WHAT'S THE BIG IDEA? SEEKING TO TOP APOLLO

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Human space flight has struggled to find its soul since Apollo. The astounding achievements of human space programs over the 40 years since Apollo have failed to be as iconic or central to society as in the 1960s. The paper proffers a way human space flight could again be associated with a societal Big Idea. It describes eight societal factors that have irrevocably changed since Apollo; then analyzes eight other factors that a forward HSF Big Idea would have to fit. The paper closes by assessing the four principal options for HSF futures against those eight factors. Robotic and human industrialization of geosynchronous orbit to provide unlimited, sustainable electrical power to Earth is found to be the best candidate for the next Big Idea.

I. INTRODUCTION AND SUMMARY

Human space flight (HSF) has struggled to find its soul since Apollo. After 1972 spacefaring nations soldiered on: workhorse rockets, first-generation space stations, reusable Shuttles, and ISS. Space-operations capability deepened, becoming more flexible, robust, and diversified, and learning from tragic lessons. Many nations developed an HSF presence by partnering with those who can launch and land humans; and this decade both a third superpower and the private sector have joined that club as well.

But why has none of this captured the attention and adoration of civilization the way Apollo did? Why have the astounding achievements of the world's human space programs failed *over the 40 years since Apollo* to be as inspirational, as gripping, as iconic, or as central to societal identity as Apollo was in the 1960s? Why has the prospect of a lunar outpost, or of touching asteroids or landing humans on Mars, failed to spark aspiration *and* commitment? Could there ever again be a "Big Idea" like Apollo, as capable of attracting and organizing the resources, talent, and cultural momentum of a nation—or of multiple nations? And if so, why can't we find it?

Against the well-documented backdrop of the historically unique circumstances that made Apollo possible, the paper proffers a remedy.

By first looking back at what has changed since the era of Apollo, the paper analyzes eight factors that contribute to the existential crisis of HSF today: (1) the evolving nature of frontiers; (2) a higher and receding threshold of wonderment; (3) technical and financial barriers to deep space exploration by humans; (4) the lifecycle of government agencies; (5) the true nature of the NASA brand; (6) likely societal motivations both inside and outside the U.S.; (7) vision-making channeled by past achievement rather than future possibilities; and (8) the first principle of marketing.

Then the paper looks forward to develop a specification for a successful Big Idea—one that could respond to the reality of these factors rather than attempting to ignore or change them. Three courses of action appear: (1) learn to be satisfied with the current equilibrium of funding and societal interest; (2) redesign the HSF "product" to be more attractive to public interest, and therefore more likely to shift the equilibrium to a higher level of government funding; (3) develop a new product that HSF stakeholders "never knew they needed" but conclude that they must have.

Measured against this framework, human exploration as traditionally promoted by the primary global spacefaring partners is the poorest candidate Big Idea. Of the four principal options for government-funded HSF goal (*Explore Mars, Settle the Moon, Accelerate Commercial Space Passenger Travel,* and *Enable Space Solar Power for Earth*), the first two are least likely to "change the game." *Explore Mars* is the default goal; neither it nor *Settle the Moon* have demonstrated since Apollo that they can get the traction required to depart from—or perhaps even sustain—the equilibrium level of support. *Accelerate Commercial Space Passenger Travel* has the potential to shift onto the second course by being directly relevant to people. *Enable Space Solar Power for Earth* is the best candidate for a Big Idea; it could offer society a genuinely new product important to today's world, it is technically the most tractable option, and it is the most likely to attract the level of private capital and international commitment required to make human space flight central again.

II. LOOKING BACK

The fleeting conditions that allowed Apollo to happen are well known:

1. The late 1950s were an era of geopolitical brinksmanship between two superpowers.
2. This competitive climate was susceptible to suasion of four key elements of society (multiple modernizing nations, a free press, the American public, and America's enemies) through unmistakable proof of high-tech prowess.

3. With the deployment of ballistic missile technology, space travel evolved rapidly from a boutique fantasy of technical enthusiasts into something almost inevitable. The notion of space travel then became a cultural novelty, as measured by the emergence of space-themed TV shows and the proliferation of toys and consumer products.
4. Earth's Moon provided a visible destination, embedded in societal consciousness throughout human history as patently unattainable, but now just on the edge of feasibility.
5. President Kennedy set an unbelievably crisp mission statement in 1961 that was in fact technically feasible.
6. Framed by a high-stakes competition, technical setbacks galvanized the American come-from-behind psyche, which rallied enough political will to bridge multiple government cycles.
7. The commitment hardened as a point of honor after the popular, legacy-setting President was assassinated.
8. The momentum built by these conditions enabled a "blank check" funding environment that, despite constant argument, culminated in a NASA budget peak five times higher than it has seen since, as a fraction of GDP. In fact, the real-year cost only tripled (from $7B to $23.9B) from conception through actuals.

Not one of these eight conditions obtains today.

III. LOOKING FORWARD

Today, eight very different factors govern the possibilities for HSF being associated with or embodying, let alone driving, a 21st-century Big Idea.

1. **Frontiers are not what they used to be**—First consider space itself. HSF was set on its "Moon shot" course in May 1961, before the first robotic probe had even been launched to another planet (Mariner 2 to Venus, in August 1962). By 1965, space could be defined as "the final frontier" by *Star Trek*. By 1972, Apollo had succeeded, the 747 was flying, and *2001: A Space Odyssey* portrayed a believable path into an open-ended space flight future. Manifest destiny deeply shaped the spacefaring enterprise: its leaders, its workers, its stakeholders, and a generation of STEM recruits. Yet real progress failed to keep pace, whether by 2001, 2012, or any credible projection of what could be achieved by mid-century. Apollo's STEM recruits are now middle aged. Their careers have largely crested, confronting them with the realization that they will never see the frontier that lured them into the field.

   Over the same four decades however, tortoise-like, robotic probes have overtaken HSF in conquering the space frontier. Machines now extend human senses, discovery, and investigation to all the planets, onto Venus and Titan, across the surface of Mars, into the main asteroid belt and the atmosphere of Jupiter, and out to the heliopause. As though from the bridge of the *Enterprise*, we routinely map the composition of strange new worlds, and discover new wonders like lava lakes on Io, seasonal flows on Mars, an ocean inside Europa with more water than Earth's, and organic-rich geysers on Enceladus. We have returned samples of the solar wind and cometary dust. And we are now finally starting to investigate the ancient habitability of Mars. The true exploration of the space frontier belongs to humanity's machines.

   Stepping even further away from HSF, non-space frontiers have risen to prominence, and this detracts from the space frontier being seen as final. As measured by the same yardsticks observable in the 1960s—rapid yield, incorporation into mainstream technology, creation of industries, government regulation, attraction of private capital, press attention, references in popular culture, and career focus by students—today's frontiers are not so much places as they are fields: genetic engineering, nanotechnology, artificial intelligence, networks, and sustainable energy. These frontiers now define the edges of human endeavor, and are rapidly remaking our world, even as space appears less and less relevant as an immediate, dominant frontier of direct human experience.

   The direct consequence of robotic exploration expanding the space frontier, and the rapid emergence of non-destination frontiers, is that we cannot take for granted the singular allure HSF once held.

2. **Today's informed population is more skeptical and cynical**—The value-proposition milieu for HSF has shifted significantly over a half century. Two-thirds of today's global populace was born after Apollo ended.[1] They have never known a time before people walked on the Moon (at least, those who believe it actually happened[2]). Their attention span is shaped by networked media, and their standard of wonderment is far higher than in the 1960s, problematic given our present inability even to repeat Apollo.

   Meanwhile, ambivalence about the benefits of technology has increased. The unbridled technology optimism that characterized the post-WWII decade fractured and dissipated after sobering societal experiences piled up: Cold War

brinksmanship, toxic industrial chemistry, vulnerability of monoculture farming, progressive resistance to antibiotics, multiple nuclear accidents, extreme deforestation and reef acidification, collapse of fisheries, infectious pandemics, unrestrained consumption of fossil fuels with attendant geopolitical and climatic consequences, widespread terrorism, cyber warfare, and many others.

In this grittier societal milieu, high-cost scientific or technological projects must overcome a barrier of cynicism to remain convincing, relevant, justified, and funded. To capture imagination today HSF projects must define a future vital enough to matter to people; and to be brought to fruition they must in addition command commitment over a duration without modern precedent.

3. **Deep-space human exploration is harder than people realized**—In the second decade of the 21st century we now understand far better than anyone did in the 1960s how technically and financially challenging deep-space HSF actually is.[3] Scores of fundamental technology advancements are all required simultaneously in areas as diverse as propulsion, system auto-reliability, life support, and surgery, to name just four. Many of the necessary technology advancements are open-ended in the sense that it is unclear how or even whether they can actually be delivered. Many more "miracles" are required to get humans on Mars than were required to implement Apollo.

   Today also we know much more about what HSF technology advancements and system developments cost. Even more clearly, the history of HSF programs demonstrates that despite our best efforts their cost cannot be predicted reliably, and therefore their budgets cannot be managed confidently. Convolving the technology uncertainty with the budget uncertainty precludes calendaring major milestones that lie far in the future. Yet multiple decades of persistent, organized effort—promoted and approved by a sequence of up to ten Administrations and twice that number of Congresses in the U.S. alone—would be required to "match" or surpass Apollo. This poses a great challenge in a flat or contracting economy, as other techno-political pressures compete with HSF, and as the cost of medical care for an aging population overtakes other discretionary spending.

   Taken together the practical technical, cost, and budget barriers for human exploration being today's Big Idea are far higher and steeper than they were for Apollo.

4. **NASA is a mature government agency**—In 1958, upon its creation, NASA was a new agency focused on a scientific frontier. Within just three years it was chartered to deliver a miraculous achievement of epochal significance, and nine years later it did. Those were heady days for a young, technical bureaucracy. Nothing seemed impossible because the "impossible" was being performed. Upon the triumph of Apollo 11, the average age at NASA was 28.[4]

   Today less than 20% of the NASA workforce is younger than 40. NASA has grown into a mature bureaucracy, with extensive physical assets located in multiple states including Florida, Alabama, and Texas. About 18,000 civil servants are on the payroll. Contractors, lobbies, and PORC distributed around the nation provide significant "inertial damping" that works to preclude structural change. This means that today's NASA is largely constrained to perform tomorrow's missions using yesterday's organizational and program model. Workforce sustainment—not given a thought during Apollo—is now a significant factor in program planning and execution.

   The very structure and bureaucratic needs of today's mature "NASA-industrial complex" may constitute an obstacle to implementing a goal unprecedented and bold enough to be a 21st-century Big Idea.

5. **The NASA brand is not limited to putting people on planets—**What is it that NASA provides in return for its share of the U.S. federal budget? The Agency produces four principal products, two large (HSF and science) and two small (aeronautics and technology). An additional, derivative product is outreach. When the Agency overhead cost structure is prorated across the product areas, HSF comprises almost two-thirds of the NASA budget, and science most of the remaining third.

   The NASA brand is potent, the envy of commercial brand managers the world over. Symbolically it is conveyed by iconic images: Saturn V liftoff, lunar Earthrise, suited Apollo astronauts, Shuttle launches, control rooms erupting upon Mars landings, the Antarctic ozone hole, the rings of Saturn, strange scarred worlds, Hubble's Pillars of Creation. It is conveyed when astronauts visit classrooms, describing for rapt children the banal made wondrous through the suspension of gravity. It is conveyed when record-breaking Internet traffic seeks to experience an alien landscape through the eyes of a machine so far away the signal takes 20 minutes to reach Earth. It is reinforced when occasional failure and

even tragedy reminds everyone just how hard are the feats NASA attempts to make routine.

The NASA brand is not limited to any of its images or activities; it comprises and transcends all of them. Marketing professionals recognize NASA as a premier brand. After more than a half century the Agency's imprimatur still connotes authoritative technical excellence, attention to detail, extremely high quality, and "cutting edge." NASA represents something special among government programs: a federal agency that undertakes high-tech and gutsy projects, yet is open to scrutiny. People expect the brand to deliver bold achievements, startling knowledge, and technical rigor. These attributes are not simply transferable to another enterprise, but they are applicable to a wide range of endeavors.

Recognizing that the NASA brand depends on, but is not constrained by, its iconic past achievements could liberate forward planning.

6. **Societal motivations are powerful forcing functions**—Societies and nations may also have "brands," reinforced over time by persistent priorities, programs undertaken, and the trajectory of history. While characterization can easily veer into caricature, polar differences in societal brand may strongly influence the investment commitments made by nations, which may in turn affect the strength and alignment of multi-national partnerships needed to complete major programs.

   Is a society motivated by bravura and invention? Does it value novelty and individuality for their own sake? Does it willingly and successfully tackle bold and hard challenges? Does it assume the mantle of responsibility for changing the world, taming and rearranging nature, conquering frontiers, controlling chaos, and exporting its own value system and way of life?

   Are all spacefaring societies motivated the same? Diverse societal brands are possible, particularly among "non-participating" societies or those just crossing the threshold into HSF capability. Might a society value ancient tradition as a guide? Could spacefaring be pursued by a society that promotes uniformity as an inherent, competitive strength more important than individual genius? Might a nation aim to develop space technologies that directly satisfy basic needs of its population?

   As more nations attain spacefaring status, we may find that heroic exploration of distant frontiers is not their shared goal, and that some nations choose to make transformational investments much closer to Earth.

7. **Vision-making "in the rear view mirror" is ineffective**—What shapes vision-setting for HSF? Are our goals and priorities derived by rationally mapping HSF capabilities and technologies to pressing problems of the day, or those we see approaching over horizon? Or is it possible that our thinking is channeled by past achievement and outdated visions? Mars was a favorite of futurists in the first half of the 20th century partly because it is one of the closest planets, its surface can be seen (unlike Venus), and it changes seasonally. The lineage is direct from Schiaparelli and Lowell's observations, through von Braun's engineering analyses for human expeditions[5] and multiple generations of NASA studies,[6] to The Augustine Committee declaring that Mars is the "ultimate destination" for human space flight.[7]

   However, we have set ourselves a trap. Regaining a former ability (like traveling to the Moon) cannot be the next Big Idea, so we try to top it. We search the short list of possible human destinations. But space is vast, containing only a few material destinations, widely separated. Venus is moot because of surface temperature and pressure; near-Earth asteroids are tiny; so Mars is next. But attaining Mars exceeds our technical capability and our budget, so our planning is stuck. As long as our vision-making is channeled by the tradition of favoring Mars and by the emotional need to repeat the Apollo pattern, there is no way out of the trap.

   Could vision-making open instead to present signs, and be drawn by future priorities? Is there a way, rather than insisting that HSF leading to Mars fulfills a natural exploration imperative, to derive instead what HSF should be and do by considering what needs are already central to society in this century, or are bound to become so?

   If the vision of what HSF could do, and be for, could be shaped to tackle tangible, even inevitable challenges facing humanity in this century, it might again become associated with a Big Idea.

8. **Violating the first principle of marketing is hazardous**—To date there have been only three major HSF programs in the U.S., and none were about exploration. Apollo was a tool to upstage the Soviet Union in the eyes of developing nations and the public; the Shuttle was a dual-use heavy-lift launch and orbital operations system whose capacity was driven by military-satellite requirements; and the ISS was a foreign-policy tool to co-opt the former Soviet Union into peacetime high-tech partnership. Proponents of a fourth major HSF program proffer exploration as its core purpose; yet for three decades this argument has demonstrably failed to win

sufficient, sustained policy and funding traction (sadly, corresponding to the working career of the generation that was directly inspired by Apollo as children).

The evidence for the "standard model" of the HSF value proposition failing to gain traction is abundant: repeated complaints that NASA has no direction despite its published priorities; an endless series of study and architecture teams; blue-ribbon commissions finding that the budget is inadequate to go beyond LEO; Congressional specification of system developments and even system architecture. Today's society is not enthusiastic to "buy" more of what the HSF community is "selling." Polls consistently find that the U.S. public is proud to have a NASA, and generally and episodically likes what it does, but thinks it costs "too much" while being quite ignorant about what its funding actually is. The evidence suggests that NASA's funding is at political and societal equilibrium—even though this level perpetually pushes the humans-to-Mars goal into the future.

Fundamentals of marketing imply that to get more support, NASA would have to change its product. The ennui of government HSF should come as no surprise. Selling what you want to sell —instead of selling what people want to buy— violates the first rule of marketing. Fixing this would require figuring out what people might want to buy.

IV. A PRESCRIPTION

The future of HSF is not ipso facto limited to humans-to-Mars. Government HSF could be shaped to yield four potential products (Table 1).[8] Among them only *Explore Mars* is traditionally and currently invested in by spacefaring governments.[3] The other three have the capacity to change the value proposition for HSF,[9] and two of them (*Accelerate Space Passenger Travel* and *Enable Space Solar Power for Earth*) offer the potential for immediacy, tangible value for large populations, and near-term attraction of private capital exceeding government funding.

Three courses of action are possible.

1. **Learn to be satisfied with the current equilibrium** and focus on protecting it. This course is at odds with actually accomplishing humans-to-Mars, but is fully consistent with jobs being the key driver of NASA's HSF program and therefore is the least disruptive. The intrinsic resonance of the vision of humans-to-Mars may continue to work, at least for a time, as the open rationale for such a program, but budget-limited infrequency of flying would pose a substantial risk to long-term sustainability. This course needs no further elaboration here: it is the default path, so most likely we will watch it unfold over the coming decades.
2. **Redesign the HSF product to be more attractive to the public** and therefore to receive expanded government funding. Since *Explore Mars* has been unable to do this, such a course would have to begin by first reshaping the HSF vision away from *Explore Mars*, to deliver instead a product of greater immediacy and relevance to a broad population. This scenario could be a textbook example of "disruptive innovation."[10] But in the context of NASA's history of HSF programs, what would it mean to "sell" a "less refined product" at "lower profit" to a "larger customer base?"

   Perhaps *Accelerate Space Passenger Travel* could fit. In the minds of most HSF engineers and managers, large numbers of people traveling in space very close to Earth would indeed comprise a poorer (less refined) product than a human crew on Mars. The science yield (profit) would be virtually nonexistent, but the technology yield (also profit) could be both relevant and transformational, including safe intercontinental travel in under an hour. The customer base would certainly be far larger: wealthy adventure travelers from around the world rather than a single government agency and its contractors. By promoting investments to enable commercial implementation of routine, accessible space flight (as its predecessor the NACA did for aviation in the 20th century) NASA would be "selling" the product. The analogies—both to the innovator's dilemma and to the growth of 20th-century air travel—are apt enough for this scenario to be hypothetically viable and a basis for strategic discussion.
3. **Develop a new product consumers never knew they needed,** but that they rapidly learn they cannot live without (and change the world in the process). The exemplar for this scenario is today's Apple. Upon returning to Apple in 1996, Steve Jobs famously solved the innovator's dilemma by inverting the company's value system to favor product innovation over profit. Sixteen years later Apple nonetheless became the highest-valued company in history, with a paper worth of over $620B,[11] along the way surpassing the inflation-adjusted value of such notable investments as Apollo (times two, in September 2011), and the U.S. interstate highway system (in February 2012).[12]

Table 1. Government investment could enable four alternative HSF futures.[8]

HSF Option	Purpose	Core Myth	Needs (+ $\$10^{11}$ over 40 yr)	Yields	Space Population ~2040
Explore Mars	• Extend direct human experience as far as possible • Understand potential of Mars to support life	Hero (Lewis and Clark)	• Public commitment sustained over several decades • International co-investment partnerships, sustained	• Cultural achievement: setting foot on Mars • Lagrange and asteroid destinations • High-tech international interdependence • Highly reliable space systems, advanced propulsion, deep-space human systems	Six international civil servants on a distant planet
Settle the Moon	• Establish humanity as a two-planet species	Pioneer (Heinlein)	• Public-private partnerships • Routine heavy traffic to lunar surface • Use of lunar resources • Broad range of technical skills and social services	• Cultural achievement: permanent human presence off-world • "Living off the land" in space • Lunar exports to Earth: REE, ^{3}He, tourism	10^3 mixed-demographic citizens raising families off-world
Accelerate space passenger travel	• Open space to citizens • Create new travel-related industries • Extend spacefaring perceptual shift to large population	Jet set (Branson)	• Public-private partnerships • "Five 9s" reliability launch and entry • Commercial space workers	• Highly reliable, reusable space vehicles • Space hotels and resort destinations • Routine in-space service industries (e.g., food, maintenance, medical) • 1-hr intercontinental travel	10^3 crew + 10^5 citizens visiting low Earth orbit every year
Enable space solar power for Earth	• Minimally disruptive transition to post-petroleum age • Create new energy-related industries • Become global exporter of unlimited clean energy	Green	• Public-private and inter-Agency partnerships • Power beaming protocols • Commercial space workers	• Cultural achievement: energy-abundant future • Changed land-use patterns • conomical heavy-lift launch • Routine in-space high-tech industries (e.g., construction, robotics, habitation	10^2 skilled workers on extended duty tours in high Earth orbit

What might constitute this kind of disruptive innovation for HSF? Perhaps *Enable Space Solar Power for Earth* could fit. Scoring this scenario against the eight forward-looking societal factors hints at the possibilities:

1. **Frontiers**—Renewable energy is a timely frontier, albeit the most prosaic of those described earlier. It lacks the mystery and allure of machines smaller than human cells, redesigning the human body for immortality, machines that emote, or people walking on Mars, but it nonetheless meets the criteria of attracting young talent, private capital, government investment, and media attention.
2. **Skepticism and cynicism**—Industrializing GEO to help bridge to a post-petroleum world could avoid stretching to make a connection between astronauts and normal people's everyday lives. HSF would be asked to serve a larger goal, rather than purporting to be the goal; indeed some contemporary advocates of robotic SPS maintain HSF would not even be required for its implementation, which would force HSF to prove its tangible value. Far fewer people would be cynical about investing in a sustainable energy solution than in getting six civil servants to Mars someday.

3. **High practical barrier**—Of the four HSF options, industrializing GEO would likely be the most technically feasible because, at root, it avoids the need for advanced propulsion, in situ resources, or citizen-level flight safety. Granted, it would require enormous quantities of heavy-lift launch, robotic operations, and mass-produced space hardware. However, both these enablers and the SPS technology itself are tractable.[3]
4. **Mature NASA**—A non-planetary HSF goal would be highly disruptive to the Agency. Center charters would require renovation; new types of project would require formulation; new contractors would require cultivation. In addition, large elements of SPS implementation would be "owned" by other agencies like State, Interior, and Defense, so new inter-agency partnerships would be essential. Such disruptive evolution might not be all bad; however, it is not clear that the NASA of today could manage to accomplish it.
5. **NASA brand**—SPS would touch every person directly, making space a vital and visible part of the fabric of 21st century society. Instead of wondering where electricity comes from, or worriedly knowing it comes from fossil fuels and fission reactors, people would know it comes "from the sky." By enabling the sustainable, clean, limitless export of electrical power, NASA would become again a geopolitical game-changer. In the process the Agency would honor and amplify its brand as bringer of an optimistic, reliable future.
6. **Societal motivations**—It is difficult to conceive of 21st-century motivations more urgent than energy security—and the national-security, export-balance, environmental, and potable-water benefits that would derive from it. Yet despite its practical benefits, the sheer scale of SPS implementation would pose a huge, visible challenge. This vision would marry bravado to husbandry, perhaps constituting an objective that multiple spacefaring nations could jointly support.
7. **Vision-making**—A vision of game-changing energy security achieved by applying space resources to escape limits to growth—that incidentally yielded cost-effective heavy-lift launch, routine operations beyond LEO, and a power-rich foundation for space exploration; and that would be within our technical and financial grasp over the next half century—certainly has the capacity to inspire the public and schoolchildren.
8. **First principle of marketing**—Steve Jobs said "it's hard for [customers] to tell you what they want when they've never seen anything remotely like it."[13]

The HSF community, led by NASA, could choose the third path out of the HSF malaise caused by the irreconcilable conflict between an old vision, real technical hurdles, constrained resources, and a changed societal context. Why not invent the future, reintroducing optimism and making HSF relevant again, by innovating a product that really would change the world? Why not finally escape the shadow of Apollo, and bring the world the next Big Idea?

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VIII. NOMENCLATURE

GDP = Gross Domestic Product
GEO = geosynchronous orbit
3He = Helium 3 isotope
HSF = human space flight

ISS = International Space Station
LEO = low Earth orbit
NACA = National Advisory Committee on Aeronautics
PORC = projects of regional concern
REE = rare Earth elements
SPS = solar power satellites
STEM = science, technology, engineering, and mathematics

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