Energy Beam Highways Through The Skies

by

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Abstract:

The emergence of Energy Beam Flight Transportation Systems could dramatically change the way we travel in the 21st Century. A framework for formulating "Highways of Light" and the top level architectures that invoke radically new Space Power Grid infrastructure, are introduced. Basically, such flight systems, hereafter called Lightcraft, would employ off-board energy beam sources (either laser or microwave) to energize on-board dependent "motors" -- instead of the traditional autonomous "engines" with their on-board energy sources (e.g., chemical fuels).

Extreme reductions in vehicle dry mass appear feasible with the use of off-board power and a high degree of on-board artificial intelligence. Such vehicles may no longer need airports for refueling (since they require no propellant), and could possibly pick up travelers at their homes -- before motoring over to one of many local boost stations, for the flight out. With off-board power, hyper-energetic acceleration performance and boost-glide trajectories become feasible. Hypersonic MHD airbreathing propulsion can enable boosts up to twice escape velocity, which will cut trip times to the moon down to 5.5 hours. The predominant technological, environmental and social factors that will result from such transportation systems will be stressed.

This presentation first introduces the remote source siting options for the space power system infrastructure, and then provides three representative laser/microwave Lightcraft options (derived from historical Case Studies): i.e., "Acorn", "Toy Top" and "Disc." Next the gamut of combined-cycle engine options developed for these Lightcraft are examined -- to illuminate the 'emerging technologies' that must be harnessed to produce flight hardware. Needed proof-of-concept experiments are identified, along with the Macro-Level Issues that can springboard these revolutionary concepts into hardware reality.

Presentation Outline

- Introduction
- Open Maglev Interstate Highway System
- Shuttle Delivered Space Assets
- Satellite Solar Power ("Floatilla")
- Beam-Powered Flight (laser/microwave)
- Human Factors in 21st Century Flight
- Summary & Conclusions
SSP-Powered Transportation & G/B Electric Grid

*MES in Power Grid.
SSP-Powered Interstate Transportation
(Integrated with Ground-Based DC Electric Grid)

- Low Voltage, High Current DC Transmission
  (instead of present AC high voltage, low current)

- High Temperature Superconductor Cable Network
  (connects rectenna receivers and ground-based SSP
  plants to cities, towns and industrial customers)

- Superconducting Cables Provide Magnetic Fields for
  MAGLEV Highway (and SMES in the Power Grid)

- Ideal Match With Developing Nation's Energy Needs
  (i.e., SSP-supplied, non-polluting electric transportation
  and base load power)

- Entire DC Power Grid Might Be Modulated to Provide
  Ultra-Low Frequency Communications to Underwater
  Communities and Submarines.
Superconductor DC Current Levitation System

End View of MAGLEV Auto and Levitating Roadbed (showing location of tractor coils)

Note: $B \propto (1/r)$ for roadbed superconductors.
MAGLEV-HYPERCARS

Ridin' The Rails: Beyond 2000

Outboard Traffic - Two Lane Highway
MAGLEV Personal Converticar Concept
(shown with wheels retracted and stabilizing fins extended)

THE SPY WHO LOVED ME
10 GW SATELLITE SOLAR POWER STATION
MultiPurpose SSP in LEO With SMES Functions

- Solar Charge Option

- Power Relay Option (from G/B grid)
Modularized Inflatable
[Kato et. al. 1989]

MODULAR INFLATABLE SPACE STATION CONCEPT

(NASA Photo)
Inflataole Gossamer SSP with SMES  
(functional development)

- Structurally Unsound  
  Lenticular Envelope

- Stable (using toroid for pneumatic inflation)
  Toroid Pneumatic Force  
  High Pressure Toroid Tube

- Stable (using SMES for magnetic inflation)
  Magnetic Force  
  Large Dipole Moment (will tilt in Earth's magnetic field)

- Spin-Stabilized with Dual-Coil SMES  
  Gyroscopic forces  
  Note no toroid tube  
  tension sheet between repulsive coils  
  (no magnetic dipole moment)

- Toroid with Dual Coil SMES  
  Coil #1  
  Coil #2  
  Internal Tension Sheet

- Add Solar Cells and Solid State Phased Array Transmitter
  Microwave Beam  
  Transmitter with Steerable Beam  
  Thin Film Solar Cell Array

- Add Forced Convection Cooling for High Power Operation
  Pressurized Pleum  
  Recirculated Helium Gas
Flotilla SPS Construction Concept

- Mass Produced Modules Built on Earth surface
  - Covered with thin film solar cells
  - Integral transceiver rectennas
  - On-board superconducting energy storage
- Direct Microwave Boost to LEO or GEO
- Robotic Link-up with other Flotilla Modules
- Each Module Becomes Phase Locked With All Others
- Potential Module Planform Geometries:
  - Hexagonal
  - Triangular
  - Circular
  - Square

GUIDING IMAGERY -- VISION DESCRIPTIONS

For HMM - Leaps of the Imagination*

- "Highways of Light"; "Energy-Beam Highway to Space"
- Space Links in a Beamed-Energy Infrastructure
- Invisible Airport, with Airborne Hubs - (Runways don't exist)
- Non-Intrusive Aerospacecraft - (Environmentally Stealthy)
  - Noise at, or below, background levels
  - Zero NOX, Soot, CO, HC's
  - Actually enhances the environment

* After John L. Anderson
Source Siting Options
(for space power system infrastructure)

Microwave Relay Options for Lightcraft Powering

- Ultralight LEO Reflector Option
  "Bicycle-Wheel" Concept
  (could also be transmissive
  Fransel laws-thin film)

- Atmospheric Transmissive Lens Option
  (created by microwave beam heating)
Framework for Very Advanced HRST Formulation

- Off-Board, Beamed-Energy Source (Microwave or Laser)
- Substitution of Off-Board Energy for HRST Mass
- Substitution of On-Board Intelligence for HRST Mass
- Use of "Motors" instead of "Engines"
- Hypersonic MHD Airbreathing Propulsion to Orbit
- Flight Vehicles with "Zero" Propellant
- Hyper-Energetic HRST Performance
- Ultra-strength, High Temperature Ceramic Structures
"AIR SPIKE" PROOF-OF-CONCEPT EXPERIMENT: A SUCCESS!

Low Drag mode with Oblique shock wave (34 KW torch power)

High drag mode with Normal shock wave (torch removed)

Mach 10 flow

plasma torch (physical spike)

electric arc location

Axi-symmetric blunt body (Apollo capsule heat shield)

*Confirmed 4/24/95 @ 10:30 PM
Microwave Powered 'Lightcraft'

To reach speeds up to Mach 3, antennas focus microwaves at points just outside the craft's rim, heating the air and turning it into an ionized gas known as plasma. Magnetic fields act as nozzles, compressing and aiming the plasma to generate thrust (bottom).

For space launches (near left), the craft acts like an electric motor. An internal antenna focuses microwaves ahead of the craft, creating an air 'spike.' The spike acts as a nose cone, greatly reducing drag. It also sets up a shock wave, forcing compressed air past high-voltage electrodes along the rim. When ionized, air acts as a conductor for current to flow between the electrodes. Interaction of flowing current and magnetic fields along the rim speeds air downward, boosting the craft.

SOURCE: NASA, Jet Propulsion Laboratory
Microwave 'Beam Rider' Propulsion System Elements

- "Air Spike" inlet
- MHD-Fanjet
- Rectifying Antenna

In hypersonic flight, externally-powered Lightcraft uses magnetohydrodynamic effect to accelerate air past its hull.

Focused microwaves shape bow shock wave ahead of ship to act as an inlet spike for the MHD Fanjet.

Microwave beam energy is converted to electricity by large rectifying antenna (85% efficient) for MHD Fanjet.
HUMAN FACTORS CONSIDERATIONS FOR "PASSENGER MOONSHIPS"

- Radiation shielding (200 MeV Solar Proton Storms)
- Pressurized, Closed-Cycle Life Support Systems
- Artificial Lunar Gravity (1/5-1/6th G, Rotate at 3 RPM)
- Comfortable Physical & Psychological Spaces (e.g. 10 to 40 cubic meters per person)
- Companionship: 3 to 5 passengers per vehicle
- High Quality Audio/Visual Communications (Virtual Reality)
- Ultra-G Protection (Launch Vehicles are Hyper-Energetic)
- Individual Escape Pod & Mini Re-Entry Lifeboats (Multiple Independent Re-entry Vehicles-MIRV)
CIVILIAN "SPACE SUIT" FOR LUNAR MICROWAVE LIGHTCRAFT

- Skin tight flexible scuba-diver's pull-over head gear (microwave reflective)
- "Heads-up" virtual reality "wet" goggles with direct retinal projection by LEDs
- Microwave reflecting grid for nasal, mouth and ear cavities
- Optional collar for fish bowl helmet
- Optional maglev belt w/flexible battery
- Skin tight "divers' suit with microwave reflecting material (spandex). Can also serve as "space activity (EVA) suit with proper head gear.
- Form fitting integral boots (microwave reflecting)

Note:
Clothing is devoid of exposed zippers, pockets, etc. that might trigger ignition of microwave-induced plasmas. Velcro fasteners would probably work.
"MAGLEV BELT" CREW TRANSFER CALCULATION

Note:
R = 5 m
r = 15 cm
I = 1 megamp

Magnetic "Lift":
- 75 kg
- 30 kg
- 15 kg

Note:
B₁ = 0.57 gauss

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ALTERNATIVE MAGLEV CREW TRANSFER MODE

Buoyant Lightcraft in hover mode with perimeter magnets energized (shown inverted for deployment)

Maglev crew transfer pod is NASA Tension Aeroshell (e.g., see NASA TN-D-2994)
Factors That Will Lead To A Revolution
(in the way we will travel in the 21st Century)

- Inflatable, Gossamer Space Structures
- Satellite Solar Power Station Grid
- Microwave and Laser Power Transmission
- High Temperature Superconductors & SMES
- Open MAGLEV Interstate Highway System
- Beam Propelled Flight Transportation
  (with environmentally friendly propulsion systems)
- Ultra-G Protection Systems - Human Factors
  (with liquid ventilation & liquid immersion)