Re: Moonbase Power

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The United States had several nuclear generator and nuclear reactor and nuclear rocket programs.

SNAP−2 has already provided power on the moon, and plainly these can be ganged together to provide sufficient power for a moonbase.

http://www.ne.doe.gov/pubs/npspace.pdf#search='nuclear%20power%20moon%20.pdf'
http://nuclear.gov/space/space−desc.html

Rockets can be powered by nuclear sources

http://en.wikipedia.org/wiki/Nuclear_thermal_rocket
http://www.newscientist.com/article.ns?id=dn3285

and these can be adapted to power generation.

http://en.wikipedia.org/wiki/MHD_generator#Research

The F1 was used with a MHD generator setup − this is just a photo of the F1 − a great engine! lol

http://aerospacescholars.jsc.nasa.gov/HAS/cirr/IMAGES/f1engine.gif

And research continues

http://www.spaceagepub.com/pdfs/Powell_1.pdf#search='nuclear%20moon%20power'
http://www.utsi.edu/News/release12−07−05newphasemhdgenerators.html

Clearly a combined program of nuclear propulsion, nuclear electric generation and nuclear electric propulsion would pay huge dividends in the serious exploration of space. In a nuclear thermal rocket engine the nuclear heat source heats a propellant that is expelled to produce thrust. This medium could be recycled in a MHD generator through a radiator. The nozzle of the rocket engine could be adapted to feed into a turbine to generate power. A less conventional approach is to use the medium directly in a MHD dynamo where it again is recycled through a radiator. Light weight efficient nuclear power sources in the megawatt range could make ion and other electric rocket technologies practical − and provide significant capabilities going forward.

The DOE has developed the NERVA engine and its smaller cousin the NEBA engine. The first is a 75,000 lb thrust engine that achieves 850 sec Isp using hydrogen as a propellant. The second is a 750 lb thrust engine that achieve 850 sec Isp and simultaneously produces 10 kW of electrical power− whether or not its thrusting.

The power in the jet is given by;

P = F * Isp * 4.91

Where P = power in watts
F = Force in Newtons
Isp=speific impulse in seconds

So, F(NERVA) = 75,000 lbs = 34,000 kg = 333.8 kN
Isp(NERVA) = 850 sec
P(NERVA) = 1.4 GW

This is the power of the jet, the efficiency of getting heat energy into the jet and getting the jet moving is around 0.85 so divide by this to obtain the total thermal power of the reactor at full thrust

1.4 GW / 0.85 = 1.64 GW

And converted to a nuclear power station this system would mass about its weight − 60,000 lbs − but at 40% efficiency, it would generate over half a GIgawatt of power − enough to power a small city − or a sizeable ion engine! .

The NEBA reactor is about 1/100th the power rating of the larger system. Equipped with a 10kW closed cycle generator which absorbs only 1% of its total thermal power. This system could easily be expanded to the 1 MW range. Its wieght doesn't scale directly, but still, a system massing 1,200 lbs and generating 10 MW is possible. Again, this could power quite a sizeable ion engine for deep space exploration.

The NEBA is in quite advanced stages of production. They can be built for around $85 million each. Unlike RTGs they can be launched quiescent, and turned on once on orbit. They can be used as a reusable kick stage to increase the high orbit lifting capacity of existing launchers. So, instead of a conventional kick stage and satellite combo, a launcher would put up a propellant tank and satellite combo. The NEBA nuclear rocket would dock with this payload, boost it to the final orbit, release it, and return to its parking orbit. In this way, the size or number of satellites attaining high orbit could be more than doubled. The NEBA based tug after hundreds of flights could be retired by carrying out a deep space mission using its improved thrust and nuclear power.

The NEBA based system could be adapted to power generation needs and placed in GEO along with a deployable space frame structure. Attachment points would permit docking of sub−satellites to the space frame structure. This system would be placed on orbit and taken to GEO by the NEBA based tug. It would then be powered up and capable of supporting dozens to hundreds of subsatellites. The NEBA based tug would then carry dozens to hundreds of satellites to the structure where they would be installed. The sub satellites wouldn't need guidance, attitude control, power systems, command and control systems, and so forth. They would just have their sensing, high gain communication, navsignal, whatever else the owner wanted to achieve with the sub−sat. This reduces weight, and complexity and cost. The owner pays a part of their revenue for the power, and other services on oribt. In this way more satellites can provide more services with less interference with one another than today.

The 10 MW space power system developed for this commercial application − and placed in several GEO, MEO, and SSP orbits − to support an expanded space services sector on Earth − could be used directly in a lunar or mars base,or a large space station or space hotel and for really capable nuclear electric tugs that dispatch really large payloads around the solar system − while providing power for them.

$10 billion spent on this sort of program − of expanded robotic exploration − including a robotic nuclear sub for explorations of the oceans of the icy moons like Enceladus − would usher us into a new age of planetary exploration, give us the fundamental capabilities we need to support this cheaply, and do far more than $100 billion spent on using LOX/LH rockets to carry out a mars expedition or a return to the moon using Apollo era lifting capacity.

Yes, a Shuttle derived FULLY REUSABLE cargo craft using a ballistic rather than a winged re−entry vehicle − no cross range − I envision a VTOVL sort of vehicle. That uses a SSME or perhaps 2 in the first stage and four RL10 engines in the upper stage − TSTO−RLV − with very small braking rockets in each stage to bring it to a soft landing − and then the parts are returned − this would support the expanded space services sector described above and work well with the systems previously described.

Hundreds of highly energetic robotic probes would be operating simultaneously throughout the solar system. A wireless spacenetwork would be accessible through the internet and folks could explore from their homes or workplace, the planets of the solar system on a nearly live basis. The 10 ton payload capacity of the TSTO−RLV described above could be adapted to take a dozen passengers into LEO, and a nuclear powered inflatable space station would be the first space hotel − http://www.thespacereview.com/article/187/1

The $10 billion in startup money could be provided by the government and the nuclear power industry, to promote a positive vision of nuclear power.

Money earned from delivery of services to Earth from space, including the next step in space tourism, would pay for these developments.

The $100 billion that NASA once said it would cost to return to the moon, could be carried out in phases using a nuclear component, building on this success of the five year program just described. Another $20 billion spent over another five years would create a larger shuttle derived vehicle and re−create the NERVA class systems with modern materials and control technologies. The balance would be used in subsequent years to dispatch payloads across the solar system, both manned and unmanned to create permanent settlements on the Moon and Mars, and outposts on the more interesting locales in the solar system, and increase the number of highly energetic, and increasingly sophisticated, robotic probes into the high hundreds to low thousands! Expanding the size, sophistication, and novelty of the growing network of interplanetary reports.

A LARGE Shuttle derives FULLY REUSABLE manned carft using as many as 7 ET ganged together propelled by 7 SSME each − 49 total − at launch, with cross−feed arrangement − to operate as a three stage craft, 4 ET, 2 ET, 1 ET − to put 550 metric tons into orbit − with a Nuclear thermal orbital stages propelled by 4 NERVA engines 300,000 lb thrust total − at 850 sec Isp − carrying a 1,000,000 pound LUNAR SHUTTLE (think of the spherical craft displayed in the movie 2001 A Space Odyssey).

Later a dual nuclear electric orbiting stage, putting out 1 GW of electricity − and running a powerful 10,000 lb thrust ion engine at 5,000 sec Isp − for efficient deep space maneuvering − carrying 300 tons of useful payload to the moon or mars. A lunar based NERVA engined craft would then be used to deorbit and orbit payloads arriving my nuclear electric rocket from Earth − at each location.

Small outposts on Mars and the Moon would be powered by the 10 MW space reactor, and the larger settlements would be powered by the 1,000 MW space reactor.

Payloads themselves would operate as sheilding and with a 300 ton total capacity − 60 tons of people and support gear would be carried with each trip − and 240 tons of cargo− doubling as radiation sheilding − would be placed around the piloted portions of the spacecraft. .

William Mook

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> Recently we had a short discussion about how to power the Moonbase. The suggestions by NASA (solar−electric and LOX/LH2 nighttime storage) was

considered somewhat strange. Specialy a suitable liquifier seemed beyond present technology. I wondered why NASA not suggested a more conservativ approach on such a crucial element of a Moon Exploration plan. I remmembered at least on nuclear reactor concept already in use 40 years ago. I found something about it on the net:

The PM−3A was a small nuclear reactor that powered the United States's research base at McMurdo sound in Antarctica. It operated from 1962 till 1972, when a leak was found and the plant was decommissioned.

It was the third in the line of portable, medium output reactors. The plant had a net output of 1250 Kw and was designed to be to fit in a C−130 (Hercules) aircraft, but was transported to McMurdo by boat. On top of producing electricity, it also ran a water distillation plant with otherwise wasted heat.
http://64.233.179.104/search?q=cache:U1H−k−MaKZsJ:everything2.net/index.pl%3Fnode_id%3D1341155+r

What fits in a C−130 for Antarctica should fit in any "Apollo on steroids" for moon launch too. Maybe the technology is from too long ago to get it up again. But there are similar systems in development elesewhere now:

The Super−Safe, Small & Simple − 4S 'nuclear battery' system is being developed by Toshiba and CRIEPI in Japan in collaboration with STAR work in USA. It uses sodium as coolant (with electromagnetic pumps) and has passive safety features, notably negative temperature and void reactivity. The whole unit would be factory−built, transported to site, installed below ground level, and would drive a steam cycle. It is capable of three decades of continuous operation without refuelling. Metallic fuel (169 pins 10 mm diameter) is uranium−zirconium or U−Pu−Zr alloy enriched to less than 20%. Steady power output over the core lifetime is achieved by progressively moving upwards an annular reflector around the slender core (0.68m diameter, 2m high).

After 14 years a neutron absorber at the centre of the core is removed and the reflector repeats its slow movement up the core for 16 more years. In the event of power loss the reflector falls to the bottom of the reactor vessel, slowing the reaction, and external air circulation gives decay heat removal.

Both 10 MWe and 50 MWe versions of 4S are designed to automatically maintain an outlet coolant temperature of 510?C − suitable for power generation with high temperature electrolytic hydrogen production.
http://www.uic.com.au/nip60.htm

I always thought about the final letter of John Young as he left NASA. He considered the availability of a few such reactors as maybe crucial for the survival of mankind. From that perspective Congress could request the development from another institution (DoD, AEC) and NASA had only to use it. Otherwise, if NASA realy has to develop it, I fear for the budget. We could loose some remaining real space exploration projects (what are allways unmanned) too.

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