Re: We can meet all our needs through space development

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- *From*: Willie.Mookie@xxxxxxxxx
- *Date*: Thu, 31 Jan 2008 01:01:38 −0800 (PST)

On Jan 30, 9:11 pm, Einar <eina...@xxxxxxxxx> wrote:

> On Jan 30, 2:44 pm, Willie.Moo...@xxxxxxxxx wrote:
>
>> On Jan 29, 10:52 pm, Einar <eina...@xxxxxxxxx> wrote:
>>
>>> like
>>> expectations of 13% efficiency not 40% as you appear to
>>> assume with
>>> solar energy. A large difference.
>>
>> While 13% was the norm in the 1980s for silicon wafers and one can actually point to them, they are not the norm for multi−specral wafers.
>>
>> http://en.wikipedia.org/wiki/Spectrolab
>>
>> NREL has already demonstrated that multi−spectral cells exceed 40% efficiency.
>
> But they´re far more expensive and moreover the 40% efficiency you were using existe only in laboratory, like I think I pointed out to you earlier.

At high concentrations,the critical cost of dollars per watt is actually better with these systems, which is why my company is using them. Expense is something I've been working on for 14 years now.

Spectrolab has done studies to show they can increase production levels to support 1.4 TW per year required to compete head to head against conventional energy sources without government subsidy.

> You should work with what is commonly available.

That's like saying 19th century man should build SSTs out of steamships. What is commonly available today does not predict what will be available in 5 or 10 years. That's why you need to go to the lab and think about things based on first principle and deep understanding − not make gratuitous statements from your gut.

> I have posted this to you before, but these people have an idea of replasing much of the fossil fule use in USA.

I gave them that idea in 1994.

> "A Solar Grand Plan
> By 2050 solar power could end U.S. dependence on foreign oil and slash greenhouse gas emissions"http://www.sciam.com/article.cfm?id=a−solar−grand−plan
>
> They intend to only use cheap 13% efficiency wafers, and have made a plan which sounds very doable within theyr stated timeframe, i.e. to 2050.

Presently 30% of all silicon produced goes into manufacturing solar panels.
Presently solar 400 megawatts per year of solar panels are produced.
Presently humanity consumes energy at a rate of 15,000,000 MW
Presently energy use grows at 4% per annum − that's 600,000 MW

To meet all future energy needs with solar sources using conventional solar panels within the next 15 years requires that 2,000,000 MW per year be produced.

To meet all future energy needs with solar sources using my CPV solar panels operating at 18% efficiency within the next 15 years,requires that 1,400,000 MW per year be produced.

At 1x solar intensity we must produce solar panels at 5,000 times the rate they are currently produced and produce silicon 1,500x greater volume.

At 2000x solar intensity (using my system) wemust produce solar panels

3,500 times the rate they are currently produced and produce silicon 1.5x the rate it is being produced today.

> However, the what I keep repeating to you is that, while I think your ideas are potentially workable, the timeframe you have thrown at us is clearly unrealistic.

Where have you done the work to support your statements?

> 2100 sounds like a workable timeframe for such extensice ideas.

I think starting today with an appropriate level of investment, 2035 to 2045 is a good time to complete the program I've outlined here.

Consider that this is 27 to 37 years

From 1903 to 1927 − from the first powered flight of the Wright Brothers to Lindberg crossing the Atlantic was 24 years

From 1927 to 1947 − from Lindberg to Yeager breaking the sound barrier − 20 years

From 1927 to 1957 − from Yeager to the first satellite Sputnik − 10 years

From 1957 to 1969 − from Sputnik to Armstrong/Aldrin − 12 years

In 1967 − the Russian space program was in tatters, it was obvious that the US was going to make it to the moon, and LBJ cut back severely investments in space, following up the cutbacks he made in the 1965 and 1966 budgets − which stopped the increase in expenditures (December 21, 1963 less than one month after Kennedy's assasination Johnson and McNamara cut back the nuclear rocket and other nuclear propulsion programs) − so after this period, humanity exited the fast track to the stars while a two generations of rocket folk have become used to slow and steady and diminishing expectations −

In an emergency the US, and other industrial nations have shown a remarkable capacity to increase the production of things that seemed impossible to build just a few years earlier. Consider the production of war materiel during world war two.

http://en.wikipedia.org/wiki/Military_production_during_World_War_II

Following the attack on Pearl Harbor America shifted into high gear and produced massive amounts of war goods. Most impressive to me is the production of 141 merchant aircraft carriers in an 18 month period.

Similar transformations can be wrought less dramatically by industry in short periods of time.

For example in 1910 International Business Machines sold its first computer to the US Census Bureau and predicted at that time every industrial nation may have need of one. By 1950 IBM felt that the Fortune 500 might have need of their powerful mainframe computers. By 1960 that was expanded to maybe 10,000 machines. Famously their mathematical experts felt that there would always be an economy of scale to make large−scale computing more favored over smaller computers. Even as late as 1967 IBM still maintained that only major corporations with annual sales over $5 million could make use of a computer.

Actual computer now in use exceeded 1 billion by 2007 − and will likely exceed the human population within the next 10 years. Depending on how you define computers. Digital processors of the type found on every remote control − exceed the capacity of early computing platforms − and they exceeded the human population 10 years ago.

From 1967 where expert opinion could argue convincingly that fewer than 50,000 machines would be sold worldwide − to 2007 where 500 million machines will be sold in12 months − a factor of 10,000 − in 40 years.

Why not do it here? What does it take? Appropriate levels of investment in appropriate goals.

> Anyow,
> by 2050 we will probably be ready to expand solar energy production into space.

Dude, we needed solar energy production in space in 1970... my reasoning below.

Have you looked at the price of oil recently? In December 2004 when I was interviewed at the White House by OSTP about energy policy, oil was $22 per barrel, and the Saudis had announced privately they were going off the $22 price cap. What could America do? I said fill the Strategic Petroleum Reserve with US made synfuel from coal at $25 per barrel − using not only my process, but the dozen other processes that are struggling out there. This will send a signal to Wall Street and the Saudis that if prices stay over $25 per barrel America has an alternative. They didn't like this idea. Instead the opted for Regime Change in Iraq promising in part to pay for it with low price oil that people would gladly sell us at $12 per barrel.

Actually if you adjust things for inflation, you will see that ever since oil was discovered in Titusville Pa, and ever since Rockerfellar started refining it after the Civil War − first for lamp oil, later for gasoline − the price of energy in the industrial world − expressed in $ per barrel has dropped from 1860 to 1960 from $100 per barrel to $2 per barrel. In 1940s King Hubbert, a Geophysicist that worked for the Feds to estimate energy reserves of Germany in world war 2 − indicated that by 1970 the US would peak in oil output and enter secondary production, and that by 2010 the world would peak in oil output and enter secondary production. In the 1950s expert opinion was that nuclear power would displace chemical power by 1970 so we didn't have to worry about it. The US entered secondary production in 1970 which produced an oil crisis and gave OPEC − which had existed powerless in the 1940s and 50s − emerged as the arbiter of oil pricing in the world. From 1970 through 2000 the largest most massive transfer of wealth in the history of mankind has occurred as the US European and Japanese populations have paid increasing amount of their productive output for the oil needed to run their industrial plants.
In the 1970s we became the worlds largest importer. In the 1990s we became the world's largest creditor. In 2001 we were attacked by spoiled brats turned zealots who were spoiled by the tremendous wealth their families earned at our expense.

Prices have risen steadily from $2 per barrel in 1960s to $100 per barrel again. As a result, capital formation rates, industrial productivity and industrial growth has been severely restricted − and far lower than it might have been. Many of the rosy scenarios of the 1960s were predicated on a continuing 3.9% drop per year in energy prices − with a continuing 8% growth in industrial output. What has happened there has been a steady 8% rise in oil prices,while there has been zero net growth in real terms − despite massive increases in automation and computing capacity.

What makes you think we can wait until 2050?

If over the past 50 years (1960 to 2010) we had seen a continuation of the 3.9% drop per year in energy prices, and a continuation of the real 8% per year growth in industrial output − we would be at $211,000 per person per year GDP (instead of $45,000 per capita per year) and the price of a barrel of oil would be $0.30 − THAT'S THIRTY CENTS A BARREL!!! Our energy use would be 100 million barrels per day − just for the US.

> I´ll expect that before then there will be a time of experimentation,

Yes. That's what we're doing now.

> i.e. small scale experiments with small solar powerstations,

Yes, we're experimenting with power beaming even as we speak.

> experiments with beemed power, etc.

Yep,.

> That´s what is allways lacking in your suggestions,,,

?

> the inevitable
> experimental phase.

We've been doing experiments since 2003 on this topic ... I have a very clear program of R&D mapped out. I have funds budgeted. I have a road map. What is your rationale to say that a 37 year program won't see as much progress as we have seen in say − personal computing?

> By 2050 the experimental phase might be over

When do you imagine it starts?

> and
> we may be ready to begin your project of building them on a significant scale − the way you suggest.

When do you imagine experiments will start? Why do you think Spectrolab is saying what they're saying? Why do you think we're shooting for 60% conversion efficiencies today with 6 junction cells? Why do you think we're shooting for 85% efficiencies with diode and free electron lasers today? lol. Why do you think we're working with large aperture optics today?

>> Now, when silicon is exposed to light, what happens is determined by the colors of the light striking it. In the case of the sun, this is given by the planck curve of a black body radiator operating at 5800K

− through an atmosphere that absorbs some of the energy − principally hydrogen...

http://en.wikipedia.org/wiki/Black_bodyhttp://en.wikipedia.org/wiki/S...

So photons that are longer or redder than 1,108 nm − don't operate the silicon cell. They merely heat it.

And, photons that are shorter or bluer than 1,108 nm − contribute only the bandgap energy to the circuit. (if its properly balanced with a load)

What happens to the extra energy?   Well, it shows up as ballistic energy in the photons in the conduction band − yep − heating the photocell again.

Then there's the recombination of electrons that get formed but not picked up − this depends on temperature.

And that's not the only source of loss − there are junction losses − resistances in the cell itself that cause current squared times resistance (i−squared r) losses − which also causes heating.

The I−squared r losses can be reduced by reducing junction resistance − in cells like those designed by Bob Swanson at Sunpower − or by reducing current for a given power by increasing number of junctions in series − in cells like those designed by Bernie Sater at Photovolt − or by combining the two together like I do with my cells at Mok Industries.

Keeping the silicon cool is how to reduce dark current losses.

This leaves you with ineffective photons. The long−wave photons that don't contribute to the cells operation − and the short wave photons that contribute onlty the bandgap energy.

Since the planck curve graphs in the references I gave are energy per wavelength versus wavelength − the area under the curve.

For each wavelength, take a ratio of the wavelength and the bandgap wavelength in the case of silicon 1,108 nm − and multiply the solar output by that ratio. So, for example, the energy in a photon with a wavelength of 554 nm (green) contributes only half its energy to the operation of the circuit. 277 nm (Violet) contributes only one−quarter its energy to the operation of the circuit. Do this across the entire planck curve (its called convolving the silicon response curve and the solar black body curve) − and you get what each color contributes to the operation of the silicon cell. Now integrate the convolved curves to get the area. Then, finally, divide the smaller area of the convolved curve with the larger area of the planck aka blackbody curve − and you get a number − around 23% − with small junction losses and temperature losses.

Now what Spectrolab did − is they combined photocells of different wavelengths and arranged to have bandgap matched light fall on each type − and use the output of all of them. NREL has shown that they operate at 40.7% efficiency with 3 bandgaps. We are discussing building 6 bandgap system (GaAs can be doped to change its bandgap energy) − that is expected to have efficiencies exceeding 60% − the practical limit seems to be 20 bandgaps − with 80% efficiencies

So, 40% has been achieved

60% is a reasonable near term research target (and the focus of current research, visit my web site, fill out a contact form,and I will send you a white paper)

80% is a plausible long term achievement

I quoted 40% overall...

> That sounds truly like an excellent technology, but how expensive would such cells be when compaired to those that already are in mass production?

I answer the cost questions below. At $12 per square inch its 40x more expensive than polycrystalline cells. Because they're able to operate at 5,000x solar intensity − the cost per watt− which is the central figure here to keep in mind − is less than a penny a watt. Now, also at 5,000x solar intensity − modest production scales translate to massive power levels. Furthermore, the scale at which Spectralab can produce today is sufficient to meet my immediate terrestrial needs. The scale it can produce at given sufficient investment capital − appropriate to the value created − it can meet the needs I outlined above.

> How quickly can the price be reduced through economies of scale?

They already produce at a price and in a volume that meets my needs − and they can exceed expectations going forward.

> Do they contain very expensive materials that will result in them staying expensive no matter what?

You have missed a central point. My patened concentrating technologies reduce the importance of material costs. At 5,000x solar intensity − used in space applications − these systems are less than a penny a watt −

> These are worthy considerations. Remember you intend to use these on a very large scale, presumably first in groundstations.

Depends on the details of the application. 5,000x solar intensity is difficult to achieve optically with systems that are cheaply put on the ground. 1,000x concentration − no problem − so we're sticking with silicon for ground applications − float silicon at $1 per square inch − yet the PV costs are on the order of a penny a watt.

> The people with
> the abow mentioned plan intend to make do with less sophisticated technology, and still think that it will be possible to significantly reduce the use of imported oil over the period to 2050.

I will make America an energy exporter again before we reach the peak in global output..

> > > The program I find believable assumed that it will take some years to
> > > achieve that 13% efficiency,

> > 40% has already been achieved, I'm funding research to see if we can achieve 60% by doubling the number of junctions, and qualified researchers feel that by increasing the number of junctions further using MEMs technology − it may be possible to get to 80% ...

> MEMs are a most important innovation. Clever use of manufacturing techniques originally used in manufacture of chips, is how most of them are made. The airbag of my car probably is activated by such a MEM.

It is definitely activated by a MEM. MEMs has proven very important in handling heat loads efficiently as well as managing optical properties.

> The question will the bee weather the trick of the chip makers can be repeated, i.e. to make enough of them to shrink the prices down to reasonable levels.

The consumer electronics industry advances a generation every 18 months. Solar applications do not need the same type of improvements. So, the 15% of productive capacity per year that gets tossed aside as new plants are built, are available for solar panel producers. Someone like myself who has sponsored half a dozen substantial solar energy projects around the world, find themselves flush with cash to buy a handful o fthese facilities and outfit them for production of 100 BILLION watts of panels per year − 14 plants like these are needed to meet the need for solar panels on a scale required to make a significant difference in the energy picture of this planet.

Success with these early projects will translate into being a dominant player in the world's $4 trillion annual energy market − and with 80% margins − (I sell fuels not hardware or technology) − I will have adequate resources to expand my base.

14 plants producing 17 sq km of solar panels a day will require 2,647 days (7 yrs 3 mos) to cover 45,000 sq km of the 100,000 sq km of land I have optioned across the US. This is sufficient to supply 287 million tons of hydrogen each year from solar sources using my 18% efficient solar panels. 177 million tons of hydrogen displaces 1.1 billion tons of coal in the nation's power plants − and an additional 110 million tons of hydrogen are combined by direct hydrogenation − no burning of coal − no production of CO_2 − to produce 7.7 billion barrels of liquid fuels. This permits the US a surplus of 1.2 billion barrels a year − which may be exported. AT $80 per barrel margin this generates $616 billion per year. About 15% of the world's market for energy. Microsoft rose in 15 years from nothing to challenge IBM as the leader in computer technology, and now owns 98% of the operating system market worldwide. These are achievable goals, given that I have spent the past 14 years laying the ground work for the next 16.

With this sort of revenue, what will it take to dominate the field going forward?

There are two approaches −

1) keep doing what works − build more panels and more panel production plants. Increase the number of terrestrial plants to 150 − and blanket 550,000 sq km of Earth to make 3.34 billion tons of hydrogen gas − to displace all current needs. This will be completed in an additional 15 years− and by that time − 25 years from today − energy use will be 266% what it is today − assuming a 4% annual compounded increase in energy use. So, we'll control 37% of the market.

2) do something more efficient − build solar power satellites − allowing me to generate 20x the energy from the same terrestrial installation − by adding 50,000 sq km of solar panels in space − while reducing my cost per watt to less than 1 cent − and pass a portion of that savings on to my customers to promote rapid growth in demand. Here I will have enough power to produce 7 billion tons of hydrogen gas per year, total demand will rise at 7% − total demand in 25 years will be 542% − I will control 40% of the market − and make 3x the profit.

> But if expensive materials are used, or materials which supply could cause a bottleneck,

AT 5,000x concentration possible with this technology, the bottleneck is in the silicon operated at 1x concentration − as I showed above.

> then they might stay expensive anyhow.

Yes, they will even get more expensive, but on a dollar per watt basis − they will get less expensive due to clever optical design.

> Moreover,
> many of the chips have become so incredibly complex, so expensive to develope that even though they are mass produced in great numbers, they ´re not especially cheap to purchase.

If you own the process where that is done, you will get them at cost. The cost is on the order of hundreds of millions of dollars. To put up a plant, especially a retooled plant purchased at a discount − costs again hundreds of millions of dollars. The value created is hundreds of billions of dollars. Not a bad deal.

> That is importan, the price.

The dollars per watt and bottlenecks are important. concentrating sunlight with low cost optics is a critical factor here and why that has been a central point of my research.

> If you are to persuate people to use
> them.

I make a commodity − gasoline, diesel fuel and jet fuel − and sell it at market rates. No one needs any persuasion. Getting utilities to buy hydrogen is a different matter. I am working on a program now to buy stranded facilities and undervalued facilities, and coal companies with power plants − to get them off dead center − and begin the transformation to a hydrogen economy with our coal fired plants.

> Today, older tech solar cells have become cheap enough that average people can affor to use them on a reasonable scale.

Conventional solar power made with polysilicon is an energy sink. You need to cheaply concentrate solar energy to reverse that.

Solar
cells f.e. on the roof of a house can really shrink the electricity
bill.

Not when you count the cost of capital tied up in conventional panels
you don't.

as current mass produced solar cells do
not achieve more than 10%,

I am mass producing CPV systems that routinely achieve 18%

At what cost when compaired with cheaper cells?

$0.07 per peak watt including all balance of system costs − when
producing hydrogen.

I can only assume that you are expecting what is now only
possible in
controlled laboratory settings will become practical mass
production,
which by the way is not an obvious assumption.

Lets do more than quote numbers shall we. Lets look behind the
numbers and then we can come to some logical conclusions.

The number you give is an average based on systems that use amorphous
or polycrystalling construction. Junction losses are extraordinarily
high in these systems. This is deemed acceptable because they can get
their silicon at very low cost compared to pure float silicon that is
a pure crystal.

What you term − experimental or laboratory − systems have far higher
efficiency.because they use float silicon − that costs about $1 per
square inch. This is about 3x higher in price than polysilicon
systems − but the output is less than double (14% versus 23%) −

I use float silicon − but fabricated in a way and cut into dies that allow me to operate it at 1,000x solar intensity. (see my web pagehttp://www.usoal.com) − this cuts the PV costs per watt way down, and lets me operate at higher efficiencies.

Ditto with the UTJ cells from spectrolab. They have a germanium subtrate − and CVD epitaxially grown − GaAs and InPh layers − whose thickness allows efficient capture of specific colors of light. These are $12 per sq inch in quantity.

So, here's the deal; lets compare the older design, with my current design (Patent #7,081,584 − Mook), and whats in the labs today that I'm expecting to use on orbit tomorrow;

sunlight − 645 milliwatts per square inch terrestrial clear day
881 milliwatts per square inch space earth orbit

mass produced conventional solar panels
14% efficient
1x concentration
645 milliwatts per square inch solar
90.3 milliwatts electrical per square inch
$0.30 per square inch cost
$3.32 per peak watt (PV cost)

Mok terrestrial PV
18% efficient (filtered)
1000x concentration
645 watts per square inch solar
116 watts electrical per square inch
$1.00 per square inch cost
$0.01 per peak watt (PV Cost)

Spetrolab 6J PV (research)
55% efficient
5,000x concentration
4,405 watts per square inch solar

2,422 watts per square inch electrical
$12.00 per square inch cost
$0.005 per peak watt (PV Cost)

I simply must disbelieve your figures until you can give some idea how
you are arriving at them.

I have not only given you pointers to research results from one of my vendors independently verified by government laboratories, I have given you an insight into my current research efforts.

Thank you for that. But as your figures clearly demonstrate the newer technologies are more expensive per square inc over to far more expensive per square inc.

So? Its dollars per peak watt that is the critical factor. which is why I computed it for you.

That matters a lot, when you intend to use them on a large scale

No, get your mind around the fact that you don't need as much material when you concentrate. How do you think I got a lower dollar per watt figure with a more expensive material? The supply problems would come if we produced enough solar panels to meet all our needs − with conventional panels. Not when we use concentrator systems.

Lets look at a 100 mm diameterwafer

1x solar intensity − terrestrial 1.1 watt electrical
1000x solar intensity − terrestrial 1,412 watt electrical
.5000x solar intensity − space 27,293 watt electrical

You need thousands of times more wafers to equal the capacity of the concentrator system − so even if you pay 3 to 40 times as much for it − you're still ahead− and your supply problems are non−existent with the concentrator systems.

However, there is naturally the issue in what setting the planned use is for. I wouldn´t be surpriced, once perfected and shown to be reliable, the high energy per square inch types will dominate

installations where cost per square inch is not so great an issue but
energy produced per square inch is.

Concentrators cannot increase the intensity of sunlight − however, higher efficiency systems do make for smaller overall systems. The critical factor is DOLLARS PER WATT − and my systems reduce costs to PENNIES PER WATT − so there's really no comparison.

Since you didn't bring it up, I haven't yet addressed the other big issue − the laser efficiency, and then the efficiency of the conversion on the ground. Free electron lasers have achieved 30% efficiencies 20 years ago, diode lasers routinely exceed 10% efficiency − yet are less tunable.

http://www.frascati.enea.it/fis/lac/fel/fel2.htmhttp://www.alfalight....

The military has focused on lightweight compact applications for years. But both teams believe for sound and valid reasons that 80% to 85% efficiencies are achievable with a dedicated effort over the next five years.

So, I have used those figures for my estimates here.

sunglight −−−> DC electricity	55%	55%
DC electricity −−−> laser energy	85%	47%
laser energy −−−> DC electricity	85%	40%

That´s a bit of an assumption.

What is?

By the way, the asteroid project you appear to be assuming sounds
really seriously expensive.

> > Cost is only one aspect, value created is the other. So, it is important to create more value than you spend in order to achieve your goals.

> Now, this asteroid operation is clearly an operation in which the will inevitably have to be a testing period.

Correct.

> This will necessiate a large trained cadre of astronauts.

Yes.

> This will moreover also necessiate quite bit of EVA training of those astronauts.

Yes

> This will in addition necessiate the development of deepspace vessels,

Yes.

> I´d say preferably nuclear powered.

That is not in my planning. Reusable heavy lift launchers hydrogen/oxygen powered, reusable heavy kick stages, hydrogen/oxygen powered, Reusable heavy lift launchers − laser powered with hydrogen propellant, reusable heavy kick stages hydrogen propellant laser powered, deep space laser probe/scan, deep space laser power, deep space laser propulsion. This is the development arc. Payloads will be, communication satellites, telerobotics, space tourists, space industry research, power satellites, moon based factories, mars base, asteroidal base, near sun solar power satellite, asteroid movement, asteroid capture, asteroid process research, test run, expansion; raw materials, finished goods, assembled goods, agriculture, forestry, homes.

> Now, I know you have suggested beemed power over the distance from the Sun. But that´s another development project with a testing period all of its own, and expenses, potential bottlenecks, etc, etc.

Yes. The communication satellite network will generate a revenue in excess of $80 billion per year − greater than all the budgets of all the space programs of all humanity. This covers launch infrastructure and launch vehicle development. Capturing 15% of a $4 trillion market generates $600 billion per year 12.5% allocated to power satellites doubles the figure above − and develops powersatellite build out infrastructure, and all the processes needed to support it− including ground and flight staff.

Please note that Mercury 7 astronauts were called for in 1959 and the first astronauts were flying in 1961. In September 1962, nine pilot astronauts were chosen and 14 more were selected in October 1963. This is when Armstrong came aboard. He was on the moon by 1969. 11 scientist astronauts were added to the astronaut program in 1967 and one went to the moon in 1971. I don't see why you think it impossible to train the right people to do the jobs asked of them.

> Beemed power will require years of testing, first small scale then large scale all of its own.

That's right and its going on today.

> Now, today we may not foresee any great difficulties. But there allmost allways are difficulties, especially when working in an environment humans stichtly speaking still have got very litle experience in working within.

That's true and I am speaking from experience. What are you speaking from?

> But, if we accept nuclear power for at the very least the first generation of deep space wessels, then at least that operation´s initial successes will not depend on the rate of development of the other program you apparently intend to run at the same time.

The HEU that formed the heart of Nerva still exists and is at Jackass flats under DOE control. It has been proposed for a number of missions. I have proposed that a nuclear tug be produced using the NEBA III reactor designed by the DOE using this material. A 5 MW thermal reactor producing about 60 kg of thrust at a 900 sec Isp. These can be built for about $90 million each − all we need is approval. My bankers − First Boston − said they'd fund it if we could be assured of launch. I went to the White House and spoke with Bill Clinton about this and the OSTP. We didn't want to trust the nuclear regulatory people, and the law allows the President to circumvent regulation and permit launching of nuclear reactors into space under his direct order. This was at the time Newt Gingrich and Clinton shut down the government. Al Gore didn't like the idea. So the whole thing was shelved. But, we had gotten NASA (who wanted a Pluto probe) and the Air Force (representing NSA I think) who wanted a very capable satelite built around our tug design, and others − along with my commercial interest. A two−stage to orbit RLV − with an SSME in the first stage, and four RL10 in the second stage would put an Atlas class payload up very cheaply. The tug would stay in orbit and basically multiply our payloads to high orbit. We'd develop automated docking and propellant transfer methods − and a satellite bus concept. Anyway we were going to launch Teledesic satellites − and we had First Boston ready to issue bonds after we got approvals to launch (with appropriate oversight of course) − I spent a year at that and it didn't work.

Aanyway, since then I don't see anything happening with nuclear − though NASA has been soft selling that issue with their Pluto mission and their new probe to Jupiter. I could forsee the nuclear thermal rocket turning into a universal space power source − first A 2 MW electrical generator − using a Brayton cycle − powering an ion rocket − then a general power source −for a Mars Direct sort of thing − and lunar and mars bases and so forth. I could see the popularity robot probes across the solar system would have − especially with interplanetary internet − and the EPA wanted us to dispose of nuclear rockets every so many flight cycles So every four years we'd take a tug − dock with a scientific payload, and do a deep space mission like the Jupiter probe proposed later by NASA... It would have been great − but it wasn't to be.

No, I'm sticking with laser thermal and laser detonation − there might be a case for laser ion − but that's what I'm doing in my long−range planning.

> So
> different development scedules, unforseen bottlenecks need not harm that operation as well.

Putting a nuclear power source in your planning guarantees bottlenecks.

> You need allways to be able to take such in stride.

That's true, that's why you make sure you're making money at each step. For example I could see that no matter who developed cost effective solar panels − certain properties would have a high value. So, I signed options and actually got paid to sign those options. That helped put us light years ahead of others in the solar panel technologies we own. Now we're sponsoring energy deals around the world. That makes us money. Next we'll actually produce synfuels − or as I like to call them sunfuels − and that will create about $40 billion in value for my companies. This will be used to exercise those options I spoke of and put up the factories needed and do the other things I spoke of. Success with that will allow a massive expansion of our R&D leading up to real power sats by 2015−2018 time frame − and expansion to a full blown system by 2025−2030 time frame. Along the way we'll do the other things mentioned − running up to asteroidal capture and processing − expanding from test systems to high value processes − to lower value as costs drop − ending ultimately with a spaceship in every garage and a space station for every family − while turning everyone into million dollar a year (in real terms) income earners.

> Now again about the asteroids, a test will have to be made with capture and moving an asteroid. Now, an easy in the relative test operation might be to attempt to move one of the asteroid that orbit close to the Earth/Moon system around the Sun.

Its best to do it in deep space far from Earth in directions that will never impact Earth.

> Now, such tests are
> very important, as you need to know weather you assumption are really reasonable, i.e. that shining a laser can tell you enough about the rock to be hauled in to be a practical method for future use, which was one of the methods you mentioned.

This sort of test can be done on the moon − at sites that have already been surveyed in detail. When you get around to actually moving something, its best to work in the asteroid belt before attempting to do something around Earth. Giving Mars a new moon, or changing the orbits of Diemos or Phobos − since Phobos is falling to Mars − it would be a candidate for 'fixing' − during a trip there. Grabbing an asteroid from the asteroid belt and bringing it into a controlled orbit around Mars would be another test.

> You need also to test the
> capture operation itself, if for no other reason that your personnel

> will need such training. But also in order to develope that operation itself.

And gain sufficient political support and answer negatives − absolutely.

> Most likely several such tests at the very least will be necessary in order to hone the methods used. In addition as they will be necessary for training purposes of the personnel, and therefore will need probably to continue.

I agree. Yet, you are needlessly dismissive, and don't quote any time frames or rationale for your attitudes.

Look at the history of lunar orbit rendezvous. Tom Dolan proposed it in 1959 and it was championed by John Houbolt. NASA thought it too risky, so Houbolt went outside channels and got support of it above his immediate superiors late in 1961. This raised a shitstorm that went right to Webb which was resolved favorably in the summer of 1962. Now, the contractors didn't know for sure that would be the mode decided on until that summer. It wasn't until 1963 that they started actually bending metal − and the first LEM wasn't flown until 1969 − meanwhile simulators were built and astronauts were trained − and a test flight was made in Earth orbit in early 1969 − and by the summer of 1969 landing on the moon.

> Naturally, there are several different problems. It would require quite a different operation to attempt to capture an asteroid which is only a loosely bound rubble, than an one which is solid through. Each type will need testing and training of its own.

That is correct − and each planned use and so forth. Absolutely. Did you know there are over 100 different kinds of recovery methods for oil well and gas well drilling? Based on the range of environmental and geological conditions? I know this because I'm in the process of patenting an improved recovery method and each kind has its own set of claims. I imagine that there will be at least as many methods of asteroidal recovery − and probably more so. So, just as you concentrate on certain asteroids at first, you also concentrate on certain high value supply chains at first. I'm not saying nickel is going to be the one − that would be premature − but nickel does come from deposits that came from meteorite falls. Nickel is a well know strategic material that will be highly valued in an economy whose energy supplies are growing. So, that may be the very first supply chain we will augment. That means we enter strategic relations with major nickel marketers and enter off−take contracts with them− this gives us details − very specific details about what sorts of nickel or nickel ore is useful to them − and then, that informs the whole process. Repeat this process hundreds of times across hundreds of materials and you get an idea of what its going to take to transfer our resource base for strategic materials off world.

Once you have exhausted the opportunities in filling the supply chains for raw materials− you add processes to deliver processed goods − instead of iron ore for example, you ship steel. then you fabricate steel parts for example, then you create finished goods − assembled goods − then agriculture − then forestry products − then homes as I said.

> I expect this beginning phase to take from 15 − 20 years,

Why? When we went from nothing in 1959 to the moon in 1969? That was a bit leap in far less than 20 years.

> concervative expectation. All through that time these personnel would have to be maintained, the scientists paid theyr salaries, etc...something you are familiar with.

Yes. It took Sony nearly a decade to develop the trinitron tube and bring it market. It took HP nearly a decade to develop the inkjet printer and bring it to market. It took Intel nearly a decade to develop IC technology and bring it to market. Why do you think it would take longer than this to do any of the steps I speak of ??

> The ships themselves would also be expensive.

So? The critical aspect is the value they create relative to their cost.

> > > It would be cheaper to send small ion powered probes to check on the asteroids.

> > Cheaper than what? Please explain how you analysed the program and come to this conclusion. Recall, that we precede dispatching the probes with a terrestrial program of observation, and follow it up by dispatching crews to the selected asteroids for processing.

> > > What powers the ion engines in your suggested approach? I use beamed laser energy.
> > >
> > > What makes you think an ion engine is superior to a laser engine of the same specific impulse but higher thrust to weight?
> > >
> > > I am building an infrastructure to carry out a program. Does the use of ion engine technology assist in that? If so how? Why is it superior to laser propulsion systems that have equal specific impulse and higher thrust to weight?
>
> The ion engines using solar cell power, are a tried and tested system.

What size collector area are you contemplating? What thrust levels? What power levels? A solar powered system driving an ion engine in the asteroid belt at high specific impulse − would take decades to maneuver itself,, and totally incapable of doing anything significant in a reasonable time. Augmented by laser energy from Earth things improve. Using laser energy to energize propellant directly − thrust to weight improves dramatically.

> That´s what they have going for them.

So you ARE suggesting we build SSTs out of steamships! lol If it cannot meet the needs of the mission − then they're not suitable. Sorry. I don't care how reliable they are. When building for the future, why not use technology appropriate to the task? Ion engines especially solar powered lack the thrust toweight and total thrust to be an effective propulsion platform fo rthe mission I am contemplating.

> Thus they will clearly be
> relativelly cheap,

Not really − because there is no commercial demand for ion engines to start out with, whereas by the time I envision my laser kick stage to be built − there will be significant commercial demand for beamed power and I will have developed a laser powered booster to increase rate of power satellite deployment..

> especially if massproduced.

Yes that always helps.

> So many could be made.
> That means theyr use will not depend on the development scedules of all the other systems you intend to be developing.

That is true of any system − even laser propulsion systems − which have higher thrust to weight.

> Remember, you are
> planning to do this all in the incredibly short period till 2050.

Yes.

> So,
> I presume that all developmens scedules more or less have to run at the same time.

Well, there is some staging − but yes.

> So, to safe time ion engined probes can be put into production right now,,,for all what it´s worth.

No, my research with laser propulsion and other's research results have indicated that this is a very interesting technology to develop − especially if you have 20 GW laser power satellites on orbit to drive them.

> In addition, you idea for Earth observation necessiated apparently the construction of number of sites. Those are not cheap.

I stated, that $30 million per year over 3 years will get me the data I need. A continued funding of $3 million per year thereafter provides a continuing stream of scientific and commercial data about small bodies.

> Depending though
> on the size of the observatories you have in mind.

A complete survey of the 300,000 known objects that might fit our
preliminary criterion.

> But, as you intend
> them to give the best idea possible from over here, they sound like
> expensive large mirrors to achieve the necessary resolution of such
> tiny at that distance objects.

olbi −optical long baseline interferometry − I have a whole research lab dedicated to advanced optics. As part of the power beam control and so forth for the proposed power sats. One of the side issues that our technology is capable of doing is creating optical long baseline interferometry using optical fibers between commercial telescopes − a quite modest array properly outfitted can create quite good images according to our models. We'll see. Furthermore, we will be building big optical systems − so, this is an important feature − and building a modest ground system from scratch − is a good way to train and get competent before doing stuff on orbit. We don't want to be like TRW with Hubble do we? lol.
.

> Now, such observatories can cost
> several billion apiece.

Depends on the details. We think we can build an adequate system for
about $75 million − and stcannot be relied upon to address these issues?

> even when assuming that you will be using the
> technologies you are assuming and moreover assuming that they really
> will work the way you assume they´ll work.
>
> So my expectation is that you will be making a series of nudges till
> you are free of the other orbits.

You will plan your trajectory with a numerical model before you
actually carry it out. When you do you will carry it out the quickest
way possible given your energy level and thrustor efficiency.

> So moving clear will take unknown
> number of years,

You will do it in months − and know precisely the maneuvers and thrust applications you'll nee.

> depending on the number of orbits necessary to cross.

You will know precisely what movements to take and the order in which to take them − shortly after you know the 1,000 bodies you will take. Like you said, they're not going anywhere until we say so.

> > > I think it would be reasonable to reckon with 5 − 10 years of gentle
> > > moving and nudging untill Earth orbit.

> > You haven't done any analysis of the critical factors and are wrongly assuming I haven't analyzed the noncritical factors you cite. That's why you are making so many mistakes.

> > A hohmann transfer orbit from Ceres to Earth is about 7 years. I have put a 10 year limit on the transfer − this gets us the 84.5 micro gee limit. You have proposed using solar sails, any practical solar sail operated at the asteroid belt will take centuries not decades to complete a transfer.

> Assuming there are no other orbits in between that must not be disturbed.

Why do you think I assume that? Especially when I said there will be terminal maneuvering to do. Why do you assume something will take 10 years when it could easily be done in 10 hours?

> However, that´s not the reality. Remember over million asteroids.

REmember i already know that. You miss my point and talk me like I'm stupid. all the orbits of all the objects are very wll known. When the 1,000 are chosen, the precise order of battle and thrustor arrangements and so forth will have been worked out in computer models before the first people arrive. Just like vonBraun could tell us the precise minute an Apollo capsule would land in the ocean, at the time it was launched from Earth − so too will the crews of the capture teams know precisely the terminal manuvers needed to carry out their missions − in the asteroid belt and in arriving at Earth.

> And we can´t move the largest asteroids.

No reason we can't except for the power levels needed to do so in a reasonable time.