodies 8-10 AM, Dale Breedlove, jdbvmt[at]netscape.com
2nd Saturdays – Conroe TX Chapter 302 10 AM Lone Star Builder's Ctr, Lone Star Executive
2nd Saturdays – Lufkin TX Fajita Fly-In (LFK)
2nd Saturdays – New Braunfels TX Pancake Fly-In
3rd Saturdays – Wings & Wheels, 1941 Air Terminal Museum, Hobby Airport, Houston TX
3rd Saturdays – Jasper TX BBQ Lunch Fly-In (JAS)
3rd Saturdays – Tyler TX Breakfast Fly-In, 8-11, Pounds Field (TYR)
4th Saturdays – Denton TX Tex-Mex Fly-In
4th Saturdays – Leesville LA Lunch Fly-In (L39)
4th Saturdays – Shreveport LA Lunch Fly-In (DTN)
Last Saturdays – Denton Fly-In 11AM-2 PM (KDTO)



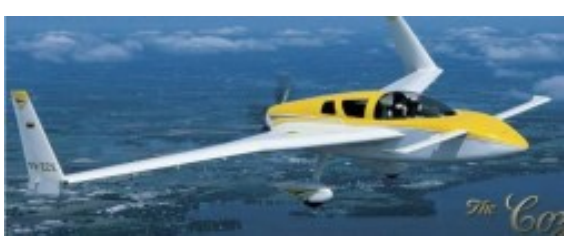


Image credits: The EAA Chapter 12 web site.

Opinion

Climate Change and Local Responses

Douglas Yazell, Editor, March / April 2013

My opinions are not necessarily the positions of AIAA or AIAA Houston Section.
editor2012@aiaahouston.org

Local responses include a citizen's responsibility to influence national and international leaders, institutions and cultures. With local responses in mind, I note that AIAA Houston Section's region includes Texas A&M University, the University of Houston and Rice University.

The names of 23 faculty members appear here as of May 29, 2013: "We, the faculty of the Department of Atmospheric Sciences of Texas A&M University, agree with the recent reports of the Intergovernmental Panel on Climate Change (IPCC) that:

1. "It is virtually certain that the climate is warming, and that it has warmed by about 0.7 deg. C over the last 100 years.
2. "It is very likely that humans are responsible for most of the recent warming.
3. "If we do nothing to reduce our emissions of greenhouse gases, future warming will likely be at least two degrees Celsius over the next century.
4. "Such a climate change brings with it a risk of serious adverse impacts on our environment and society."

A nearby AIAA Section includes the University of Texas at Austin. The same four statements appear on a web page there along with the names of 24 faculty members: "Reality of Human Influence on Global Climate: We, the members and colleagues of the Jackson School of Geosciences program in Climate Systems Science, agree with the scientific assessment presented in reports by the IPCC that… [the same four statements].

Professor Dessler of Texas A&M University stated on chart 37 from an October 2011 presentation that the number of "skeptical" climate scientists in Texas is zero.

Professor John Nielsen-Gammon of Texas A&M University's Department of Atmospheric Sciences writes the Climate Abyss blog for the Houston Chronicle. The title for his entry of May 16, 2013 blog entry is, "The Size of the C." He concludes that entry by writing, "For policy purposes, the key question is not whether global warming is happening (it is), or whether man is a major cause (we are). The key question, upon which all policy decisions hinge, is the size of the C." He presents two acronyms, potentially catastrophic Anthropogenic Global Warming (cAGW) and likely Catastrophic Anthropogenic Global Warming (CAGW).

Our next issue of Horizons will cover the AIAA Houston Section Annual Technical Symposium (ATS 2013) of Friday, May 17, 2013, at NASA / JSC Gilruth Center. We can already access charts presented by Professor Nielsen-Gammon at this event.

National Public Radio (NPR) praised the Alliance for Climate Education (ACE) in a May 7, 2013 broadcast. As shown in the map, ACE works with high school students around the country, but the closest location to Houston for their current work is Dallas.

NASA's web site called Global Climate Change looks great based on my quick look today. On the web page about Effects, they define some phrases used by the IPCC: "Definitions of likelihood ranges used to express the assessed probability of occurrence: *virtually certain >99%, very likely >90%, likely >66%. Source: Summary for Policymakers, IPCC Synthesis report, November 2007*."

Effects of global climate change on that NASA web page include North America, recent changes, and future trends. I conclude the cost of climate change is already very high.

The NASA web page has this quote, too: "Scientists have high confidence that global temperatures will continue to rise for decades to come, largely due to greenhouse gasses produced by human activities. The Intergovernmental Panel on Climate Change (IPCC), which includes more than 1,300 scientists from the United States and other countries, forecasts a temperature rise of 2.5 to 10 degrees Fahrenheit over the next century."

A great friend recently said it seems the IPCC is complaining about tiny temperature increases. The NASA web page asks and answers this question on that Effects page: "So, the Earth's average temperature has increased about 1 degree Fahrenheit during the 20th century. What's the big deal?"

I conclude this time with the NBC TV news item in the sidebar.

An NBC TV news report of March 11, 2013 (*Journey to the Bottom of the Earth*) included this quote: "We should not kid ourselves in thinking that that will not have consequences. We don't necessarily need to fear change, but it will change the world as we know it."

Above: Current locations for the high school work of the Alliance for Climate Education (ACE). Image credit: ACE web site.

The JSC Astronomical Society

JIM WESSEL, JSCAS EDUCATIONAL OUTREACH CHAIRMAN

The Johnson Space Center (JSC) Astronomical Society (JSCAS) meets on the second Friday of each month at 7:30 PM at Universities Space Research Association (USRA) building at 3600 Bay Area Blvd at Middlebrook Drive. This building is also used by the Lunar and Planetary Institute (LPI). The JSCAS web site address is easy to remember: www.jscas.net. The next meetings are June 14 and July 12, 2013.

JSCAS has agreed to contribute one or more pages in every bimonthly issue of Horizons. The JSCAS contributions to will typically feature a calendar of upcoming events, and other assorted astronomy related articles of interest to our readership. We are grateful for their support! JSCAS is very active, with educational outreach such as star parties and monthly open-to-the-public meetings. Those meetings feature high-quality presentations ranging from what's in the current month's night time sky for beginner observing, astronomical oddities, a *Member's Minute* (typically a shorter presentation), a novice Question and Answer session, and of course the changing monthly main talk which covers a gamut of interesting topics, all of which form an excellent astronomy lecture series available to the public totally FREE. Membership to JSCAS is based on continual attendance only, as there are no dues, no by-laws and very few rules.

Of interest, JSCAS has recently developed a loaner telescope program, in which various makes and models of telescopes can be borrowed short term by its membership. This allows curious individuals to try-before-you–buy and before they make a substantial investment in their own observing equipment. Another new development is JSCAS' DVD library. Over 200 high quality DVDs on a diverse range of astronomy related topics are available to be checked out, just like at a regular library.

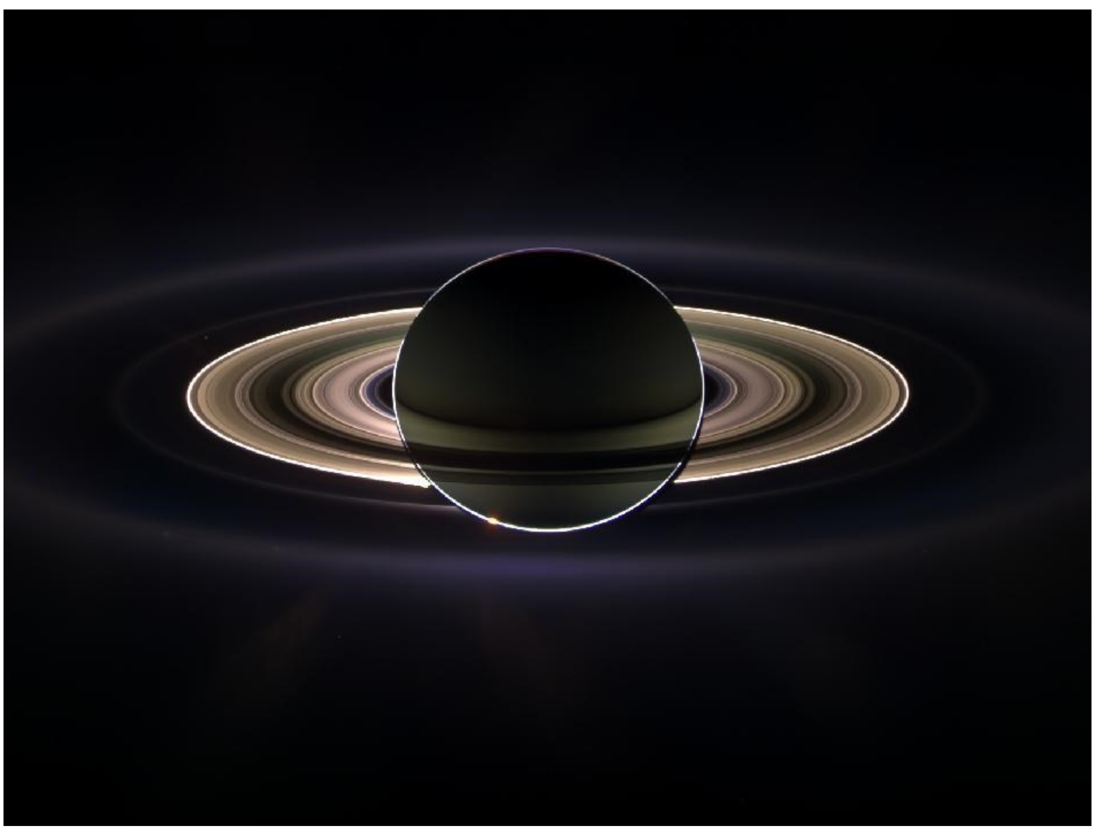
JSCAS is a strong supporter of the Houston area Astronomy Day celebration held in October each year at the George Observatory inside of Brazos Bend State Park, southwest of Houston. This year's event is October 12th, and features a full day and night of fun activities and learning opportunities for the whole family. More details will be provided in *Horizons* closer to the date.

For those with an interest in astronomical observing, JSCAS takes biannual trips to its dark site in west central Texas at the Ft. McKavitt historical site. These 3 day gatherings are opportunities to catch up with old acquaintances and share some truly amazing food, and view some of the best night time skies in North America.

Upcoming JSCAS star parties and related JSCAS events will be listed here in the JSCAS pages in future issues of Horizons.

A few upcoming events from the JSCAS web site calendar page are presented here:

- June 7, 2013: Haak Winery Star Party.
- June 14, 2013: Dr. Stephen Bradshaw, Rice University, *Solar Activity and Consequences for Earth.*
- July 12, 2013: Dr. Aaron Clevenson. His presentation title will be announced as soon as possible.



A backlit image of Saturn from the Cassini spacecraft. Credit: NASA-JPL Space Science Institute.

Calendar

All calendar items are subject to change without notice.

Section council meetings: email secretary2012[at]aiaahouston.org

Time: 5:30 - 6:30 PM usually

Day: First Monday or Tuesday of most months except for holidays.

Location: NASA/JSC Gilruth Center is often used. The room varies.

Recent Section events

Our Section's Annual Technical Symposium (ATS 2013) took place on Friday, May 17, 2013, thanks in large part to General Chair Ellen Gillespie. Our Section's web site has a page devoted to this event, including many of the PowerPoint charts from our presenters.

Upcoming Section events

Audiobook in work by Ted Kenny, NASA/JSC, Chair, AIAA Houston Section History technical committee, *Suddenly Tomorrow Came, A History of JSC*

Thursday, June 13, 2013: Dinner meeting. This is our Section's annual awards dinner meeting. This year's meeting is dedicated to the late James C. McLane, Jr. The speaker is Dr. Harold "Sonny" White, NASA / JSC. Subject: warp field physics work at NASA / JSC.

August 2013: The Section's annual leadership retreat is often held in August. The new AIAA year starts on July 1, 2013.

Above: Attendees at our Section's leadership retreat of August 15, 2012.

2013 Conferences www.aiaa.org (Events link)

6 June 2013 Williamsburg, Virginia, 2013 Aerospace Today and Tomorrow

12 - 14 June 2013 Istanbul, 6th Int'l Conference on Recent Advances in Space Technologies

17 - 19 June 2013 Washington, DC, 2013 American Control Conference

24 - 27 June San Diego, AIAA Fluid Dynamics and Co-located Conferences and Exhibit

14 - 18 July 2013 Vail, Colorado, 43rd International Conference on Environmental Systems

15 - 17 July San Jose, California, 49th AIAA/ASME/SAE/ASEE Joint Propulsion Conference & Exhibit & 11th International Energy Conversion Engineering Conference (IECEC)

11 - 15 August Hilton Head Island, SC, AAS/AIAA Astrodynamics Specialist Conference

12 - 14 August 2013 Los Angeles, California, AIAA AVIATION 2013

15 - 16 August 2013 Los Angeles, CA, 2013 Regional Leadership Conference

19 - 22 Aug. Boston, AIAA GN&C & Co-located Conf's & AIAA Infotech@Aerospace 2013

10 - 12 September 2013, San Diego, California, AIAA SPACE 2013 Conference & Exposition

14 - 17 October 2013, Florence, Italy, 31st AIAA International Communications Satellite Systems Conference (ICSSC)

2014 Conferences www.aiaa.org (Events link)

13 - 17 January 2014, National Harbor, Maryland, AIAA SciTech 2014

30 April 2014, Washington, DC, 2014 Aerospace Spotlight Awards Gala

5 - 9 May 2014, Pasadena, California, SpaceOps 2014

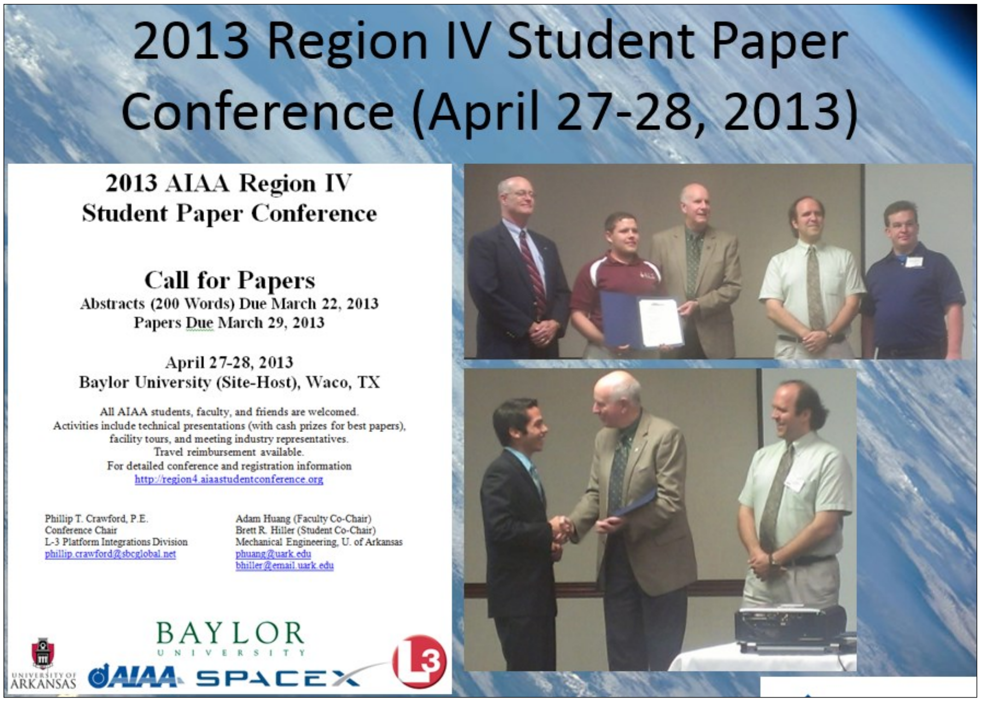
16 - 20 June 2014, Atlanta, Georgia, AIAA AVIATION 2014

28 - 30 July 2014, Cleveland, Ohio, AIAA Propulsion and Energy 2014

5 - 7 August 2014, San Diego, California, AIAA SPACE 2014

Horizons: published bimonthly by the end of February, April, June, August, October & December at www.aiaahouston.org.

Section News

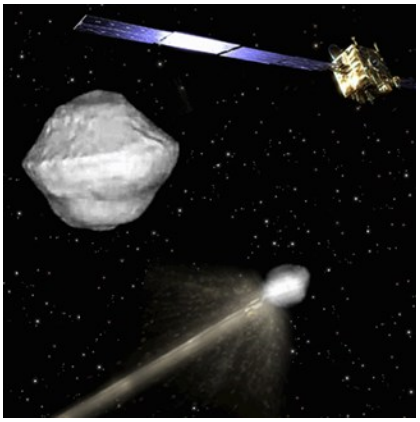


Left: In the top picture at right is Section Chair Daniel Nobles. To his right is Stephen J. Brock (AIAA).

Below: The Yuri's 5k fun run has grown over the years. This year it moved to a new venue to handle the enthusiasm. More than 500 people showed up in Nassau Bay to run past the houses of astronauts, engineers and flight directors who have worked hard over the years at NASA. This year's donation to the Challenger Learning Center from the runners will be around $7,800! Congratulations to all who participated in raising funds for a great cause! [Michael Frostad]

Section News

ESA Asteroid Impact Mission Targets Didymos



February 22, 2013 (ESA)

ESA's proposed Asteroid Impact and Deflection Assessment mission now has a target: asteroid Didymos. The recent Russian meteor and, on the same day, our planet's close encounter with an even larger chunk of celestial debris underline the need for us to learn more about these high-speed space rocks. [Full story…]

Right: The key moment of the Don Quijote mission: the Impactor spacecraft (Hidalgo) smashes into the asteroid while observed, from a safe distance, by the Orbiter spacecraft (Sancho). Image credit: ESA.

Association Aéronautique et Astronautique de France (3AF)

Sister Section of AIAA Houston Section since 2007
Jumelée avec AIAA Houston Section depuis 2007

Section News

Left: James C. McLane, Jr. (1923-2012), our 1971-1972 AIAA Houston Section Chair. In 1987, he co-founded our sister section relationship with the Shanghai Astronautical Society (SAS). This page shows McLane at left at NASA / Johnson Space Center in 1972. More images of McLane are in this issue on the next page and the back cover page. Image credits: James C. McLane III.

The 2013-2014 Executive Council will consist of:

Chair: Michael Frostad
Chair-Elect: Michael Martin
Vice-Chair, Technical: Clay Stangle
Vice-Chair, Operations: Eryn Beisner
Secretary: Shen Ge
Treasurer: Jennifer Wells
Councilor: Irene Chan (Two year Term, 2013-15)
Councilor: Robert Plunkett (Two year Term, 2013-15)

The American Institute of Aeronautics and Astronautics (AIAA)

AIAA Houston Section Since 1962

P.O. Box 57524
Webster, TX 77598

Executive Council
July 01, 2012 - June 30, 2013

www.aiaahouston.org

Chair
Daniel Nobles / SAIC
281-483-8360 (w) 979-255-4780 (cell)

Chair-Elect
Vacant

Past-Chair
Sean Carter / NASA
281-244-7232 (w) 832-651-1000 (cell)

Secretary
Robert Plunkett / MEI
281-483-2797

Treasurer
Clay Stangle
281-217-2172

Vice Chair - Operations
Michael Frostad / Jacobs
281-461-5867

- College and Co-Op: Dr. Gary Turner / Odyssey, 281-862-7825
- Honors and Awards: Jennifer Wells / UTAS, 281-336-6302
- Membership: Lisa Voiles / USA, 281-244-6467
- STEM K-12: Svetlana Hanson / Tietronix, 281-326-0779
- Professional Development: Angela Beck / Engineering Redesign
- Newsletter: Douglas Yazell, 832-366-5292
- Publicity: Shen Ge, 770-617-4046
- Programs: Dr. Pamela Loughmiller, 607-227-2620
- Public Policy: Melissa Gordon / Lockheed Martin, 321-446-2776
- Scholarship: Rafael Munoz / NASA, 281-483-3427
- Young Professionals: Tom Horn / Barrios, 540-748-0442
- Communications: Eryn Beisner / Barrios, 281-244-0212
  - Webmaster: Irene Chan, 323-393-5723
  - E-Mail: Ryan Miller/ Boeing, 281-226-4430

Councilors (2-year terms ending June 30, 2014)

- Alan Sisson, 281-235-2075
- Christopher Davila / Barrios, 281-244-8173
- Larry Friesen / UHCL, 281-334-5268
- Shirley Brandt, 713-542-9085
- Sarah Shull / NASA, 281-244-6441

Councilors (2-year terms ending June 30, 2013)

- Michael Martin / TAMU, 979-220-5517
- Alicia Baker / Baker Hughes, 713-927-2044
- Ellen Gillespie, 281-682-3653
- Matt Johnson / LMCO, 281-333-6080
- Melissa Kronenberger / SAIC, 281-335-2270

Vice Chair - Technical
Brian Banker / NASA
281-483-7907

- Astrodynamics: Dr. Albert A. Jackson / Jacobs, 281-483-5037
- Automation and Robotics: Dr. Zafar Taqvi / Barrios, 713-392-1280
- Program Management & Integration: Dr. Satya Pilla / Boeing, 832-858-3982
- Extra-Vehicular Activity: Daryl Schuck/ Honeywell, 281-532-5203
- Guidance, Navigation, and Control: Dr. Steven E. Everett / Boeing, 281-734-6284
- History: Ted Kenny / NASA, 281.244.0078
- In-Space Imaging and Crew Observations: Dr. Kamlesh Lulla / NASA, 281-483-5066
- Space Operations: BeBe Kelly-Serrato / A-SCC, 281-798-9060
- Life Sciences, Space Processes, and Human Factors: Julie Mitchell / NASA, 281-244-7417
- Propulsion and Power Systems: Sheikh Ahsan / NASA, 281-244-6826
- Safety and Mission Assurance: Roger Kleinhammer / SAIC, 281-335-2303
- Systems Engineering: Gary Brown / Booz Allen Hamilton, 713-933-6814
- Space Commercialization: (Open)
- International Space Activities Committee: Ludmila Dmitriev-Odier / USA, 832-524-6307

Downloaded February 17, 2013

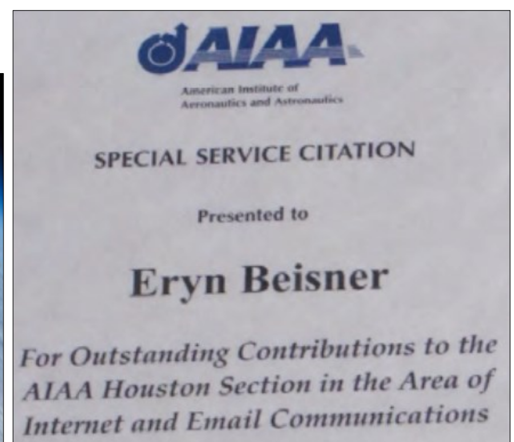
Executive Council Voting Members (20) are identified by:

Section News

This page: James C. McLane, Jr. (1923-2012), our 1971-1972 AIAA Houston Section Chair. In 1987, he co-founded our sister section relationship with the Shanghai Astronautical Society (SAS). This page shows McLane in basic training in Macon, Georgia. More images of McLane are in this issue on the preceding page and the back cover page. Image credits: James C. McLane III.

Above: Shen Ge (left) is awarded an AIAA Special Service Citation presented by AIAA Houston Section Annual Technical Symposium (ATS 2013) General Chair Ellen Gillespie. This award was presented just before the start of the ATS 2013 luncheon keynote panel discussion at the NASA / JSC Gilruth Center.

Above: Daniel Nobles awards AIAA Special Service Citations to Eryn Beisner (left) and Irene Chan (right) during the March 28, 2013 dinner meeting at the NASA / JSC Gilruth Center. These citations are signed by Michael Griffin, President, and Merri J. Sanchez, Vice President, Member Services. Sanchez is a former AIAA Houston Section Chair.



AIAA

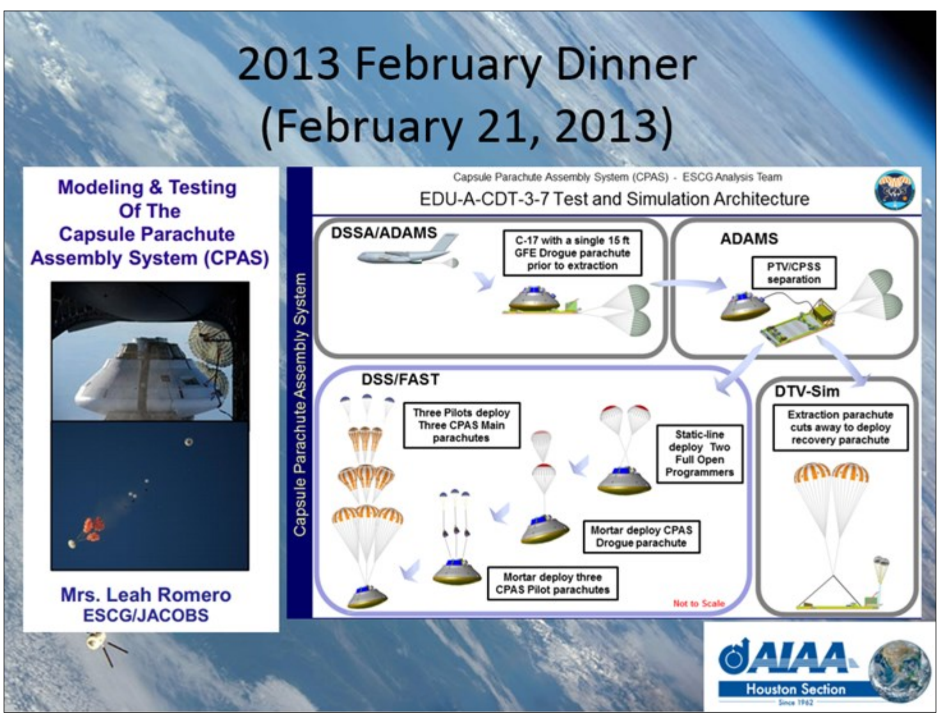
American Institute of Aeronautics and Astronautics

SPECIAL SERVICE CITATION

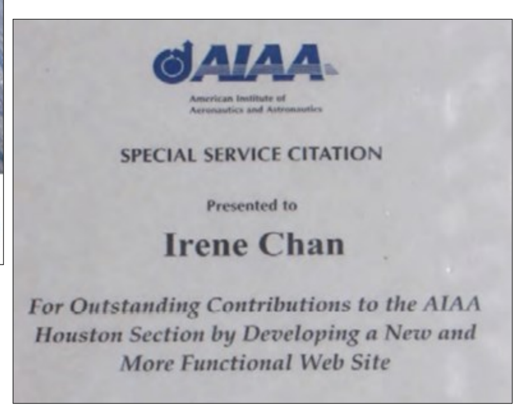
Presented to

Eryn Beisner

For Outstanding Contributions to the AIAA Houston Section in the Area of Internet and Email Communications



Above: Mrs. Leah Romero was our dinner meeting speaker for February 21, 2013. As noted on the Calendar page in our last issue, her maiden name was Olson, in case you look for her AIAA papers. Our Section's web site provides links to her PowerPoint charts, her videos, and related files.



AIAA

American Institute of Aeronautics and Astronautics

SPECIAL SERVICE CITATION

Presented to

Irene Chan

For Outstanding Contributions to the AIAA Houston Section by Developing a New and More Functional Web Site

Dinner Meeting Featuring Wayne Hale

DOUGLAS YAZELL, EDITOR

This popular dinner meeting took place at the NASA / JSC Gilruth Center Alamo Ballroom on March 28, 2013, with an audience of more than 50 people. Some of the information is not available to the press, so starting below we present a somewhat similar address given by AIAA Houston Section Member Guy Thibodaux back in 1966. Guy was our Section's 1969-1970 Chair. We can find an oral history and biography here.

Above: Guy Thibodaux (right) at an AIAA Houston Section dinner meeting of May 26, 2010. At left is the featured dinner speaker Mr. Bohdan (Bo) Bejmuk, a member of the Augustine Committee whose human spaceflight review report was released in 2009. Image credit: Douglas Yazell. Image source: Horizons, July 2010, dinner meeting article starting on page 8.

SYSTEMS TESTING IN THE SPACE AGE

AN ADDRESS BY

JOSEPH G. THIBODAUX

TO THE

AEROSPACE PROPULSION TESTING ASSOCIATION
NASA MANNED SPACECRAFT CENTER
WHITE SANDS TEST FACILITY
DECEMBER 7, 1966

Completion of the Gemini Program last month marked NASA's sixteenth consecutive successful manned venture into Space. While every system and component did not work perfectly, the major mission objectives were accomplished and all crews were successfully recovered. Gemini paves the way for Apollo and inspires confidence that we can successfully land man on the moon and return them safely to earth.

The Apollo Program is the most complex engineering task men have ever attempted. Each discipline has exercised all the imagination and ingenuity it can muster to cram the most performance into the least volume and weight. All components and systems must function in ranges of environmental conditions not normally found on earth. The multitude of components and Subsystems has many interactions and interfaces with other components and systems. Many thousands of people are involved in all aspects of the program. All of this creates an unusual degree of complexity.

(Continued on page 45)

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The program requires that we develop this complex system to a high degree of maturity and confidence in a reasonable time and at a reasonable cost. We cannot afford to build thousands, or hundreds, or even tens of boosters and spacecraft and fly them to get the statistical confidence we would like to have. This is in real contrast to the practice of other industries. It is even in sharp contrast to past space industry practice. I have a friend who was a production engineer in an automatic transmission plant. He told me he could build and throw away ten thousand transmissions a year if it was necessary to set up his line properly and keep it turning out quality products. He also said that a complete transmission cost less than 40 dollars. At about$1,000.00 a pound or more, we can't afford to throw that much spacecraft hardware away.

We are being required to change our philosophy a bit. We are being required to show that the Government-Industry team has learned some lessons from all of the missile-space programs of the past and that these lessons can be applied to the Apollo Program.
The keystone in the arch of success in the program is test, test, and more tests. A thorough, comprehensive ground test program is the only way we can develop mature systems which will succeed in early flights. We are well down the road toward successful qualification of most of the major subsystems; I would like to review for you some of my impressions of the past pertaining to the Apollo test programs and philosophy.
Before discussing the Apollo test program and philosophy, I'd like to tell you something I learned about testing last week. Usually, when I'm asked to address a group, I consult my favorite reference authority "Webster's Dictionary" to bone up on the subject. How many of you in the audience know that the word "test" is derived from earlier words in English, French, and Sanskrit meaning cup, or a piece of burned clay pottery. The clay cups were used in assaying or refining precious metals in ancient times. For those of you who speak French, Spanish, Italian, or German, the words tasse, taza, tazza or tasse all mean cup and sound much like the English word test. Incidentally, the definition of test in the context we are here today is an examination, or trial to prove the value, or ascertain the nature of something and the method, or process for making such an examination.

In the Apollo Program, the general philosophy is to provide the maximum confidence for crew safety and in a secondary sense, provide reasonable confidence for mission success. The Program is designed to avoid loss of mission or crew as a result of single point failures. Where possible, redundant components are provided, and in many instances redundant systems are provided. For example, all primary propulsion systems have redundant valves in the engine and pressurization system. The reaction controls have two complete systems, either of which can successfully perform its required function. While we do not have redundant primary propulsion systems, each backs the other up. In the event of failure of the descent engine, the ascent engine is used in an abort mode. Likewise, in the failure of the Service Propulsion System, the descent engine can be used for a free return trajectory to Earth. Since the primary propulsion systems are non-redundant, successful completion of the mission requires their satisfactory operation — crew safety is not affected unless a failure is catastrophic; i.e., a large explosion, or that two primary propulsion systems fail on a single flight.

The objectives of our test program are first — to demonstrate that hardware design and manufacturing is satisfactory for operation under all normal conditions encountered in a lunar mission. Second to characterize the limits within which the system performs as a result of varying environmental conditions and manufacturing tolerances. And finally, to determine off-limits operating characteristics which result from a failure of one or more redundant components. An added feature of the test program is to verify satisfactory operation of servicing equipment and procedures, and the training of personnel, the fact that men fly the spacecraft propulsion systems makes the job more complicated. Booster engines always operate under preplanned conditions; i.e., fixed thrust programmed attitude and minor variations in duration. Spacecraft engines must operate on any mission duty cycle which can be flown within the limits of total propellant consumption and this is responsible for much of the complication in planning tests as well as designing and building hardware.

Above: Gemini 11 Maintenance. The Gemini 11 spacecraft is lowered onto a dolly for preflight maintenance before stacking on the Titan rocket at the Kennedy Space Center. Dick Gordon and Pete Conrad would liftoff in this spacecraft on September 12, 1966 for a mission lasting almost three days. The crew practiced docking with the Agena unmanned docking craft, and Gordon also performed two spacewalks during the mission. Image credits: Great Images in NASA (GRIN) for 1966.

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Section News

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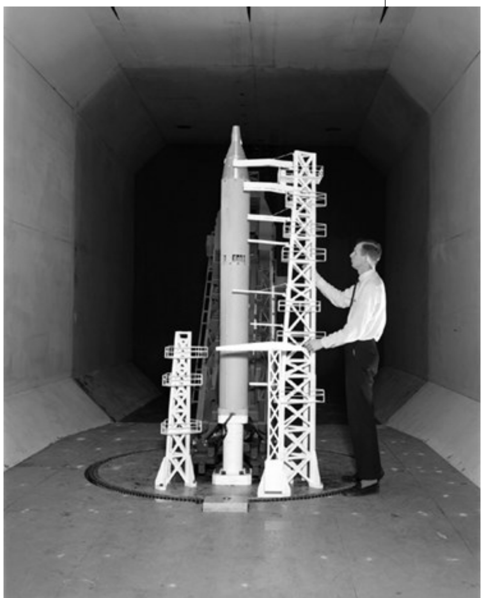

Above: Titan with Gemini capsule in the Transonic Dynamics Tunnel. Langley wind tunnel. Image credit: Great Images in NASA (GRIN). 1964.

A test program is usually composed of the following elements - hardware, facilities, software, paperwork and people. People are the most important part of the program as the other items are their creations. Let's discuss people first. Some of the key words relating people and test are philosophy, competence, rigor, discipline, planning, honesty, integrity, organizational motivation and teamwork. That's a big mouthful of words. We assume that people are competent, honest, and motivated; however, we still must recognize that each of us has a bad day. We also recognize that with such a large number of people participating in the program, even with excellent screening, a few who are not up to the required standards are hired. These inherent human failings are the most difficult to admit, and they are the ones which are most likely to cause troubles.

People in test are required to find not only the design or manufacturing mistakes made by others; they must also help ferret out their own weaknesses. This requires an unusual amount of honesty and integrity. A single unreported, or unadmitted mistake committed by a test specialist can destroy millions of dollars worth of hardware, cause unsafe hardware to be flown, or even cause major redesign of a system or component that was more than adequate With a program Costing $l0, 000,000 a day to run, such unnecessary redesign lengthens the program and results in the loss of many times the cost of a test or value of the hardware. We should give medals and awards for admission of honest mistakes committed in a test program, I would say that errors Committed in Apollo testing which were not surfaced have been a substantial cause of program slippage and increased program costs.

Motivation is another problem. Test people perform a service and often feel like frustrated designers who are not allowed to be very creative. Occasionally their attitude is "let's show those damned design engineers and manufacturing type that their designs and products are no good and proceed to tell them how it should have been designed or built in the first place". This is the "test specialist's backlash". We have experienced this attitude at some installations — White Sands is not one of them, This is not a healthy attitude.

We all perform a service for someone else and at times our role is dominant and at other times subservient Each of us must recognize when to be dominant or subservient - the proper times are different for different disciplines it is the job of management to make each group or organization feel like an equal member on the team, and to equally recognize creativity whether it be in test activities or design, or management, or operation, or manufacturing. When this is accomplished, motivation and the pride of accomplishment which is attendant with motivation will follow despite some of the hardships which I will touch on later.

We said people make honest mistakes, and we regretfully admitted that all people are not necessarily honest, in the consumer industry when this happens, someone is at the complaint window returning an article, or he complains bitterly to his friends and neighbors and stops payment on his account. Statistically, the number of poor articles a reputable manufacturer turns out is low; however, it is too high to accept in a manned space program. I cannot picture three astronauts returning an engine which failed to start. For this reason, planning, rigor, and discipline are important if we are to learn what is wrong with hardware and eliminate human error.

Good planning is always the first step. In a good organization, planning is accomplished through teamwork; the basic requirements are set up by engineering who designed the article to operate to a given set of specifications. Data requirements are also the responsibility of engineering. Manufacturing should be consulted on handling, assembly, disassembly and potential repair or modification of the test article. Operations should participate in servicing procedures and GSE performance. Test should be responsible for all facility—test article interfaces, data acquisition and processing and overall test planning and finally, the actual conduct of the test. This teamwork and communication is not always evident; in fact, it is sometimes nonexistent and is replaced with parochial or provincial

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Section News

attitudes and interest which cause jurisdictional disputes that result in inefficiency, foot dragging and buck passing. This is one of the things you can least tolerate or forgive in an organization because it is caused by pettiness, poor organization and poor management, and has nothing to do with individuals technical competence or honesty. This has been responsible for a considerable loss in efficiency on Apollo.

The continued coordination throughout the program is a must. The loop must repeatedly be closed between all parts of an organization all the way through the last segment of the organization until completion of the program.

Rigor and discipline are important. In qualification testing, each step must be defined and rigorously adhered to. This is extremely necessary where many people are involved in testing complex hardware in an equally complex facility. It provides the only opportunity to learn exactly what was wrong with the article, the facility, the procedure, or the planning and an opportunity to verify what was wrong. We insure rigor and discipline by inspection and quality assurance.

This is an affront to the test specialist's dignity to have someone checking upon his every move. If he participated in the detailed planning, is it unreasonable to expect him to do what he said in the order he said he was going to do it? People check drawings for mistakes, calculations for mathematical errors, contracts for legal loopholes, manufacturing for discrepancies in materials or tolerances, audit money handlers for honesty, edit reports and documents - which is really exempt? And yet I know of games people play with millions of dollars worth of hardware just to see if an inspector can catch someone's willful mistake, Remember ,inspectors aren't perfect either. A successful program requires everyone's best effort and cooperation.

Hardware and the facility which tests it can present many difficult problems, Often management dictates that old facilities be used because they are available and have not returned their capital investment this is certainly permissible if they can accomplish the job efficiently and above all on time. Remember, if a test causes a system to pace a launch - we lose $10,000,000 a day for each day of delay.

With new, complex hardware, often new complex facilities are required. Generally, they can be planned, constructed, and shaken down while the spacecraft system is being designed and manufactured. The facilities-hardware interfaces must be thoroughly studied and test procedures and other necessary paperwork planned well in advance, Teamwork and participation of the test organization, the program, cannot occur too early, Lack of proper planning, paperwork, and shakedown of facility-test article interfaces can result in catastrophes or near catastrophes, we always hope for the latter. It is our Policy to run a formal acceptance inspection of all test articles at the plant, and all facilities prior to operation The inspection team is empowered to require any obvious discrepancies to be corrected before operation In the case of the test facility inspection — we call these Operational Readiness inspections — not only the actual physical facility is considered, but the state of readiness and training of personnel, and their organization is considered.

Usually one mandatory requirement is a detailed failure modes and effects analysis, this is an analysis which assumes failures of critical items in the facility and evaluates its effect on the safety of personnel or potential damage to test article or facility. Some of the results are quite interesting. Often, we do not catch all potential failure modes in the analysis - they show up in testing. Again, we hope none are catastrophic or result in injury to people. In general, despite all of the complexity, rigor, discipline and frustration, the qualification programs on Apollo are proceeding well and at this time are not pacing the program. We have had many spectacular failures, and I cannot say with all honesty that we could not have accomplished more with less effort. I must say that as one who has been in some facet of the business of testing during my entire professional career, I understand the frustrations of the business. I know it seems that test hardware deliveries are always late -That the hardware is never shipped complete - and that supporting GSE never operates properly, I also know that the test organization is usually the last one to be called into the program and the last one to be advised of the test requirements. I also know that all schedule slippages are to be made up by the test organization. I've seen for myself the long hours worked each day seven days a week for months at a time.

Above: Apollo Block II Saturn I aerodynamic integrity. Langley wind tunnel. Image credit: Great Images in NASA (GRIN).

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Above: Vacuum instrumentation research at Lewis Research Center, now John H. Glenn Research Center. Image credit: Great Images in NASA (GRIN). 1960. Aeronautical research.

Likewise, I have talked to many people who changed jobs and wound up in a test organization. Many have told me they have never had such a challenging, interesting and

rewarding job. I consider the early apprenticeship I served in a test organization the most valuable experience I have received, and as a matter of policy, I require cooperative students assigned to my organization to spend part of their on-the-job training in our Thermochemical Test Branch. The contributions of testing to the Mercury, Gemini and Apollo Programs are quite evident. I'm sure many in the audience were outstanding contributors to the success of these programs, I hope your deliberations here today and tomorrow am fruitful and enlightening, and will contribute to even more efficient test operations in the future. Test hardware, facilities, manpower, and time are the major items of expense in the development of spacecraft and boosters. We need all the talent and help we can get.

Above: Image credit: Copied from an earlier page in this issue, four pages before this page.

Right: Excepts from the Thibodaux biography on the NASA oral history web site.

NASA Johnson Space Center Oral History Project
Biographical Data Sheet

NAME: Joseph Guy Thibodaux, Jr.

EDUCATIONAL BACKGROUND:
BS in Chemical Engineering, Louisiana State University, Baton Rouge, Louisiana 1942

MILITARY EXPERIENCE: Officer, United States Army (1943-1946)

PRE-NASA CAREER:
Officer, United States Army Corps of Engineers, Burma, Pacific Theater of Operations (1943-1946)

National Advisory Committee for Aeronautics (NACA) Langley Memorial Aeronautical Laboratory/Langley Research Center, Langley Field, Virginia
Propulsion Engineer, Pilotless Aircraft Research Division (PARD) (1946-1949)
Head, Model Propulsion Section, PARD (1949-1955)
Head, High Temperature Materials Section (1955-1958)

NASA CAREER:
NASA Langley Research Center, Langley Field, Virginia
Chief, High Temperature Materials Branch (1958-1964)
Consultant to Space Task Group (STG) Director (1958-1964)

Chief, Propulsion and Power Division, NASA Manned Spacecraft Center/Lyndon B. Johnson Space Center, Houston, Texas (1964-1980)

PROFESSIONAL & HONORARY SOCIETIES:
- Fellow, American Institute of Aeronautics and Astronautics (AIAA)
- Chairman, Houston Section AIAA
- Member, AIAA Technical Committee on Solid Rockets
- Member, NASA Research Advisory Committee on Chemical Propulsion
- Member, Interagency Chemical Rocket Propulsion Group

AWARDS & CITATIONS:
- NASA Exceptional Service Medal (twice in 1969)
- AIAA James H. Wyld Propulsion Award (1970)

Our History Committee's Audiobook Project

Douglas Yazell, Editor

Ted Kenny is making great progress on the audiobook version of Suddenly Tomorrow Came… A History of the Johnson Space Center. Ted is the AIAA Houston Section Chair of the History technical committee. The book's author, Dr. Henry C. Dethloff, will do a little bit of reading for the audiobook eventually.

Ted set up a recording studio at a desk in his office at NASA / JSC. An ordinary desk has blankets draped over a structure designed to allow a reader to sit at the desk and read while ambient noise is reduced or eliminated. He did an impressive job with his own reading and editing, then he invited me to read about eight pages from the start of Chapter One. Ted might be able to edit my work into something we can keep, but I prefer to do it again one day so that I can actually follow the instructions he placed on our Google documents. Some preparation is required at least a day in advance.

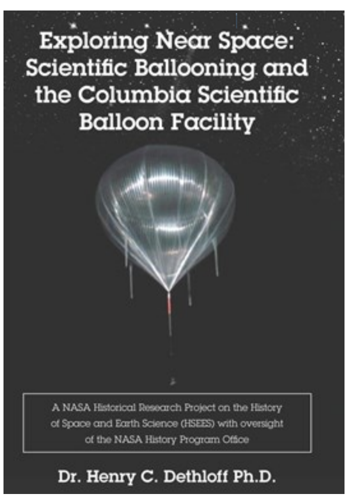
Dr. Steven E. Everett and Norman Chaffee are two other readers lined up so far. Quite a few readers and proofers will be needed. Volunteers can contact us in the usual ways, including the email address on page four of every issue of Horizons.

At Norman's request, Ted will also use his excellent sound studio for the NASA Alumni League (NAL-JSC) oral history project. Great work has already been done on that NAL-JSC task, but it slowed down recently, though the need is as great as ever.

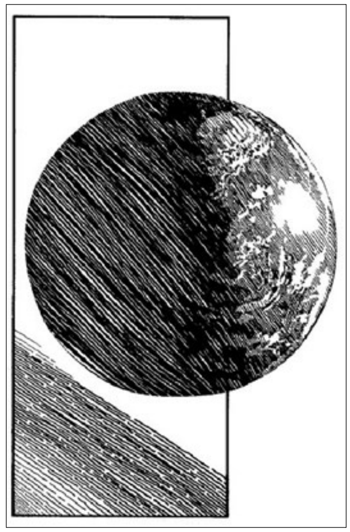
Dethloff, Texas A&M University Professor Emeritus of history, received his undergraduate degree from the University of Texas, his MA from Northwestern State University (Louisiana), and Ph.D. from the University of Missouri. He served on active duty in the Navy (1956-1958) and in the Navy Reserves to 1969. He taught at the University of Southwest Louisiana (1962-1969) and Texas A&M University (1969-1999), also serving as Department Head (1980-1985). He retired in 1999 as Professor Emeritus. He is now President of Intaglio Research (1982-present).

Dethloff is the author or co-author of more than thirty books. He edited *Aerial Navigation* (Intaglio Press, 2003), a translated edition of a 1903 French publication on the history of flight.

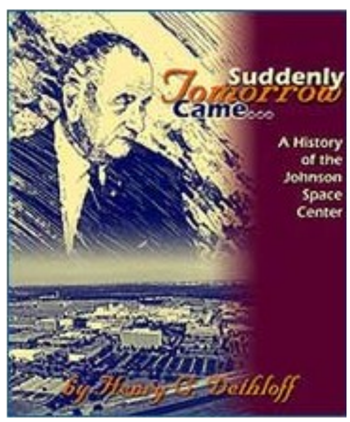
Above: Author Dr. Henry C. Dethloff. Image credit: Dr. Dethloff.



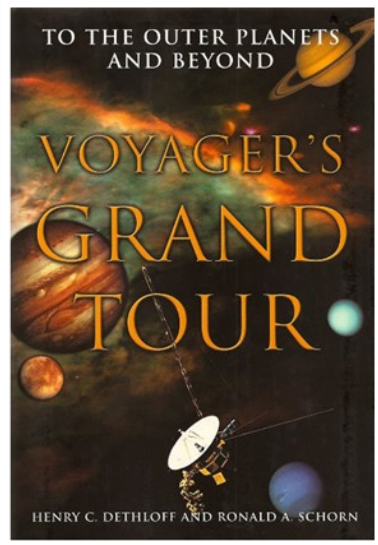
Above: This 2012 book by Dr. Henry Dethloff reminds us that AIAA Houston Section includes two NASA facilities, NASA / JSC in Houston, Texas and the subject of this book in Palestine, Texas. Image credit: Amazon.



Above: Chapter 17. Space Station Earth. From the book Suddenly Tomorrow Came… A History of the Johnson Space Center. Image credit: NASA.



Above: The 1993 book by Henry C. Dethloff. Ted Kenny, Chair of AIAA Houston Section History technical committee, is leading a team in creating the audiobook. Norman Chaffee and Dr. Steven E. Everett are two of the readers signed up so far. A third reader is the author, Henry C. Dethloff. Image credit: NASA/JSC.

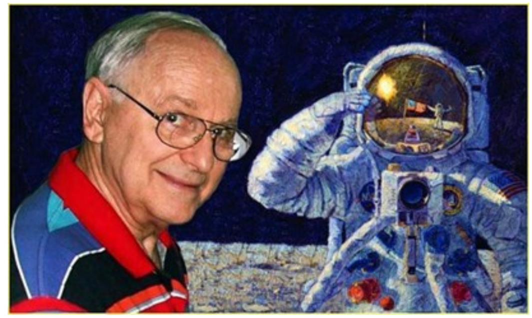


Above: Voyager 1 and Voyager 2 were launched in 1977. Since then they have traveled farther than any human object. Voyager 1 is now more than ten billion miles from the sun and is headed to the utmost boundary of our solar system. This 2003 book originally published under the auspices of the Smithsonian Institution tells the story of their journey through the solar system and beyond. The authors' unparalleled access to NASA archives and imagery make this the authoritative work on the subject. The book includes eight pages of photographs and computer generated imagery and black and white photos throughout. Image and text credit: Amazon.

Student Section News

Rice University AIAA Student Section Advisor:
Professor Andrew Meade, *meade[at]rice.edu*
713-348-5880, www.ruf.rice.edu/~meade/

Above: Image credit: Rice University.



Right: Artist and NASA Skylab and Apollo astronaut Alan Bean spoke at Rice on March 21, 2013. The video is no longer online at this link. Image credit: Rice University.

Team Aether in the AIAA Design / Build / Fly Competition

CLAY STANGLE, AIAA HOUSTON SECTION TREASURER

The students of Team Aether at Rice University will be putting a year's worth of hard work in the air at the end of April. These students have entered an AIAA Design/Build/Fly competition that is doubling as some of the students' senior design engineering projects. The team is made up of both seniors and underclassmen and three exchange students from Tunisia via web meeting last semester and who are on campus this semester. They have been meeting on a weekly basis since last August, with mentors Clay Stangle from Boeing Houston and Justin Figueroa from Boeing Seattle who is former Rice student. Justin participated in the same competition.

The goal is to build a remote controlled aircraft from scratch, using no outside machining, that completes the three missions from the competition. Sizing and shape guidelines were derived from these requirements and the students were graded in their senior design class by how well they perceived these requirements and met them. This semester the students are procuring their materials and are building the plane. This is a great learning experience for the students as they are building the craft; having to find and decide what materials to use and what things are needed beyond their original design and what things won't work.

The Tunisian students are electrical engineers and are providing the electronic avionics and propulsion aspects of the aircraft. They are also in charge of the website and media sharing that the ten-member team utilizes to keep in touch, as well as the some of the virtual testing that was done with a model of the students' plane. Some of the underclassmen are members of the Rice AIAA student chapter. They are helping the team with design and build aspects, as well as making travel arrangements to help get the team to Arizona for the competition.

Above: Members of Team Aether. Image source: Clay Stangle, AIAA Houston Section.

Above: Image credit: Rice University.

Student Section News

Please send inputs to Dr. Gary Turner, our College and Co-Op Chair. His e-mail address is: *collegecoop2012[at]aiaahouston.org* His backup for this task is Editor Douglas Yazell: *editor2012[at]aiaahouston.org*. Our Section's web page lists the related websites. We publish most bimonthly issues at www.aiaahouston.org by the last day of each even-numbered month, and the submissions deadline is three weeks earlier. The November / December issue is an exception. It is published by December 10, not December 31.

Student Section News

The Texas A&M University AIAA student section started work on its web site for the new year as of August 10, 2012: http://stuorg-sites.tamu.edu/~aiaa/

TEXAS A&M UNIVERSITY

Faculty advisor: Professor John E. Hurtado, *jehurtado[at]tamu.edu*, 979-845-1659.

Brian Freno '08 Chair	Bob Cline '13 Speaker Chair	Chris Greer Graduate Representative
Rahul Venkatraman '13 Vice Chair	Nhan Phan '14 SEC Chair	Nicholas Ortiz '13 Senior Class Representative
John Guthery '11 Secretary	Travis Dawsey Activity Chair	Alejandro Azocar '14 Junior Class Representative
Erica Lovig '13 Treasurer	Nick Page '16 Publicity Chair/ Webmaster	Logan Hodge '15 Sophomore Class Representative
		Jacob Shaw '16 Freshman Class Representative

Valasek, John

Professor

Turner, James D.

Director Of Operations, Cass

Vadali, Srinivas Rao

Professor

Junkins, John

Distinguished Professor

Regents Professor

Holder of the Royce Wisenbaker Chair

Above: A few of the outstanding aerospace engineering faculty of Texas A&M University. They often help AIAA Houston Section, along with others including Professors Daniele Mortari, John E. Hurtado, David Hyland and Tom Pollock.

Student Section News

Please send inputs to Dr. Gary Turner, our College and Co-Op Chair. His e-mail address is: *collegecoop2012[at]aiaahouston.org* His backup for this task is Editor Douglas Yazell: *editor2012[at]aiaahouston.org*. Our Section's web page lists the related websites. We publish most bimonthly issues at www.aiaahouston.org by the last day of each even-numbered month, and the submissions deadline is three weeks earlier. The November / December issue is an exception. It is published by December 10, not December 31.

Collier's 1952-54

Man Will Conquer Space Soon! (1952-54)

DOUGLAS YAZELL, EDITOR

The Horizons Collier's Team

Douglas Yazell, Editor
Scott Lowther, Aerospace Projects Review (APR)
Dr. Albert A. Jackson IV
Ron Miller, Black Cat Studios
Melvin Schuetz, bonestell.com
Frederick Ira Ordway III
John Sisson, Dreams of Space
Arthur M. Dula
Shirazi Jaleel-Khan

Quite a few more people make these articles possible, including the Horizons team listed on page 2. Thanks to all involved!

In this issue of Horizons we present the fifth of eight installments in this Collier's space series, Man Will Conquer Space *Soon!*

Colin Davey sent us a two-page article about the start of this Collier's series in a 1951 conference in San Antonio, Texas! That appears later in this issue.

Our advertisements from the Heinlein estate include a four-page newsletter about the Virginia Edition of Heinlein's writing. It is a privilege to be a part of something new from the late (1907 - 1988) Robert A. Heinlein.

Heinlein took a phone call at his home in Colorado Springs, Colorado in 1957 from a 16-year-old Albert A. Jackson IV, who was passing through town with his family while on vacation from Dallas, Texas. Our Horizons Collier's team member Al was asking for a signature. Heinlein said yes to the request, but there was a

(Continued on page 53)

	"Man Will Conquer Space Soon!" in 8 Issues of the Weekly Magazine Collier's 1952-54	Cover Image	Page Count
1	March 22, 1952: Man Will Conquer Space Soon! What are we Waiting For? pp. 22-23, The Editors Crossing the Last Frontier, pp. 24-29, 72, 74, Dr. Wernher von Braun A Station in Space, pp. 30-31, Willy Ley The Heavens Open, pp. 32-33, Dr. Fred L. Whipple This Side of Infinity, pg. 34, Dr. Joseph Kaplan Can We Survive In Space? Pp. 35, 65-67, Dr. Heinz Haber Who Owns the Universe? Pp. 36, 70-71, Oscar Schachter Space Quiz Around the Editor's Desk, pp. 38-39	Yes	25
2	October 18, 1952: Man on the Moon Man on the Moon, p. 51, The Editors The Journey, pp. 52-58, 60, Dr. Wernher von Braun Inside the Moon Ship, pg. 56, Willy Ley	Yes	11
3	October 25, 1952: More About Man on the Moon The Exploration, pp. 38-40, 44-48, Dr. Fred Whipple & Dr. Wernher von Braun Inside the Lunar Base, pg. 46, Willy Ley	No	10
4	February 28, 1953: World's First Space Suit Man's Survival in Space, 10 Contributors & 3 Artists, edited by Cornelius Ryan pp. 40-41 Picking the Men, pp. 42-48	Yes	10
5	March 7, 1953: More About (Continuing) Man's Survival in Space Testing the Men, pp. 56-63	No	8
6	March 14, 1953: How Man Will Meet Emergency in Space Travel Concluding Man's Survival in Space: Emergency! pp. 38-44	Yes	9
7	June 27, 1953: The Baby Space Station: First Step in the Conquest of Space Baby Space Station, pp. 33-35, 40, Dr. Wernher von Braun with Cornelius Ryan	Yes	6
8	April 30, 1954: Can We Get to Mars? / Is There Life on Mars? Is There Life on Mars? pg. 21, Dr. Fred L. Whipple Can We Get to Mars? pp. 22-29, Dr. Wernher von Braun with Cornelius Ryan	Yes	10

This issue

Above: Man Will Conquer Space Soon!, a series of articles from 1952 to 1954, from the weekly magazine Collier's. Source for most of the table: Wikipedia, Man Will Conquer Space Soon!, an article first written by John Sisson.

Collier's 1952-54

(Continued from page 52)
small problem. That one-page story is presented a few pages later in this issue.

AIAA Houston Section will hold its Annual Technical Symposium (ATS 2013) at NASA / JSC Gilruth Center from 7:45 AM to 4:30 PM. A social gathering might take place at 5:00 PM, too, at the nearby Hilton Hotel on NASA Road 1 (NASA Parkway). Horizons Collier's team member Art Dula is scheduled to be a member of the keynote panel discussions at the luncheon.

The 2004 Ansari X-Prize gave a boost to private space industry just as the 1952 - 1954 Collier's series gave a boost to the American space program. Anousheh Ansari will be a morning keynote speaker at ATS 2013. She will also be a member of the keynote panel discussion during the luncheon. Ansari became an astronaut and space tourist in 2006 with her eight-day stay [Wikipedia] aboard the International Space Station (ISS).

I send my apologies to our readers as this March / April 2013 issue of Horizons arrives online at www.aiaahouston.org a bit later than its deadline of April 30, 2013. We had a good run of on-time publication since about the time I started as editor on April 11, 2011.

The May / June issue of Horizon is scheduled to be online by May 31, 2013. Once we conclude the Horizons Collier's series in our September / October 2013 issue, we can turn our attention to publishing the entire Collier's series of about 89 pages in a single publication.

Issue 3 of 8:
The cover image
is not related to
Man Will Conquer Space Soon*!*

This issue of Horizons

Issue 5 of 8:
The cover image
is not related to
Man Will Conquer Space Soon*!*

Above: Image credits: Scott Lowther, with help from other Horizons Collier's team members.

Collier's 1952-54

San Antonio & the Genesis of the Collier's Series, "Man Will Conquer Space Soon!"

COLIN DAVEY

Above: Walt Disney, left, and Wernher von Braun, right. Dr. Wernher von Braun, then Chief, Guided Missile Development Operation Division at Army Ballistic Missile Agency (ABMA) in Redstone Arsenal, Alabama, was visited by Walt Disney in 1954. In the 1950's, von Braun worked with Disney Studio as a technical director, making three films about space exploration for television. A model of the V-2 rocket is in background. Image source: Wikipedia. Image credit: NASA.

The *Collier's Man-Will-Conquer-Space-Soon* series arguably made the American space program possible by making space travel seem real in the minds of the American public, thus generating enthusiasm necessary to support the massive expenditure of tax dollars.

And one event arguably made the *Collier's* series possible: the innocuously titled *Symposium on the Physics and Medicine of the Upper Atmosphere*, held in San Antonio Texas, November 6-9, 1951. That event brought Wernher von Braun together with Cornelius Ryan and Chesley Bonestell for the first time.

Although most Americans were skeptical about space travel at the time of the Collier's series, space-travel had been largely shown to be technologically feasible. And that was largely due to the efforts of Wernher von Braun. Von Braun was a student of Hermann Oberth, one of the fathers of rocketry and astronautics (along with Konstantin Tsiolkovsky and Robert H. Goddard.) He started experimenting with rockets and writing about the science of space travel as a teenager in the 1920s. From approximately 1933 to 1950, he was sequestered away working on secret rocket-related military projects, first for the Nazis, and after World War II, for the Americans. But he was unable to apply his craft directly on behalf of his dreams of artificial satellites and trips to the Moon and Mars. In fact, at one point, he was arrested by his Nazi employers for two weeks for diverting attention from weapons development to space travel.

Once in America, von Braun was freer to discuss his dreams of space travel to whoever would listen, but he hadn't yet found a platform that received the mass public attention he desired. One obstacle he had to overcome was his Nazi past. For example, he was not invited to the Hayden Planetarium symposium. And although he was invited to attend the San Antonio symposium, he wasn't asked to speak. As Fred Whipple said, "at that time, von Braun was sort of in the doghouse, for some people did not want a German engineer sending up our first satellite."[1] Whipple was the chairman of the Harvard Astronomy Department. He had spoken at the Hayden Planetarium symposium, the San Antonio symposium, and was a contributor to the *Collier's* series.

Although *Collier's* associate editor and reporter Cornelius Ryan was very skeptical and uninformed about astronautics and space travel, he attended the San Antonio symposium because he was sent by *Collier's* managing editor Gordon Manning. Several weeks earlier, on October 12, a few *Collier's* reporters had attended the F*irst Annual Symposium on Space Travel* at the American Museum of Natural History's Hayden Planetarium in New York. Manning was intrigued by what he heard from his reporters, so when he read a brief article about the upcoming San Antonio symposium in the *New York-Journal American*, he decided to send Ryan.[2]

Manning also sent artist and space-travel visionary Chesley Bonestell to San Antonio. Bonestell, who had done some work for *Collier's* before, developed an early interest in astronomy before developing a career in architectural art. In the 1940s, he combined his artistic skill with his interest in astronomy, developing a uniquely realistic style of space art, which he published in numerous national magazines, beginning with a series of stunning paintings of Saturn viewed from various moons of Saturn, published by Life Magazine in 1944. Bonestell had collaborated with space-travel visionary Willy Ley on the book "The Conquest of Space," published in 1949. Ley was the organizer of the aforementioned Hayden Planetarium symposium, and a key contributor to the *Collier's* series.

(It was Willy Ley who originally introduced von Braun to Oberth in 1930.[3] In 1935, as the Nazis rose to power, Ley fled Germany to America. In 1946, shortly after von Braun defected to America, he reunited with Ley, visiting him in Queens, N.Y.[4])

In addition to Ryan, Bonestell, von Braun, and Whipple, several other San Antonio attendees became contributors to the *Collier's* series, including: Fritz Haber, Heinz Haber, Joseph Kaplan and Hubertus Strughold.[5]

By all accounts, Ryan came to

(Continued on page 55)

(Continued from page 54)

the conference very skeptical and uninformed about the concept of spaceflight, and was unable to follow the very technical discussions. According to Kathryn Ryan (Cornelius Ryan's widow), at one point, "He was sitting in a room where this rather striking blue-eyed blond German was at the blackboard, chalking all sorts of mathematical equations. Suddenly, there was a sort of collective gasp around the room; there seemed to be a tremendous amount of excitement in the air. Connie [Ryan] happened to be seated next to Chesley Bonestell, whom he knew, and Chesley was as excited as everyone else. Connie asked Chesley: 'What's going on here?' Chesley [who also hadn't met von Braun before San Antonio] replied: 'Dr. von Braun has just shown us a way to go into space!'"[6]

Von Braun himself relates: "Leaving one of the sessions and stepping [up] to the bar of the hotel... I made the acquaintance of a good-looking Irishman who, gazing at the crystal highball between his hands, was sunk in a brown study. 'They've sent me down here to find out what serious scientists think about the possibilities of flight into outer space,' he growled. 'But I don't know what these people are talking about. All I could find out so far is that lots of people get up there to the rostrum and cover a blackboard with mysterious signs.' I volunteered to help."[7]

Whipple also met von Braun for the first time at San Antonio: "I was delighted to meet him because I felt that he would be the man who was going to put us into space."[8]

Whipple described an evening when he, von Braun and Joseph Kaplan (a professor of upper atmospheric physics at UCLA, and one of the symposium's organizers) cornered Ryan at a table in the dining room. Long into the night, over cocktails, dinner, and after-dinner cocktails, "The three of us worked hard at proselytizing Ryan." According to Whipple, "That evening he appeared to be highly skeptical... Von Braun... [was] certainly one of the best salesmen of the twentieth century. Additionally, Kaplan carried the aura of wisdom and the expertise of the archetypal learned professor, while I had learned by then to sound very convincing."[9]

As a result, according to Mrs. Ryan, "He was absolutely convinced. He came back trying to figure out how to get *Collier's* interested in space stations, spaceships, and flights to the Moon."[10]

The first issue hit the newsstands four months later and the rest is history.

Colin Davey (web page www.colindavey.com) is author with Thomas A. Lesser, Ed.D. of The Heavens in the Attic: The Hayden Planetarium (1935-1997) *(in preparation). He also author with Frank Poloney of* Learn Boogie Woogie Piano.

Thanks to John Sisson, research librarian and author of the Dreams of Space *blog for supplying hard-to-find source material.*

[1]Neufeld p 256, Stuhlinger & Ordway p 112
[2]Liebermann 1992 p 135
[3]Neufeld p 39
[4]Neufeld p 232
[5]List of attendees from White & Benson
[6]Stuhlinger & Ordway p 113
[7]Neufeld p 256
[8]Stuhlinger & Ordway p 112
[9]Whipple p 128-129
[10]Stuhlinger & Ordway p 113

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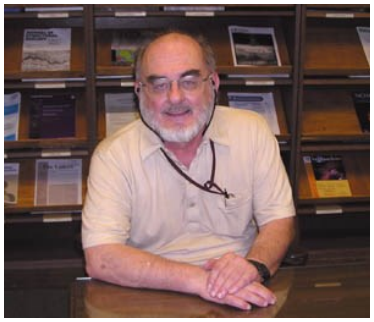
Collier's 1952-1954

The 1957 Encounter: Robert A. Heinlein and Albert A. Jackson IV

DOUGLAS YAZELL, EDITOR



Above: Dr. Albert A. Jackson IV, in a photograph from the web site for the Lunar and Planetary Institute.

Robert Heinlein (July 7, 1907 - May 8, 1988) took a phone call at his home in 1957 from a 16-year-old Albert Jackson. It is a privilege for Horizons to present advertisements in this and recent issues from the Heinlein estate regarding the Virginia Edition of Heinlein's writing. One of our Horizons Collier's team members, Dr. Albert A. Jackson IV, has a nice Heinlein souvenir, a postcard from Heinlein to Al postmarked August 8, 1957, from Colorado Springs, Colorado.

Al's father was taking the his family by car from Dallas to Colorado for a vacation, which meant fly fishing for Al's father. Mr. and Mrs. Jackson were in the car with their three children, Al, his younger brother, and their sister, the youngest. After they crossed most of Colorado Springs, Colorado, they stopped at a service station. Al looked up the phone number there for the famous author and found Heinlein listed in the book. Al put a nickel in the slot and called him to ask for an autograph for a paperback copy of the novel for juvenile readers, Starman Jones.

Heinlein said sure, I will tell your parents how to drive to my home. Once Al's mother was on the phone to get directions, it became clear that a drive back across town was required, and the parade down their main street would block most of the desired routes. A man at the service station explained how difficult the drive would be, and Al's father did not want to take the time.

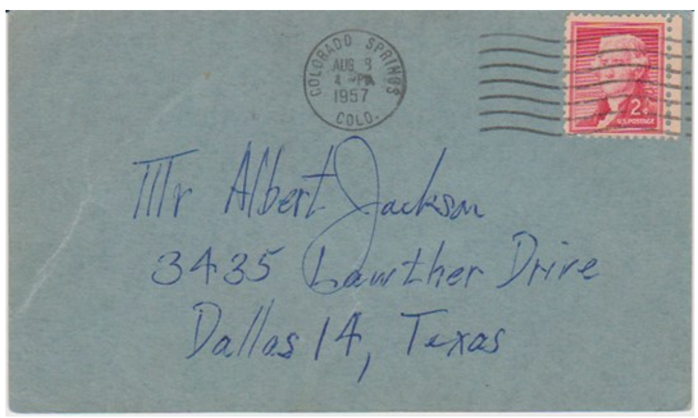
Heinlein then volunteered to make a note of Al's address and send a postcard.

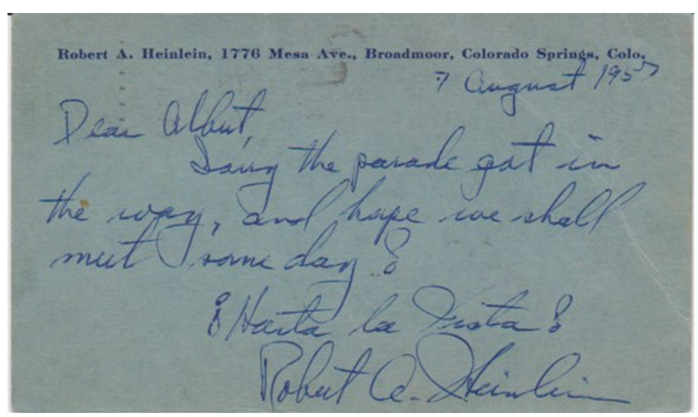
The parade that gave them so much trouble was not a July 4 Independence Day parade, but it was probably July or August of 1957.

In 1979 Al was editor of the newsletter of the San Francisco Section of AIAA. Al was given the task of contacting Heinlein to ask the author to be a dinner speaker. Heinlein's address at his home in California was private, but Al found the address from a graduate of the Naval Academy. Al sent the request along with a copy of the postcard. Heinlein phoned Al to explain that not enough time had passed since his brain surgery, so he would not be able to travel to the dinner meeting.

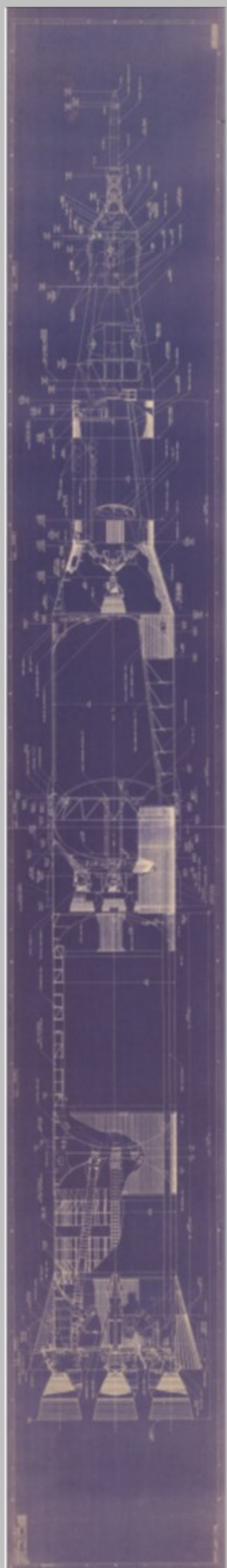
As noted in earlier issues of Horizons, Al was inspired by the Collier's series of articles, Man Will Conquer Space Soon! Al earned his master's degree before working as a crew instructor for the backup lunar module trainer during the Apollo program. He then left NASA to pursue his Ph.D. in physics, taking a short break from AIAA, too. He returned to the NASA / JSC community as a contractor employee, no longer a civil servant.

Al is now an AIAA Associate Fellow, a Fellow of the British Interplanetary Society and a visiting scientist at the Lunar and Planetary Institute in Houston.





Above: The 1957 postcard from Heinlein to Jackson. Image credit: Dr. Albert A. Jackson IV.



Saturn V Inboard Profile Prints Now Available

Approximately six feet long, this full-color print is a reproduction of NASA-MSFC drawing 10M04574, the Apollo 8 Saturn V. Looks great ! Hang one on your wall and be the envy of all your co-workers. Available for $35 plus postage at up-ship.com

http:/www.up-ship.com

Lunar Module Equipment Locations diagrams

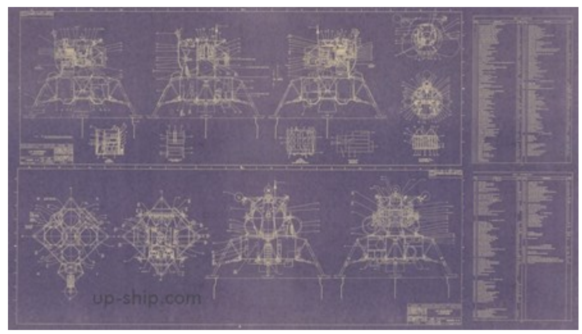
Full color, high quality print of NASA-MSC drawing dated January 1969 showing the Lunar Module and many of the important bits of equipment that went into it.

Prints are about 32 inches/81 cm wide by 18 inches/46 cm tall.

The original was B&W. It has been converted to a full-color "blueprint" using the Saturn V as a color reference.

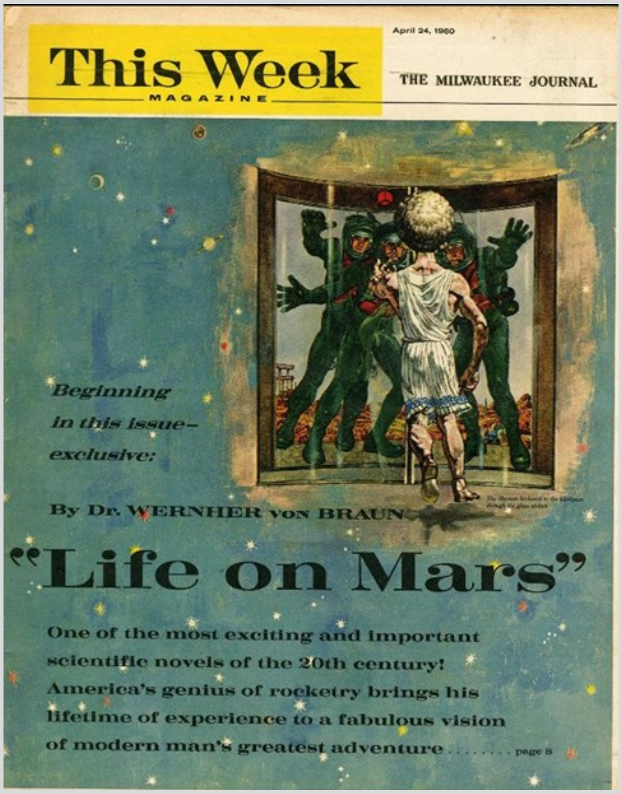
http://www.up-ship.com/drawndoc/saturnvprints.htm

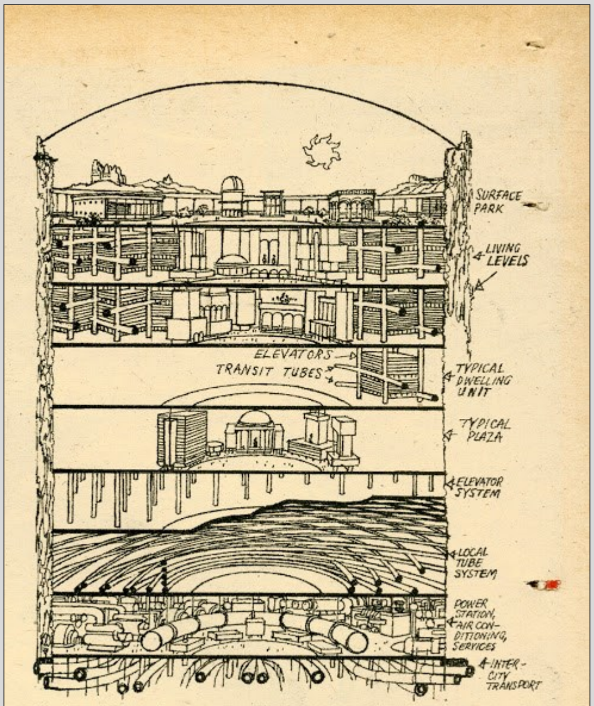
$25



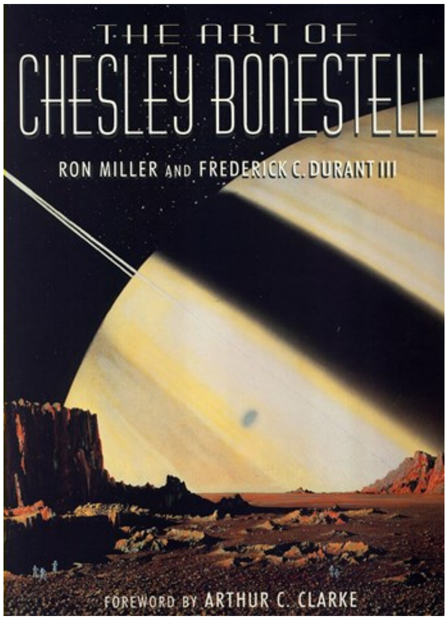
Dreams of Space
Books & Ephemera

Non-Fiction Children's Books
about Space Flight from 1945 to 1975
http://dreamsofspace.blogspot.fr





Ahla was built in 15 circular plazas



Award winner Ron Miller & Black Cat Studios

Ron Miller, winner of the 2002 Hugo Award (World Science Fiction Society) for Best Related Work: The Art of Chesley Bonestell

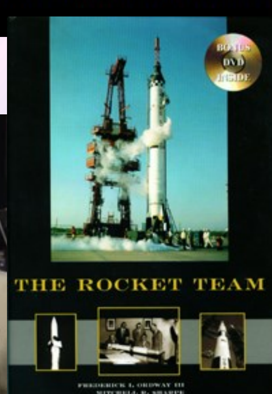
The Chesley Bonestell Archives of Melvin H. Schuetz

www.bonestell.com

A former satellite controller in the U.S. Air Force and private industry, Melvin H. Schuetz has researched and collected publications from around the world containing Bonestell's art for more than four decades. His book, A Chesley Bonestell Space Art Chronology, is a unique reference bibliography containing detailed listings of over 750 publications which have included examples of Bonestell's space art.

Space scientist and well-known author of visionary books on spaceflight. Ordway was in charge of space systems information at the Marshall Space Flight Center from 1960 to 1963 and before that performed a similar function for the Army Ballistic Missile Agency. For many years he was a professor at the University of Alabama's School of Graduate Studies and Research. However, his greatest contribution has been to the popularization of space travel through dozens of books that he has authored or coauthored. He was also technical consultant to the film 2001: A Space Odyssey and owns a large collection of original paintings depicting astronautical themes. Ordway was educated at Harvard and completed several years of graduate study at the University of Paris and other universities in Europe.

www.cgpublishing.com



Frederick Ira Ordway III

Co-Author with Mitchell R. Sharpe of The Rocket Team

Dreams of Space, Books & Ephemera

Non-Fiction Children's Books about Space Flight from 1945 to 1975

http://dreamsofspace.blogspot.fr

Classics Illustrated were comic books intended to educate as well as entertain. They often were fictional "classic" books in comic book form such as Moby Dick. They also had a special series called "The World around Us." These were non-fiction comic books about topics of interest.

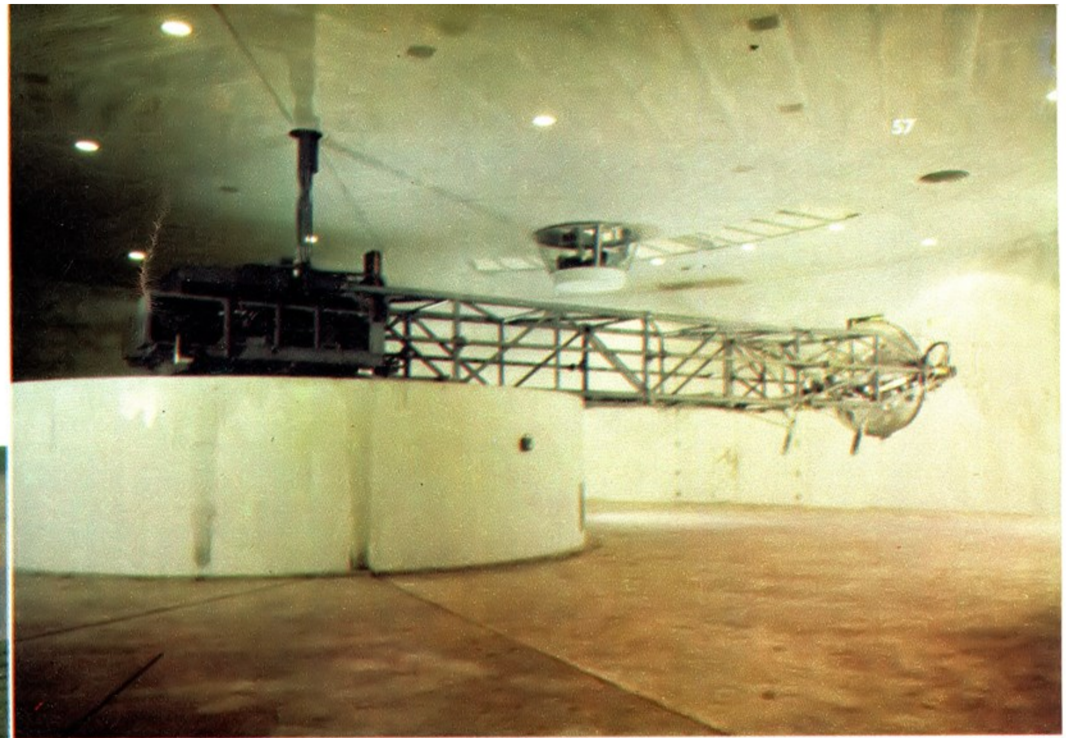
Classics Illustrated. Illustrated by Gerald McCann, Sam Glanzman and John Tartaglione. The Illustrated Story of Space (80 pages), 26 cm, softcover.

Contains illustrated stories on training for space, the first rocket to the Moon, the history and use of the rocket, the launch of Vanguard 1 and the construction of a space station. "The World Around Us" (#5) January 1959.

Testing the Men

ROLF KLEP

Disaster is the penalty for an error in space. The pioneer rocket crews will practice for perfection on earth, aided by a gallery of wonderful machines



RALPH ROYLE

Navy centrifuge at Johnsville, Pa., one of several in use to simulate acceleration force

Eleven top experts contributed to the symposium, Man's Survival in Space. This part, the second of three, is based on papers done by Dr. Wernher von Braun, chief, Army Guided Missiles Laboratory; Dr. Hubertus Strughold, head, Air Force Dept. of Space Medicine; Dr. Fritz Haber of the same agency; Dr. Donald W. Hastings, national psychiatric consultant to the Air Force; Dr. James P. Henry, Air Force Aero Medical Laboratory; rocket expert Willy Ley. Collier's Cornelius Ryan assembled the material

HOW do you make a space man out of an earth man? The tests a human encounters in space, the tasks he is charged with in rocket flight, are like nothing he knew on solid ground: flattening acceleration pressures; brain-twisting navigational problems; nerve-racking confinement in cramped quarters; the problem of moving from one point to another when you're hovering 1,000 miles above the ground. No man experiences such difficulties on earth. How does he prepare to meet them in space?

He must prepare on the ground. When he actually gets into space, it will be too late to start learning. Massive, dramatic machines are the teachers—and they already are roughly blueprinted.

One machine (you can see it at the left) will whirl crews around at speeds that reproduce the breath-taking, body-crushing pressures imposed by a fast-rising rocket ship. As the trainer rotates, problems will be fed into the cabin requiring split-second, co-ordinated action from the nearly immobilized crew.

A second machine will teach man to move around in the weightlessness of space. He'll spin, cartwheel, fly violently backward, roll and twist until he gets the hang of self-locomotion.

Trainees also will be jammed together for days in a sealed, boilerlike chamber—working, sleeping, eating, relaxing in a confined space and in a pressurized, synthetic atmosphere.

Navigators dare not be wrong in space; a fractional error may put a speeding vehicle thousands of miles off course. So navigators will have the

Crew centrifuge would expose five persons at once to g pressures, while instructors sent in problems requiring immediate solution. In action, cabin nose would swing down, bringing it into line with centrifuge arm. Operators suspended beneath ceiling could rotate cabin to simulate realistic emergency at launching

Numbing acceleration pressures almost immobilize rocketeers at launching—yet they

most complicated—and most striking—trainer of all: a huge globe which will simulate the vastness and stark beauty of space; sitting inside, the navigator-trainee will get most of the errors out of his system before they can do any harm.

Five Years' Hard Study for Trainees

Besides training in these simulators, most of them designed by Dr. Wernher von Braun, the world's top rocket engineer, the crews will get a tough classroom schedule, taking courses in rocket and instrument design, physics, astronomy, navigation (for all personnel) and basic medicine. The training will take five years, and each of the crew members who graduates will have the equivalent of a master's degree in at least one specialty.

How many will graduate? About five out of every 60 who start the training course. But even those 60 will have been carefully selected; so the graduates will be the cream of a carefully chosen group that once numbered hundreds.

We know we can build superbly engineered rockets to carry man into space; in picking our crews we must aim for the same degree of perfection. Before an applicant is accepted, he must meet rigid physical, educational and age requirements (Collier's, February 28, 1953). He must be between the ages of twenty-eight and thirty-five; he must have a college education; he must be of medium weight, and between five feet five and five feet eleven inches tall. (Exceptionally tall or short people tend to have poor blood-circulation control, which hampers them in adjusting to the stresses of space travel.)

Of every 1,000 applicants who meet those standards, 940 are expected to wash out during the stringent medical and psychiatric examinations which precede training. And now, in the training phase, we'll find that 55 of the remaining 60 students can't cope with the physical, emotional and educational demands of rocket flight.

Perhaps the toughest test will be the trainee's ability to function swiftly and efficiently during acceleration.

Flight into space will be made in three-stage rocket ships: vehicles built in three sections, each with a bank of powerful rocket motors. The first stage, or tail section, provides the tremendous power needed to get the rocket ship off the ground; at an altitude of 25 miles, the first stage is cast loose and the rockets of the second stage, or center section, start firing. At 40 miles, the center section is dropped, and the third stage, which contains the crew compartment, continues on into space. All during the ascent, the rocket ship is guided by an automatic pilot. The pilot is operated electronically by a magnetic tape into which precise instructions have been fed beforehand.

How Acceleration Affects the Crew

As each stage takes over the task of propulsion, there is a sharp drop in acceleration, followed by a sudden thrust forward as the new bank of rockets bursts into action. The crew members feel a numbing acceleration pressure, like the pressure you feel against your back when you step on the gas in an auto, but many, many times more powerful.

The first great acceleration shock comes shortly after launching: from a standing start, the rocket surges to a speed of 5,250 miles an hour in 84 seconds. The second stage propels the rocket for 124 seconds, building up to a speed of 14,364 miles an hour, and the third stage, which then takes over, requires another 84 seconds to hit top speed—18,468 miles an hour. At each spurt, the rocket passengers are crushed against their seats with enormous force.

At the two acceleration peaks (about 80 seconds and 300 seconds after launching), the pressure is equal to nine times a man's weight—that is, nine times the force normally exerted by gravity. Scientists call it nine gravities, or nine g's.

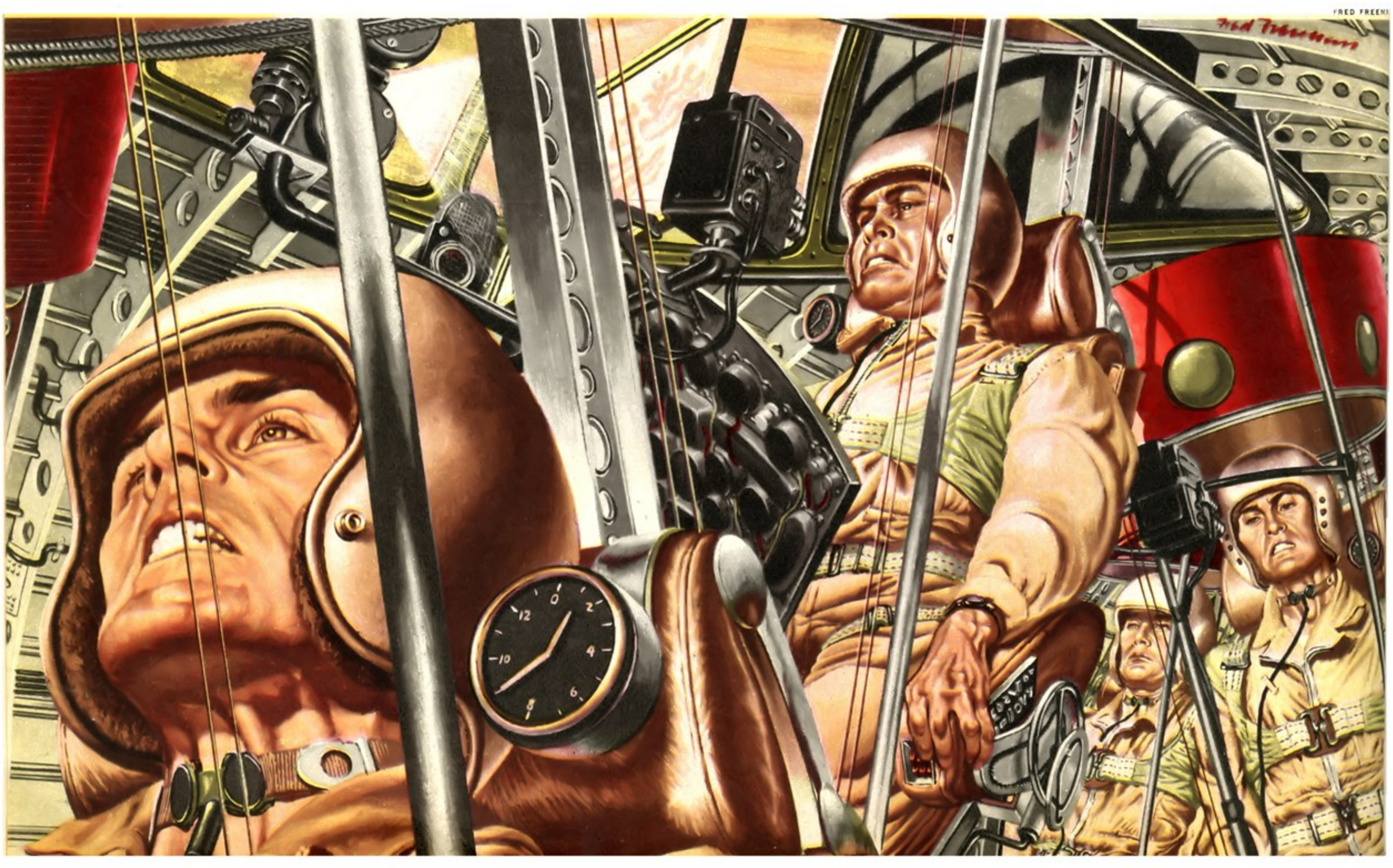
Position Governs Time of Blackout

Can a man operate under such pressure? Yes, if he's sitting in the proper position. If the direction of the pressure is from his head to his feet, the blood drains from his brain, and he blacks out at only four or five g's. If the direction is from foot to head, the blood rushes in the other direction, and he can take barely 2½ g's. But if the pressure is from chest to back, some men can withstand as many as 17 g's without difficulty. How do we know? We have a machine that exposes men to g-forces, a centrifuge consisting of a cage on the end of a long arm, which whirls around like a bucket on the end of a string. Just as a stone in such a bucket will be pinned to the bottom, so a man in the centrifuge is pinned back against his seat. The faster the cage goes around, the more g pressure the man experiences.

Dr. James Henry, one of the Air Force's top physiologists, has found that men spun in the centrifuge at the Wright-Patterson Air Base in Dayton, Ohio, can take up to 10 g's, chest-to-back, and still move their arms and legs.

That's important. It means that if something goes wrong during the first five minutes of rocket

Within cabin of swiftly rotating centrifuge, crew is subjected to terrific strain like that of rocket acceleration. Force sustained equals nine times a man's weight, or nine g's. Problems calling for group action are fed into trainer; crew responds by using fingers to strike armrest buttons



must act fast in emergencies

flight, the crew will be capable of taking emergency action, up to as many g's as they're likely to experience.

But emergency action in a rocket ship calls for split-second co-ordination among several people. So we'll train our crews in a bigger, more complicated centrifuge; the cage will be a near replica of the cabin of a rocket ship. The crew members will sit in contour seats so adjusted that the simulated acceleration pressure will strike them from chest to back, and during the test runs they will be fed emergency problems by instructors on the outside. The training probably will go something like this:

The captain and crew strap themselves into their chairs. Ahead of them, projected on the frosted glass of the cabin canopy, they see a color film showing a blue sky dotted with white clouds.

After a last-minute instrument check, the captain presses a button on the armrest of his chair. The rockets of the first stage begin to mutter; a muffled rumble emerges from hidden loud-speakers in the cabin.

The instructor at the remote-control board outside now gives the captain the launching signal. A light flashes in the cabin, and the captain pushes another button, turning the motors on full power.

The noise from the loud-speakers grows to a roar. The centrifuge begins to spin, simulating the lift of the rocket ship. The sudden surge throws the crew members back hard into their seats. As the white clouds on the canopy race toward the ship and disappear, the faces of the occupants begin to strain under the mounting pressure.

The sky darkens quickly to a jet black that is broken only by stars, glinting cold and sharp directly ahead. As the centrifuge picks up speed, the breath is driven from the bodies of the crew members, and their muscles become almost powerless against the g pressure; yet they watch the orange-red illuminated dials which register a multitude of performance signals. If anything goes wrong, they must be ready to act.

And suddenly, as the peak pressure of 9 g's approaches, something does go wrong.

Danger from Jamming of Fuel Pumps

A high-pitched klaxon horn blasts over the motor roar, and a light flickers near one of the dials on the engineer's panel: one bank of fuel pumps has jammed, and the lines providing the pumps with pressure may burst. Squeezed almost immobile between the chair backs and the tremendous pressure bearing down on their chests, the crew members must act—decisively and quickly.

The engineer's thumb gropes for the interphone switch on his chair arm. "Engineer to captain. Series five pumps are stuck!" The captain must make a hasty decision. The rocket trouble is sure to affect the ship's flight path; yet in a few moments the troublesome first stage is due to be jettisoned. Should he try to keep going? Or should he plan a forced landing or escape procedure? In the last, he can either gain more altitude for safety's sake, or get rid of both the first and second stages immediately and head back for the earth. He decides to continue.

"Captain to navigator. Check flight path with ground station."

The radio operator, hearing the order, gives the navigator direct contact with the earth. The navigator speaks briefly, listens, then switches his set back to intercom with a movement of his finger. "Navigator to copilot. Tape 13."

The copilot turns his wrist until his hand is over a tape selector panel, then punches button 13.

The engineer, meanwhile, has applied a partial corrective for the faulty rockets. "Increasing the speed of remaining pumps," he announces, as soon as the intercom is open.

The navigator in turn prepares to call the ground for another heading, to compensate for the increased power put in by the engineer. The infor-

Here's what happens to a man subjected to head-to-foot g pressure, the kind an airplane pilot experiences in pull-out from a dive. Force drags facial muscles downward, drains blood from head, causing average man to black out at 5 g's. A rocket crew member would feel such force if he leaned forward during launching

Foot-to-head force pulls muscles upward, causes blood to rush to man's head. A normal man can take only about 2 g's in this direction before he experiences the condition called red-out. Aircraft pilots performing difficult outside loop know this feeling, as would a rocket crewman leaning too far back at acceleration peak

Problem of g force can be licked if direction of pressure is from chest to back. Men in centrifuge tests have endured up to 17 g's of this kind without blackout or red-out, and space vehicle crews will be seated so acceleration forces strike them this way. All of these photos were made in Navy and Air Force centrifuges

PHOTOGRAPHS FOR COLLIER'S BY RALPH ROYLE

Moving around in weightless space is tricky; you can spin, cartwheel, or tumble

mation he gets will affect the copilot, and the captain will have to take the actions of both into account in making further plans.

And all this time, the radio operator has been busy sending step-by-step reports back to the ground station, so the people there will know what happened in case the rocket ship crashes.

All this action has occurred in seconds. Inside the whirling cage, television cameras have caught the whole scene. Outside, instructors have watched TV screens and light panels, and have timed and recorded every move. By the time the first stage is cast loose, 84 seconds after launching, the emergency is over. Two more accelerations, as the second and then the third stage rockets open fire—and the centrifuge slows down and finally stops.

Many Wash Out in Centrifuge Training

There will be many centrifuge tests before a trainee steps into his first real rocket ship. Many of the students never will see the inside of a space vehicle, because they will wash out in centrifuge training.

Some people are more susceptible to g pressures than others; some will be able to take the pressures, but will falter when their judgment is tested in the spinning cage. They will be eliminated.

Still more will fail because they can't cope with the next machine, the personal-propulsion trainer.

What's so tricky about personal propulsion? The answer is almost everything—in space.

When a space vehicle circles the earth at the right distance and speed, it becomes a satellite, like the moon. A rocket ship 1,075 miles away, traveling 15,840 miles an hour, would circle the earth endlessly. Its speed at that distance would exactly counterbalance the earth's gravity. Once moving at the right speed, it wouldn't need power, because there's nothing in space to slow it down (as there is near the earth, where the atmosphere ultimately brakes the speed of any falling body). The ship would just stay up there, making one trip around the globe every two hours.

Suppose a man stepped out of the vehicle (protected by a space suit, of course). He, too, would be a satellite, spinning around the earth in the so-called two-hour orbit. He would remain in space, hovering near the rocket ship.

But suppose there were two rocket ships, and he wanted to move from one to the other. There's only one practical way for him to do it: each visitor to space will carry a small rocket motor in his hand. By firing it dead ahead, he'll make himself fly backward. When he wants to stop, he'll fire a short burst to one side. That will make him spin part way around. Two more pulls of the trigger—one to stop the spin, the other to halt his flight—and there he is.

It's complicated, and with a couple of hidden traps. What if he fires a trifle too high? He's apt to start tumbling end over end. If he holds his arm a little off to one side, he will spin like a top. If he fires sharply to the left or right, he may start cartwheeling. And it might be hard to stop.

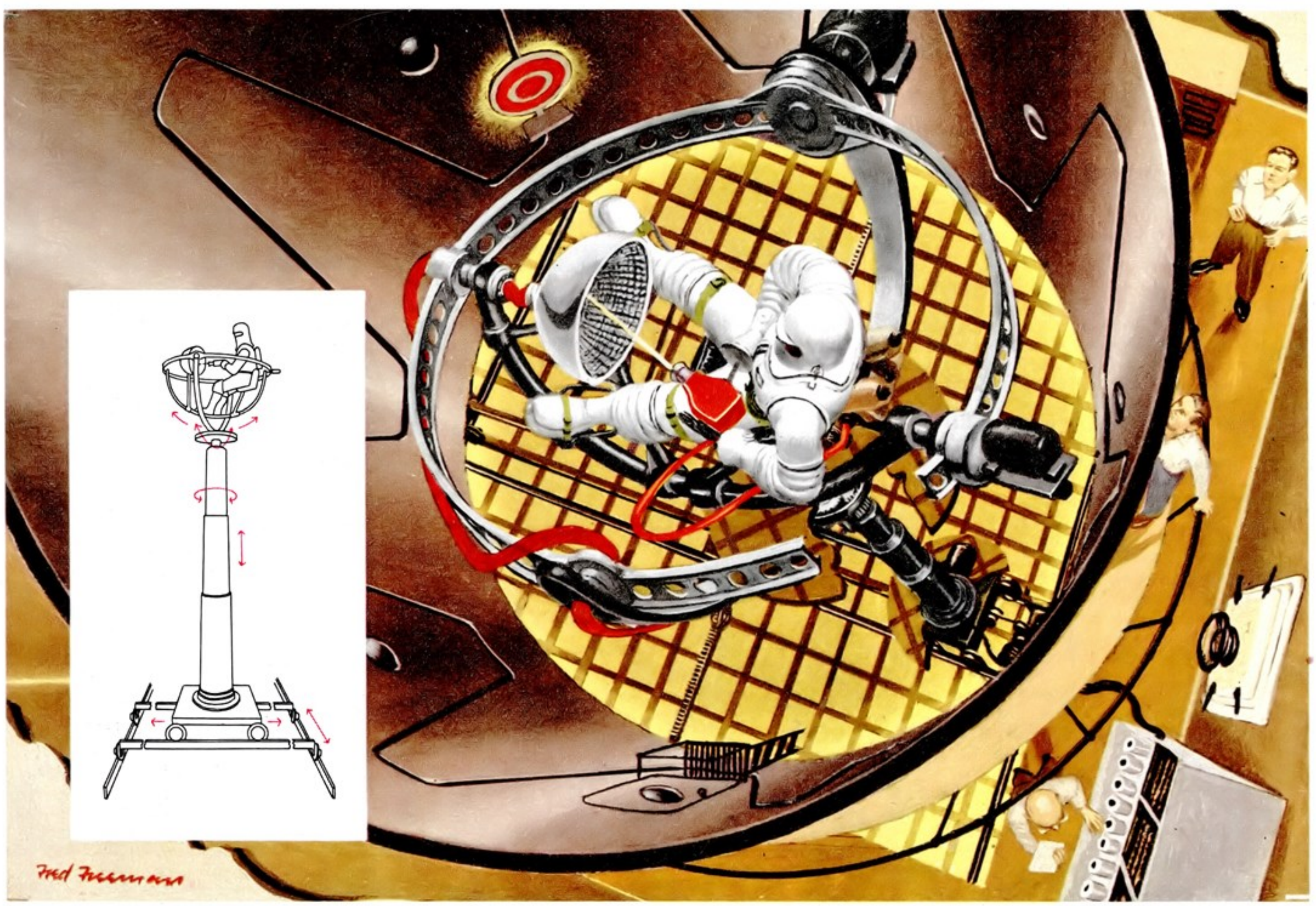
The way to prevent such mishaps is to train the crew members before they ever get into space. We can't duplicate the weightlessness man will experience as a satellite. But we can almost duplicate the spin, roll and pitch hazards of personal propulsion.

Instruction in Personal Propulsion

The student of personal-propulsion training, garbed in a bulky space suit, sits on a chair at the top of a slender telescoping pole. The chair is mounted within rings which enable it to roll sideways, or rock forward and backward. A system of rollers, elevators and gears also makes it possible to move directly backward and forward, or to either side; to go up and down, or to spin to right or left. In front of the student are concentric wire mesh screens studded with photoelectric cells which react to a light ray from the student's propulsion gun. The cells are connected to electric motors which set the chair in motion.

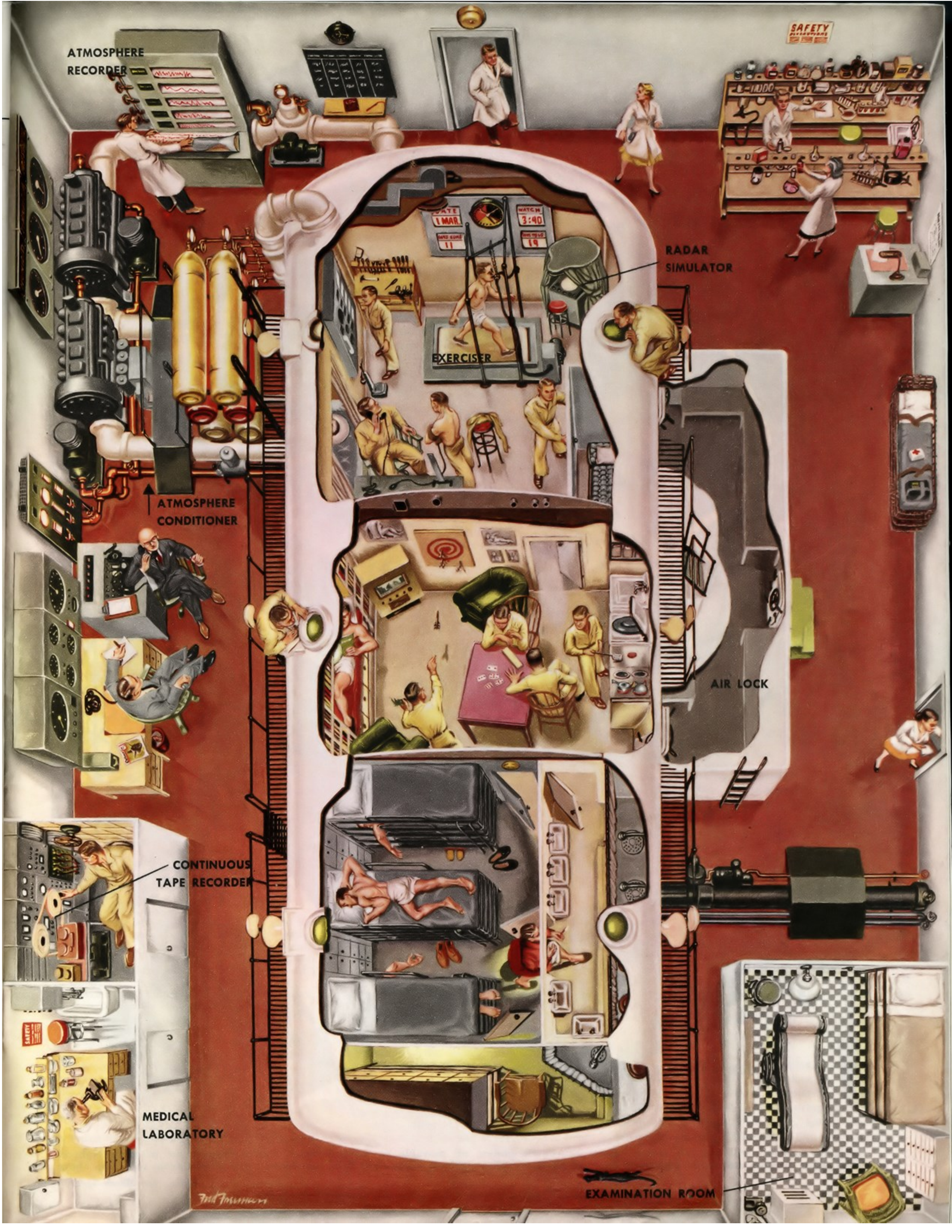
By firing directly in front of him, the student will propel himself backward. Any slight error in his

Crew trainees will stay for weeks on end in this sealed tank. Experts will observe how students react to each other—and to an air mixture of 40 per cent oxygen and 60 per cent helium (on earth, it's 20 oxygen, 80 nitrogen)



Man wanting to go from one rocket ship to another in space will propel himself with rocket gun. This trainer teaches him to aim properly, avoid gyrations. To reach target, trainee shoots light ray—instead of rocket gun—at electric-eye dish. Bad aim makes him spin and roll

DRAWINGS BY FRED FREEMAN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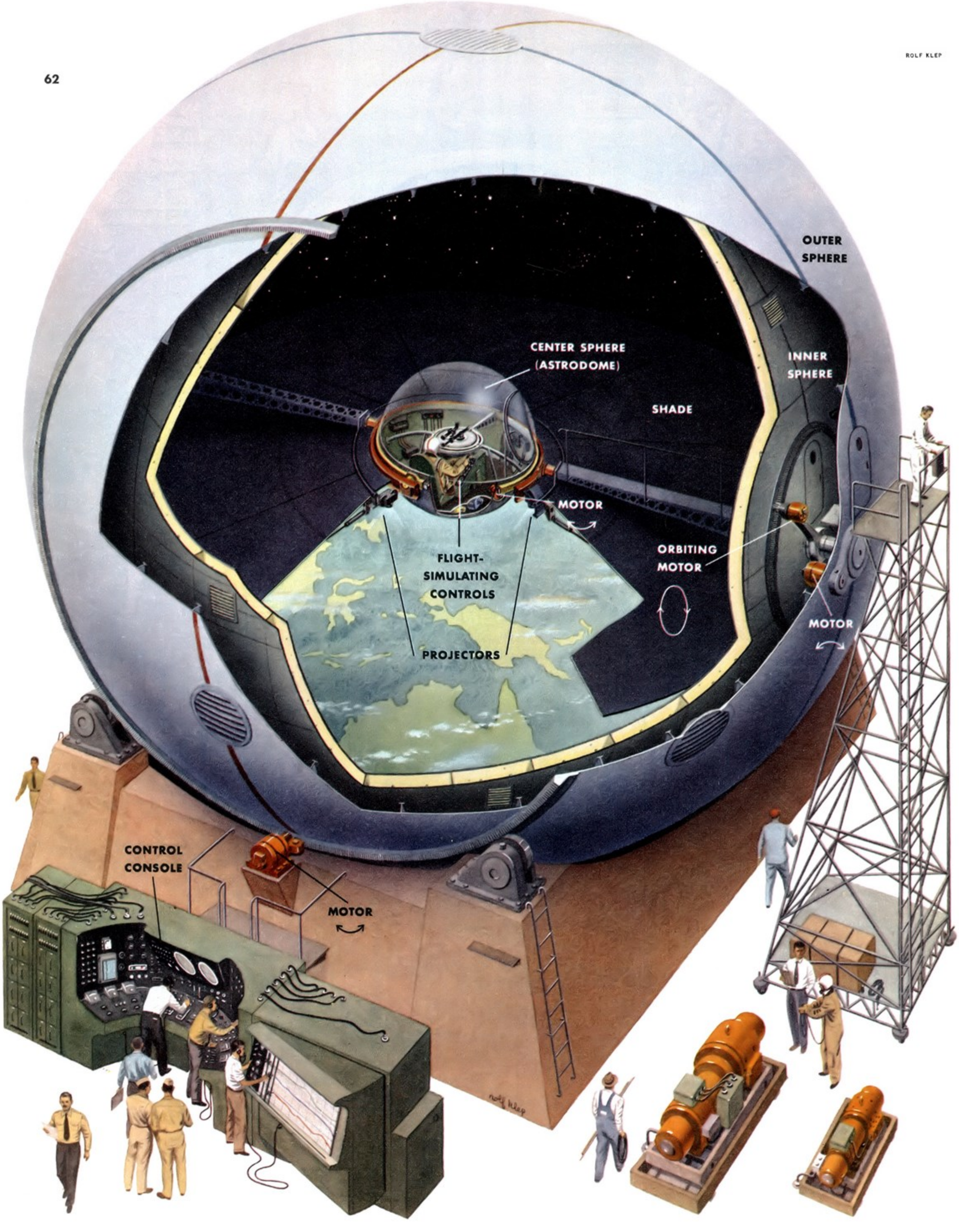


Navigator students will use this trainer—three concentric globes, all movable to simulate space flight. Trainee sits in center sphere, takes sights on stars and earth, which are depicted on inner sphere. Shade keeps light from the filmed earth picture from reflecting above aim will have the same effect as a comparable error in space: he'll spin, cartwheel or tumble.

There's one more aspect of personal propulsion which the simulator can't duplicate exactly. Suppose a man blasts himself backward and suddenly finds his gun is jammed or out of fuel. Unless other men become aware of the danger in time to rescue him, won't he go plummeting off into space with nothing to stop him? No, he'll wear a protective life line, tied to the rocket ship. Not only will it keep him from becoming lost; it also will extend his range, because he can use up the fuel in his gun, then float back to the ship with one tug on the line.

Personal propulsion is a problem space men and women encounter outside the rocket ship. They'll also have to adjust to life *inside* the vehicle, and another trainer will help prepare them for that.

What difficulties will they face? A much lower atmospheric pressure than they're used to; personality conflicts resulting from long periods spent in close quarters with the same few people; psychological reactions to a monotonous existence in a small area. Those are the main problems; there are also a few minor ones.

All of them (with the exception of weightlessness, which can't be reproduced on the ground) will be simulated in the next trainer, a crew pressure chamber. Ten to 15 men at a time will spend several consecutive weeks in the chamber, getting used to the cramped quarters—and to one another.

Why so long? A trip to the two-hour orbit, where we someday hope to build a permanent station, will take only about an hour. Why force the trainees to spend weeks together?

Because they probably will be the crews which—after the space station is built—will pioneer in interplanetary flight. A trip to Mars will take eight months, one way. The men of a crew will be under severe stress during such a trip, and we must know *now* which ones are able to take it.

Reasons for Ban on Women

Women, who may beat out men for certain crew jobs, won't go along on interplanetary journeys, where privacy will be lacking for long periods. So they'll take the chamber tests separately, and briefly, in preparation for the shorter flights that they will make.

The chamber will be like the interior of a rocket ship—functional, pressurized and cramped. Most of the pressure problems have been worked out by the physiologist-engineer team of Drs. Hubertus Strughold and Fritz Haber. The chamber's interior pressure will not be that of the earth at sea level, which is about 14½ pounds per square inch, because such pressure would impose too much of a strain on the junctions where pipes and tubes pass through the sides of a rocket-ship cabin. A pressure of about eight pounds will be used, equivalent to an altitude of 15,000 feet.

After a short adjustment period, most men can breathe comfortably at that altitude. Increasing the percentage of oxygen in our artificial atmosphere, from the 20 per cent a man is accustomed to on the ground to about 40 per cent, will make it easier.

There will be another change in the atmosphere, suggested by Willy Ley, noted rocket expert and writer. Instead of nitrogen, which makes up about 80 per cent of the earth's air, helium will be pumped in. Nitrogen in the blood tends to form bubbles when there is a rapid change in pressure (which might occur by accident in space), producing the painful—and possibly fatal—affliction known as the bends. Helium does not form bubbles in the blood as easily as nitrogen does, so it poses no problems.

The psychological problems of the sealed cabin are even more interesting than the physical. Men working under strain for long periods tend to become irritable and less efficient; in long-distance aircraft they generally start growling at one another after about eight hours, and show a marked loss of efficiency after about 15 hours. Some do better than others, and tests in the pressure chamber will enable us to pick the top men.

How about those who show signs of early strain, those who start sulking and finally lapse into an unsociable silence? Are they finished?

No, but special efforts will be required to match them to the proper crewmates. Psychologists have found that they can almost eliminate friction on aircraft crews by choosing men with like interests, background and education.

Cases of Claustrophobia Are Rare

Besides indicating their ability to work as a team, the trainees may display other psychological reactions to the chamber tests. A few rare cases of claustrophobia may develop, for example, although Dr. Donald W. Hastings, the Air Force's chief psychiatric consultant, expects such fear of confined space to be rare. The ability of the men to act in crisis situations may be tested again; if a man becomes sick, his fellow trainees will care for him (unless an emergency develops, of course). Temperature and atmosphere changes will be fed into the room to test the physical—and emotional—responses of the students. Routine flight problems will be passed to the trainees to keep them busy, and exercise machines will be available inside the chamber to keep them fit.

But no problems that a navigator solves in a pressure chamber will prepare him for those he encounters in flight. The fourth simulator is aimed primarily at him, although other crew members will use it.

The navigation simulator consists of three spheres: a large globe, 30 feet in diameter, with two concentric spheres inside. The smaller of the two inner spheres, measuring about six feet across, is the navigator's compartment, or astrodome. The larger, which fits just inside the exterior globe, is, in effect, a great picture of the universe, with the earth looming large below.

The inside of this middle sphere is pitted with small holes through which light shines, to simulate the constellations. The earth is depicted by color movie film, projected against the inner skin of the sphere.

The big picture-sphere makes a complete rotation every two hours, so that the student navigator gets the illusion of starting in the two-hour orbit.

GEORGE WISLER

Air Force officers with model of new navigator-training plant, Wright Air Development Center, Dayton, O. Huge trainer is latest step in direction of navigation simulator on facing page

For the navigator, rocket flight will differ from aircraft flight in several important respects.

First, he won't have the usual landmarks and radio aids; his only points of reference will be the earth below and the stars above.

Second, during the outward flight, the normal navigational problems have been solved in advance and worked into the automatic pilot; so almost all the navigator's work will occur just before and during the rocket ship's return earthward from space.

The homeward journey is begun by cutting the speed of the rocket ship, so it no longer is moving fast enough to continue as a weightless satellite; it then starts to fall out of the orbit, toward the earth. The speed is reduced by turning the vehicle tail-end-to, so that the rocket motors point in the direction of movement, and employing a short burst of power. The strength and duration of the rocket thrust—if properly aimed and timed—will put the vehicle precisely on course for its destination on the earth.

The navigator's main job is to make the aiming and timing as nearly accurate as possible; if that's done correctly, the rest of the homeward navigation will virtually take care of itself. If his initial calculations are wrong, there may be trouble, for the rocket carries very little fuel on the return trip and it may prove difficult to correct the course. Obviously, the departure timing depends on what part of the earth is opposite the vehicle; under certain conditions, the problem is so complicated that the navigator must wait for a better moment.

A Test in the Astrodrome

In training, the student navigator will take his seat within the astrodome, and instructors outside will set up a problem by moving the stars to a certain position and by selecting a specific picture of the earth to be screened below him.

From then on, the trainee operates the simulator. He determines his present attitude (*attitude*, not altitude) by taking sights on the stars and the earth. Then he decides on his desired attitude for time of departure, and aligns the ship properly, by pressing buttons on a control panel at his right. In a real rocket ship, the buttons would cause the ship to tilt to the desired position; in the simulator, the pictures of the stars and earth shift instead.

The navigator then checks his exact location in space by radioing to the ground, confirms his timing calculations—and is ready to go.

Every move that he makes will be charted on the panel outside. New problems and emergency situations may be posed by the instructors, and careful measurements will be kept of his position, to determine the degree of error in his calculations.

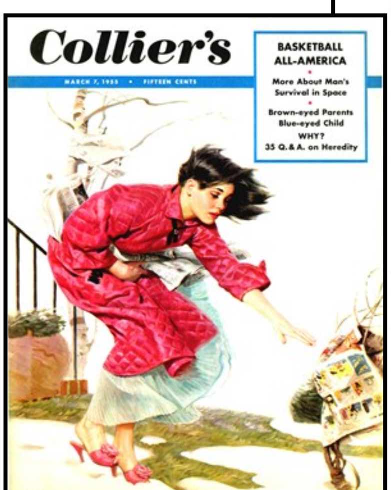
For most of the crew members, the navigation trainer will be an interesting machine whose main purpose will be to familiarize them with the kind of scenery they'll see in space. For the navigator trainee, fighting to keep from being eliminated, it will be a major obstacle. Some navigator students will wash out.

By the time all the trainees have passed through all the simulators, only five will be left of the 60 who started the course (and of the 1,000 who originally applied for it).

Now comes flight training.

Next Week Disaster can strike in space, as it can anywhere else. How does a rocket crew save itself when its vehicle starts blowing up at a speed of 15,000 miles an hour, 1,000 miles from solid ground? Scientists tell the answers

Collier's 1952-54



4

Picture OF THE MONTH

Bogart and Allyson!!!

The years to come will have to go some to top this twosome! Here's TNT teaming of the kind that is reminiscent of those Gable-Gardner and Taylor-Turner combos. And if memory knows a bigger or better showcase for their torrid talents than M-G-M's bold and beautiful "Battle Circus"—memory just isn't telling this excited previewer.

Excited? "Scorched" is closer! Without a doubt, "Battle Circus" is the warmest, most wonderful story of desire-under-fire to come out of the war and into the heart. In it Humphrey Bogart really meets his match ...and she's terrific! A new June Allyson—still winsome (and then some!) but with a smoldering hint of volcanoes to come. And June *does* bust out all over, while all Bogart's breaking loose in this story of a half-naive, half-knowing nurse who comes to Korea to help win the war and can't help winning a one-man war called Bogart.

Last year's Academy-Award winner is in there power-pitching again as an Army major, a surgeon with a first-class touch, a scalpel-sharp temper, and the bedside manners of a marine on leave. Out of gentlemanly respect for June's tender years and inexperienced ears, Bogart waits a full thirty seconds or so after meeting her before inviting her to see the sights, starting with the inside of a tent.

To sample you a sample of the crackling love-talk writer-director Richard Brooks has them tossing at one another: "Please, major, stop creeping up on me," says June. "Stop talking like a vice squad," says Bogart. "Aren't you too old for this kind of thing?" says she, retreating. "When I'm too old for it I'll be dead," says he, advancing.

But all the time he's declaring war on her defenses, she's invading his heart. Then D-Day for the real thing can't come too soon for him.

The screen's top topkick, Keenan Wynn, is just about perfect as an ex-circus roustabout bringing Barnum & Bailey techniques to these Army tactics. In tempo, temperature, and between-the-bombs tenderness, "Battle Circus", is surefire, sheer flame and sure fun!

★ ★ ★

M-G-M presents HUMPHREY BOGART, JUNE ALLYSON in "BATTLE CIRCUS" with Keenan Wynn and Robert Keith. Screen play by Richard Brooks. Based on a story by Allen Rivkin and Laura Kerr. Directed by Richard Brooks. Produced by Pandro S. Berman.

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March 7, 1953

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The Cover

Although spring is only a stone's throw away, it's still blustery, and sloppy enough underfoot to make the retrieving of a runaway Sunday paper an uncomfortable business. Artist Tom Lovell, of Westport, Connecticut, posed Miss Penny Peterson, daughter of Ridgefield artist Perry Peterson, and achieved this realistic circumstance without the benefit of a Hollywood wind machine.

Week's Mail

The Cutter and the Cop

EDITOR: I just can't stand these smart dopes who are always picking your articles to pieces, and finding little errors in some of your pictures.

By the way, where's the sleigh bells on your very fine cover for the Jan. 24th issue? ALLAN J. WYLIE, Tampa, Fla.

... The Jan. 24th cover is splendid, but evidently Bill Randall is just a young fellow who never drove a cutter. Being an old-timer who has driven many, I never saw a rig of this kind without chimes on the shafts and frequently on the harness.

Also, how is Randall going to stop this rig? No breeching shown.

J. F. DAVIS, Barton, Wis.

... Your cover shows a fine-looking horse, but what is he doing? Trotting? Pacing? Galloping? Looks like maybe his owner wished he had been a dog instead and trained him as a pointer.

PETE WARD, Washington, D.C.

We figure that he's neither pointer nor pacer, but a trotter who's having a little trouble getting that left hind foot up, due to a slow track.

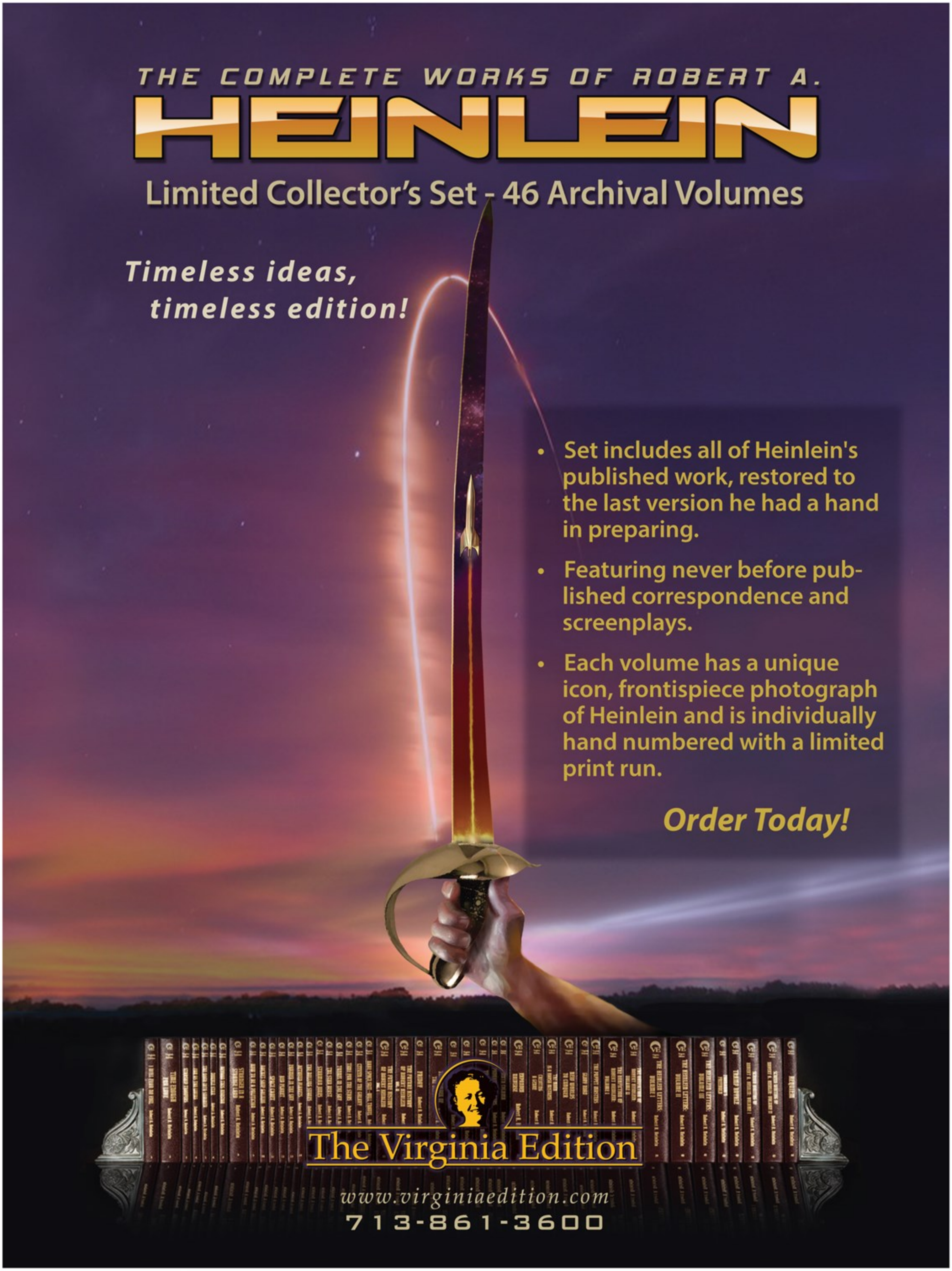
Training to Defend Alaska

EDITOR: In Big Drop in Alaska (Jan. 24th), your magazine stated that "our best hopes to dim the Alaskan gleam in Stalin's eye are pinned on the men who wear Airborne on their sleeves. Exercise Warmwind more than proved it is a wise decision."

It seems to us of the 196th Regimental Combat Team that we have been slighted by your article because of the major role we of the 196th and 4th RCTs would play in the defense of Alaska.

The 196th RCT is continually con-

Above: Scanned images from the cover and table of contents page from the weekly magazine Colliers, May 7, 1953.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Exerpt from "Ray Guns and Rocketships"
first published in 1952

It was suggested that I comment on the writing of science fiction for children. I am not sure just how to do this as I am not sure that I have written any sciene fiction for children. It is true that I have a group of books which are catalogued as being intended for "boys of ten and older"—but I have found that this list is read by adults as well as by boys (and girls!) and that my books intended for adults are read by my younger readers as well as by adults. Science fiction is quite ambivalent in this respect. A book so juvenile that it will insult the intelligence of adults is quite likely to insult the intelligence of the kids.

When I was a child myself I used to get quite annoyed at authors who "wrote down." When I was first asked to do a book intended for kids I swore a solemn oath that I would never "write down"—it is better by far that a child should fail to grasp some portion of a story than it is to patronize him. So I believe and my experience seems to bear me out. In my own work I make just two minor distinctions between copy intended nominally for adults and copy intended nominally for not-yet-adults. In the boys' list I place a little less emphasis on boy-meets-girl and a little more emphasis on unadulterated science—but these are matters of slight emphasis only. On the first point I am obeying a taboo set up by adults, it being my own recollection that kids get interested in boy-meets-girl at a very tender age. On my second point it is my recollection and my more recent observation that kids are more interested in "how" and "why" than their parents usually are. The kids really want to know how the spaceship operates; the adults frequently don't care—so I try to give the kids enough detail in matters technological to satisfy them without giving so much that it will bore an adult. In any case a science fiction story should be a story first of all; it is not intended to replace science text books.

But most especially in writing for kids the science in it should be valid. When they spot an error they are not likely to forgive it.

In many ways science fiction belongs to the kids. They know that "it hasn't happened yet"—but they believe that it will happen. They expect to grow up to build space ships, to pilot them. They still believe in change and they are undismayed by the wonderful and terrifying future we have in front of us. If an adult enjoys science fiction, it is almost a guarantee that he has managed to carry over a youthful point of view, a mind not yet calcified, a belief in change and the future. It is for the youngster and for this adult who still has something of youth about him that we write.

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Exerpt from "All You Zombies"

First published in The Magazine of Fantasy and Science Fiction (March 1959)

2217 TIME ZONE V (EST) 7 Nov 1970 NYC—"Pop's Place": I was polishing a brandy snifter when the Unmarried Mother came in. I noted the time—10.17 p.m. zone five or eastern time November 7th, 1970. Temporal agents always notice time & date; we must.

The Unmarried Mother was a man twenty-five years old, no taller than I am, immature features and a touchy temper. I didn't like his looks—I never had—but he was a lad I was here to recruit, he was my boy. I gave him my best barkeep's smile.

Maybe I'm too critical. He wasn't swish; his nickname came from what he always said when some nosy type asked him his line: "I'm an unmarried mother." If he felt less than murderous he would add: "—at four cents a word. I write confession stories."

If he felt nasty, he would wait for somebody to make something of it. He had a lethal style of in-fighting, like a female cop—one reason I wanted him. Not the only one.

He had a load on and his face showed that he despised people more than usual. Silently I poured a double shot of Old Underwear and left the bottle. He drank, poured another.

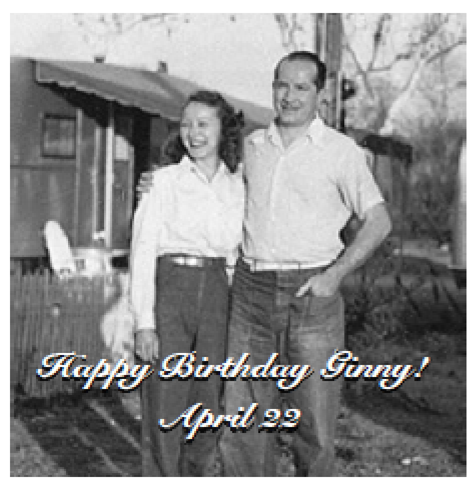
I wiped the bar top. "How's the 'Unmarried Mother' racket?"

His fingers tightened on the glass and he seemed about to throw it at me; I felt for the sap under the bar. In temporal manipulation you try to figure everything, but there are so many factors that you never take needless risks.

Continued on page 4.

The Virginia Edition

The Virginia Edition represents authoritative texts for all of Robert Heinlein's published fiction and nonfiction, newly typeset, whenever possible from the editions put in final form by Heinlein's own hand. In other cases, the definitive texts are represented by editions restored to their intended state, in publications overseen directly by Virginia Heinlein after her husband's passing. Mrs. Heinlein's role in perpetuating her husband's work and legacy was at all times crucial, both during and after the writing. It is truly fitting that her name be remembered in close connection with his.



Robert Heinlein and Virginia Gerstenfeld late fall 1947. Permission by Robert A. and Virginia Heinlein Prize Trust.

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I saw him relax that tiny amount they teach you to watch for in the Bureau's training school. "Sorry," I said. "Just asking, 'How's business?' Make it 'How's the weather?' "

He looked sour. "Business is okay. I write 'em, they print 'em, I eat."

I poured myself one, leaned toward him. "Matter of fact," I said, "you write a nice stick—I've sampled a few. You have an amazingly sure touch with the woman's angle."

It was a slip I had to risk; he never admitted what pen-names he used. But he was boiled enough to pick up only the last. " 'Woman's angle!' " he repeated with a snort. "Yeah, I know the woman's angle. I should."

"So?" I said doubtfully. "Sisters?"

"No. You wouldn't believe me if I told you."

"Now, now," I answered mildly, "bartenders and psychiatrists learn that nothing is stranger than the truth. Why, son, if you heard the stories I do-well, you'd make yourself rich. Incredible."

"You don't know what 'incredible' means!"

"So? Nothing astonishes me. I've always heard worse."

He snorted again. "Want to bet the rest of the bottle?"

"I'll bet a full bottle." I placed one on the bar.

"Well—" I signaled my other bartender to handle the trade. We were at the far end, a single-stool space that I kept private by loading the bar top by it with jars of pickled eggs and other clutter. A few were at the other end watching the fights and somebody was playing the juke box—private as a bed where we were. "Okay," he began, "to start with, I'm a bastard."

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James C. McLane, Jr. (1923-2012), was our 1971-1972 AIAA Houston Section Chair and co-founder (in 1987) of our sister section relationship with the Shanghai Astronautical Society (SAS). The current contact person in Houston for that work in Marlo Graves. She traveled to China on behalf of our Section a few years ago. She is a graduate of the 2006 Space Studies Program (SSP) of the International Space University (ISU) in Strasbourg, France, a nine-week course. She worked for ISU during the 2007 SSP in Beijing.

From James C. McLane III, March 2013 (More McLane photos are on two other pages in this issue in our Section News pages.):
"While emptying out a closet in my father's house I found hundreds of great old photos. Most I had never seen so I will be busy scanning for the next year or so. The biplane shots were basic training in Macon Ga. The parade (below) was one my Dad organized when he was Cadet Commander at training in Lynchburg, Virginia. He is standing second from left. The color shot is from a 1972 NASA photo (my father: standing on left).