International Space Agency, ISA

International Space Administration

Founded In 1986 -&- Incorporated In 1990

Presently Seeking International Treaty -&- Charter Status

2017 - PROPOSAL

INTERNATIONAL SPACE PLANE

ELECTROMAGNETIC ASSISTED SPACE LAUNCH SYSTEM

(ISP) PROGRAM -&- (EASL) SYSTEM

INTERNATIONAL SPACE AGENCY
ISA ISA
INTERNATIONAL SPACE PLANE (I. S. P.) PROGRAM

International Space Agency, I.S.A.
International Space Administration

PURPOSE: (I.S.P.) Program Is Based On 5 Basic Principles.

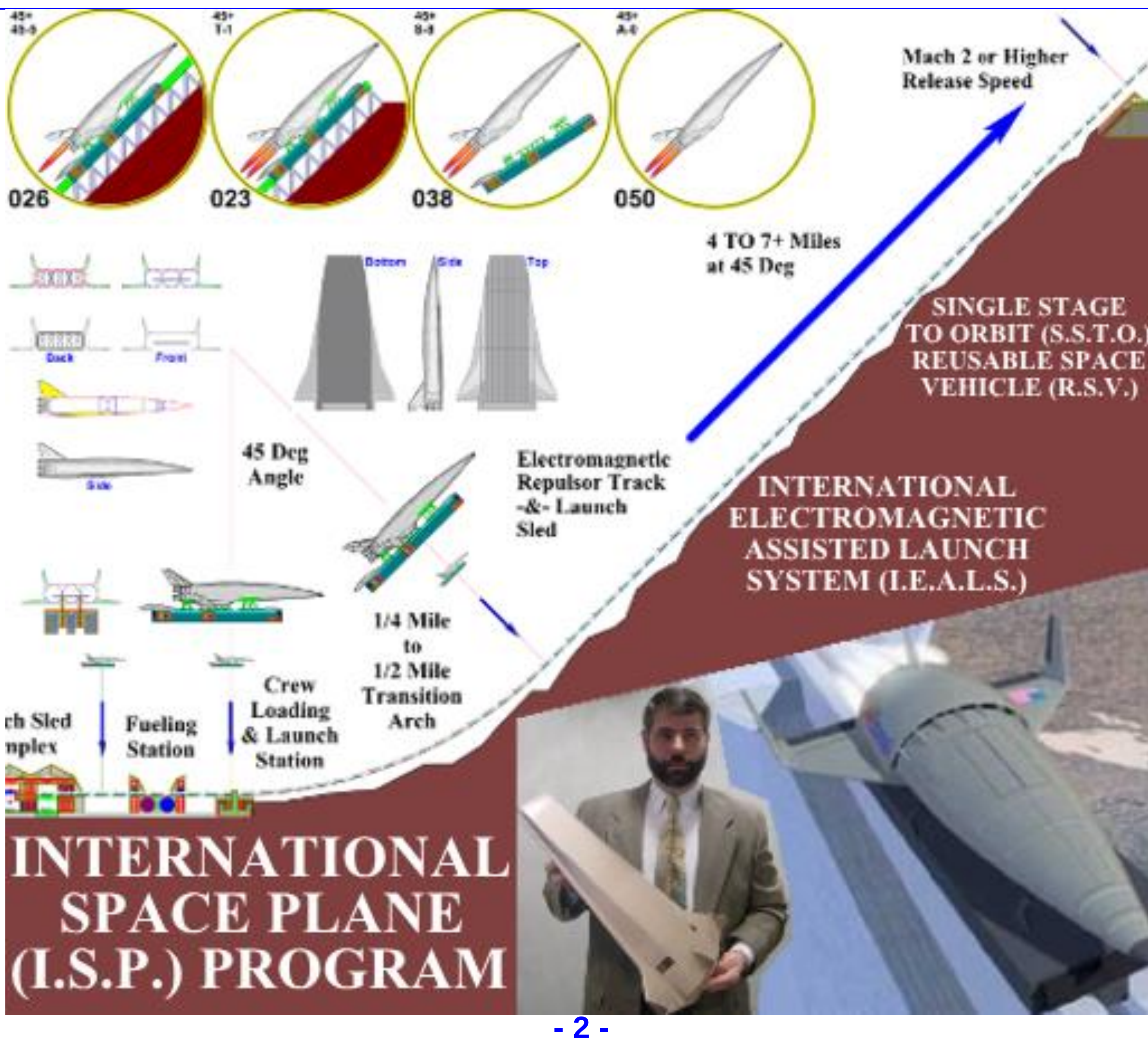
1) "Ballistic & Non-Aerodynamic Lifting Vehicles" *which are designed as Disposable* ***(Expendable)*** *Launch Vehicles are not efficient; waste large amounts of precious materials and human resources; and present a space debris hazard in Earths Orbit* ***(Orbiting Debris)*** *and on the Earths Surface* ***(Reentry Debris).*** *SpaceX and its so called reusable boosters are sadly just a money mill that leads to a dead end, and will never truly achieve sustainable* ***RLV/SSTO*** *of any meaningful scope, scale or duration.*

2) *Using* ***EXTERNAL*** *energy sources not carried on* ***(in)*** *a space launch vehicle increases the launch vehicles fuel efficiency and cargo carrying capability,* ***(Assisted Launch),*** *and applies* ***"First Stage"*** *Launch Velocities* ***"Or Substantial Part Of"*** *Single Stage To Orbital Insertion Velocities. Assisted Launch is critical to* ***RLV/SSTO.***

3) *A totally reusable* ***"One-Vehicle Architecture"*** *is most cost, materials, and labor effective and operationally sound strategy to employ in a space launch vehicle.* ***Launch Return "LR"- Reusable Space Vehicle "RSV"- Single Stage To Orbit "SSTO" - Aerodynamic Lifting Body "ALB", This is KEY to Preservation of Resources***

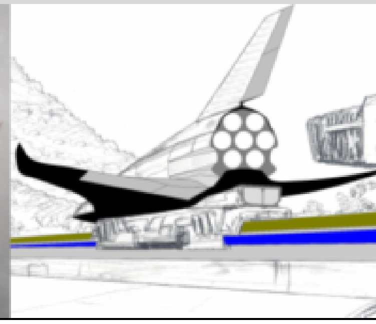
4) *Utilizing Earths atmosphere for aerodynamic lift, braking, Oxygen (****O2****) for launch propulsion, and re-entry, will increase the launch vehicles efficiency and capabilities. Also, Strategically Launching from Earths Equator at a Mountain Site, will also add free launch to orbital velocity to any launch vehicle, and high altitude launch release.*

5) *Creating a* ***NEW*** launch philosophy, systems, technologies that will allow for wide range of mission requirements & capabilities with out numerous, repetitive, costly, wasteful redesign and reconfiguration. In effect, the system employed in an Aircraft Carrier for Launching Aircraft of varying Types, Weights, and Capabilities; except the (ISP) Assisted Launch System would be scaled up and more sophisticated technology.



1988 / 2005 / 2017 / 2019 Proposal - Operational & Programs Charter For The
"International Space Plane (ISP) Program" -and- "Electromagnetic Assisted Space Launch (EASL) System"

A. General Information


Project Title:	*International Space Plane (ISP) Program - &- Electromagnetic Assisted Space Launch (EASL) System*
Brief Project Description:	The International Space Plane (ISP) Program, which was started in 1988 by the International Space Agency (ISA) at Cornell University in Ithaca, New York State, in the United States, and is based on the work of the Father of the Rocket Age and Designer of the Apollo Moon Rockets, Dr. Werner von Braun, and is presently looking for a Mountain Launch site on the Earths Equator, and most specifically in Brazil. The ISP Program has its conceptual roots in, **Ref1:** "Silver Bird" WW2 German Space Plane & Assisted Launch System.; **Ref2:** 1952 Movie "When Worlds Collide" in which the work of Werner vaun Braun and NASA where show cased. Of course these earlier designs used "Rocket Sleds" to achieve first stage assisted launch, but in the (ISP) Program more powerful and modern application of Electromagnetic Repulsor "Rail Gun" Technology is used to achieve first stage assisted launch. *54 page detailed thesis paper is included with this condensed proposal synopsis.*
Prepared By:	**Dr. Alexander Bolonkin – Russia / United States** **Member, Board of Directors -&- Chief Science Officer (CSO)**, International Space Agency, ISA **Director**, International Space Plane (ISP) Program, International Space Administration **Admiral, Rick R. Dobson, Jr. - United States** **Chairman, Board of Directors , CEO, Founder,** International Space Agency, ISA **Assistant Director**, International Space Plane (ISP) Program, International Space Administration **Mr. Robert D. McGown, MSci - United States** **Member, Board of Directors**, International Space Agency, ISA **Director, International Mars Programs Office**, International Space Administration **Advisor**, International Space Plane (ISP) Program, International Space Administration *2005 / 2017 - Advisor & Contributor - Dr. Kenneth House, Scientist & Meglev Systems Researcher, NASA, United States* *2002 / 2006 - Advisors & Contributors - Mr. Jerald Schneider, PE, SE - United States* **-and-** Mr. Vadim Makarov, PE, SE - Russia / United States **-and-** *Dr. David Maker, Scientist - United States*
Date:	**ISP Concept Work Completed 11 June 1988, Re-Released 17 May 2005, Re-Released 1 May 2017**

B. Project Objectives:

PURPOSE: The International Space Plane (ISP) Program Is Based On 5 Basic Principles.

1) "*Ballistic & Non-Aerodynamic Lifting Vehicles*" which are designed as Disposable (*Expendable*) Launch Vehicles are not efficient; waste large amounts of precious materials and human resources; and present a space debris hazard in Earths Orbit (*Orbiting Debris*) and on the Earths Surface (*Reentry Debris*). SpaceX and its so called reusable boosters are a money mill that leads to a dead end, and will never achieve RLV/SSTO.

2) Using *EXTERNAL* energy sources not carried on (*in*) a space launch vehicle increases the launch vehicles fuel efficiency and cargo carrying capability, (*Assisted Launch*), and applies "First Stage" Launch Velocities "Or Substantial Part Of" Single Stage To Orbital Insertion Velocities.

3) A totally reusable one-vehicle architecture is most cost, materials, and labor effective & operationally sound strategy to employ in a space launch vehicle. *Launch Return* **"LR"**- *Reusable Space Vehicle* **"RSV"**- *Single Stage To Orbit* **"SSTO"** – *Aerodynamic Lifting Body* **"ALB"**

4) Utilizing Earths atmosphere for aerodynamic lift and braking, and Oxygen (*O2*) for propulsion, will increase the space launch vehicles efficiency and capabilities. Strategically Launching from the Earths Equator will also add free launch to orbital velocity to any launch vehicle.

5) Creating a *NEW* launch philosophy, systems, technologies that will allow for wide range of mission requirements & capabilities with out numerous, repetitive, costly, wasteful redesign and reconfiguration. In effect, the system employed in an Aircraft Carrier for Launching Aircraft of varying Types, Weights, Capabilities; except the (ISP) Assisted Launch System would be scaled up and more sophisticated technologically.

CAPABILITY: Specific Areas of Mission & Operations & Management Authority:

- Airbus Industries Management and Manufacturing Model Applied to the ISP Program, with Pay Per Launch Funding Strategy
- Launch Goal of 3 to 7 Launches Per Day Capability (1095 to 2555 Launches Per Year) Manned & Unmanned Operations
- Totally 100% Reusable Launch Vehicle and Robust Ground Assisted Launch System, *"No Waste of Materials or Labor"*.

BENEFITS: Cheap, Routine, Robust, and Safe Access to Earth Orbit, in a Program of Sufficient Scope & Scale to Insure Longevity.

FUNDING: A Single or Combined Grant or Donation in the sum of $7 Million U.S. Dollars is sought, to fund a "Start Up" Perpetual Research, Development, and Operations Program, to obtain/secure key Scientific, Engineering, Flight Personnel, Facilities, Equipment, and Materials required to build, organize, and operate an **International Space Plane (ISP) Program**.

International Space Agency , I.S.A.

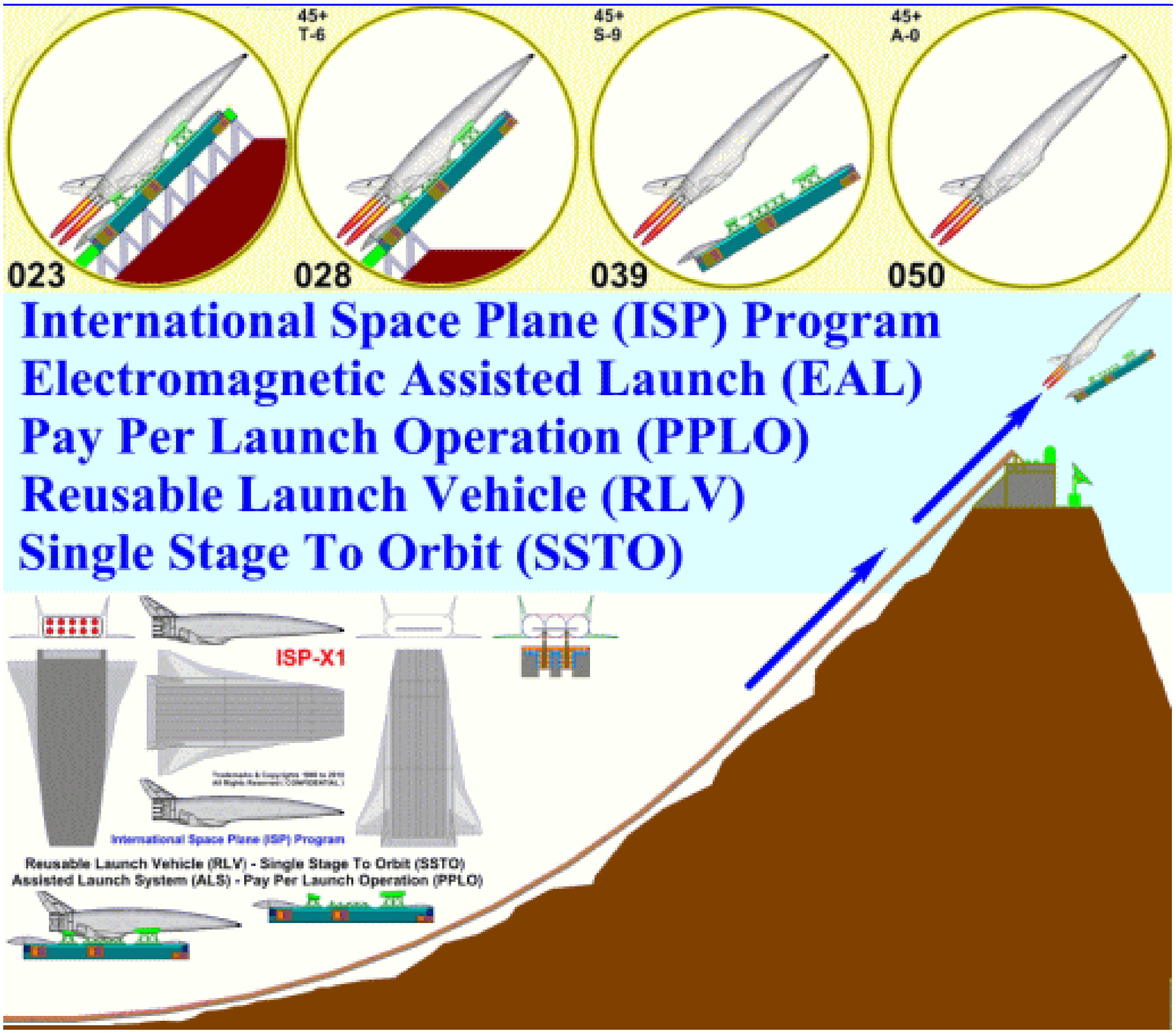
International Space Administration

Founded In 1986 -&- Incorporated In 1990

Presently Seeking International Treaty -and- Charter Status

2013 - PROPOSAL

INTERNATIONAL SPACE PLANE (I.S.P.) PROGRAM / OFFICE



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WEBGATE: www . international - space - agency . org SECURE WEB SITE: https : // www . isa - hq . com

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INTERNATIONAL SPACE AGENCY

International Space Agency (ISA)
(ISP) -&- (IASL) PROGRAM COVER PAGE

Confidential Program Proposal To NASA

Exploration Directorate, NASA Headquarters
Submitted For Review On: 1st June 2005

NASA HQ Sponsor: Mr. Ghassem R. Asrar, Ph.D.
Deputy Associate Administrator for Science
Phone: (202) 358-2165 Email: ghassem.asrar@nasa.gov

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ISA: ISP -&- IASL PROPOSAL DIRECTORY

International Space Plane (ISP) Program & International Assisted Space Launch (IASL) System

International Space Agency (ISA)
International Space Plane (ISP) Program

2005 Main Directives -&- Program Goals

The International Space Plane (ISP) Program (http://www.international-spaceplane-program.org), which was started in 1988 by the International Space Agency (ISA) (https://www.international-space-agency.org) (https://www.isa-hq.com) at Cornell University (http://www.cornell.edu) in Ithaca, New York State, in the United States of America, and is based on the work of the Father of the Rocket Age and the Designer of the Apollo Moon Rockets, Dr. Werner von Braun (http://history.msfc.nasa.gov/vonbraun/bio.html), and is presently looking for a mountain launch site on the Earths Equator, and most specifically in Brazil.

The International Space Plane (ISP) Program Is Based On 5 Basic Principles.

1) "***Ballistic & Non-Aerodynamic Lifting Vehicles***" which are designed as Disposable (***Expendable***) Launch Vehicles are not efficient; waste large amounts of precious materials and human resources; and present a space debris hazard in Earths Orbit (***Orbiting Debris***) and on the Earths Surface (***Reentry Debris***).

2) Using ***EXTERNAL*** energy sources not carried on (***in***) a space launch vehicle increases the launch vehicles fuel efficiency and cargo carrying capability. (***Assisted Launch***)

3) A totally reusable one-vehicle architecture is most cost, materials, and labor effective & operationally sound strategy to employ in a space launch vehicle. ***Reusable Space Vehicle* "RSV"- *Single Stage To Orbit* "SSTO"**

4) Utilizing Earths atmosphere for aerodynamic lift and braking, and Oxygen (***O2***) for propulsion, will increase the space launch vehicles efficiency and capabilities.

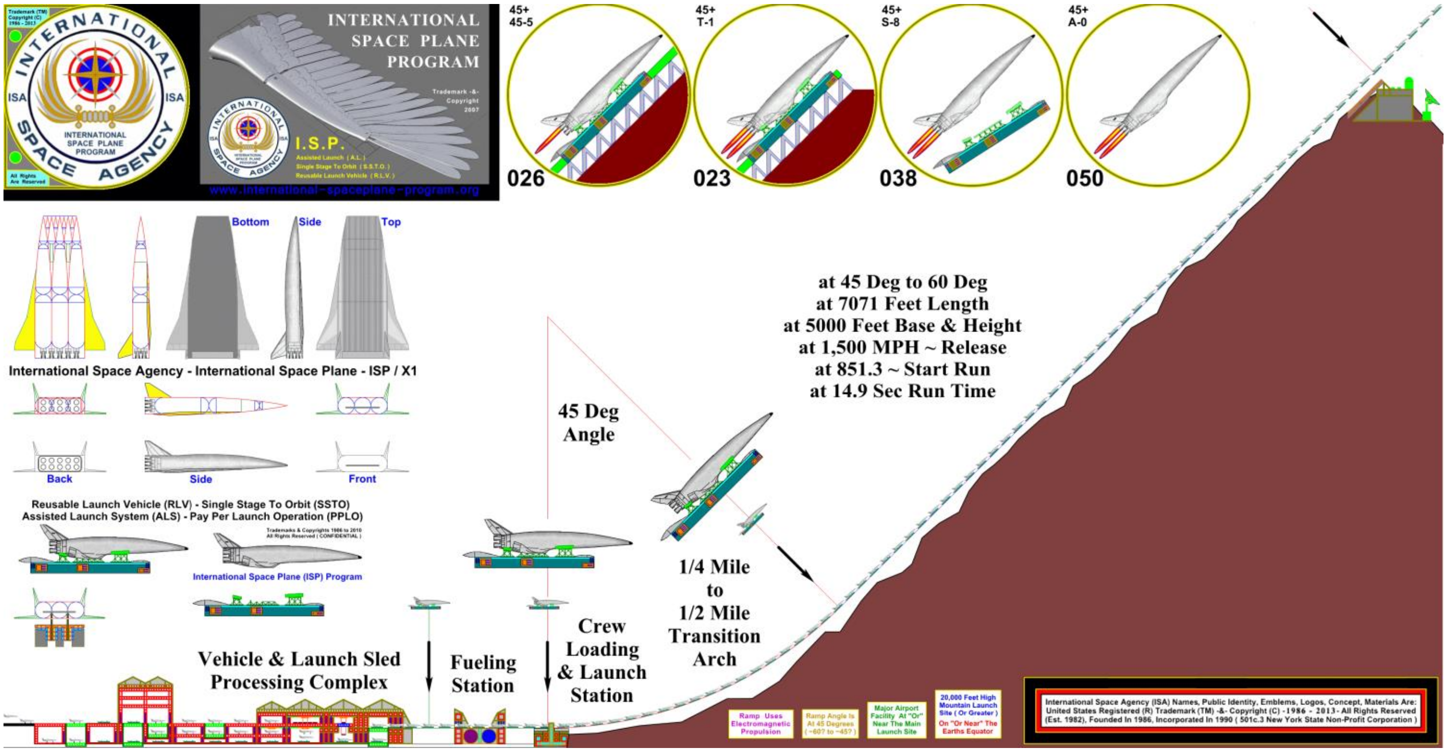
5) Creating a ***NEW*** launch philosophy, systems, and technologies that will allow for wide range of mission requirements and capabilities with out numerous, repetitive, costly, and wasteful redesign and reconfiguration. In effect, the system employed in an Aircraft Carrier for Launching Aircraft of varying Types, Weights, and Capabilities; except the (ISP) Assisted Launch System would be scaled up and more sophisticated technologically. (**Reference: WW2 Era German Space Plane and Assisted Launch System "*Silver Bird*"**)
(**Reference:1952 Movie "*When Worlds Collide*" Technical Consulting By "*Werner von Braun" & "NASA"***)

When the International Space Plane (ISP) Program was conceived and started in the 1980's, the (ISP) Program was more about a "***NEW SPACE LAUNCH PHILOSOPHY***" than it was about any single Space Launch Vehicle or Space Launch System.

The International Space Plane (ISP) Program seeks to promote, design, build, and operate a Space Launch System that can provide daily, if not many times a day, Space Launch Capability on a large scale. This goal is out side the ***NATIONAL DOMAIN*** and must be achieved through ***MULTI-NATIONAL*** means and infrastructure. (**Example: *Airbus Corporate Model Of Management, Manufacturing, And Operations***)

At present the International Space Plane (ISP) Program is ready to find a suitable mountain launch site near the Earths Equator. The Electromagnetic Assisted Space Launch System and the Reusable Launch Vehicle could be designed and built for less than the present cost of several Space Shuttle (STS) launches. Using Space Plane Designs already in National Inventories will decrease costs and advance the time table from R&D to Operation.

More information can be found on the main International Space Plane (ISP) Program website, or found on the website of the International Space Agency. ***Ad-Astra! To The Stars! In Peace For All Mankind***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I.S.P.
45+ 45-5
026
45+ T-1
023
45+ S-8
038
45+ A-0
050
Bottom
Side
Top
International Space Agency - International Space Plane - ISP / X1
Back
Side
Front
Reusable Launch Vehicle (RLV) - Single Stage To Orbit (SSTO)
Assisted Launch System (ALS) - Pay Per Launch Operation (PPLO)
International Space Plane (ISP) Program
45 Deg Angle
at 45 Deg to 60 Deg
at 7071 Feet Length
at 5000 Feet Base & Height
at 1,500 MPH ~ Release
at 851.3 ~ Start Run
at 14.9 Sec Run Time
1/4 Mile to 1/2 Mile Transition Arch
Vehicle & Launch Sled Processing Complex
Fueling Station
Crew Loading & Launch Station
Ramp Uses Electromagnetic Propulsion
Major Airport Facility At "Or" Near The Main Launch Site
20,000 Feet High Mountain Launch Site (Or Greater)
On "Or Near" The Earths Equator
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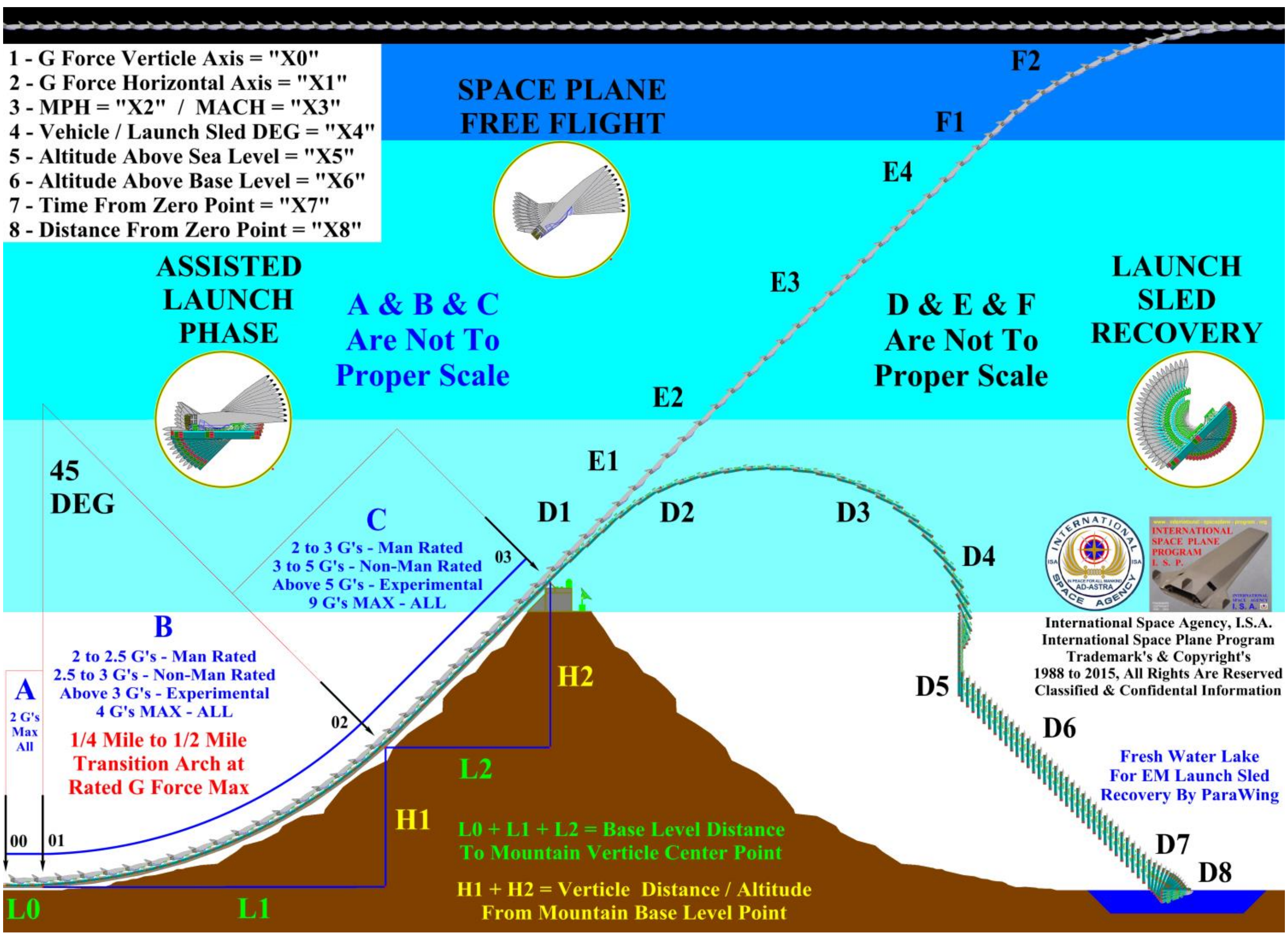
1 - G Force Verticle Axis = "X0"
2 - G Force Horizontal Axis = "X1"
3 - MPH = "X2" / MACH = "X3"
4 - Vehicle / Launch Sled DEG = "X4"
5 - Altitude Above Sea Level = "X5"
6 - Altitude Above Base Level = "X6"
7 - Time From Zero Point = "X7"
8 - Distance From Zero Point = "X8"
SPACE PLANE FREE FLIGHT
ASSISTED LAUNCH PHASE
A & B & C Are Not To Proper Scale
D & E & F Are Not To Proper Scale
LAUNCH SLED RECOVERY
F2
F1
E4
E3
E2
E1
D1
D2
D3
D4
D5
D6
D7
D8
45 DEG
C
2 to 3 G's - Man Rated
3 to 5 G's - Non-Man Rated
Above 5 G's - Experimental
9 G's MAX - ALL
03
B
2 to 2.5 G's - Man Rated
2.5 to 3 G's - Non-Man Rated
Above 3 G's - Experimental
4 G's MAX - ALL
A
2 G's Max All
1/4 Mile to 1/2 Mile Transition Arch at Rated G Force Max
02
00
01
H2
L2
H1
L0
L1
L0 + L1 + L2 = Base Level Distance To Mountain Verticle Center Point
H1 + H2 = Verticle Distance / Altitude From Mountain Base Level Point
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International Space Plane Program
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Fresh Water Lake For EM Launch Sled Recovery By ParaWing

ISA: (ISP) & (IASL) Proposal Opening Comments By: Mr. Rick R. Dobson, Jr., Chairman & CEO, ISA
Admiral Dobson, gives special thanks to: R. Gopalaswami - India, AVATAR Space Plane Program - gopalavatar@123india.com
This is the basic configuration of the International Space Plane (ISP) Program and International Assisted Space Launch (IASL) System, which the International Space Agency (ISA) will support, promote, and push forward as strongly as possible, and is the premise on which we feel very confident of success in these regards, with the proper support & funding, as is requested for "Stage 1".

The core propulsion element of the proposed IASL System will be based on **Electromagnet Repulsor Technology** used only as a Propulsion Element, and "**NOT**" to **Levitate or Suspend** the EM Launch Sled & RLV/SSTO Space Plane during the launch sequence. No need to waste limited money and resources to try to manipulate and control this very precise and very hard to control approach of Levitation or Suspension, especially at Mach 1 to 2+, which must be achieved! The use of Electromagnetic Repulsor Technology for "**Propulsion Only**" **is a relatively simple application**, and is very straight forward, at least from a control standpoint. Turn the power level up and get more thrust; and, turn the power level down and get less thrust. The use of Electromagnetic Forces as the Core Propulsion Element means that "**NO**" **Reaction Fuel (Liquid or Solid) and the Related Structure** which would be required to house this Reaction Fuel and the Engine or Nozzle Elements that would be needed to Translate the Reaction Fuel into Propulsion Forces. This all adding up to great Mass, Bulk, and Complexity to the EM Launch Sled, RLV/SSTO Vehicle, and will also translate into much greater Loads/Stress on the EM Launch Sled, RLV/SSTO Vehicle, and Indeed on the IASL Ramp Structure which will be required to bear the Shear Mass & Weight of all this Reaction Fuel, Extra Structure, and Propulsion System whatever that may be; and as well, will bear the dramatically increased and induced Stress and Loads as a result of all this extra Mass on board. Using a Electromagnetic Repulsor Based Propulsion system means the Thrust or Propulsion Forces generated will be limited only by the amount of power that can be generated & transmitted to, and through, the IASL Ramp System & EM Launch Sled; and that "**NO**" **Reaction Mass, Extra Structure, or Complex Propulsion System** is required; so, the IASL System & EM Launch Sled would "**ONLY**" need to carry the **Repulsor Coils & Structure** to support the RLV/SSTO Space Plane, Only! This means Dramatically Less Onboard Mass, which will translate into a Dramatic Reduction in Mass & Complexity of the IASL System & EM Launch Sled, and related Stress & Forces on the Entire IASL System & Ramp Structure. This Electromagnetic Repulsor System would be able to provide a variety of Acceleration Forces and Release Speeds, just like an Aircraft Carrier Catapult System does on a smaller scale. Each RLV/SSTO Space Plane or Launch Vehicle, would have very different launch acceleration force & release speed requirements and specifications based on the vehicles mission parameters and cargo sensitivity to acceleration G-forces. Human & G-Sensitive Cargo Missions for "**Low-G**" Launch; and Non-Human & Non-G-Sensitive Cargo Missions for "**High-G**" Launch. Just exactly like a modern Aircraft Carrier Catapult launches a wide range of Aircraft Types, Sizes, and Weight; at a wide range of Acceleration G-Forces and Release Speeds.

Also, as far as the IASL Ramp Launch Location and Configuration! A **Location on the Earths Equator**, or as Close as Possible; and to use a **Mountain Site** which can provide a near constant slope or grade as close to **45 degrees** as possible; and to have a total Track Length between **4 & 7+ miles**. This Launch Site will have a large airfield able to support a wide range of operations; both commercial passenger & cargo, and launch operations and related air traffic needs. RLV/SSTO Space Plane or Launch Vehicles can be built or serviced or received from orbit, from anywhere in the world, and then shuttled to the Orbital Launch Site with small intercontinental ferry trips, for launch preparation and orbital launch, at the primary IASL site, or sites. Brazil, would be a good and stable location.

Also, as far as the RLV/SSTO Vehicle, we are using the X-33 Venture Star as a "**BASE LINE**" vehicle. Other similar Space Plane efforts in Russia, Europe, India could also be used as potential candidates for the IASL System as **RLV/SSTO ISP Launch Vehicles**, such as AVATAR, BE Sanger 600, and others as well. We don't want to reinvent the wheel, and so intend to utilize what is here now!
* Keep it as simple, noncomplex, and straightforward as possible, using as much off the shelf technology & knowledge as possible!
* Develop, Construct, and Operate the ISP Program & IASL System in an **Airbus Industries like Management Model**, with a Philosophy of "**Pay As You GO" & "Launch For Hire**", backed by Multi-National Government Core Infrastructure and Supported & Used By Private Sector Organizations & Entrepreneurial Investment & Uses. **Core Focus of Providing 3 to 7+ launches Per Day!**

Directives & Objectives & Base Line: ISA – (ISP) Program & (IASL) System

This is what the International Space Plane (ISP) & International Assisted Space Launch (IASL) System Program is all about!

01) Electromagnetic Repulsor Propulsion Based System - Onsite Nuclear or Conventional Power Station, Transmission, Storage.
02) Launch Ramp Length - 4 to 7 Miles (½ Mile Horizontal, ½ Mile Transition Horizontal to 45 Degrees, 3+ miles at 45 Degrees)
03) Launch Ramp Angle - As Near To 45 Degrees As Possible.
04) Launch Ramp Location - Earths Equator or as close as possible and the **Highest Mountain Site** able to obtain or access.
05) RLV/SSTO Launch Vehicle - Use of X-33 as System Base Line, but we are reviewing numerous other USA, Russian, European, Indian RLV/SSTO Vehicles as potential ISP/IASL Program candidates. Multiple RLV/SSTO Vehicles with Various Capabilities. (Crewed/Passengers, Modules/Components, Consumables/Cargo, Fuel/Water Tankers, Scientific/Commercial, Special Purpose)
06) ISP/IASL Program - Conducted in a Airbus Industries like Management Model, using "PAY AS YOU GO" & "LAUNCH FOR HIRE" strategies, through Multi-National Government & Private Sector Collaborative/Cooperative Infrastructure & Programs.
07) ISP/IASL Program - would be conducted through the ISA Organization & Charter and Treaty Based. Non-Military Program.
08) ISP/IASL Program - from Start to Full Operation will be planned to be **completed in 5 to 7 years**, and able to maintain a routine daily launch schedule of between ***3 to 7+ launches per day***, as its base line operation goals. (***1095 To 2555+ Launches Per Year***)
09) Once the ISP/IASL Program is in full operation - Second Site near by, or other location on Earths Equator, will start to be implemented, and will then offer **Two Fully Operational ISP/IASL Systems**, so as to have **Program Redundancy** and back up in case of mishap, or down time for conducting routine maintenance, regular upgrades, and safety checks.
10) Orbital Refueling Capability - would be a **Major Element of ISP/IASL Program**. Allowing a wider range of Orbital Break Options and Capabilities. **Excess electric power at Launch Site will be used to crack water into H_2 & O_2 for Fuel needs**.

Dr. Kenneth House, Scientist & Researcher, NASA, Marshall Space Flight Center – My research has primarily investigated the use of linear induction motors as the launch-assist propulsion. From the maglev trains and emals catapult developments, it appears that the technology is available to move large masses at subsonic speeds. A trade study was done in the mid-90's that showed an optimum speed of ~ 300 - 400 nts with decreasing returns as the launch-assist speed went higher due to the aerodynamic loads. The ramp concept does require an additional thrust component from the motor for the gravity load, which requires more electrical power and weight in the track. The failure mode of losing power and rolling back down into your launch facility must be considered. Electrical Power Generation (such as flywheel alternators to supply power); Power Conditioning Equipment (AC to the DC Bus Voltage); Variable Frequency Inverters for the linear motor; Closed-Loop Position Feedback Controller; Release Mechanism and Controller; Carrier Vehicle - Logistics, Handling, Maintenance; Flight Vehicle - Logistics, Handling, Storage, Maintenance, Fueling, Loading, Command & Control Center. Should reference John Suter & Gordon Woodcock's ARTS concept. The EM technology exists for subsonic transport of massive objects, but I am unaware of any research that indicates it would work for MACH 1 or 2, or higher, which is the regime in which you propose to operate. The NASA EMLA working group has its own agenda & strategy for research, you are invited to join them. See what they are doing and how you can participate & contribute. Contact Michael Wright at Goddard.

Mr. Jerald Schneider, PE, SE, President & CEO, Schneider Structural Engineering, Inc. – The structural design would not be exceptional in materials. Special regard for non-magnetic materials and consideration of thermal effects if rocket assisted acceleration is used. Design within high magnetic field environments can be accomplished with minimal or no new technology. Analysis & design of the structure under high dynamic loads is within the current available technology. Selecting a site away from the areas that significant technical prowess will greatly affect the efficiency and expense of operations. Environmental studies & impact studies will be required and must be considered in the selection of the site. Costs of construction will greatly increase as the location becomes increasingly remote. Quality Control of all elements of the ramp construction, maintenance, and operation will increase as the site becomes increasingly remote. Regular inspection of the ramp structure will be required. Sensors could be included in the initial design of the structure to aid in determining the health and ongoing safety of the structure.

Dr. David Maker, Scientist – The proposed Ramp is parabola on its side with release point at 45 degrees with Repulsor induction motors. Track could be around 2.5 miles long, but with a net vertical displacement of less than a mile. It would be capable of launching an RLV at around mach 2 and around 6g's of acceleration. The $v=v_o+V\ln(m/m_o)$ mass ratio considerations will then allow an X-33 to be capable to orbit with payload. Electromagnetic Repulsor would need power line connections to the power grid and arrangements for power sharing with the utilities. While it is operating over the launch period , it would require the power output from a 1 gigawatt power station. Electricity could be used at off peak use hours for Electromagnetic Repulsor operation induction coil storage . Note that $\frac{1}{2}Li^2 = 10$billion joules $\approx \frac{1}{2}Mv^2$ where $v=700$m/sec, $M=100{,}000$kg L, the inductance, would need to be in the hundreds of millions of Henries for ~10amp current. The hydrogen and oxygen fuel for the RLV could be separated from water on site by electrolysis using the electricity that at other times would be needed for Electromagnetic Repulsor operation. Thus NO fuel would have to be transported to the site with local stream water providing the hydrogen and oxygen source. The 1 gigawatt sled power could be provided directly by a single electrical power plant for launch energy $\frac{1}{2}Li^2$ created by opening up (the circuit of) a 100 million Henry coil given 10 amp current flow through it. For a solenoid $L= \mu_o n^2 A = K4\pi X10^{-7}(N/x)^2\pi r^2$ it is easily possible to have many thousands of windings N compressed into a meter length x but having at least 10 meters radius=r and to have the very large ferromagnetic permeability K core solenoid. This could give the 100million Henries. The R/L time constant could be large enough for launch given a suitable coil resistance R. This would be for the X-33 without those heavy aerospike engines with the new carbon fiber fuel tank and possibly methane slush fuel mixed with the liquid hydrogen. At first it could be used to launch people into space, with more payload capability to follow later. This would be useful for space station work and moon mission transfers. At White Sands and Alamogordo there is already an assisted launch infrastructure that could be useful for support. At Holloman air force base a maglev that is 4 times longer than this one, has already been built. It would be a real spaceport. If functioning the way we envision it would mean cheap access to space, complete reusability. With the assisted launch capability of Magnetic Repulsor there would also be substantial payload capability. Passengers could travel to this location using commercial air travel and then walk directly over to the part of the terminal that would provide the magnetic repulsor technology that would take them into space. It would make moon and mars missions finally mean something: we could stay in these places because we could then afford to, not have these decade long hiatuses between trips. The RLV could be used as a space tanker for ventures beyond earth orbit. This could be done if the crew quarters were modular, replaceable with unmanned fuel tank launch capability. The fuel and crew quarters would weight about a 1/9 the total weight, about 30,000 pounds. It would give children a reason to hope, make space accessible to all people and lead also to resurgence in interest in pursuing science once again. A huge economy based on the large-scale human habitation of space could result. The dream would then finally come true. Ad-Astra To The Stars would finally mean something.

Dr. Alexander Bolonkin, Scientist (Russia & USA) - I think, it will useful to consider the researching a cable-fly-wheel propulsion system as the alternative and supporting propulsion (thrust) system. The final speed is not much (M=2) and launcher does not have to totally depend on the electromagnetic system thrust. The cable-fly-wheel thrust system is a cheap thrust system and used as aircraft catapults in aircraft carriers and glider fields. The cable-fly-wheel could be located up-range with the cables attached to either side of the launch sled and could pull the sled and vehicle up the 45 degree incline, and add additional thrust forces in addition to the Electromagnetic Thrust. Not necessary to do the installation near equator. The profit is small (about 100 m/s), but that creates a lot of problems with foreign countries. The latitude may be 30 degree from equator. Design of any NEW installation is begun with the TEORETICAL RESEARCHS, ESTIMATIONS, and COMPUTATIONS. That must be the goal of STAGE 1. This Stage 1 outline requests 6-12 months of time for completion, and will be cost a minimum of around $500,000. That is the basis for all the next Stages and research. Results will be the main parameters of future system. If not done at this stage, proposal supporters will not know what technology & manufacturing is needed. Stage 1 allows for final decision about possibility, cost, and profit of the proposed system.

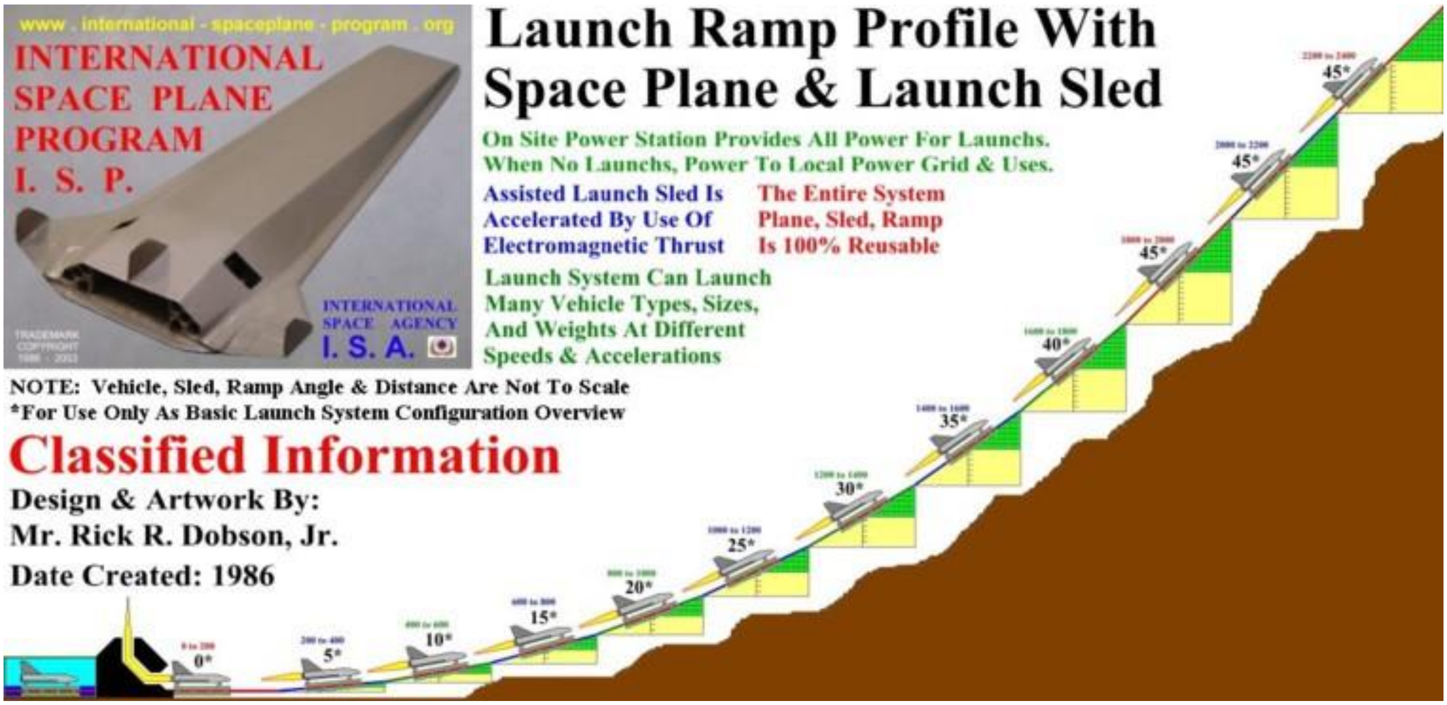
International Space Agency (I.S.A.) I.S.P. & I.A.L.S. Proposal

International Space Plane (I.S.P.) Program

International Assisted Space Launch (I.A.S.L.) System

http:// www . international – spaceplane – program . org

INTRODUCTION -&- OVERVIEW



OPENING COMMENTS -&- PREAMBLE

The International Space Agency (ISA) was Founded in 1986, Formally Incorporated and set up in 1990 as a "Not for Profit" 501c.3 Organization. It's Vision, Charter, Constitution, and History is attached with this proposal, or at weblink: http://www.international-space-agency.net/color_flyer_2005.html

Among the various programs & systems now being proposed, to be facilitated and undertaken, by the ISA; is an International Space Plane (ISP) Program, and is among one of its highest priority goals and endeavors at the present time. A key and critical element of the ISP Program, is the International Assisted Space Launch (IASL) System. The IASL System would be composed of an Electromagnetic (EM) Based Launch Ramp System & EM Launch Sled. This IASL System would be situated on the side of a Mountain Site, at or near a 45 Degree Angle, and at or near an Earth Equatorial Location. The IASL System would be able to launch various vehicles (RLV's & ELV's & Hypersonic Aircraft & SSTO Space Planes & Assorted High Speed Aerodynamic / Ballistic Test Vehicles), at or near Mach 2, or above. This would be a global civil space effort.

There is presently a great need for **routine & cost effective** Earth Orbital Access, of **scale & duration**. The United States now faces the realities of an aging, outdated, resource wasteful, and unpractical Space Shuttle Fleet. This Shuttle system presently has no replacement. The high level of cost and sophistication to achieve this goal of developing a Shuttle replacement and creating a fully reusable launch system of scale and scope of operations, therefore mandates that such a project must be conceived and realized with broad and robust international cooperation and collaboration, at both the Government and Private Sector levels and participation.

The International Space Station (ISS) has proved this fact to be true. Even so, ISS is only a very good first step in the right direction, and a work in progress. The ISS now sets the stage and direction for ISA endeavors, like the International Space Plane (ISP) Program, International Assisted Space Launch (IASL) System, and other programs such as **International Luna Bases & Exploration, International Mars Bases & Exploration**.

The philosophy and management model of Multi-National Aerospace Companies like Airbus Industries in Europe could, and most likely would, be the best model and basis on which the proposed ISA efforts & endeavors like the ISP Program & IASL System, and Other Proposed ISA Programs, might draw upon for its present and future planning & implementation of its goals, policies and objectives. Indeed, this is now the case.

Role Of ISA In International Joint Space Programs, Missions, And Projects

Like in all proposed programs, goals, endeavors, missions, and projects of the ISA Organization, the role of ISA will be that of a neutral global focal point, diplomatic conduit, and enabler organization, allowing a wide range of peaceful civil space endeavors & enterprises & programs and act as an enabler, diplomatic, standards, training, and program management & oversight organization. This would allow a wide range of Government and Private resources to be brought to bear on common space endeavors, with very well defined rules, requirements, and plans, for development & operation. Also to provide a core infrastructure and culture able to provide a high degree of Quality Control and Standards, and Central Training and Organizational Synergy, across a wide range of National, Cultural, and Scientific & Technical Disciplines, on very large and complex civil space endeavors, in a Multi-National context. The United Nations "OOSA" is not the proper venue for this.

Therefore, ISA may thus be viewed as a not-for-profit provider of International Aerospace Corporate and Program Management Services to all Nations (Governments) and Organizations (Private Sector) globally which are interested in joining hands in peaceful international civil space exploration programs, systems, and missions, through cooperation, collaboration, and joint ventures. This would include such large scale and complex projects such as International Luna and Mars Exploration, Missions, and Bases, and Indeed Programs like the International Space Plane (ISP) Program; as well as many other potential space projects not mentioned here.

BELOW ART WORK FROM THE 1952 MOVIE "WHEN WORLDS COLLIDE" AND IS SOME OF THE LATE WERNHER VON BRAUNS IDEAS FOR AN ASSISTED LAUNCH SYSTEM ON THE SIDE OF A MOUNTAIN, USED ONLY AS AN EXAMPLE OF THIS CONCEPT OF ASSISTED LAUNCH.

OVERVIEW -&- OBJECTIVES

Potential International Programs, Missions, And Projects for ISA

Since its inception, the ISA has focused its international and national efforts to seek interest and participation of sovereign nations and their public & private institutions as joint participants in potential ISA international programs, missions, and enterprises. These include large projects like the International Space Plane (ISP) Program, International Earth Orbital Infrastructure (IEOI) Program, International Luna Exploration (ILE) Program, International Mars Exploration (IME) Program, and Other Proposed ISA Programs. One of these proposed missions, which is now being proposed by Indian interests working with ISA in this regards, is particularly relevant to developing countries. This would be the capability to carry to earth's orbit the components and elements of Space Solar Power Satellites and power systems. These large power satellites and power systems would be one way to provide power to ground receiving stations on the Earth's Surface. These systems and facilities could be used to accommodate the rapidly growing demand for electrical power, present & future, from developed & developing countries, globally, and especially those with large populations. Also, these space based power systems & facilities could be used to generate much needed power in earth's orbit and in Space, as large multi-national space endeavors and facilities grow in scope and scale in the coming years.

Following such efforts as the ISP/IASL Program, and efforts for near-earth space power systems & satellite missions, the ISA, now having developed the needed infrastructure, systems and procedures for these programs & systems, would in partnership with member nations & private sector organizations, institutions, and persons, globally; Plan, participate in, and undertake, deep space missions such as International Luna & Mars Exploration, Missions, and Bases, as well as many more potential large civil space projects not mentioned here.

Other concepts under very focused and active examination by the ISA, include RLV & SSTO Spaceplane Launch Systems, like an Electromagnetic Assisted Space Launch Technology and Facilities, which have the potential to add initial launch velocity to any RLV / SSTO Spaceplane, Space Vehicle, or Aerodynamic Test Vehicle or Hypersonic Aircraft, without the penalty of added launch weight or mass. The Assisted Space Launch Element will be a key and critical element to the International Space Plane (ISP) Program, especially in regards to RLV's & SSTO's which could be designed, built, deployed, easily with in a 5 to 7 year time frame.

Notice: This proposal is broken down into 2 interrelated, but separate areas of consideration. Part 1, which mainly deals with the overall scope & elements of the International Space Plane (ISP) Program, and addresses primarily the Launch Vehicles (RLV/SSTO). Part 2, which mainly deals with the overall scope and elements of the International Assisted Space Launch (IASL) System, and addresses primarily the Electromagnetic Repulsor Based Assisted Launch Ramp Systems.

ISP/IASL PROPOSAL - PART 1 - RSV/SSTO SPACEPLANE

INTERNATIONAL SPACE PLANE (ISP) PROGRAM

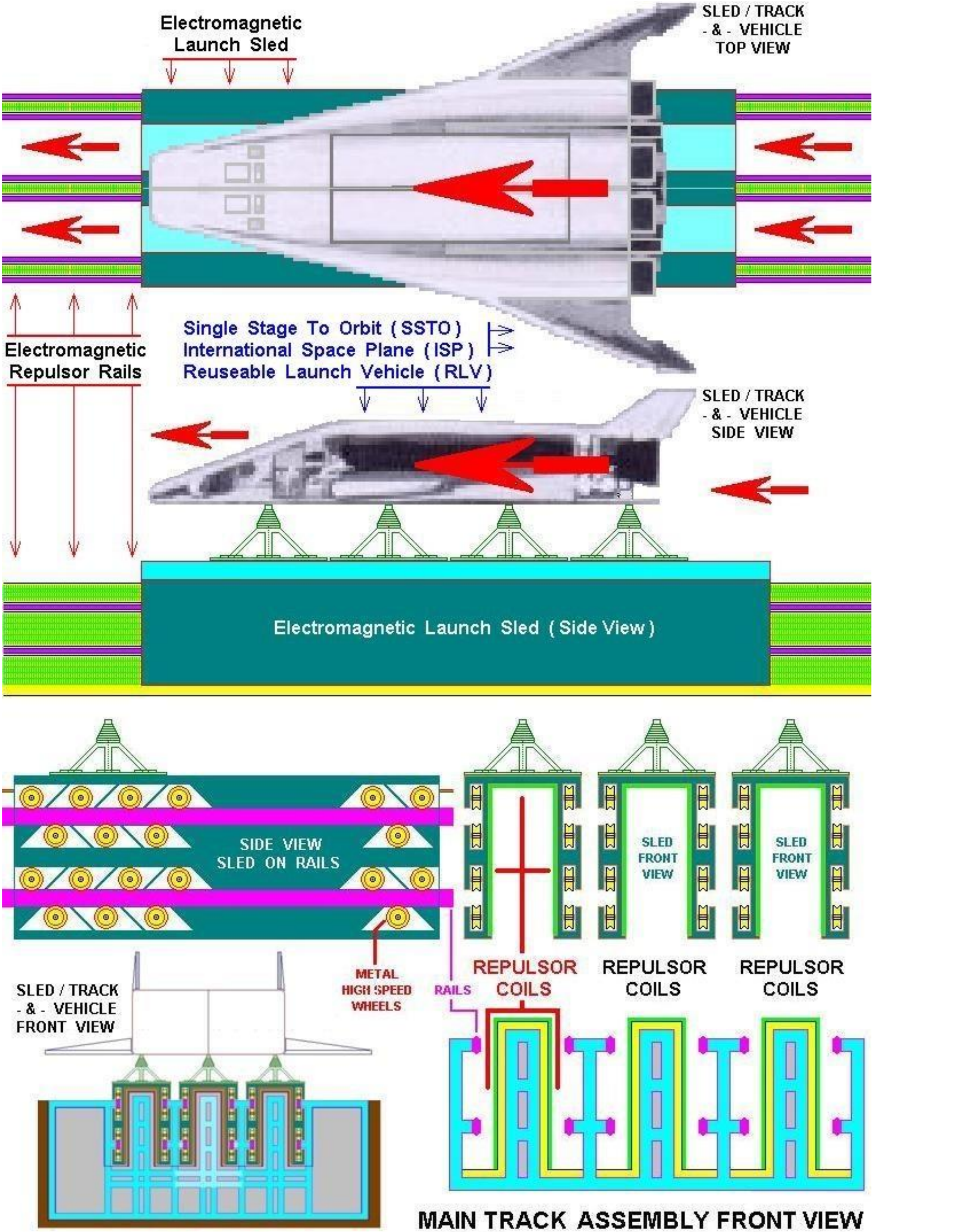
The ISA has kept abreast and informed of international developments in the basic area of safe, affordable, and routine access to space, as the first element for realization of future space exploration endeavors. Many concepts and proposals of universal interest are known from published literature, media, and conferences, globally. Some potentially "breakthrough" space plane system design concepts & efforts have evoked special attention in the USA, Russia, Europe, Japan, and India.

Among these many potential ISP candidates, globally, is the well-known United States RLV/SSTO system concept the X-33. Yet another is the advanced aerospace system design concept published as "AVATAR" aerobic RLV/SSTO space plane from India; and its mission for launching a wide range of Cargo & Personnel into Earths Orbit. Chief among these planned AVATAR missions and capability, would be to carry to Earths Orbit the components and elements of Space Solar Power Facilities to provide power to Ground Stations on the Earths Surface, and to generate much needed power in Earths Orbit and in Space for growing space facilities and infrastructure in the near future. Also the X-33 Venture Star space plane in the U.S.A., and BE Sanger 600 spaceplane in Germany, are just a few of many such programs globally. There are many others which also have been noticed, but due to need to narrow and focus this proposal and its length, these many other systems globally are not mentioned directly by name or specifics.

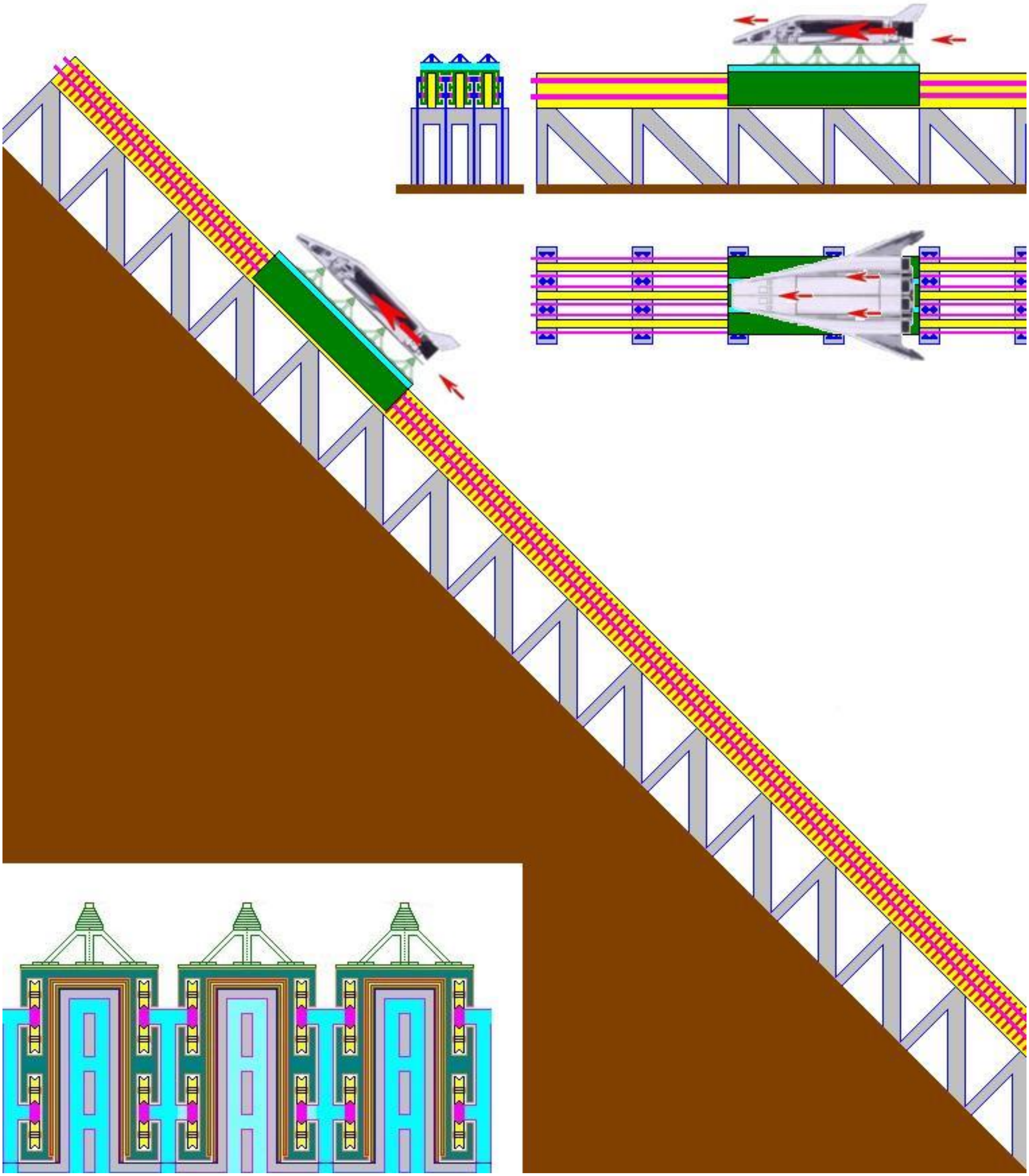
Other launch concepts under active examination by ISA, includes RLV/SSTO Space Plane Launch Systems, like an Electromagnetic Repulsor Based Assisted Space Launch Ramp Technology, which has the potential to add initial launch velocity to an RLV/SSTO Space Plane or Vehicle without the penalty of added launch weight or mass. The Assisted Space Launch Element is a Key & Critical element of the International Space Plane (ISP) Program. This International Assisted Space Launch (IASL) System an Element of the ISP Program is covered in more detail in Part 2 of this proposal.

The design, development, and deployment of an International Space Plane (ISP) Program is a long term global venture which has to pass through well defined, time-bound programmatic stages. Each Stage has a well-established System & Technology Design Review process between each Stage. These technology management systems and practices are well established in the space agencies of all advanced space faring nations globally. However, a brief overview of this process "from mind to market" is described in this proposal, and is typical of what the ISA perceives (tentatively) for ISP (RLV/SSTO) Vehicle & Assisted Space Launch (ASL) Program:

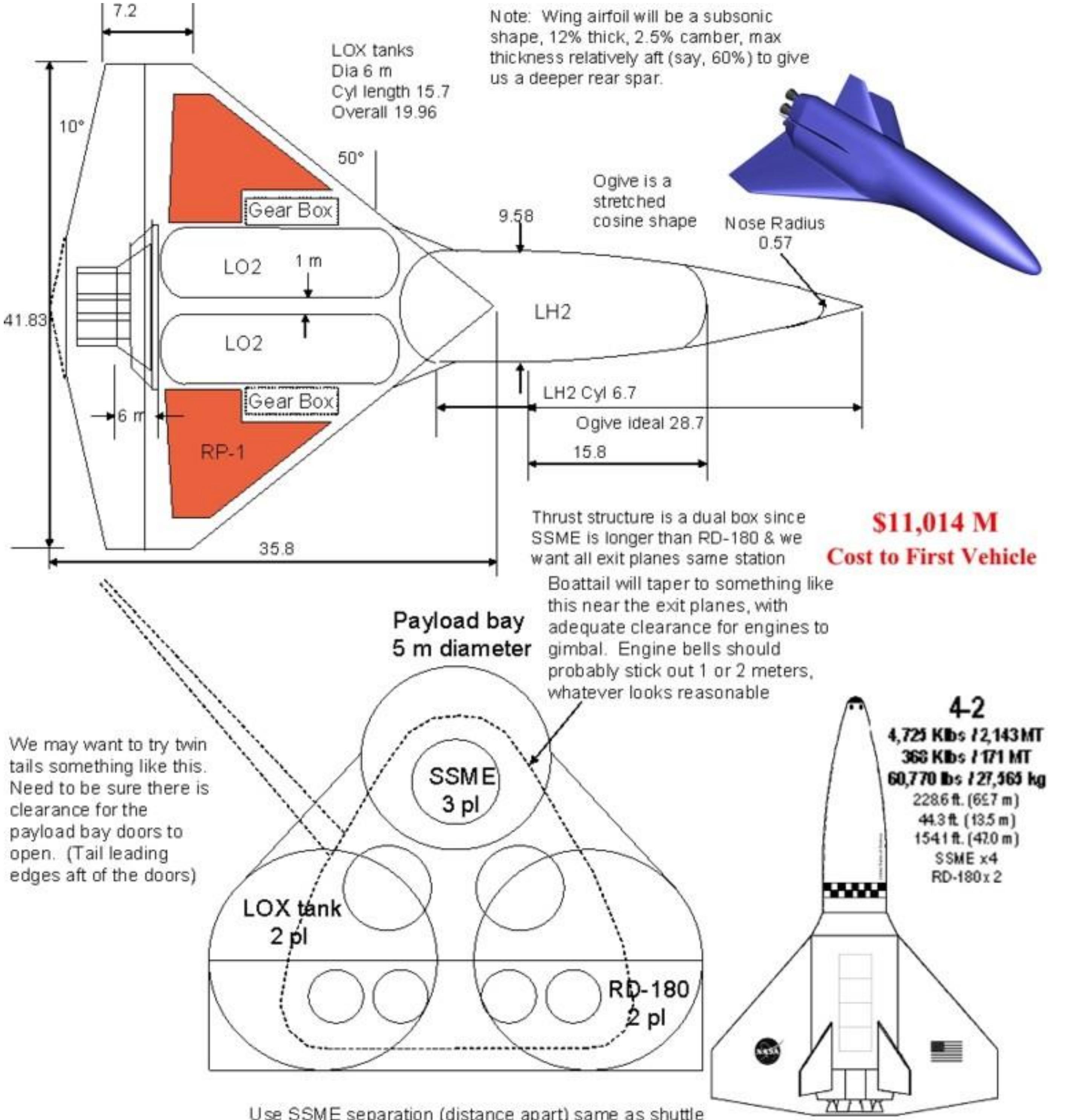
DESIGN OUTLINE OF CORE ISP PROGRAM & IASL SYSTEM ELEMENTS

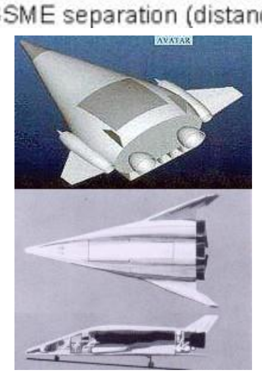


THE ELECTROMAGNETIC REPULSOR RAMP ON THE SIDE OF THE MOUNTAIN IS TO BE AS CLOSE TO 45 DEGREES AS POSSIBLE. THE RAMP SYSTEM CONSISTS OF THREE REPULSOR TRACKS SITUATED ON SUPPORT STRUCTURES CONNECTING THE TRACK SYSTEM TO THE MOUNTAIN SURFACE, AND IS SIMILAR TO HIGHWAY OVERPASS OR BRIDGE CONSTRUCTION. THE ELECTROMAGNETIC REPULSOR COILS ARE LOCATED ON THE EXTERIOR OF THE 3 TRACK SECTIONS AND ON THE INTERIOR SURFACES OF THE ELECTROMAGNETIC RUPULSOR LAUNCH SLED. TRACK SYSTEM WILL BE BETWEEN 4 AND 7 MILES IN LENGTH, AND DESIGNED TO ACCELERATE THE LAUNCH SLED AND RLV/SSTO SPACE VEHICLE AT, OR AS NEAR TO MACH 2 AT THE POINT OF RELEASE AS POSSIBLE, WITH G-FORCES BETWEEN 2-G's AND 6-G's FOR MANNED VEHICLES, AND 6+-G's FOR UNMANNED VEHICLES AND NON-G SENSITIVE PAYLOADS. ELECTROMAGNETIC LAUNCH SYSTEM COMPONENTS, LAUNCH SLED, AND LAUNCH VEHICLE ARE NOT TO SCALE. A LARGER DETAIL PRESENTATION OF THE 3 REPULSOR TRACKS, AND LAUNCH SLED ON RAIL/TRACK SYSTEM, IS IN THE BOTTOM LEFT HAND CORNER.



PLEASE SEE BELOW A FEW EXAMPLES OF RLV / SSTO LAUNCH VEHICLE CANDIDATES





PROPOSED ISA: (ISP) PROGRAM & (IASL) SYSTEM - STAGE 1

Systems Concept Design /Interim Preliminary Design Stage (Part 1 & Part 2)

1) Planned Time Frame & Dead Line Goal: 6 Months to 1 Year, For The Completion Of Stage 1

2) Proposed Program Oversight & Management:

A) Schneider Structural Engineering, Inc. – Primary Ramp Structure & Civil Engineering Consultant
B) National Aeronautics & Space Administration, NASA - Primary Aerospace / EM Systems Consultant
C) Sky Ramp Organization – Primary Concept & Scientific/Mathematical Modeling Consultant
D) Russian Space Agency, European Space Agency, Other National Space Agencies - Will Be Sought As Full Active Participants

3) General Description Stage 1 Goals/Mission: ISP RLV/SSTO: Systems Concept Design /Interim Preliminary Design Stage, including drawing up of mission performance specifications. The scope of work would include System and Sub-system Concept design, models, demonstrators, computer graphics modeling, and preliminary CAD based engineering drawings, performance at design and off-design conditions. This Stage would examine the safety features and safety margins at all segments of flight to and from orbit, system and sub-system weight estimation, specifications and identification of sources of critical technologies, definition of Systems Integration capabilities/institutions, and ground/flight Test Facilities available/required for system and technology development on a global basis. Also included will be small-scale proof-of-concept tests on critical materials and components. This Phase will end with a Project Feasibility and Full Techno-economic Report. **IASL: Covered here in general, see Part 2 for details.**

4) US/NASA Funding Request: Amount Requested $6,000,000 (Minimum $4,000,000 is needed)

5) Needed Elements For: Funding Resources, Personnel Infrastructure, and Research & Development

I.) Access to NASA/Government Facility & Computer Resources for Modeling & Computations: $????

Note A: This Access is requested as part of this Proposal Request

Note B: Resources of Private Firms, of which they or their personnel are part of this proposal, will be used when ever possible, and as part of dedicated funds for Specialists involved below.

Note C: However, we are proposing that **$50,000** be designated for Modeling & Computations Resources as a general use fund, to be used when and where required, or other resources are required in this regards.

II.) Engineering, Scientific, Technical Personnel needed for this project: Total $870,000

$40,000 **A)** Civil Engineer – Specialist in Geology & Construction Site Analysis
$40,000 **B)** Civil Engineer – Specialist in Site Survey & Mapping
$40,000 **C)** Structural Engineer – Specialist in Concrete & Metal Structures (Building & Highway Construction)
$40,000 **D)** Mechanical Engineer – Specialist in Metal Rail Systems & Mechanical Systems
$40,000 **E)** Aeronautics Engineer – Specialist in Aerospace & Space Plane Systems (Structures)
$40,000 **F)** Aeronautics Engineer – Specialist in Aerospace & Space Plane Systems (Propulsion)
$40,000 **G)** Aeronautics Engineer – Specialist in Aerospace & Space Systems (Flight Control & Navigation)
$40,000 **H)** Aeronautics Engineer – Specialist in Aerospace & Space Plane Systems (Thermal Protection)
$40,000 **I)** Aeronautics Engineer – Specialist in Aerospace & Space Plane Systems (Fuel Systems)
$40,000 **J)** Aeronautics Engineer – Specialist in Aerospace & Space Plane Systems (Computers & Electronics)
$40,000 **K)** Magnetic Systems Engineer – Specialist in Electromagnetic Systems & Materials
$40,000 **L)** Power Systems Engineer – Specialist in Power Generation, Transmission, and Storage Systems
$40,000 **M)** Scientist – Physics & Mathematics – Specialist in Acceleration Forces
$40,000 **N)** Scientist – Physics & Mathematics – Specialist in Aerodynamic Forces
$40,000 **O)** Scientist – Physics & Mathematics – Specialist in Electromagnetic Forces
$40,000 **P)** Scientist – Physics & Mathematics – Specialist in Advanced Rocket Propulsion Systems
$20,000 **Q)** CAD Operator – Specialist in Civil Engineering & Map Making
$20,000 **R)** CAD Operator – Specialist in Structural Engineering & Blue Prints
$20,000 **S)** CAD Operator – Specialist in Mechanical Engineering & Blue Prints
$20,000 **T)** CAD Operator – Specialist in Electromagnetic & Electrical Engineering & Blue Prints
$20,000 **U)** CAD Operator – Specialist in Aerospace & Space Craft Engineering & Blue Prints
$30,000 **V)** CAD Operator – Specialist in Large Complexes & Industrial Facilities Rendering & Blue Prints
$40,000 **W)** Project Manager – Specialist in Large Program & Project Management
$30,000 **X)** Project Technical Writer – Specialist in Scientific & Technical Writing & Editing
$30,000 **Y)** Project Graphic Artist – Specialist in Rendering of Diagrams, Art Work, and Technical Drawings
$30,000 **Z)** Project Computer Animation – Specialist in Computer Animation of Project Concepts & Technology

III.) General Personnel needed for this Project: Total $230,000

- $30,000 **A)** Executive Secretary to the Project Manager
- $20,000 **B)** General Secretary & Receptionist
- $20,000 **C)** General File Clerk
- $20,000 **D)** Public & Media Relations Representative
- $40,000 **E)** Administrative Computer Data Entry & Office Computer Systems Specialist
- $20,000 **F)** Government & Diplomatic Relations Representative
- $20,000 **G)** Historian & Writer
- $20,000 **H)** Photographer & Videographer
- $40,000 **I)** Retained Attorney & Law Firm for Patent, Trademark, and Copyright issues

IIII.) General Project Office & Facilities & Travel Budget: Total $350,000

- $50,000 **A)** Project General Office Equipment & Computers
- $50,000 **B)** Project General Office Consumables, Paper, Computer & Printer, Art & Graphic, Supplies
- $100,000 **C)** Project Site Inspections, Official Project Travel & Lodging & Stipends
- $50,000 **D)** Project Communications: Phone, Fax, Internet, Postal Mail & Deliveries, Teleconference
- $100,000 **E)** Government, Private Sector, and Public Outreach & Advertising

V.) General Project Consulting Costs for Government & Private Sector Interests: Total $500,000

- $50,000 **A)** United States Government & NASA Consultant
- $50,000 **B)** Russian Government & RSA Consultant
- $50,000 **C)** European Governments & ESA Consultant
- $50,000 **D)** China, Japan, India Government & CNSA, JAXA, ISRO Consultant
- $50,000 **E)** Other Governments & National Space Agencies Consultant
- $50,000 **F)** United States Aerospace & Space - Commercial, Industrial, Commerce Private Sector Consultant
- $50,000 **G)** International Aerospace & Space - Commercial, Industrial, Commerce Private Sector Consultant
- $50,000 **H)** Prospective Project Site Location - Outreach & Negotiations Consultant
- $50,000 **I)** International Space Law, Treaties, Regulations Consultant
- $50,000 **J)** International National Security, Military, and Weapons –Treaties & Regulations Consultant

VI.) Project Technology Test & Demonstration & Systems Models & Demonstrators: Total $1,000,000

- $100,000 **A)** A fully functional small-scale engineering model will be built as a systems & project demonstrator.
- $600,000 **B)** A full scale, 500 ~ 1000 foot piece of Launch Ramp & Launch Sled & Ramp Systems will be built.
- $100,000 **C)** A set of Computer Generated Movies, showing all aspects of the project elements will be created.
- $50,000 **D)** A number of Scaled Systems & Engineering Models will be commissioned and built.
- $50,000 **E)** A number of pieces of Artwork and Graphics will be commissioned, showing all project elements.
- $100,000 **F)** A full in depth set of CAD presentations with all system specs, designs, and system specifications.

VII.) Project Launch Vehicle Candidates Explored, 3 candidates selected for study: Total $1,000,000

Note: 3 potential Launch Vehicles & Configurations will be identified as Launch Vehicle Candidates.

- $100,000 **A)** A full indepth study of a wide range of Potential Launch Vehicle RLV/SSTO Candidates,Globally.
- $250,000 **B)** A detailed study of Launch Vehicle RLV/SSTO Candidate # 1 Jointly with Candidate Sponsors.
- $250,000 **C)** A detailed study of Launch Vehicle RLV/SSTO Candidate # 2 Jointly with Candidate Sponsors.
- $250,000 **D)** A detailed study of Launch Vehicle RLV/SSTO Candidate # 3 Jointly with Candidate Sponsors.
- $100,000 **E)** A detailed study of final selected Launch Vehicle RLV/SSTO Candidate, and Candidate Sponsors.
- $50,000 **F)** A number of Scaled Vehicle & Systems & Engineering Models will be commissioned and built.

6) Coordinated System & Mission Planning and Design Study: This will be Key to the start-up of this phase would be a Coordinated Planning & Design Study between NASA, and either a **(example 1: USA X- 33 SSTO/RLV Space Plane System & Mission)** United States based effort; or **(example 2: Indian Avatar SSTO/RLV Space Plane System & Mission)** from another Nation, **"like India"**, which is positioned and able to share its knowledge domain and efforts in breakthrough SSTO/RLV design and related commercial space missions; or a joint, collaborative, and mutually beneficial joining of the best and proven elements of many such programs, and diverse resources, into one robust and dynamic effort & program.

A) The ISA is strategically positioned and uniquely structured to offer its international aerospace corporate management and other key services, as mentioned earlier in this Proposal, for such a Coordinated Program & System, Planning & Design Study.

B) The ISA, on the basis of a Formal Agreement (Treaty / Charter) between NASA/USA -and- ISRO/INDIA -and- OTHER NATIONAL SPACE AGENCIES/NATIONS GLOBALLY -and- PRIVATE SECTOR (NGO) ORGANIZATIONS GLOBALLY -and- THE ISA ORGANIZATION, will help to facilitate a coordinated, holistic & synergetic & mutually beneficial planning and design study on ISP (ex: X-33, ex: Avatar), with flexible, adaptive, re-configurable designs, with the focus on critical & key technology areas and driven service sectors, is respectfully suggested, as the best option, logical path to success, and most efficient means to an end.

C) The Primary Objectives of this Coordinated ISP Program, System & Mission Planning and Design Study, facilitated by ISA, Between: NASA & United States Government, proposed National Partner like ISRO & Indian Government, and other partners from Space Nations Globally, like Russia, Europe, Japan, China, and Other Nations, and also many partners from Private Sector (NGO) Organizations Globally, like Boeing/USA, Ariane Space/France, Energia/Russia, Great Wall Industries/China, and Others Globally, would be as follows:

1) To develop a holistic/synergetic & mutually beneficial, systems, technology and applications perspective for unique, integrated air/space transportation systems & missions globally, for interested nations and private sector organizations, which can be justified by the twin tests of, necessity and proportionality.

2) To focus these Planning and Design studies on specific and critical selected systems and missions, towards fulfilling the strategic global Civil & Commercial needs of the Worlds Nations, and for Global Business & Private Sector (NGO) Opportunities, in a well coordinated and integrated manner, ***in the areas of aeronautics, aerospace, civil aviation, and space exploration and space launch related applications.***

3) To carry out Conceptual Design Studies on Hypersonic, Trans-Atmospheric, Fully Reusable, Single-Stage-To-Orbit, Aerospace Vehicles, like the Indian Avatar, and/or, the USA X-33, and/or Other Such RLV/SSTO Vehicles and Space Plane Systems and Mission Concept, Globally. This Study would be done ***for the identification of local and global civil commercial and business needs and opportunities in aerospace and space exploration & space launch applications***, and recommends a conceptual design suitable for engineering & technology development, production and marketing, in a 5 to 7 yr. time frame.

4) To carry out Conceptual and Interim Preliminary Design Studies on a RLV/SSTO Space Transportation System & Technology Demonstrator, which has the capability to demonstrate and qualify all critical technologies for both Hypersonic Transcontinental Passenger/Cargo carrying aircraft as well as fully Reusable Single-Stage-To-Orbit Aerospace Vehicle concepts recommended and pursued by this ISP Planning & Design Study.

5) To very strongly pursue as a key and critical element of the ISP Program, and to conduct this as a parallel but separate element (Part 2) of this proposal**.** ***This to use of an Electromagnetic Based Launch Ramp System, for Assisted Space Launch (ASL) of the ISP RLV/SSTO Space Plane,*** under Study in this proposal (Part 1). This is more fully described in Part 2 of this Proposal, which described and titled the International Assisted Space Launcher (IASL) System.

6) To identify Critical Technologies and Test Facilities for immediate, intermediate, and long term design and development, and to further initiate and pursue in-depth studies needed carrying forward these ISP planning and design studies for implementation of the recommended air/space transportation systems and missions, which are out lined in this proposal.

7) To identify aerospace institutions, and professionals, globally already networked and identified as potential or needed partners by ISA, where necessary, in Government, Commercial, Scientific, Academic, and Public & Private Sectors & Establishments, in the areas of *aeronautics, aerospace, civil aviation and space exploration*, who have the capabilities, capacities, and stability necessary for participation, and are willing to foster, promote, and participate in such unique and advanced aerospace systems and missions, and the ISA has proposed for ISP Program, which is outlined in this proposal.

8) To estimate, identify, clarify, present in an detailed & organized report, the: time, costs, physical & human resources, institutional support globally, and new/strengthened institutional linkages needed for time targeted development cycles for the systems & missions, identified in this ISP Planning & Design Study.

9) To recommend an Action Plan to implement the recommendations of this ISP Planning & Design Study Report in the remaining parts of Stage 1, and subsequent parts of this international joint ISP space program, mission, and endeavor which would be facilitated and enabled by the ISA Organization.

***Here the (ISP Program Part 1) & (IASL System Part 2) Branch Off & Break Down Into Separate Parts.**
***See ISP/IASL Proposal: Part 2 – For details of the International Assisted Space Launch (IASL) System.**

PROPOSED ISA: (ISP) PROGRAM - STAGE 2
Preliminary System and Subsystem/Component Engineering Design Stage

STAGE 2 – Planned Time Frame & Dead Line Goal: 1 Year to 2 Years

STAGE 2 – Description: Preliminary System and Subsystem / Component Engineering Design Stage, including detailed engineering drawings , material and test specifications, manufacturing processes, and design of jigs, tool, & fixtures required for prototype/limited quantity manufacturing processes. Also included will be building of a full-scale engineering mock-up of the launcher & vehicle and its major sub-systems. This Phase will end with a Preliminary Engineering Design Review.

PROPOSED ISA: (ISP) PROGRAM - STAGE 3
System Design and Development Stage

STAGE 3 – Planned Time Frame & Dead Line Goal: 1 Year to 2 Years

STAGE 3 – Description: System Design and Development Stage including full-scale sub-systems (engines, airframe and avionics) development and ground testing over the full flight envelope to fully establish the engineering feasibility of the System Design, Systems Integration, ground systems design and development, and full-scale prototype building for experimental launch & flight trials. This Phase will end with "Roll Out" of the first prototype space plane and fully operational assisted space launch system.

PROPOSED ISA: (ISP) PROGRAM - STAGE 4
Critical Engineering Design Review Stage

STAGE 4 – Planned Time Frame & Dead Line Goal: 6 Months to 1 Year

STAGE 4 – Description: Critical Engineering Design Review Stage, which is critical for flight test clearances prior to the first prototype flight trials, and building of several prototypes. This Phase will end with clearance to fly the first prototype and the Flight Trials program approved for implementation.

PROPOSED ISA: (ISP) PROGRAM - STAGE 5
Qualification Engineering Review Design Stage

STAGE 5 – Planned Time Frame & Dead Line Goal: 6 Months to 1 Year

STAGE 5 – Description: Qualification Engineering Review Design Stage, which is essential to qualify & certify the Space plane and launcher system at sub-systems and systems levels, prior to series manufacture and deployment of the Aerospace vehicles by its ultimate user(s). This Phase will end with successful Users Flight Trials, and series production fully established.

PROPOSED ISA: (ISP) PROGRAM - STAGE 6
Operational Deployment Stage

STAGE 6 – Planned Time Frame & Dead Line Goal: 6 Months of Full Operational Testing

STAGE 6 – Description: Full Operational and Deployment Stage. It must be noted that the Goal of the International Space Plane (ISP) Program is to field an OPERATIONAL SSTO Vehicle and Launch Infrastructure with in 5 to 7 years. It must be noted that the International Space Plane (ISP) Program will endeavor to draw upon already existing Technologies & Programs Globally to accomplish its Goals; and great care will be taken not to needlessly drive up program costs due to duplication of already achieved and developed programs and efforts globally.

ISP/IASL PROPOSAL - PART 2 – ELECTROMAGNETIC LAUNCH RAMP
International Assisted Space Launch (IASL) System / Program

The IASL system concept, technology, and program proposal would be an intrinsic, key, and critical part of the ISP – RLV/SSTO Space Plane Coordinated Planning & Design Study, as out lined in general through out this ISP/IASL proposal, and most specifically in Part 1 of this ISP/IASL proposal. Its primary use will most likely be best suited for pure rocket-based RLV's & SSTO's. However, since no operational Ground Based Assisted Space Launch System has ever existed or been done before. So, at this early and cutting edge stage, the IASL Program is fully extended in an exploratory and evaluatory way to, and use by/for, air-breathing & hybrid propulsion based SSTO's & RLV;s, which will also be examined in detail during the course of the ISP planning & design studies, facilitated by the ISA.

The Basic Purpose, Goals, Design Elements Of The Proposed IASL System

1) Basic IASL System - Purpose: To eliminate wasteful stage 1 expendable launch vehicles and to allow a variety of RLV's & SSTO's to be developed and operated that take advantage of an assisted launch system, which will allow for more efficient and less wasteful orbital space launch systems & Operations.

2) Basic IASL System - Goals: To field a cutting edge, state of the art, and robust assisted space launch system of scale and wide range of operations and capabilities, which uses a high mountain launch site located on or as near the Earths equator as possible and has a launch ramp which will be as near to 45 degrees as possible and uses electromagnetic repulsor technology as its primary propulsion system, and would be able to launch a wide range of RLV's, SSTO's, HSAV's, and Test Vehicles at various accelerations and release speeds, which are optimum for the vehicles being launched.

A) Potential IASL System Program Participants, and Program Scope & Scale: International Scope, with National Governments & Private Sector Interests Globally, being involved at all levels and Stages.

B) Potential IASL System Program Funding Needs, and Program Funding Strategies: Development Costs, Operation Costs, and Funding Strategies: Examples: Taxes/Government, Profits/Commercial, Grants/Academic, and Donations/Private.

C) Potential Uses of Program, System, and Facility: Examples: Government, Commercial, Scientific, Academic, and Private Sector Organizations, Institutes, and Persons.

It would be a real International (Multi-National) spaceport, if working the way we envision it. This would mean cheap access to space, and complete program/system/vehicle reusability. With the Assisted Launch Capability of Magnetic Repulsor Launch System and Technology, there would be substantial orbital payload capability. Launch Vehicles, Cargo, Space Crews, Personnel, and Civilian Passengers could travel to this location using commercial air travel or shuttle flights and then go directly to the part of the terminal that would take them into space; or in the case of the Launch Vehicles shuttled in, would be prepped for orbital launch. It would make moon and mars missions finally mean something: we could stay in these places because we could then afford to, and not have these decade long hiatuses between these flag planting trips. Large amounts of waste in the use of expendable launch vehicles would be solved with the ISP/IASL totally reusable program and systems.

D) Types, Sizes, Capabilities, Purposes of RLV's / SSTO's Space Planes & Launch Vehicle Candidates:
(ie: Large, Medium, Small & Mission Specific, Cargo, Passenger) & (ie: Venture Star) This would be for the X-33 without those heavy aerospike engines. At first it could be used to launch 3 people into space, with more payload capability to follow later. This would be useful for space station work and moon / mars mission transfers.

E) Proposed & Planned IASL Program Infrastructure, Other Than The Launcher Facility & Vehicles:
Electromagnetic Repulsor would need power line connections to the power grid and arrangements for power sharing with the local utilities, or have its own dedicated power station, which would be the more preferred option. Large commercial airfield and related support infrastructure. Rail & Roadway access to a seaport, and major population and industry centers. On site technical, manufacturing, servicing, repair capabilities & infrastructure. On site fuel production capabilities and infrastructure.

F) Orbital Refueling Capability of RLV's / SSTO's Space Planes & Launch Vehicles:
Some RLV's & SSTO's could be used as space tankers to supply an orbital refueling infrastructure, and could support a wide range of increased orbital operations and for ventures beyond Earth orbit. This could be done if the crew sections of certain RLV's & SSTO's were modular & replaceable with unmanned fuel tank launch capability, or by creation of dedicated tankers.

G) Large Scale Transport of Non-G Sensitive Fuel, Cargo, Raw Materials to Orbit, Utilizing Other Supporting Systems (ie: Space Cannon/Rail Gun/Future Exotic or Non-Conventional Technology)

H) Use of present Systems & Resources already in use to Support and Enhance EM Launcher Facility & Program & Services

At White Sands and Alamogordo there is already an assisted launch infrastructure that could be useful for support.

I) Training, Education, and Research & Development

Training would be available to operate the Ramp Systems & Launch Vehicle

J) Society Supports & Outreach

It would give children globally a reason to hope and dream, and would make space accessible to all qualified, law abiding, and peaceful peoples of Earth. The dream of a true space faring society would finally come true. It might also lead to a resurgence in interest in pursuing science and technology once again. It will also enhance and encourage international good will and peace.

K) Enlist the help of as many Supporters and Participants as possible
None Listed at this stage of the Proposal

L) Program/Project Proposal Co-Signers (Supporters/Sponsors: 10to20 Globally Known & Respected)
(ie: People Like Burt Rutan, Scientists, Astronauts/Cosmonaughts, Government Space Officials)
None Listed at this stage of the Proposal

3) Basic IASL System - Design Elements & Configuration:

A) Electromagnetic Repulsor Technology Based: Primary Propulsion (Thrust) Components & Systems:

B) Electromagnetic Repulsor Technology Based: Primary Propulsion (Thrust) Components & Systems:

C) Launch Ramp & Sled: Performance Goals Are To Launch Various Vehicles At, or Above, Mach 2

Mach 2+ with 2-G to 3-G acceleration. The v=vo+Vln(m/mo) mass ratio considerations then allow an X-33 capable to orbit with payload.

D) Launch Ramp & Sled: Power Generation, Transmission, Storage - Infrastructure, Facilities, Systems:
Electricity could be used at off peak “non-launch windows” use and hours for Magnetic Repulsor operation. The hydrogen and oxygen fuel for the RLV could then be separated “Cracked” from water on site by electrolysis using the electricity that at other times would be needed for Magnetic Repulsor operation. Thus NO dangerous fuels would have to be transported to the site.

E) Launch Ramp: Utilizes Standard Highway Overpass, Concrete & Steal Construction Engineering:

F) Launch Ramp: Length of Launch Ramp, Is Proposed To Be A Total Of, Between 4 & 7 Miles Long:

G) Launch Ramp: Located On Side Of A Mountain At, Or As Near As Possible To, Earths Equator:
Best or Proposed Locations for System / Facility (Mountain Location On or Near Earths Equator) If put on the side of a mountain in the southern United States, <25degN lat., facing east The track needs to be about 1/3 longer because it won't be at the equator. There are such mountains at White Sands, near Alamogordo, NM and in Texas

H) Launch Ramp: Incline & Angle Is At, Or As Near As Possible To, 45 Degrees Constant Grade:

I) Launch Ramp: Uses Metal Rails, and Lunch Sled With (Over/Under Configuration) Metal Wheels:

J) Launch Sled & Systems: Electromagnetic Repulsor Technology Based Propulsion & Key Systems:

K) Launch Sled & Systems: Interaction With The RLV / SSTO Space Plane During Launch Cycle:

L) Launch Sled & Systems: Sled Braking, Sled Recovery, Sled Emergency & Back-Up Systems:

PROPOSED ISA: (IASL) SYSTEM - STAGE 2

Preliminary System and Subsystem/Component Engineering Design Stage

STAGE 2 – Planned Time Frame & Dead Line Goal: 6 Months to 1 Year

STAGE 2 – Description: Preliminary System and Subsystem / Component Engineering Design Stage, including detailed engineering drawings , material and test specifications, manufacturing processes, and design of jigs, tool, & fixtures required for prototype/limited quantity manufacturing processes. Also included will be building of a full-scale engineering mock-up of the launcher and its major sub-systems. This Phase will end with a Preliminary Engineering Design Review. Launch Site Selection and Evaluation.

PROPOSED ISA: (IASL) SYSTEM - STAGE 3
System Design and Development Stage

STAGE 3 – Planned Time Frame & Dead Line Goal: 6 Months to 1 Year

STAGE 3 – Description: System Design and Development Stage including full-scale sub-systems (Ramp, Launch Sled, Power & Operational Systems) development and launch testing over the full envelope of speeds and G-Forces to fully establish the engineering feasibility of the System Design, Systems Integration, power & operational systems design and development, and full-scale prototype building for experimental launch trials. This Phase will end with operational first prototype launch ramp structure and fully operational launch system.

PROPOSED ISA: (IASL) SYSTEM - STAGE 4
Critical Engineering Design Review Stage

STAGE 4 – Planned Time Frame & Dead Line Goal: 2 Months to 6 Months

STAGE 4 – Description: Critical Engineering Design Review Stage, which is critical for launch & pre-flight test clearances prior to the first prototype launch & pre-flight trials, and building of support facilities and airfield. This Phase will end with clearance to test the first prototype in a series of test launch & flight trials program approved for implementation.

PROPOSED ISA: (IASL) SYSTEM - STAGE 5
Qualification Engineering Review Design Stage

STAGE 5 – Planned Time Frame & Dead Line Goal: 2 Months to 6 Months

STAGE 5 – Description: Qualification Engineering Review Design Stage, which is essential to qualify & certify the launcher system at sub-systems and systems levels, prior to series full operation and deployment of the launch system and candidate aerospace vehicles by its ultimate user(s). This Phase will end with successful launch test and test flight vehicle trials, and series production fully established for any other duplicate systems.

PROPOSED ISA: (IASL) SYSTEM - STAGE 6
Operational Deployment Stage

STAGE 6 – Planned Time Frame & Dead Line Goal: 6 Months of Full Operational Testing

STAGE 6 – Description: Full Operational and Deployment Stage. It must be noted that the Goal of the International Assisted Space Launch (IASL) System, is to field an OPERATIONAL EM Launch System and Launch Infrastructure with in 3 to 4 years. It must be noted that the International Assisted Space Launch (IASL) System will endeavor to draw upon already existing Technologies & Programs Globally to accomplish its Goals; and great care will be taken not to needlessly drive up program costs due to duplication of already achieved and developed programs and efforts globally.

Organizational & Management Infrastructure within ISA

The ISA organization will evolve and be appropriately organized and well established for each of the above Stages progressively according to the unique requirements of each Stage.

However, the ISA would emphasize that while any system is being planned and designed, like the X-33 or the aerobic Reusable Launch Vehicle (such as the “Avatar” system), the ISA would consider this as just some of many prospective ISP Program candidates. The ISA’s facilitation of any particular concept design does not mean commitment to its final acceptance for promoting its design engineering, technology development, and final deployment by prospective users, or the ISA Organization, in the International Space Plane (ISP) Program.

Further, it is known from the open literature that the basic system concept design, as in India’s Avatar, is based on the assumption that supporting technology elements from many nations. Hence, the ISA participation in ISP systems planning and design processes to enable selection of the best prospective RLV/SSTO candidate, and/or would consider that candidates like the "Indian Avatar" and its best system & concept elements may be technologically combined with RLV/SSTO technologies & candidates from USA, Russia, Europe, Japan, etc.

Thus, the Coordinated ISP System & Mission Planning and Concept Design Study, such as the "Indian Avatar" and "USA X-33", would be seen by ISA as potential first stage effort candidates, and would be looked at from a purely & exclusively exploratory & focused effort and project, to develop, build, and field a first ISP operational proto-type RLV/SSTO space plane. But even so, as mentioned above, the door will always be left open for vision beyond "Avatar" or "X-33" which are viewed by ISA as only a first step in the right direction.

The views of the ISA in respect to ownership, design and development, manufacture, marketing, and deployment of an ISP are presented in Appendix "A" for reference by the appropriate NASA authority reviewing this Proposal

PROPOSED ISA: (ISP) PROGRAM & (IASL) SYSTEM – KEY POINTS

Basic Funding Needed For Stage 1: Total Costs: $4 Million to $6 Million - Total Requested: $ 6 Million

Potential Participants & Scope Of Stage 1, And All Stages Thereafter: The main Space Nations of the United States, Russia, Europe (E.S.A.), China, Japan, India, and other Developed & Developing National Space Agencies, as well as Commercial, Industrial, Scientific, Academic, NGO's / NFP's, and Private Organizations & Institutes, Globally. Funding can be obtained through a number of sources and strategies. Examples: Taxes/Government, Profits/Commercial, Grants/Academic, and Donations/Private.

Potential Benefits Of Stage 1, And All Stages Thereafter: Massive Jobs Programs, Increased Economic Stability, Reduction Of International Tensions, Globally; Creation of Massive International Space Launch Capability & Infrastructure.

PROPOSED ISA: (ISP) PROGRAM & (IASL) SYSTEM PURPOSE, GOALS, AND MISSION FOR ALL STAGES

It must be noted that the Goal of the International Space Plane (ISP) & International Assisted Space Launch (IASL) Program is to field an OPERATIONAL RLV/SSTO Vehicle and Assisted Space Launch Infrastructure **"WITH IN" 5 to 7 years.** It must be noted that the International Space Plane (ISP) & International Assisted Space Launch (IASL) Program will endeavor to draw upon already existing Technologies & Programs Globally to accomplish its Goals; when ever, where ever possible, and so great care will be taken not to needlessly drive up program & launch costs due to duplication of already achieved and developed programs & efforts globally.

The ISA organization will evolve and be appropriately organized and well established for each of the above Stages progressively according to the unique requirements of each Stage.

However, the ISA would emphasize that while any system is being planned and designed, (like the aerobic Reusable Launch Vehicle such as Avatar, also the X-33 Venture Star, and Sanger 600 Systems), the ISA would consider this as just a number of many prospective ISP Program RLV/SSTO candidates. The ISA's facilitation of any particular concept design does not mean commitment to its final acceptance for promoting its design engineering, technology development, and final deployment by prospective users, or the ISA Organization.

Further, it is known from the open literature that the basic system concept design for these and other systems globally is based on the need and assumption that supporting technology elements from many nations. Hence, the ISA participation in systems planning and design processes to enable selection of the best candidates would consider that any potential candidates and their best system & concept elements may be technologically co-joined with technologies from America, Russia, Europe, Japan, etc.

Thus, the Advanced Aerospace System Planning and Concept Design Study, for any ISP candidates, would be seen by ISA as a first stage effort, and would be looked at from a purely exclusive and focused effort and project. But even so, as mentioned above, the door will be left open for vision beyond any single candidate RLV/SSTO launch vehicle, which is viewed by the ISA as only a first step in the right direction.

Appendix "A" - The views of the ISA in respect to ownership, design and development, manufacture, marketing, and deployment of an ISP are now presented below for consideration.

Critical questions and answers delineating the views of the ISA in respect of the fundamental planning premises for this Proposal are placed below, peer review and diplomatic dialog and input is encouraged:

1. WHO WOULD PARTICIPATE, FUND & COORDINATE STAGE 1 OF ISP/IASL: THE SYSTEMS CONCEPT DESIGN AND INTERIM PRELIMINARY ENGINEERING DESIGN STAGE, STARTING WITH THE "COORDINATED PLANNING & DESIGN STUDY"?

International Participation: Once the Nodal Agency (ISA) and other Countries "is/are" identified, and the "Coordinated Planning and Design Study" is approved, Nations required to participate in the Systems Concept Design and Interim Preliminary Engineering Design Stage, will be tentatively identified by the Nodal Agency (ISA) and participants Globally. Key potential RLV/SSTO space vehicle candidates would be narrowed.

Funding: ISA may also provide an estimate for the total Systems Concept Design and Interim Preliminary Engineering Design Stage, and the structure of funding expected from other nations. It is expected that almost all nations identified might already be Member States in the ISA, as this program develops in meaningful ways.

Organization of the Planning & Design Study and Stage 1 of the ISP

It is proposed that for **Stage 1**, an International Steering Committee of the ISP and several ISP Task Forces could be set up by the ISA and participating Government & Private Sector Organizations, Institutes, and Persons, jointly with, and trough the ISA Organization, and under the ISA Charter & Umbrella.

This **International Steering Committee of the ISP (Stage 1)** would consist of the Chairpersons of Steering Committees set up in different Nations and Private Organizations wishing to be involved in **Stage 1** of the ISP Program. This International Steering Committee could then act as the oversight and focal point for **Stages 2-5** stages of this effort and study, whose detailed elements would be conducted **by a coordinated system of special Task Forces, local and global, "National" & "International / Multi-National"**.

At that stage, ISP-ISA linkage may be formalized as a Formal Treaty Institution and International Charter Based Organization for legally establishing the leadership, organizational, and management responsibilities between Member Nations, Institutes, Organizations, and Authorized Persons, ISP, and the ISA. The treaty institution may also include, as signatories, the major participants in **Stage 1** of the ISP Program.

Thereafter, the ISA would provide the needed International Corporate Services by facilitating dialog and negotiations with and between ISA Member States & Organizations & interested Parties (including future Users) to help negotiate the required international funding, as envisioned by the ISA-ISP, for **STAGE 1**: The ISP Systems Concept and Interim Preliminary Design Engineering Stage.

2. WHO WOULD OWN THE ISP? ("~OWNERSHIP" USE & PASSAGE & RIGHTS)

PLEASE NOTE: the term "~OWNERSHIP" in relation to ISA Assets and Programs, like the International Space Plane (ISP) Program, is **NOT "OWNERSHIP" in the traditional sense!** No more than a Highway or Bridge or Tunnel is owned by any of the many Persons both Government and Private Sector who drive on and use these assets.

When such assets are built, in many cases a ***TOLL*** is established for ***use (passage)*** of these assets, and certain rules of use are established such as speed limits, weights, ect. In principle this is what ***"OWNERSHIP"*** represents here, in regards to the International Space Plane (ISP) program. These assets then are centrally maintained in most cases by local municipalities or Government Agencies, but in some cases Private Organizations. In the case of ISP, the International Space Agency would be the recognized and responsible caretaker and operator of the ISP Program and its Facilities, Personnel, and Assets. And in fact the ISA would be the owner of the ISP***, on the behalf of, and in the service of, its member Nations & Private Organizations***. ***ISA is the Highway Department, ISP Program & IASL System are the Highway, Users are Member Nations***.

*** This issue would arise and be addressed towards the completion of Stage I.**
However, the view of the ISA is that ISP should be JOINTLY owned by participating nations / organizations / institutions, based on the proposed level of their contributions to **Stage 2-to–5** of the project. For example, those entities who propose to contribute 30% to **Stages 2-5**, i.e. design engineering, development, manufacture, personnel, deployment, and operation would have rights to 30% of the ***"~Ownership"*** ie: **USAGE** as long as it falls within the pre-agreed Charter & Treaty Agreements signed by the participating nations and private organizations.
The design of an ISP ***"~Ownership"*** ie: Usage Charter between all the participating nations, organizations, institutions, and facilitation between Nations for negotiation and signing, will be another one of the International Corporate and Diplomatic Services offered, enabled, and provided by the ISA.

3. WHO WOULD BE THE CUSTOMER (S) FOR THE ISP & ISA?

The potential customers are to be identified in **STAGE 1** of the ISP. The ISA will provide the required Corporate Management Services and thereby facilitate the global identification of potential customers for the ISP in Stage 1 itself. Thereafter, the potential users would be inducted as ISA Member States & Organizations, as agreed and approved, and as treaty participants, if they are not already so.
The ISA would like to emphasize that it would ensure participation of only those Global Customers or Nations who are approved by ISA Member States & Organizations and who will, or are able to, abide by all ISP Program Protocols & ISP "~***Ownership"*** ie: Usage Charter, and established ISA Charter & Treaty Agreements.

4. WHO WOULD BUILD THE ISP ? (i.e. THE SYSTEMS INTEGRATORS)

The ISP System Integrators would be identified in ISP Stage 1 itself. The ISA would provide the required Corporate Management Services to facilitate the Global ISP program identification and negotiations with potential Systems Integrators. For this purpose, the ISA will provide the required corporate/project management services to plan, organize and arrange its personnel, through, and by, its Member States & organizations, for this purpose of systems integration of the aerospace vehicle and its servicing and operation for the ISP Program.

5. WHO WOULD OPERATE THE ISP ?

ISA, and its Member States & Organizations operating within the ISP Ownership and Usage Charter, would also offer launch-for-hire services, globally, as agreed, and with in the pre-agreed ISP Charter. For this purpose, the ISA will provide the required corporate/project management services to plan, organize and arrange its personnel, through, and by, its Member States & organizations, for this purpose of operating the ISP.
*Fees & Launch Charges: Launch-for-hire Operations, would be used to maintain/upgrade ISP Program assets & resources.

6. WHO WOULD FUND THE ISP ACTUAL DESIGN & DEVELOPMENT PROGRAM, AND HOW WILL IT BE ORGANIZED?

*This issue would also arise towards the completion of Stage I.

Funding, it is expected that nations, organizations, and institutions participating in these Stages would **JOINTLY** fund the actual full-scale design and development program. Based on the proposed level of their funding, material, personnel contributions to ***Stage 2-to–5*** of the project, ownership/usage rights would accrue.
As described earlier, for example, those nations who propose to contribute 30% to ***Stages 2-5***, i.e. design engineering, development, manufacture and deployment, would have rights to 30% of the ownership and usage as long as it falls within the pre-agreed ISA & ISP Charter/Treaties signed by the participating nations.
The facilitation of dialogs and negotiations for determining the level and international structure of funding for ***Stage 2-5*** i.e. design engineering, development, manufacture and deployment, will be another one of the International Corporate Services offered by ISA.
Organization ***Stages 2-5*** of the ISP Program It is proposed that this funding may form a part of ISA core budget, through, and by, its Member States & Organizations. At that Stage, an ISP Commission could be set up under the aegis of the ISA Charter, and Treaty Agreements including a Board of Directors and other joint operational level leadership, organizational, and technical/quality control structures.

This ISP Commission would consist of the Chairman/President/CEO or Appointed High Level Representative of each nation/organization involved in ***Stages 2-5*** of the ISP Program. This ISP Commission could then act as the oversight and focal point for ***Stages 2-5*** of this effort and study.

7. WHAT IS ROLE OF ISA IN VARIOUS STAGES OF THE ISP/IASL PROGRAM?

As mentioned earlier, ISA will act as the neutral focal point and enabler organization i.e. enabling a wide range of Government and Private resources to be brought to bear on a common goal and central project with very well defined rules and requirements, for development & operation. Thus the ISA will essentially be the core International Corporate and Project Management Service for the ISP program.

Some of the critical International Corporate and Project Management Services for the ISA: ISP/IASL Program which have been identified above are:

1) Facilitating the Planning and Design Studies on Advanced Aerospace Systems Globally by providing an international corporate service linkage with the Nodal Agency ISA and other Nations as might be required in this Study. This may be formalized as a Treaty Institution for legally establishing the ISA & ISP organization and management responsibilities between Member States & Organizations and the ISA. The ISA Charter and Core Treaties may also include, as signatories, the major participants in **Stage 1** of the ISP.

2) ISA will participate in the International Steering Committee of the ISP **(Stage 1)** whose detailed elements would be conducted by a coordinated system of special Task Forces, local and global, facilitated and overseen by the ISA where needed.

3) The ISA would provide the needed International Corporate Services by facilitating dialog and negotiations with and between ISA Member States & Organizations & interested Parties (**Including Future Users**) to help negotiate the required international funding, as envisioned by the ISA, for **STAGE 1:** the Systems Concept and Interim Preliminary Design Engineering Stage.

4) The ISA will provide the required Corporate Management Services and thereby facilitate the Global identification of potential customers for the ISP in **Stage 1** itself, who will, or are able to, abide by all ISP Program **Protocols & ISP "~Ownership" and Usage Charter/Treaties.**

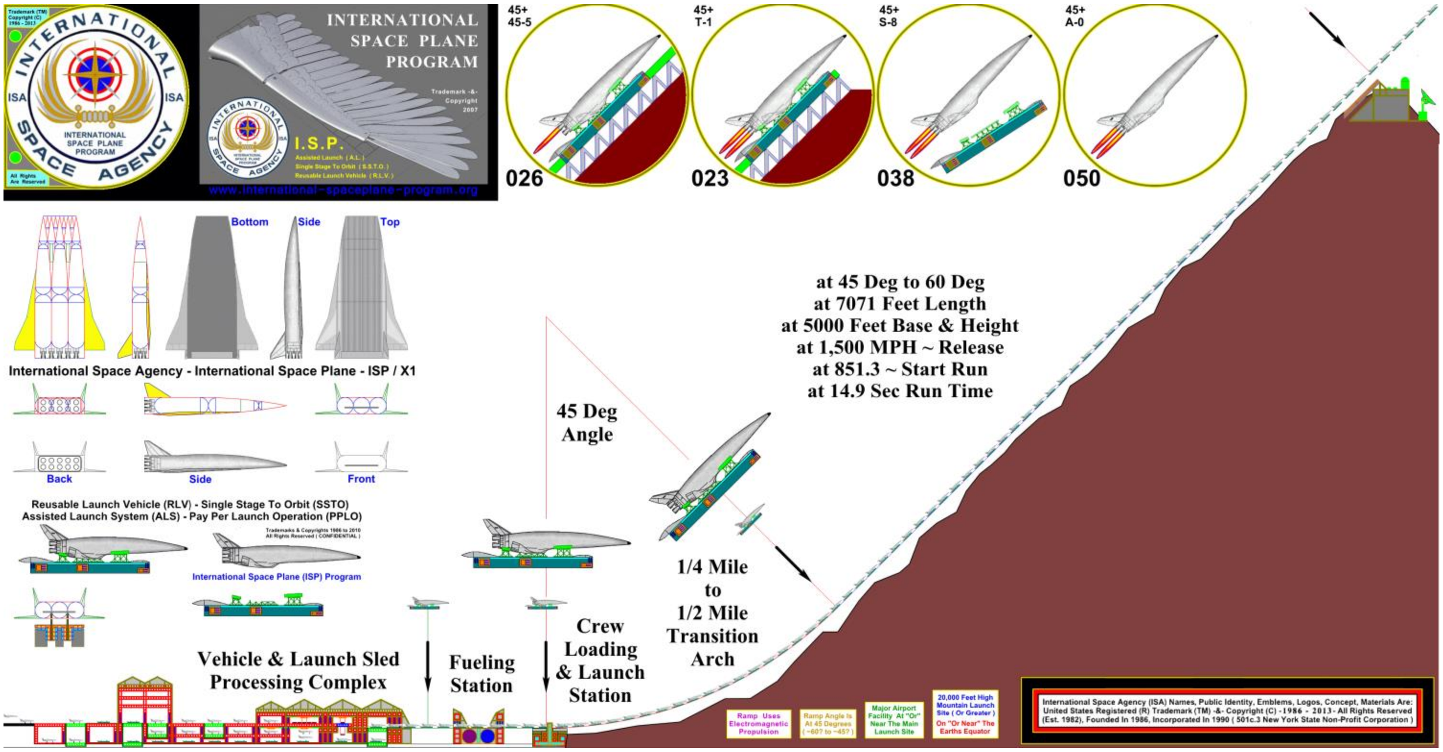
5) The ISA would provide the required Corporate Management Services to facilitate the ISP Program and negotiate with potential Systems Integrators. For this purpose, the ISA will provide the required corporate/project management services to plan, organize and arrange its personnel, through, and by, its Member States & organizations, for this purpose of systems integration of the aerospace vehicles and IASL for the ISP.

6) The ISA would provide the needed International Corporate Services for design of an ISP Ownership and Usage Charter between all participating nations, organizations, and institutions, and facilitation between nations for negotiation and signing, will be another one of the International Corporate Services offered by ISA.

7) ISA, and its Member States & Organizations operating within the ISP Ownership and Usage Charter, would also offer launch-for-hire services, globally, as agreed, and with in the pre-agreed ISP Charter. For this purpose, the ISA will provide the required corporate/project management services to plan, organize and arrange its personnel, through, and by, its Member States & organizations, for the purpose of operating the ISP.

8) The facilitation of dialogs and negotiations for determining the level and international structure of funding for **Stage 2-5** i.e. design engineering, development, manufacture and deployment, will be another one of the International Corporate Services offered by ISA.

9) Facilitating the creation and functioning of an Apex Level ISP Commission for Governance of the proposed ISP program, which could be set up under the aegis of the ISA Charter, including a Board of Directors and other joint leadership and operational level organizational structures.



INTERNATIONAL SPACE AGENCY
ISA
INTERNATIONAL SPACE PLANE PROGRAM
INTERNATIONAL SPACE PLANE PROGRAM
I.S.P.
45+ 45-5
45+ T-1
45+ S-8
45+ A-0
026
023
038
050
Bottom
Side
Top
International Space Agency - International Space Plane - ISP / X1
Back
Side
Front
Reusable Launch Vehicle (RLV) - Single Stage To Orbit (SSTO)
Assisted Launch System (ALS) - Pay Per Launch Operation (PPLO)
International Space Plane (ISP) Program
at 45 Deg to 60 Deg
at 7071 Feet Length
at 5000 Feet Base & Height
at 1,500 MPH ~ Release
at 851.3 ~ Start Run
at 14.9 Sec Run Time
45 Deg Angle
1/4 Mile to 1/2 Mile Transition Arch
Crew Loading & Launch Station
Fueling Station
Vehicle & Launch Sled Processing Complex
Ramp Uses Electromagnetic Propulsion
Ramp Angle Is At 45 Degrees (~60? to ~45?)
Major Airport Facility At "Or" Near The Main Launch Site
20,000 Feet High Mountain Launch Site (Or Greater)
On "Or Near" The Earths Equator
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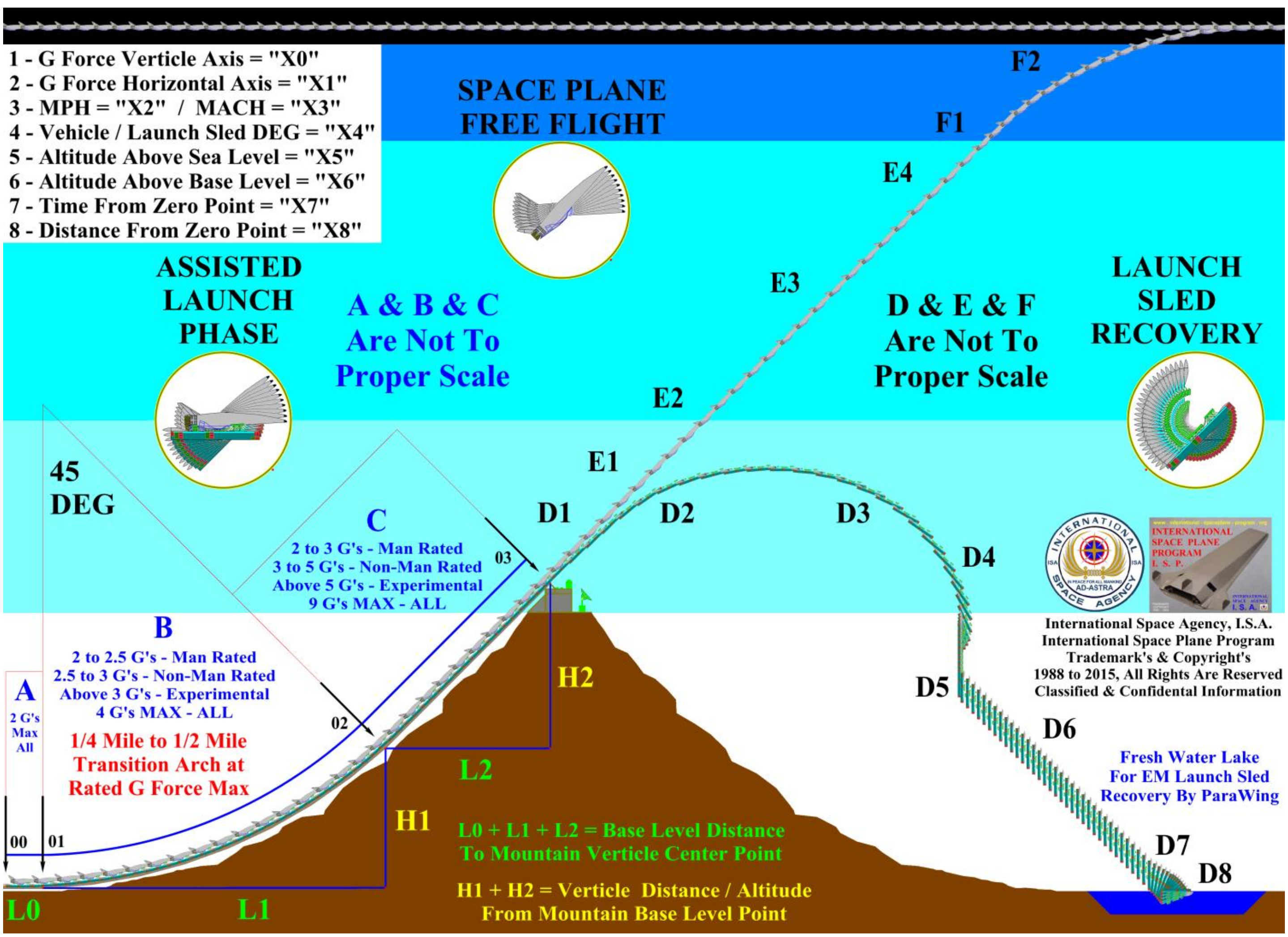

1 - G Force Verticle Axis = "X0"
2 - G Force Horizontal Axis = "X1"
3 - MPH = "X2" / MACH = "X3"
4 - Vehicle / Launch Sled DEG = "X4"
5 - Altitude Above Sea Level = "X5"
6 - Altitude Above Base Level = "X6"
7 - Time From Zero Point = "X7"
8 - Distance From Zero Point = "X8"
SPACE PLANE FREE FLIGHT
ASSISTED LAUNCH PHASE
A & B & C Are Not To Proper Scale
D & E & F Are Not To Proper Scale
LAUNCH SLED RECOVERY
F2
F1
E4
E3
E2
E1
D1
D2
D3
D4
D5
D6
D7
D8
45 DEG
C
2 to 3 G's - Man Rated
3 to 5 G's - Non-Man Rated
Above 5 G's - Experimental
9 G's MAX - ALL
03
B
2 to 2.5 G's - Man Rated
2.5 to 3 G's - Non-Man Rated
Above 3 G's - Experimental
4 G's MAX - ALL
02
A
2 G's Max All
1/4 Mile to 1/2 Mile Transition Arch at Rated G Force Max
00
01
H2
L2
H1
L0
L1
L0 + L1 + L2 = Base Level Distance To Mountain Verticle Center Point
H1 + H2 = Verticle Distance / Altitude From Mountain Base Level Point
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Fresh Water Lake For EM Launch Sled Recovery By ParaWing

SOME TECHNICAL & MANAGERIAL PERSPECTIVES UNDERLYING THE IASL CONCEPT

Concept Contributions By: Dr. David Maker, I.S.A. - I.S.P. / I.A.S.L. Program, Proposal Foot Notes:

Here is that proposal so far. It needs a lot more specificity. It has to address all the key objections that people have to this kind of thing, be compelling. But I have gone a long way in that regard.

One issue that I am working is on the (force) static's of a full cryogenic fuel tank sitting horizontal. It has to be supported by many points but yet has to be allowed to (thermally) contract when the cryogenic fuel is added. Thus it has to sit on top of many small rollers on the sled! Thus the push has to be from the back on the sled, since these rollers won't do that. Secondly there is the question of how to use a minimum amount of interior structural reinforcement for a huge fuel tank sitting horizontal. It appears to me that very little reinforcement is required at all!

That roller carriage supports the fuel weight when stationary and at 3-4 Gs acceleration from the sled pushing on the bottom of the tank along the track direction the "dynamics" is that of a nearly vertical fuel tank as in ordinary rocketry!!!!

It's as if that tank reinforcement problem doesn't really exist at all, with lightweight cables offering the best hope of reinforcing the interior if that should still be necessary.

Replacing that heavy aerospike engine with conventional rocket engines may compensate for this small weight increase as well. The RLV rocket engine has to be ignited before leaving the sled and yet these rollers must not tear off the thermal tiling when release occurs.

Thus the sled must decelerate (but not the RLV) and jerk downward on RLV release, allowing inertia and the ignited rocket engines to carry the RLV. The point is to make it so there is little added internal structural reinforcement needed for a X-33 type vehicle on the rocket sled.

Otherwise the added RLV weight defeats our purpose. The next issue is that of track length and location. The most ideal design I know of is a parabola on its side with the release point at 45deg pitch. This saves a huge amount on vertical mountain requirements.

The 'small' track radius of curvature only exists on the section of the track where the speed is smallest so that centrifugal force (mv^2/r) torques are smallest.

For mach 2 release, instead of 2.5 miles vertical, you need only about 3/4 of a mile vertical which could be found in many places in the continental US, including in southern Texas, and at White Sands NM, especially on west side of that mountain range near Alamogordo NM.
For political reasons the Magnetic Repulsor sled facility probably cannot be situated on the equator so the track must made longer to compensate for the lower initial velocity of higher latitudes.

Note the initial velocity east due to the earth's rotation goes approximately as 1000cos(lat) so for lat=25 deg (southern US) this is 1000(.91); you need an additional 93mph from the track.

the release velocity goes as the square root of the length (times 2g) the track length must then be increased by about a third. Thus a vertical mile should be allowed (instead of 3/4 mile) for mach 2 launch which is still achievable at many places in the southern USA.

Why not horizontal launch you ask? If you release a RLV moving at mach 2 ~700m/sec and demand lets say that it be moving near 60 deg pitch after 1000 meters, what centripetal acceleration is necessary? It is 50 g s.

The structural integrity is gone. So how many kilometers radius of curvature do you need for about a 1 g centripetal acceleration given this type of release? At least 50km.

So for at least 30 miles the RLV is moving in the lower densest part of the atmosphere doing work against the air as it goes. Approximate work=1/2CArhov^2 50000 ~10^13 joules, way higher than the assisted launch energy itself. You lose all the energy you gained from the assisted launcher.

Scientific Research Title

Equatorial Mountain Side Based - Electromagnetic Repulsor (Thrust/Powered) (Ramp & Rail) Mounted Reusable Magnetic Repulsor Sled System for Launching RLV/SSTO Spacecraft & Airborne Test Vehicles At Supersonic Speeds.

Introduction

Mankind has been unable to find an inexpensive method of launching large objects into space. For the past 40 years, the only method has been multi-stage rockets. There has always been great interest in a single stage Reusable Launched Vehicle (RLV). In fact, today's "Space Shuttle" was envisioned as a single stage vehicle, but that proved impractical. NASA canceled a more recent attempt at a single-stage design, the X-33, in January 2001 when problems proved insurmountable. The solution is an "assisted launch" to propel the RLV to supersonic speeds before it fires its engines. However, the technology for current single-stage proposals is far too immature. Numerous discussions by the authors led us to realize that current technology will allow a thrust-powered inclined Electromagnetic Repulsor sled system to solve this problem.

Brief Summary

No one has considered using proven Electromagnetic Repulsor systems. Our figures prove that large RLV's can be propelled to supersonic speeds using Electromagnetic Repulsor. The major challenge is identifying large mountains with lengthy inclined slops on which to build the rail system. The system may begin on an inclined track directly from a launch pad, or it may begin horizontally and ramp up to the desired inclined launch angle. A review of each element of the title is helpful:

Equatorial Mountain Side Based - Electromagnetic Repulsor (Thrust/Powered) (Ramp & Rail) Mounted Reusable Magnetic Repulsor Sled System for Launching RLV/SSTO Spacecraft & Airborne Test Vehicles At Supersonic Speeds.

Reusable - keeps launch costs reasonable compared to the traditional method of disposable rocket stages.

Thrust / Powered - Electromagnetic Repulsor Technology.

Ramp & Rail-Mounted – mounted on steel rails with metal wheels. The rails will be mounted on a lengthy inclined track.

Electromagnetic Repulsor Sled – to be accelerated "launched" by Electromagnetic Repulsor Forces at high speeds. This launch sled which contains the Electromagnetic Repulsor Coils and supporting structure is connected to the object or space vehicle to be launched.

RLV/SSTO Spacecraft – these systems are provided an assisted launch to Low Earth Orbit to reduce the size and weight of spacecraft. Also intercontinental high speed, supersonic, and hypersonic aerodynamic vehicle could also be provided an assisted launch to reduce fuel use at the critical acceleration to mach speed and climb to altitude.

Example Test Vehicle RLV – this system would be useful for launching a variety of test aircraft and missiles, or to test their aerodynamic properties at high speeds. X-33 Venture Star, without the heavy aerospike engines, with the new carbon fiber fuel tanks and possibly with methane sludge in the liquid hydrogen fuel tanks to increase fuel weight vs. fuel tank weight. 270,000 pounds thrust, wedge shaped with some lifting body capability. Aerospike engines replaced by two lighter conventional rocket engine giving 700,000 pounds thrust. Because of the conformal roller method of RLV support by the sled little in fuel tank structural reinforcement would be necessary on the RLV.

Supersonic speeds – launch speeds in excess of Mach are possible, here mach 2.

Detailed Description

Why Using Electromagnetic Repulsor Technology To launch An RLV / SSTO Space Plane Into Orbit, At Mach 2 Off A Rail-Mounted Sled, From A Mountainside Launch Ramp Which Is At A Near 45 Degree Angle, Will Work.
This is not a theory; the technology has existed for years. This idea falls under the category of "assisted launch". Several ideas have been proposed is the past using different techniques. A brief review follows:

Integrated Impulse Equation Mass Ratio Requirements: **ISP and Space Data Table ISP and Mass Ratio Considerations for RLV for the Mach 22 to Orbit Given the Track Mach 2 Release**

Newton's second law implies that F=dp/dt=d(mv)/dt. d(mv) is composed of the incremental propellant mass dm going out the back at propellant velocity V (impulse =Vdm) and rocket mass m forward at small velocity dv due to the motion backwards of propellant mass dm (impulse =mdv) . There are no external forces in this scenario so the net momentum change of the center of mass is zero so that <-Vdm=-mdv->

Rearrange this equation to read dv=V(dm/m) and integrate (dm/m) =ln(m_f/m_o) so that:

v=Vln(m_f/m_o)=Vln(1/r) where r is the mass ratio, **see the graph provided below**.

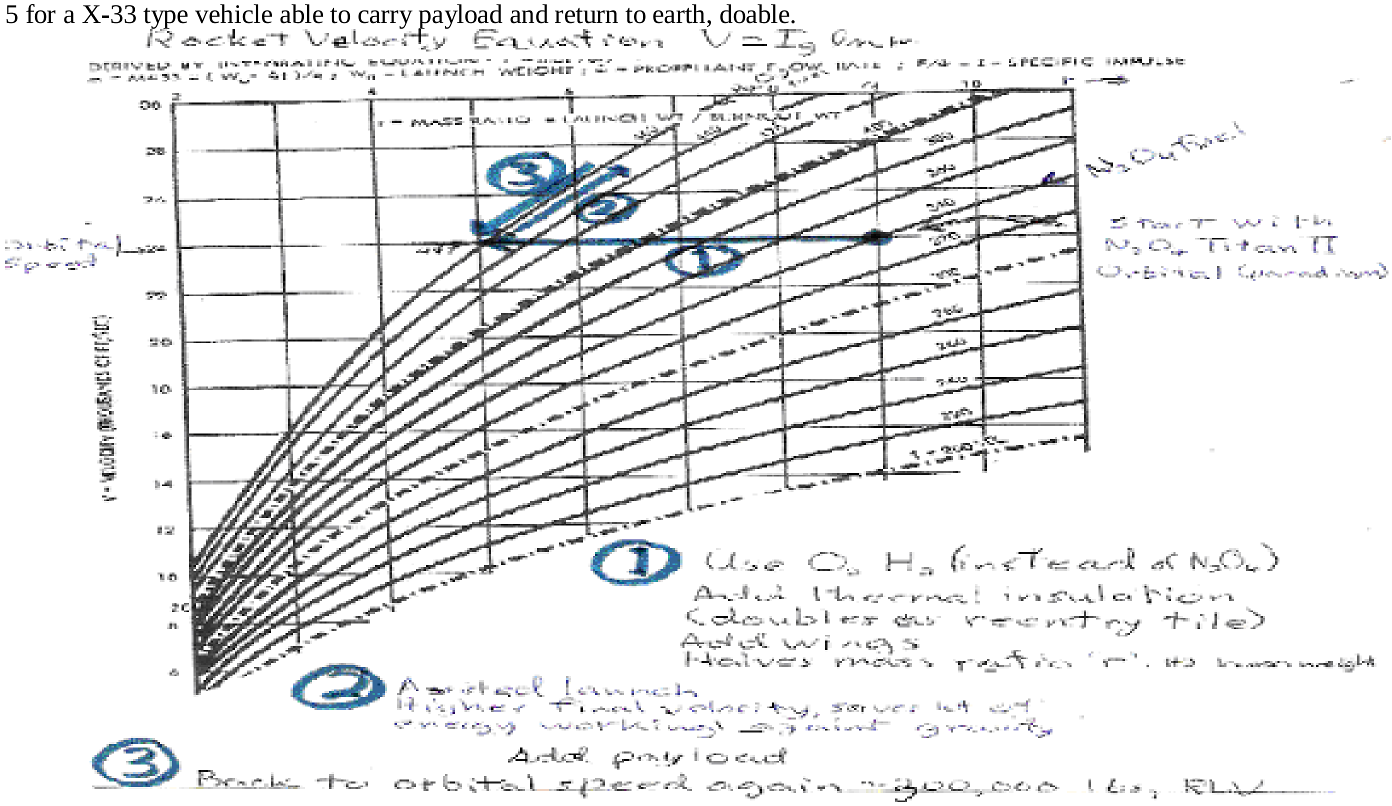
The m_f is the deadweight plus payload and deadweight is a function of the surface to volume ratio (how much surface vs. volume there is) the engine weight, payload,... The surface to volume is smallest for a large near radius spherical object and a small surface to volume ratio is what is required here. A titan II is known to have the sufficiently low surface to volume ratio given its ISP to orbit.

Below is a graph (From the NASA space data handbook) of velocity vs. mass ratio r for various ISP s (specific impulse), which are related to fuel exhaust velocity For 24,000 ft/second orbital velocity, Nitrogen tetroxide isp of 340 we see from the graph that the mass ratio r is about 9.

Here we reason out how to obtain a RLV single stage to orbit for Magnetic Repulsor launch.

For 24,000 ft/second orbital velocity, Nitrogen tetroxide isp of 340 we see from the graph that the mass ratio r is about 9.

In step one of this thought experiment we exchange the nitrogen tetroxide fuel for a higher ISP fuel H2-O2 increasing the isp to about 490 (step 1) but with the H2 decreasing the fuel density causing us to lengthen the fuel tank if we are to have the same fuel weight. At the same time we put wings on the titanII first stage and thermal insulation with the thermal insulation doing so for both reentry and the cryogenics. This effectively doubles the deadweight and so halves the mass ratio to 5 (step 1 still) and by flattening (width twice the height) we have an X-33 type with aerodynamic lift characteristics requiring only small wings. But because of the assisted launch it will move at about the equivalent of 1/10 of orbital velocity faster (step 2). Add payload (step 3) and take into the account the savings in time in doing work against gravity by assisted launch and that brings it back to 24000 ft/sec orbital velocity. Thus instead of the Titan II first stage mass ratio of 9, where it is able to carry its huge first stage, we have here 4 parts fuel to 1 part structure for a mass ratio of 5 for a X-33 type vehicle able to carry payload and return to earth, doable.



Electromagnetic launch – A 1985 project at the Lawrence Livermore National Laboratory concluded that the cost per joule of just about any kind of electric gun is so high that it's basically prohibitive. Several similar patents exist which propose using this technique, such as: Electromagnetic transportation system for manned space travel (7,795,113). The Holloman aerodynamic horizontal test track in New Mexico **has achieved MACH 8 using electromagnetic propulsion for small objects.**

Fuel Tank Static’s and Dynamics

One issue that I am working is on the (force) static’s of a full cryogenic fuel tank sitting horizontal. It has to be supported by many points but yet has to be allowed to (thermally) contract when the cryogenic fuel is added. Thus it has to sit on top of many small rollers on the sled! Thus the push has to be from the back on the sled, since these rollers won't do that. Secondly there is the question of how to use a minimum amount of interior structural reinforcement for a huge fuel tank sitting horizontal. It appears to me that very little reinforcement is required at all! That roller carriage supports the fuel weight when stationary and at 3-4 Gs acceleration from the sled pushing on the bottom of the tank along the track direction the "dynamics" is that of a nearly vertical fuel tank as in ordinary rocketry!!!!

It's as if that tank reinforcement problem doesn't really exist at all, with lightweight cables offering the best hope of reinforcing the interior if that should still be necessary. Replacing that heavy aerospike engine with conventional rocket engines may compensate for this small weight increase as well.

RLV Release

The RLV rocket engine has to be ignited before leaving the sled and yet these rollers must not tear off the thermal tiling when release occurs. Thus the sled must decelerate (but not the RLV) and jerk downward on RLV release, allowing inertia and the ignited rocket engines to carry the RLV. The point is to make it so there is little added internal structural reinforcement needed for a X-33 type vehicle on the rocket sled. Otherwise the added weight defeats our purpose.

Track Length and Location and Description

The next issue is that of track length and location. The most ideal design I know of is Ramp, with a parabolic shape on its side on its side with release the point at 45 degrees, 2.5 miles in length with the upper end ¾ mile higher than the lower end. This saves a huge amount on vertical mountain requirements. The 'small' track radius of curvature only exists on the section of the track where the speed is smallest so that centrifugal force (mv^2/r) torques are smallest. Note the curve at the lower end is allowed because that is where the velocity is smallest (thus less concern about mv^2/r centrifugal force bending torques). Thus using elementary kinematical equations:

$v=\sqrt{2as}$ **so** $s=\frac{v^2}{2a}=\frac{(2*340)^2}{2*(6*9.8)}=3{,}932m$ ≈4km≈2.5miles

So the inclined track must be on the order of 2½ miles (13,200 feet) long. For mach 2 release, instead of 2.5 miles vertical, you need only about 3/4 of a mile vertical. The placement in the lower 48 states (US) is possible because of the mere ¾ mile vertical displacement of the track, saving a substantial amount on vertical mountain requirements. There are many possible track locations which could be found in many places in the continental US, including in southern Texas, and at White Sands NM, especially on west side of that mountain range near Alamogordo NM. Put on the side of a mountain in the southern United States, <25degN lat., facing east the track needs to be about 1/3 longer because it won't be at the equator. For political reasons the Electromagnetic Repulsor sled facility probably cannot be situated on the equator so the track must made longer to compensate for the lower initial velocity of higher latitudes. Note the initial velocity due to the earth's rotation goes approximately as 1000cos(lat) so for lat=25 deg (southern US) this is 1000(.91); you need an additional 93mph from the track. Because the release velocity goes as the square root of the length (times 2g) the track length must then be increased by about a third. Thus a vertical mile should be allowed (instead of 3/4 mile) for mach 2 launch 6g acceleration which is still achievable at many places in the southern USA.

Need Launch Pitch Angle

Why not horizontal launch you ask? The main reason for not doing horizontal launch is if you release a RLV moving at mach 2 ~700m/sec and demand lets say that it be moving near 60 deg pitch after 1000 meters, what centripetal acceleration necessary? It is 50 g s. The structural integrity is gone. So how many kilometers radius of curvature do you need for about a 1 g centripetal acceleration given this type of release? At least 50km. So for at least 30 miles the RLV is moving in the lower densest part of the atmosphere doing work against the air as it goes. Approximate work=1/2CArhov^2 50000 ~10^13 joules, way higher than approximately the assisted launch energy itself. All the energy gained from the assisted launch is lost in pushing sea level density air for a long distance. The X-33 failed without assisted launch.

NASA hoped to build the X-33 RLV as the world's first single-stage to orbit spacecraft. This would allow safer and inexpensive space launches, compared to the "Space Shuttle" which requires an expensive first-stage booster rocket. However, after many years of research design incorporating the latest technologies, NASA was unable to develop a design that would allow the X-33 to reach orbit under its own power. As a result, the X-33 project was canceled in January of 2001. It was clear that the X-33 could make orbit with assisted launch. Also those heavy aerospike engines must be replaced by conventional rocket engines. The X-33 must be situated in a carriage on the sled that supports the fuel tank structure so that additional structural support is not necessary when the fuel tank is full of fuel. Inductive breaking must be used for sled. This sled must allow for the contraction of tank on fueling with these cold liquids.

The value of Initial Velocity, which assisted launch, provides

The core of the problem is that given the choice between a large initial mass m_0 launch system and a large initial velocity v_0 system. Let me make the case for the large v_0 option. Let m_0 be the total initial fully loaded mass of the rocket, 'm' the mass after the fuel is expended, V=exhaust velocity =4500 m/s, (calculated from H_2+O I_{sp}) v=8km/sec orbital velocity, t =8min time to orbit without having the initial velocity v_0. "R" the usual value of m_0/m for the case v_0 =0. The $t(v_0)$ term is the decrease in time (term) to orbit due to the fact of having an initial velocity. So this time is subtracted from the real time to get an effective time.

$t(v_0)$=60X1.5sec (saves ~1.5 minutes in flight , maxQ from 50-85sec), V=4500(m/s)=isp for H_2+O. t=8min., v_0=700 m/s=Mach2 with pneumatic (or catapult) non-detonation heating. Thus in the rocket equation (resulting from integration of the impulse equation):

$v=v_0-gt+V\ln\left(\frac{m_0}{m}\right)$ so dividing by Vand taking the exponential and solving for m_o/m:

$$\exp\left[\frac{v-v_0+gt-gt(v_0)}{V}\right]=\exp\left[\frac{-v_0-gt(v_0)}{V}\right]\exp\left[\frac{v+gt}{V}\right]=\exp\left[\frac{-v_0-gt(v_0)}{V}\right](R)=\frac{m_o}{m}$$ =1.42R again with R being the exponential term without assisted launch.

Thus the booster can be .7 times smaller for unmanned payloads, nearly half the size! This would make it so that even the large X-33 RLV could make it into orbit! The original X-33 design launched vertically from a dead-start could reach only about Mach 15, needing Mach 24 to make orbit. An assisted launch could close the gap. The ability to add this much extra mass in the form of reentry tiles (with a modification to X-33 like lifting body shape) would clearly still have orbital possibilities.

They key is to consider the pre maxQ vertical component of gt(v_o) term in the impulse equation. This represents the work that would have had to have been done against gravity had the larger fuel load been carried up. This term is two to three times larger than the v_o itself. It represents essentially a large "amplification" of the effect of assisted launch.

Example: Electromagnetic Repulsor sled, uses (4) 656,000lb thrust to launch a X-33 size RLV with sufficient speed to make orbit.

Dynamics of Track - Sum of forces=F=ma=thrust-½CAρv^2-mgsintheta =thrust-airfriction-gravity with an averaged drag coefficient C (for supersonic C gets messy, velocity dependence even on rlv shape, theta=45deg., mg=270,000pounds) results in 2.5 million pound thrust at the top of the track for a 270,000 pound RLV at 6g acceleration. The RLV reaches mach 2.

Example Parameters For: **Launch weight of an X-33 = 273,000 lbs**

Thrust = (4 x 656,000 lbs) or a total of 2,624,000 lbs of combined thrust (Thrust of each proposed RS-68 = 656,000 lbs each)

Newton's Second Law used to Calculate Required Thrust

Newtons's 2nd law F=ma
Sum of Forces =Air Resistance+Thrust+gravity+Friction=ma
4X656,000 lbs=2,624,000 lbs Thrust

Air Resistance: ρV=m , V=Ax so dm/dt=ρdV/dt=ρA(dx/dt)=ρAv in D≈(½)CρAv^2
Given typical vehicle drag coefficient C=.5, (conservative estimate of drag coefficient C which itself varies with velocity at supersonic speeds), near sea level ρ≈1kg/m^3 at v≈2X340m/sec, 10X30 m^2 cross section, then:

D≈(½)CρAv^2 =.5(.5)(1kg/m^3)(10mX3m)(2*340m/s)^2 =3,468,000N=778,000 lbs. * **Friction also contributes a little here.**

Gravity Force: Take sled plus rocket motors to be about 100,000 lbs weight at top of track since all the fuel has been used in the rocket motors. So F_g =mgsinθ=(273,000+100,000)sin45°=263,711 lbs

Total Force Required for 6 G's: **Total Force=-air resistance-Thrust-gravity+Friction=ma=m6*9.8**

Total Force=-D+Thrust+F_g=m6*9.8 Thrust-778,000-263,711=ma=(263,000/32)6*32=1,578,000= lbs
So required Thrust =2,620,000 lbs provided by Magnetic Repulsor must be provide at the top of the track.
Magnetic repulsor vendors claim they can provide 700kpd thrust, so need at least 3 in parallel near the top.

So required Thrust =2,620,000 lbs provided by Electromagnetic Repulsor must be provide at the top of the track.
The energy is provided by shorting out a ½ Li^2 a approximately H=100million Henry coil, An easily built very large coil containing thousands of pounds of high permeability ferromagnetic core material. Track mounted on raised concrete, like an expressway ramp, about 15+ feet wide, like a monorail, so the sled cannot leave the track.

A spoiler can be used at the top of the track along with other brakes to help keep the sled moving on a downward moving track while the RLV leaves according to Newton's First Law. Large decelerations of the sled are possible because the RLV containing the people will be airborne. The m6g thrust requirement is provided by Electromagnetic Repulsor.

Track Length For 6g Acceleration and Mach 2 Final Velocity:

$$v=\sqrt{2as} \quad \textbf{so} \quad s=\frac{v^2}{2a}=\frac{(2*340)^2}{2*(6*9.8)}=3{,}932m$$ ≈4km≈2.5miles

So the inclined track must be on the order of 2 ½ miles (13,200 feet) long. Since the Earth has dozens of mountains over 20,000 feet tall, building a rail ramp up a mountain at a 45-degree slope is certainly feasible; using the same construction techniques used to build interstate highways and rail lines through large mountain ranges. But it is best to build this in the United States at below 25N latitude and then add a 1/3 length to the track to compensate for being so far from the equator. It could even then be built near the Holloman 8mile maglev track. This track, up the side of mountain, would be a shorter track than what is already at Holloman!!

Variables for Inclined Electromagnetic Launch Systems

Each launch site must be custom designed based on a variety of factors:

Location of launch site – A location closer to the earth's equator is greatly advantageous for spacecraft launches, ideally pointing east. A large steep mountainside in needed to support the inclined rail. A rural area is best because of the launch noise and sonic booms. The best area to build this is on the side of a mountain near Alamogordo New Mexico or in the southern United States, <25degN lat., facing east the track needs to be about 1/3 longer because it won't be at the equator. The placement in the lower 48 states (US) is possible because of the mere ¾ mile vertical displacement the track saving a substantial amount on vertical mountain requirements. There are many possible track locations in the continental US, including in southern Texas, and at White Sands NM, especially on west side of that mountain range near Alamogordo NM. For political reasons the Magnetic Repulsor sled facility probably cannot be situated on the equator so the track must made longer to compensate for the lower initial velocity of higher latitudes. Note the initial velocity due to the earth's rotation goes approximately as 1000cos(lat) so for lat=25 deg (southern US) this is 1000(.91); you need an additional 93mph from the track. Because the release velocity goes as the square root of the length (times 2g) the track length must then be increased by about a third. Thus a vertical mile should be allowed (instead of 3/4 mile) for mach 2 launch with 6g acceleration which is still achievable at many locations in the southern USA.

Power Source For Magnetic Thruster From Large Induction Coil - The 1 gigawatt sled power could be provided directly by a single electrical power plant for 8 seconds or the energy $\frac{1}{2}Li^2$ released by opening (the circuit of) a 100 million Henry coil given 10 amp current flow through it. For a solenoid self inductance= $L= K\mu_o n^2 A=K4\pi X10^{-7}(N/x)^2\pi r^2$ so it is easily possible to have many thousands of windings N compressed into a meter length (note that number gets squared) x but having at least 10 meters radius=r and to have the very large magnetic permeability K (ferromagnetic-1000) core solenoid. This could give the 100million Henries. The R/L time constant could be large enough (~8 seconds) given a suitable total electromagnetic repulsor track resistance R. For continuous power then only about 10 megawatts (given a one hour launch cycle) are needed also to include the power for the electrolysis giving the H2 and O2 for the RLV from local water supplies so that fuel need not be trucked in.

Number of Magnetic Repulsor Thrusters Varies with Distance Up the Track - From Dr. House: "A trade study was done in the mid-90's that showed an optimum speed of ~ 300 - 400 nts with decreasing returns as the launch-assist speed went higher due to the aerodynamic loads." This is consistent with the very large 2.5 million pound thrust requirement calculated here with v=700m/sec into $\frac{1}{2}C\rho Av^2$, $A=10m^2$, sea level $\rho=1kg/m^3$, C a conservatively large ½ for the air resistance component of the F=ma calculation which also includes $mg\sin\theta$ (with θ=45degrees) and thrust.

Here then there would be (3) 700,000 pound thruster electromagnetic repulsors in parallel at least near the top of the track where the air resistance is largest. But these would not be spread out over the length of the track, just up near the top to keep the acceleration constant at the highest air resistance ($\sim v^2$)where the speed is largest. Near the bottom only 2 of these thrusters are needed.

Size of potential vehicles – the weight of the objects to be launched and their aerodynamic characteristics determine the length of track and thrust required. The X-33 was barely capable of getting into orbit with assisted launch. Any smaller mass and orbit is not possible. The X-33 would have weighed 270,000 pounds. This is a lower limit on the size of the RLV. A 2.5 kilometer track with 6g acceleration would then require 2.5 million pounds thrust.

Test Vehicle RLV - X-33 without the heavy aerospike engines, with the new carbon fiber fuel tanks and possibly with methane slush in the liquid hydrogen fuel tanks to increase fuel weight vs fuel tank weight. 270,000 pounds launch weight, wedge shaped with some lifting body capability. Aerospike engines replaced by two lighter conventional rocket engine giving 700,000 pounds thrust. Because of the conformal roller method of RLV support by the sled little in fuel tank structural reinforcement would be necessary on the RLV.

Horizontal Load Bending Moments on RLV Minimized by Suitable Sled Support - There must be more than just 3 point support for the fully fueled RLV on its side when on the sled. otherwise a great deal of heavy structural reinforcement is required and the rocket won't orbit given the added deadweight. The support is from many body conforming rollers on the top of the sled to the bottom of the RLV, the N rollers allowing fuel tank expansion and contraction for cryogenic fueling and less RLV internal structural reinforcement required for support against bending moment stresses. The force on each support is approximately 270,000/N. Thus if N =1000 the force on each roller is approximately 270 pounds, thus requiring very little added fuel tank structural reinforcement

There Is Some Yaw Capability for RLV after Launch - This velocity is a cosine component here so nearly flat at the top allowing for substantial *angle* change with little change in velocity magnitude. In that regard note that there is still mach 22 left to use rocket motor thrust (which can be slightly different between the two rocket engines) to change direction. 20 deg yaw still gives a velocity component cosine of .94; not much orbital velocity taken off by a substantial change in yaw (yaw would then have a 40 deg range here).

Desired Speed of Launch – faster is usually better, but the thrust needed, angle of launch, and length of track are constraints.

Desired Angle of Launch - Horizontal Launch Not Advocated Here - 45 Degree Pitch Launch Instead – Spacecraft going for orbit are best at near vertical take-off from the end of the rail. Of course the higher the angle the more thrust needed to achieve the desired speed, and rail/track construction becomes more difficult. We also do not advocate doing Horizontal launch here. If you release a fat RLV moving at mach 2 ≈700m/sec and demand lets say that it be moving near 60 deg pitch after 1000 meters, what centripetal acceleration is necessary? It is about 50 g s. The structural integrity is then gone. So how many kilometers radius of curvature is needed for about a 1g centripetal acceleration given this type of release? At least 50km. So for at least 15 miles the RLV is moving in the lower densest part of the atmosphere doing work against the air as it goes. Estimated work= $\frac{1}{2}CA\rho v^2 \bullet 20000 \approx 5X10^9$ joules, approximately the assisted launch energy itself. All the energy gained from the assisted launch is lost in pushing sea level density air for a long distance. What is customarily ignored by advocates of horizontal track is that the RLV must be fat (have larger 'A' in the air resistance equation) to have enough mass ratio, thus the work done against pushing air is greater than they calculate.

Maintenance and Support Choice – a system may use a dead start in which the object to be launched is mounted on the inclined rail in front of the thrust-powered sled and launched directly with a large "blast off". A second option is for a horizontal support area in which the launch begins on a horizontal rail and ramps up to the desired angle on the track as soon as possible to avoid inducing G-Forces on the Launch Sled and Vehicle. At some locations, it is impractical to locate the support areas near the mountain base, so the track may begin with several miles of horizontal rails where a specially designed rail tug pushes the sled up to the inclined area before the thrust engines ignite. Ideally, a large airfield will exist nearby to allow spacecraft to land for easy reuse.

Braking System – Unless the sled is designed to go airborne and fly to an airbase for reuse after launching the RLV or be recovered by a parachute and retro rocket deceleration to a soft ground landing, some induction braking mechanism is needed on the rail. There are a dozen possible methods using simple existing technology. Water release at the top of the track would provide the sled braking after RLV release; it would take about 8 seconds for the RLV to reach the top, enough time for the release of water from tanks along the track edge to get onto the track where at the top there wouldn't be any electrical connections, The water wall flowing down the track near the top would stop the sled in about a 100feet, which could then be slid back down the track to be reused. The 8 seconds of RLV travel on up the track is enough for substantial water coverage of the track with some upward thrust given the water for purposes of slowing its initial flow down the track. Water would be released from $40m^3$ volume tanks near the top of sled path slowing down the sled in that way just as at China Hat rocket sled facility where there is also water braking. This only requires about 40 cubic meters of water which can be calculated by using F=ma and the kinematical equations. The water section of the track could easily be isolated from the electrical section by a 100foot monorail section allowing the water to rapidly drain off before it reached the electrical section of the track.

Scientific & Mathematical Model Abstract

Magnetic Thruster Assisted Launch For Reusable Launch Vehicle To Orbit

This method will allow a reusable rail-mounted Electromagnetic Repulsor sled to launch spacecraft or airborne vehicles from earth at supersonic speeds using existing technology properly integrated into an inclined ramp & rail system. This system is much safer than the traditional method of launching rockets vertically since the launch can be aborted if problems develop. Moreover, it is far less costly since the launch ramp and sleds can be reused many times after a launch, and the rail system can accommodate a wide variety of sleds to launch various space vehicles, aerodynamic vehicles, and objects of many different sizes and speeds. This in general can be directly compared to the small scale version of this concept, which is the present day Aircraft Carrier Catapult Launch Systems, which are very effective and can launch many types, sizes, and weights of aircraft at may different G-Forces and Release Speeds.

Summary of Arguments For Magnetic Thruster Assisted Launch

Required Thrust - The first thing to understand is what are the largest thrusts required. 2.5 million pounds thrust is required at the top of the track for this magnetic thruster because of the v^2 dependence on air resistance, the 2 mile length of the track, the large mass of the RLV and the 6g acceleration. This would require 3 700kpd repulsor thrusters at top, only one near the bottom. **Magnetic vendors claim they can provide 700kpd repulsor thrusters. "But Kenneth House says that"** The EM technology exists for subsonic transport of massive objects, but I am unaware of any research that indicates it would work for MACH 1 or 2, or higher". So the research on high velocity magnetic thrusters for RLV mass objects needs to be done. Putting these thrusters in parallel for example is one such option for increasing the thrust.

Type of Track - Answers the question of whether such a track is too long for continental US construction. This track configuration would only require a vertical displacement of ¾ mile. This is doable within the US south of 25N latitude, at many mountain locations.

Sled Brake - Can show the sled brake at the top of the track need be only water for deceleration over 100feet. Also need 100 feet of narrow track for water to drain away before it can reach the electrical section.

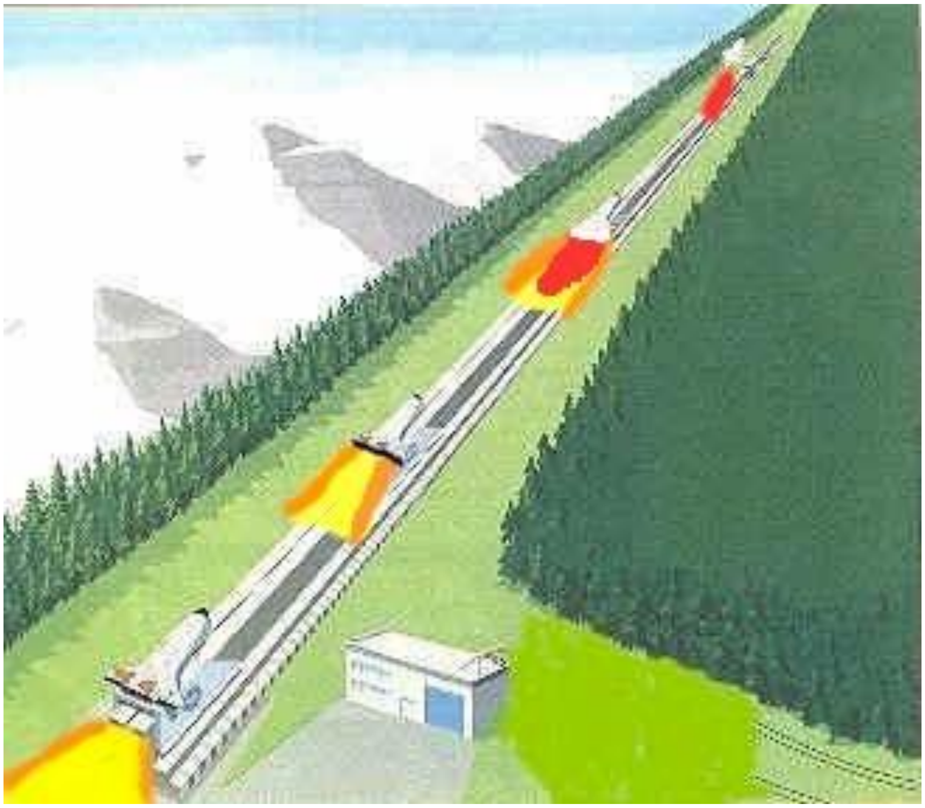
Power Supply - 10 meter radius, thousands of windings, ferrous core coil discharge. Again practical. 10 megawatts continuous power is all that is required with 1gigawatt for 8 second for track operation given a one hour cycle of launches.
RLV Fuel – Excess power is applied to do electrolysis of locally available water supplies so O2, H2 fuel need not be trucked in.

There Is Some Yaw Capability For the RLV after Sled Launch - Because of the cosine velocity component dependence there can be some yaw change given little velocity change.

Number of Magnetic Repulsor Thrusters Varies with Distance Up the Track - There has to be more and/or bigger thrusters for the upper section of the track to keep the same acceleration given the higher air resistance at the higher speed ($\sim v^2$).

Horizontal Load Bending Moments of The Fragile RLV - These can be minimized by more than just 3 point support for the fully fueled RLV on its side when on the sled.

ISP and Space Data Table ISP and Mass Ratio Considerations **- For a RLV for the mach 22 to orbit given the track mach 2 release there must be a favorable mass ratio which there apparently was for the X-33, at least if it used assisted launch. The heavy aerospike engines must be replaced with two standard rocket engines and then perhaps methane slush could be introduced as well in with the liquid hydrogen and also the new carbon fiber fuel tanks. The horizontal bending moments must be minimized by many roller supports so that there is no new structural reinforcement required that would otherwise nullify the gains from the assisted launch.**



Note: See Below: Independent Program Cost Estimates, NASA & Skyramp Organization

I.S.A. – I.S.P. / I.A.S.L. Program Phase	Program Cost Est.	Program Time Est.
Mountain Site Surveys	$ 1 Million ~?	12+ Months
Mountain Site Selection	$ None ~?	None
Ramp Design & Cost Estimate	$ 2 Million ~?	12+ Months
Ramp Facility Construction	$ 100 Million ~?	36+ Months
TOTAL - RLV / SSTO Vehicle R&D!? This Based On From Scratch! *Using Existing Program Will Cut This Cost by 50% or More!	$ 11,014 Million ~? Above Is From Scratch *$ 5,007 Million ~?	36 to 60+ Months *Using Existing Program *24 to 36+ Months
TOTAL ($ 5 Billion to $ 11 Billion)	$ 11,117 Million ~?	60 to 84 Months

INTERNATIONAL SPACE AGENCY

ISA ISA

INTERNATIONAL SPACE PLANE (I. S. P.) PROGRAM

Space Plane Mounted On Top Electromagnetic Launch Sled

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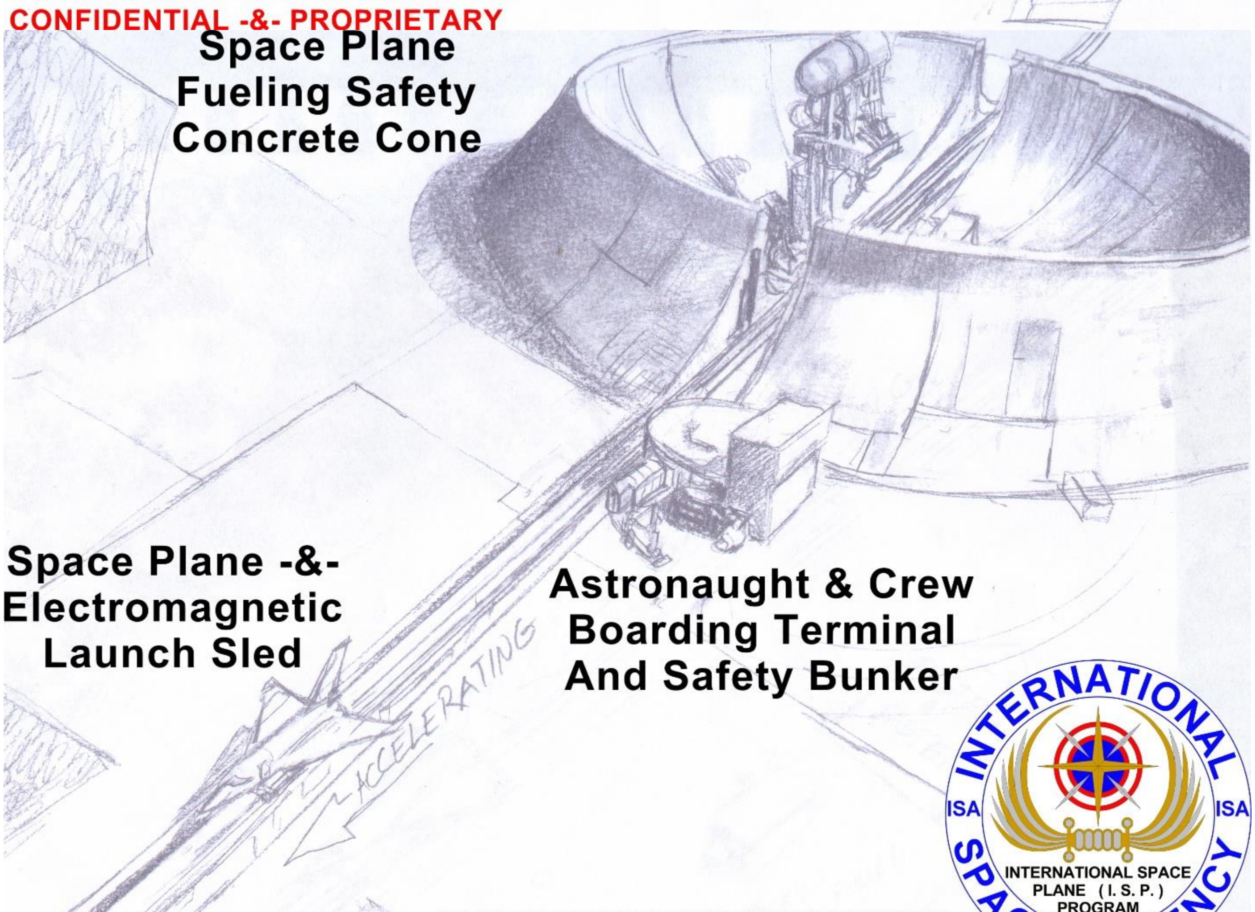

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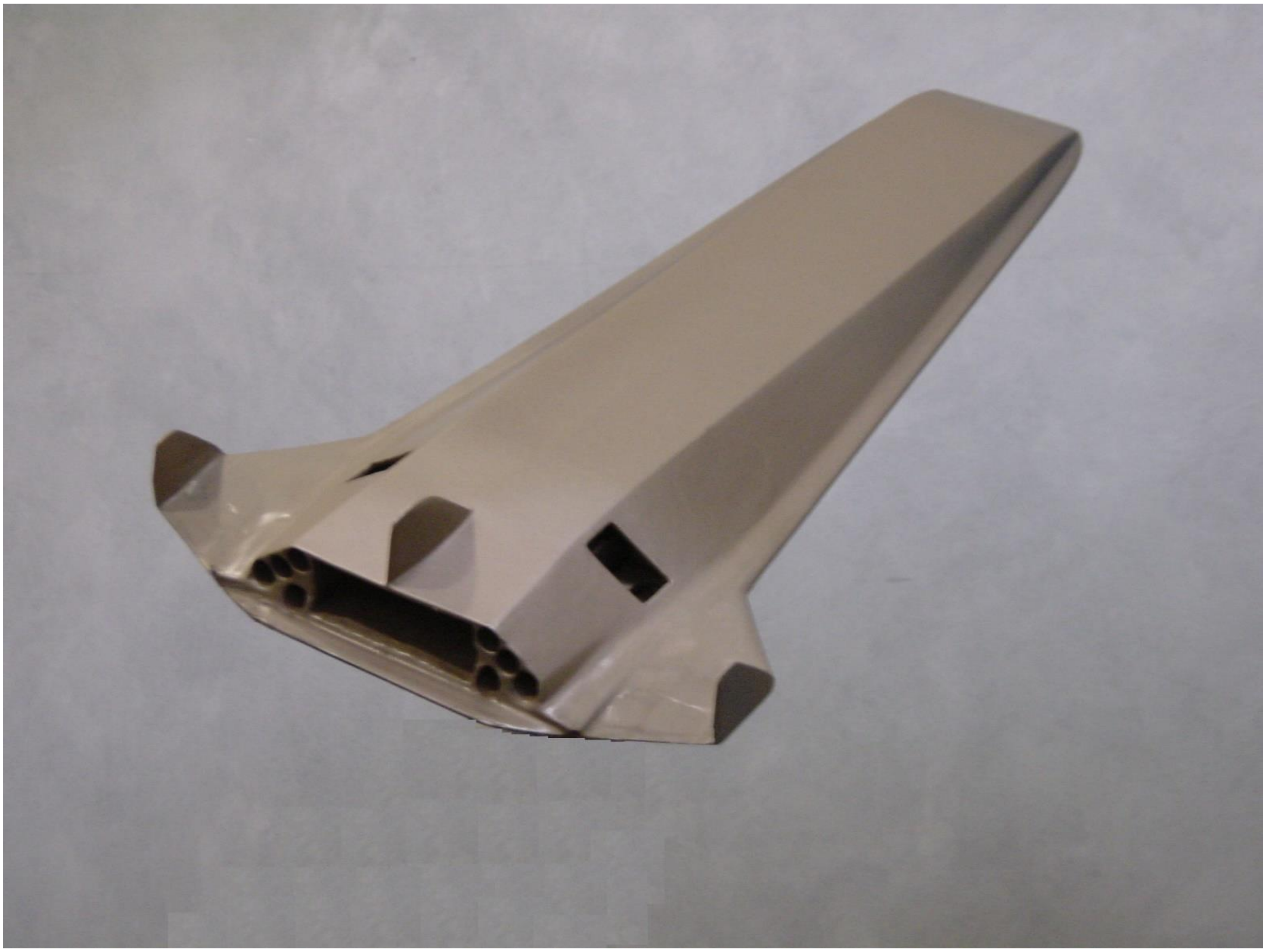
SPACE AGENCY
I.S.P.
Assisted Launch (A.L.)
Single Stage To Orbit (S.S.T.O.)
Reusable Launch Vehicle (R.L.V.)



Rick R. Dobson, Jr. - Designer
Aerodynamic Prototype Model
October 1988 at Cornell University
Ithaca, New York State, U.S.A.


International Space Plane (I.S.P.) Program
Launch / Flight / Return Operations Center
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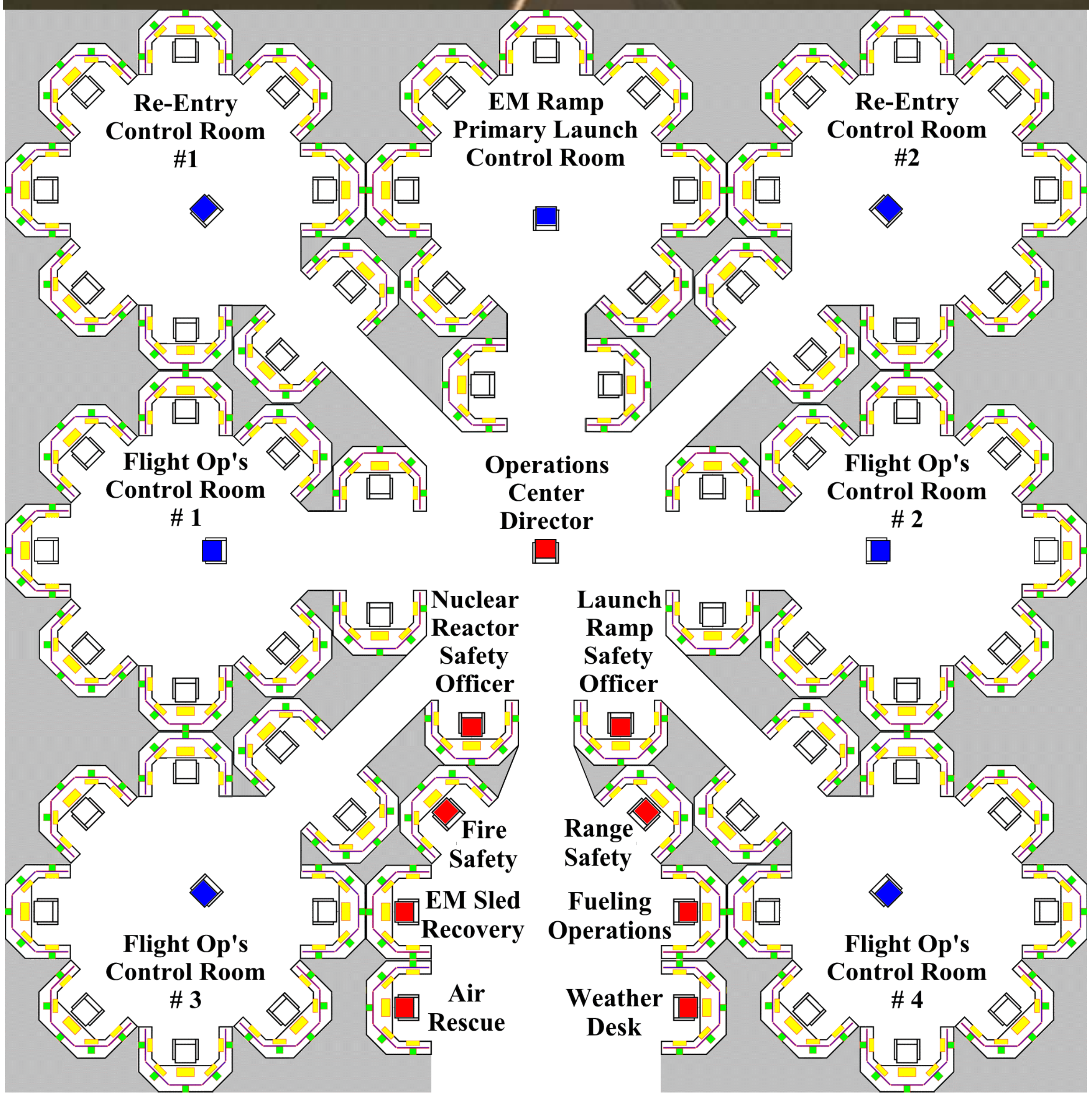
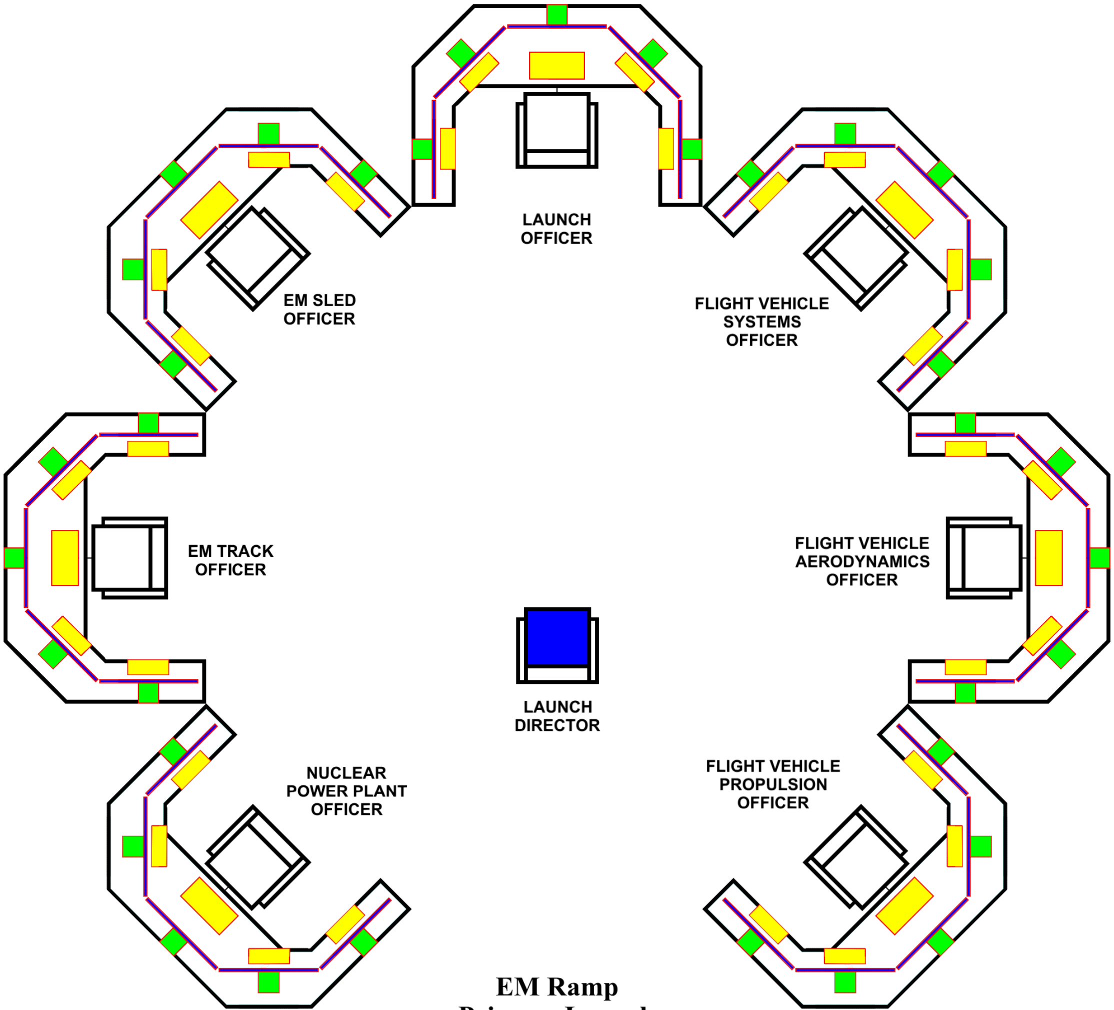
INTERNATIONAL SPACE PLANE (I. S. P.) PROGRAM
International Space Operations Center
(I.S.O.C.)
INTERNATIONAL SPACE AGENCY
ISA
INTERNATIONAL SPACE OPERATIONS CENTER (I.S.O.C.)

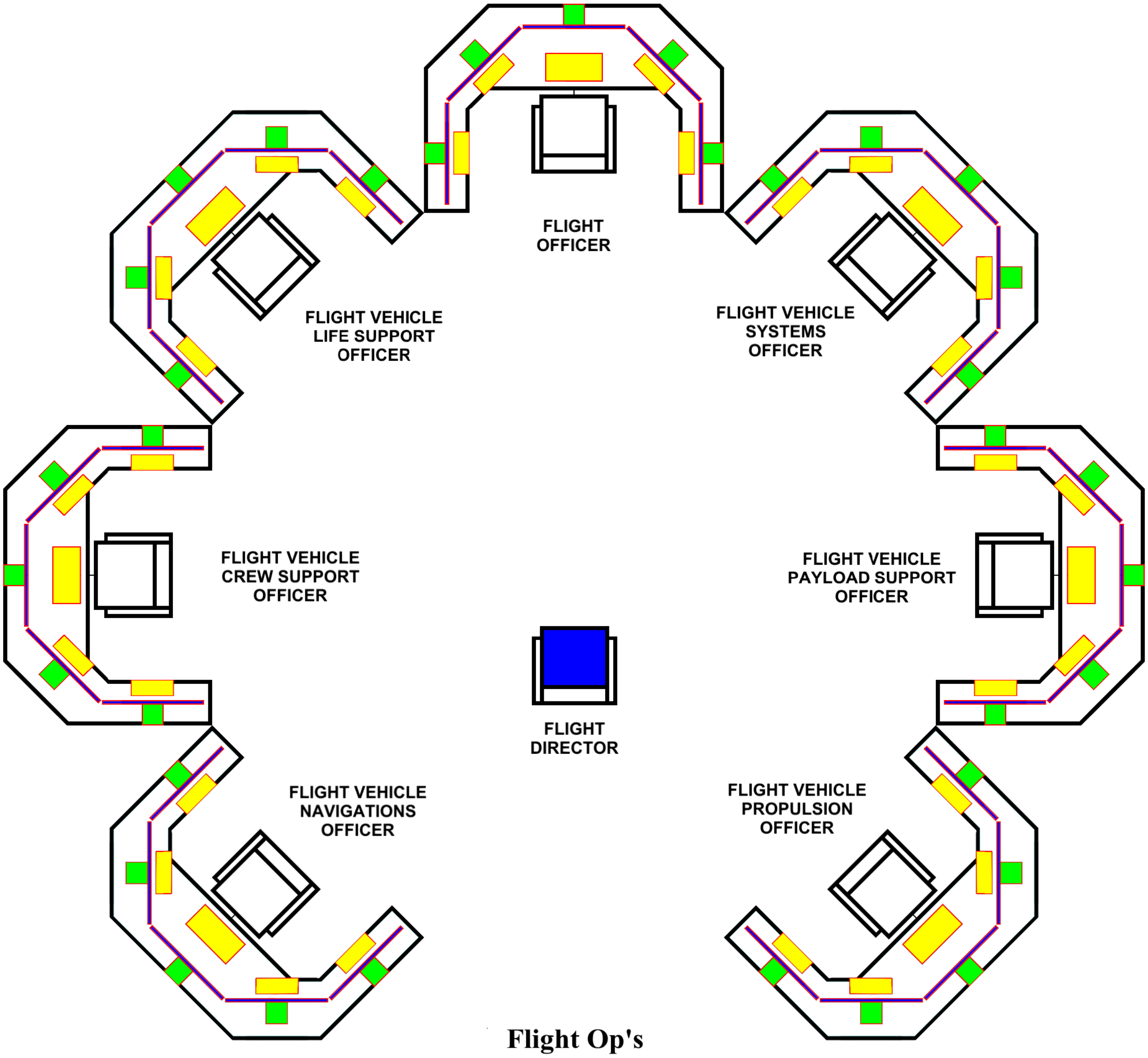

Re-Entry Control Room #1
EM Ramp Primary Launch Control Room
Re-Entry Control Room #2
Flight Op's Control Room # 1
Operations Center Director
Flight Op's Control Room # 2
Nuclear Reactor Safety Officer
Launch Ramp Safety Officer
Fire Safety
Range Safety
EM Sled Recovery
Fueling Operations
Air Rescue
Weather Desk
Flight Op's Control Room # 3
Flight Op's Control Room # 4

Primary EM Assisted Launch Control Room



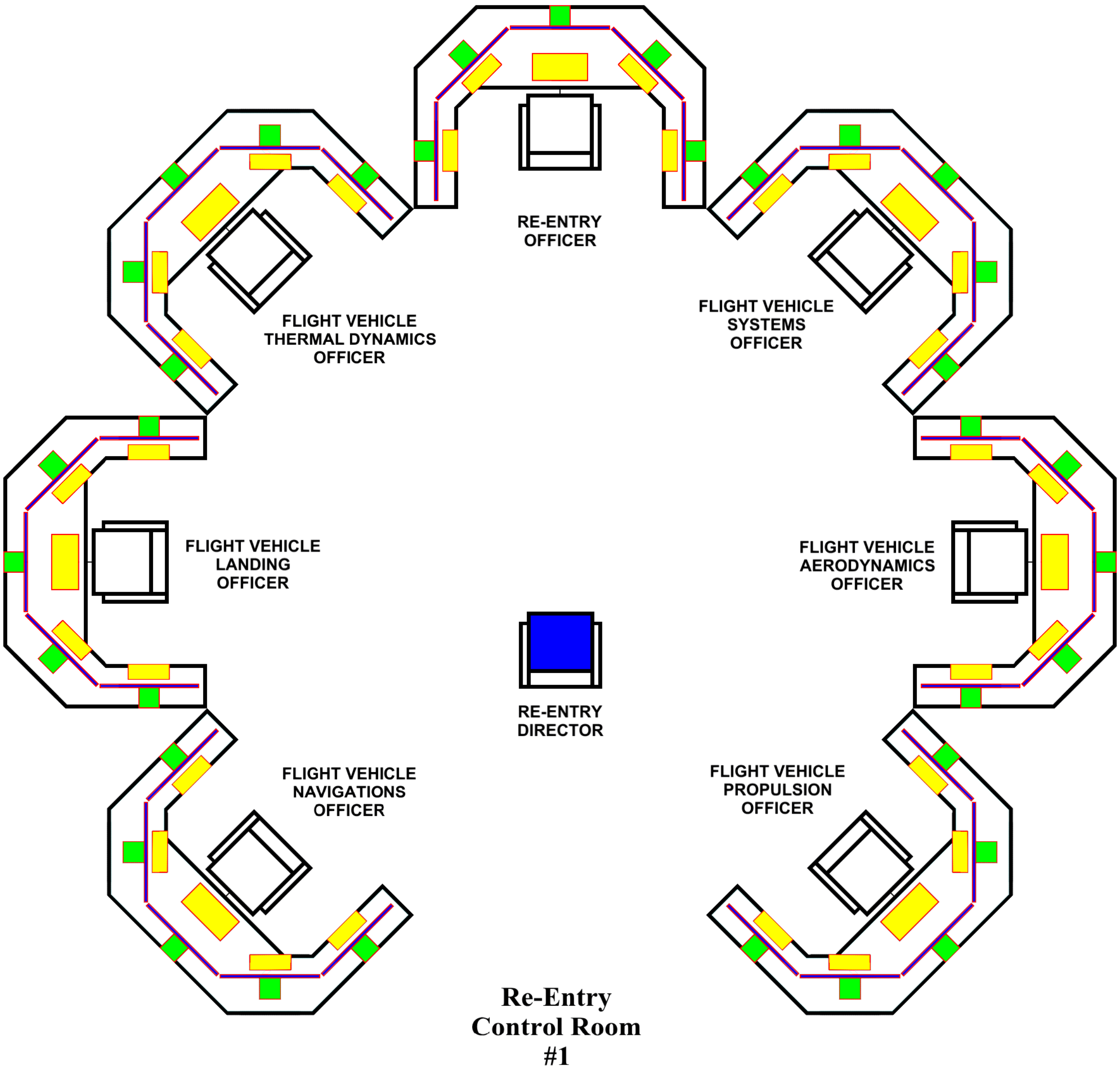
EM Ramp
Primary Launch
Control Room

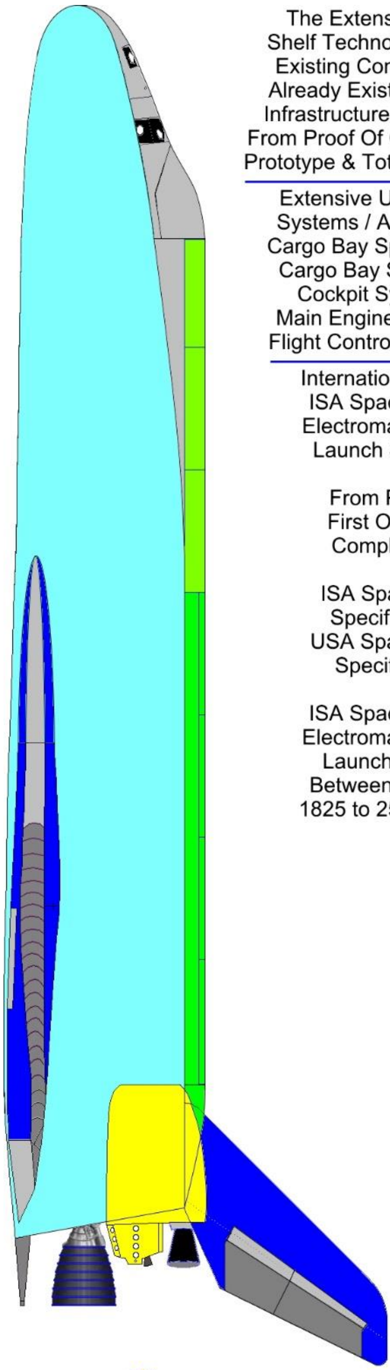
Orbital Flight Operations Control Room #1



Flight Op's
Control Room
1

Space Plane Re-Entry Operations Control Room #1





The Extensive Utilization Of Off The Shelf Technologies And Use Of Already Existing Contractors And Suppliers Of Already Existing Machining And Tooling Infrastructure Will Dramatically Cut Time From Proof Of Concept To First Operational Prototype & Total Cost Of R&D & Production

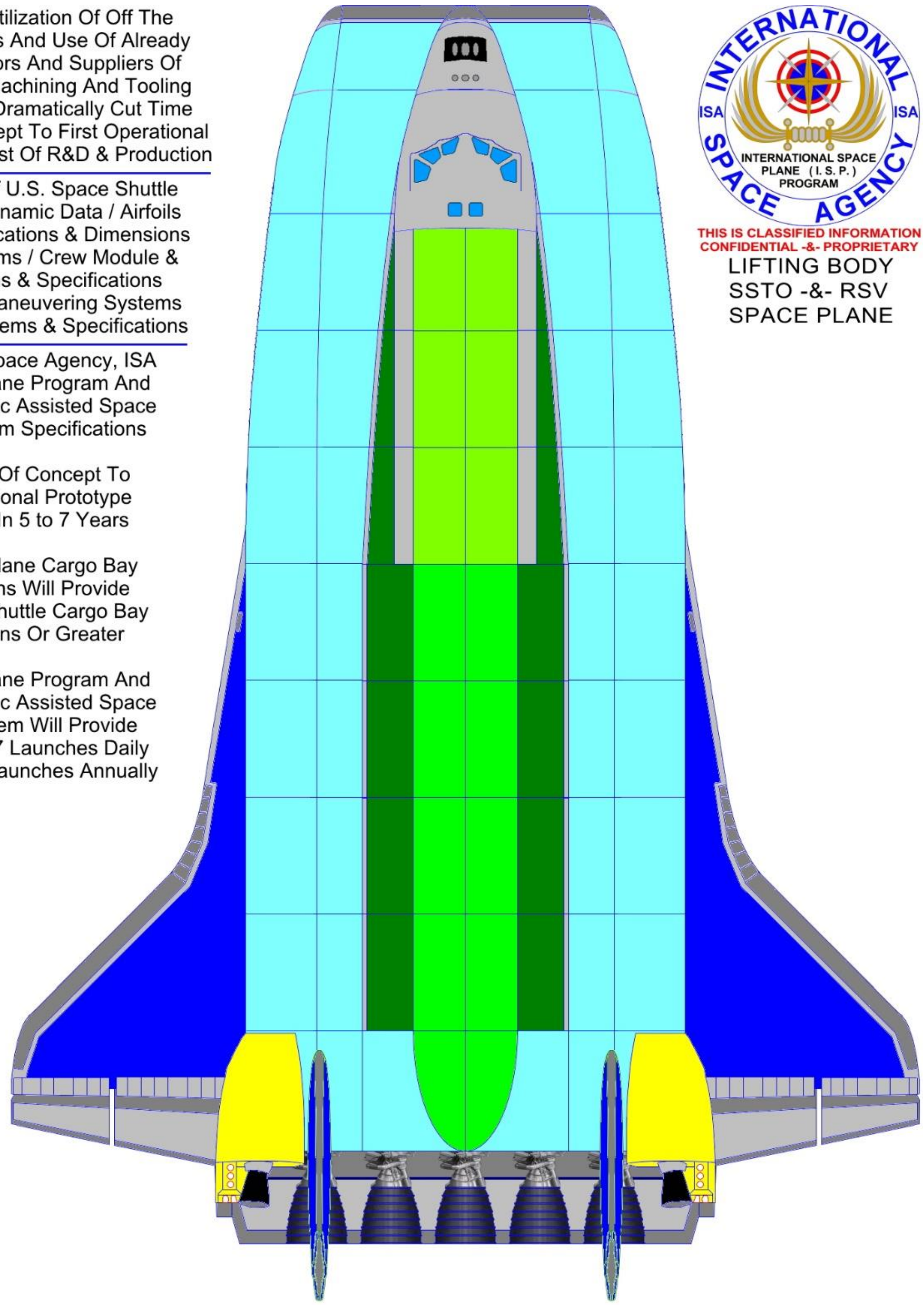
Extensive Use Of U.S. Space Shuttle Systems / Aerodynamic Data / Airfoils Cargo Bay Specifications & Dimensions Cargo Bay Systems / Crew Module & Cockpit Systems & Specifications Main Engines / Maneuvering Systems Flight Control Systems & Specifications

International Space Agency, ISA ISA Space Plane Program And Electromagnetic Assisted Space Launch System Specifications

From Proof Of Concept To First Operational Prototype Completed In 5 to 7 Years

ISA Space Plane Cargo Bay Specifications Will Provide USA Space Shuttle Cargo Bay Specifications Or Greater

ISA Space Plane Program And Electromagnetic Assisted Space Launch System Will Provide Between 3 & 7 Launches Daily 1825 to 2555 Launches Annually



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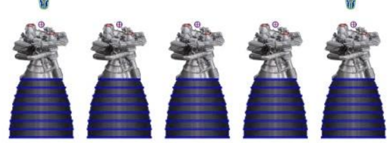
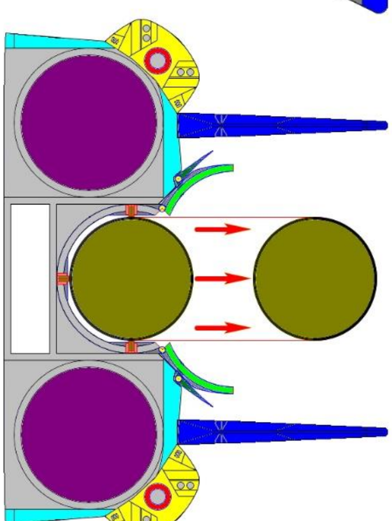
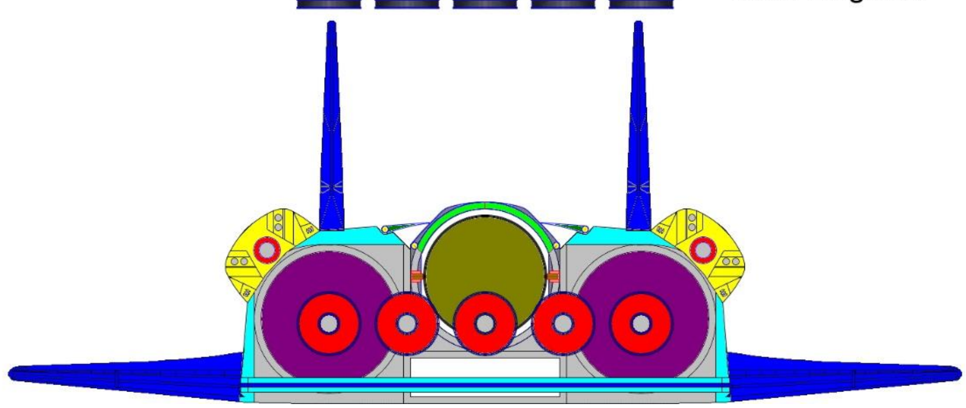
LIFTING BODY
SSTO -&- RSV
SPACE PLANE

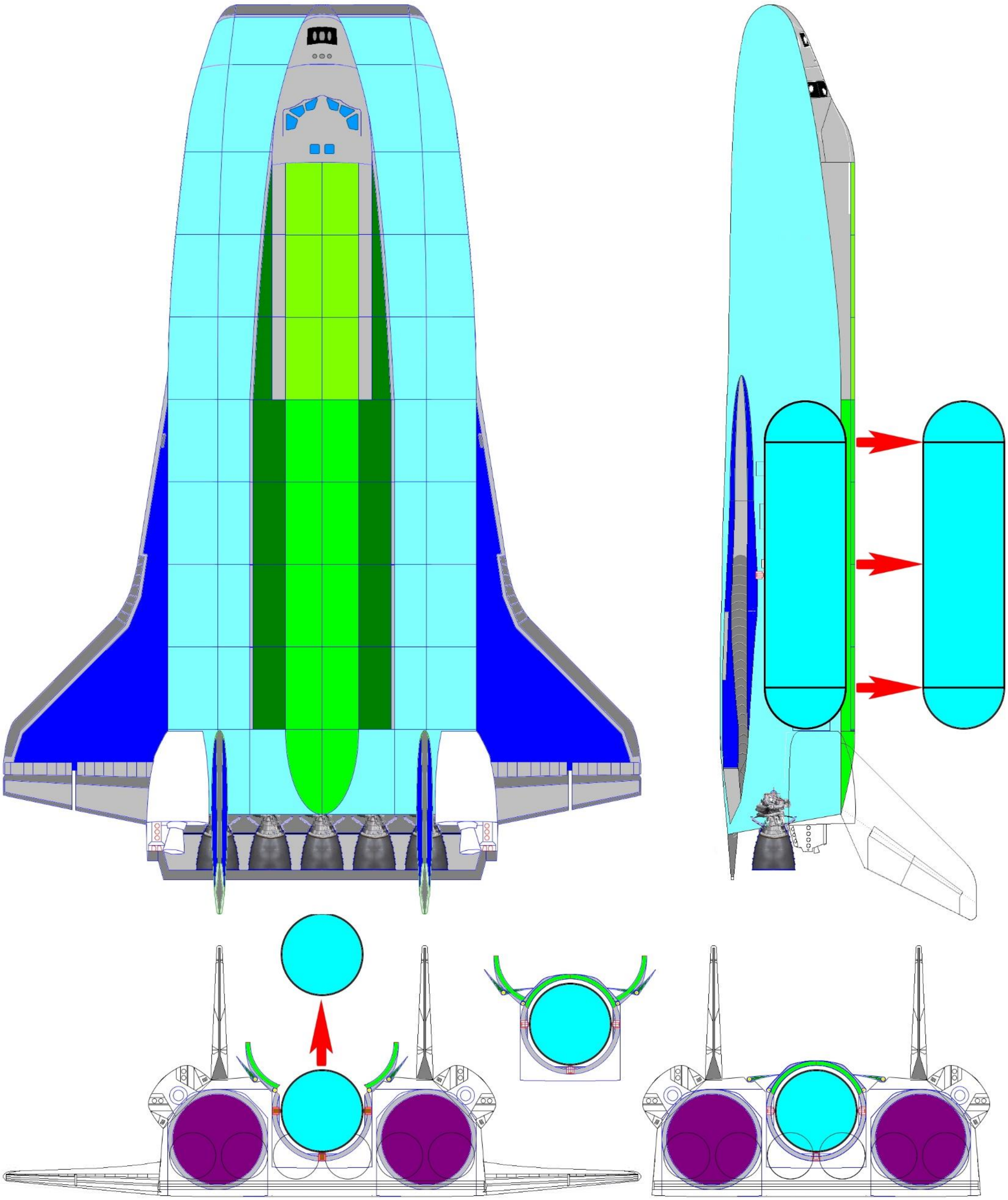


(5) Five
U.S. Space Shuttle
Main Engines

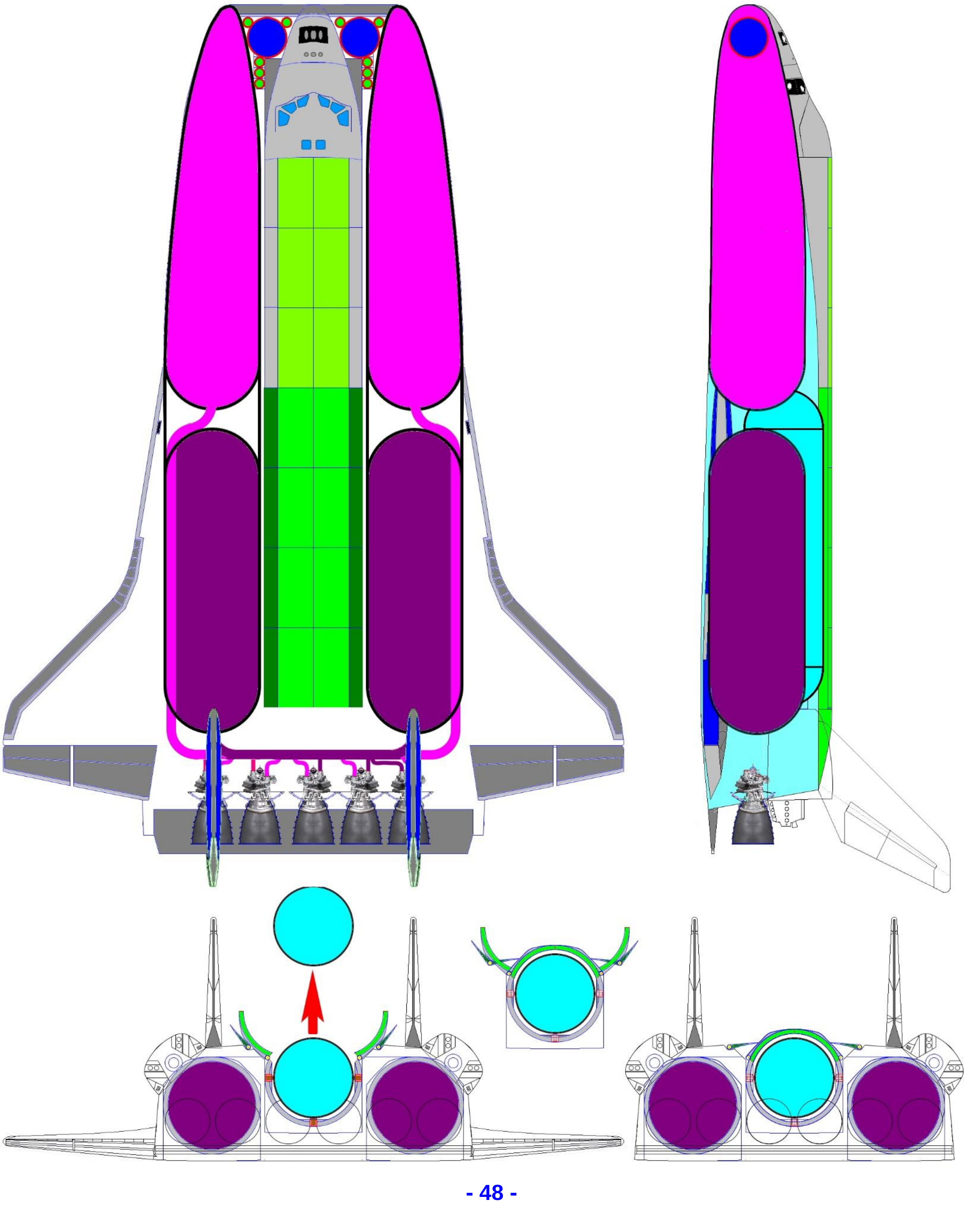




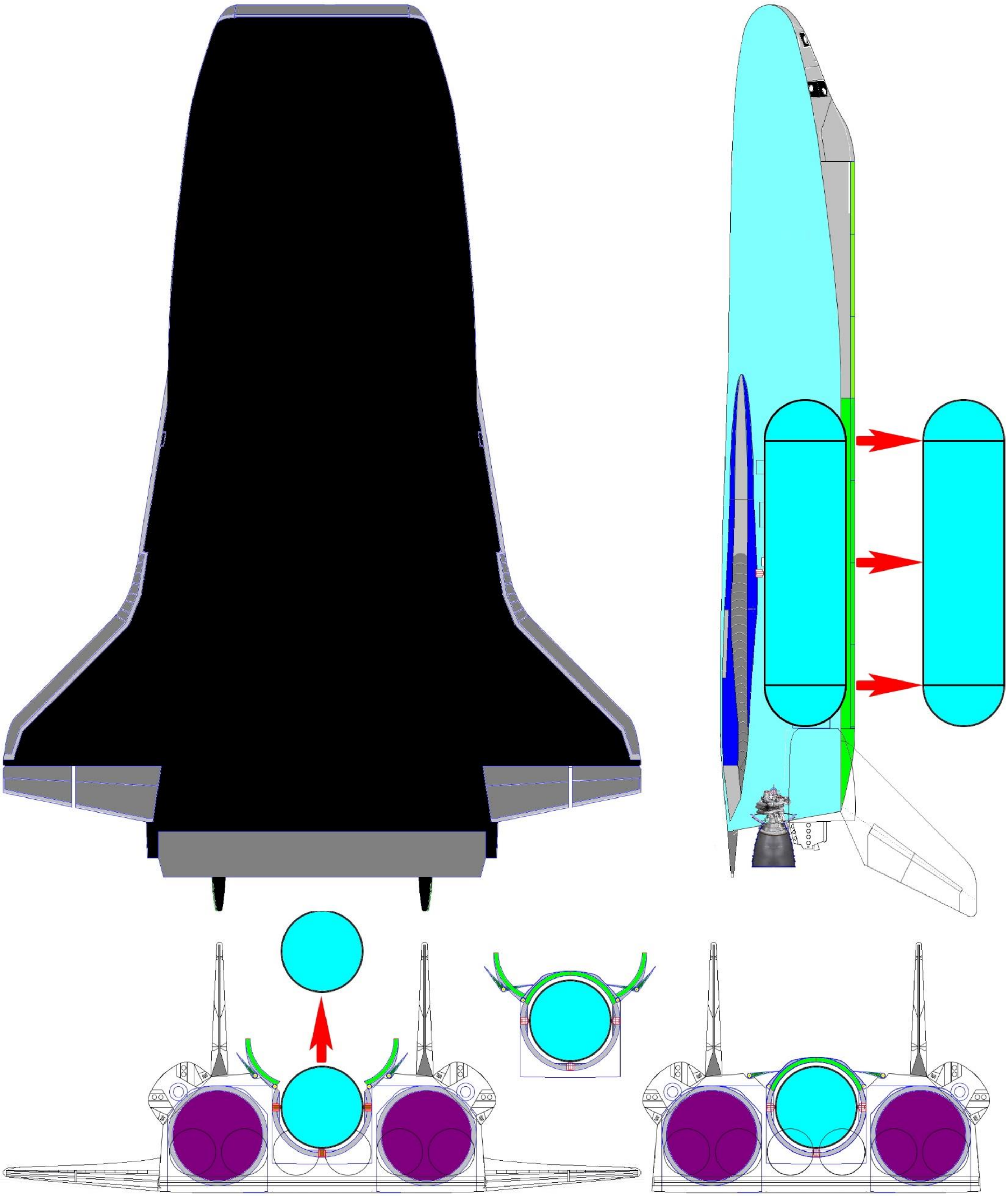
Proposed Airframe Configuration



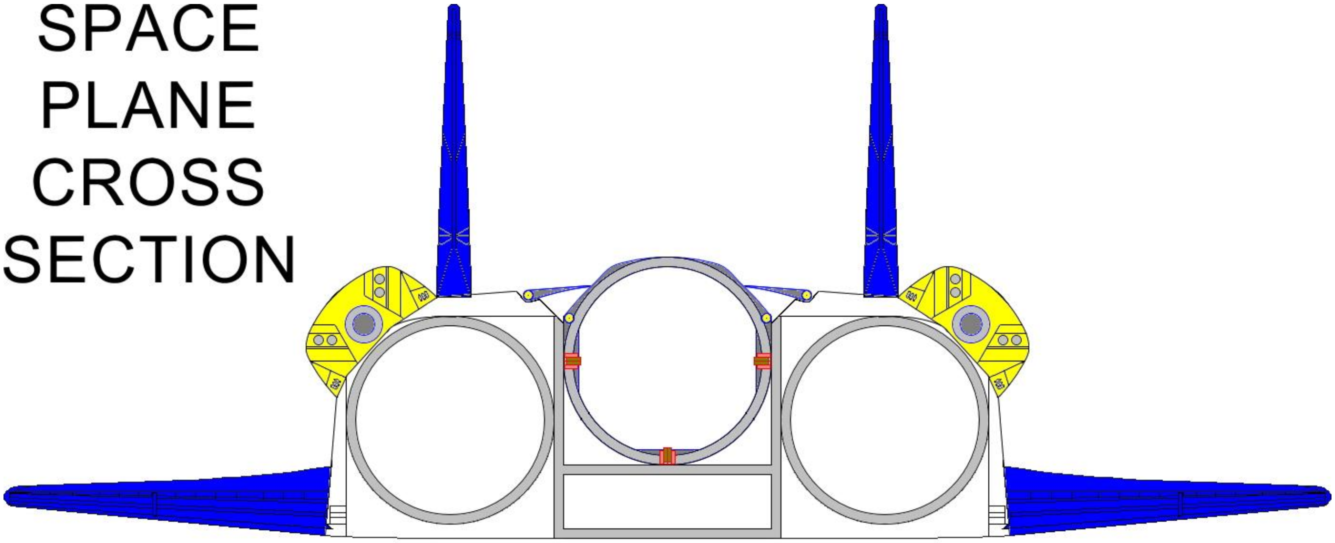
Proposed Fuel Tank Configuration



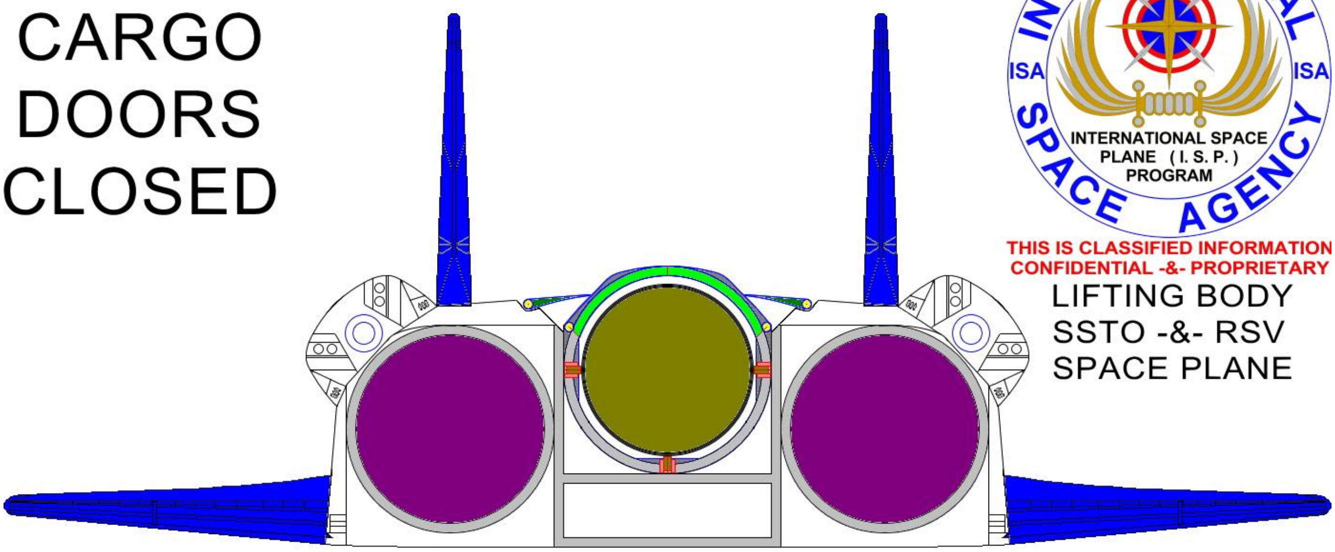
Proposed Sprayed On Heat Shield



SPACE PLANE CROSS SECTION



CARGO DOORS CLOSED



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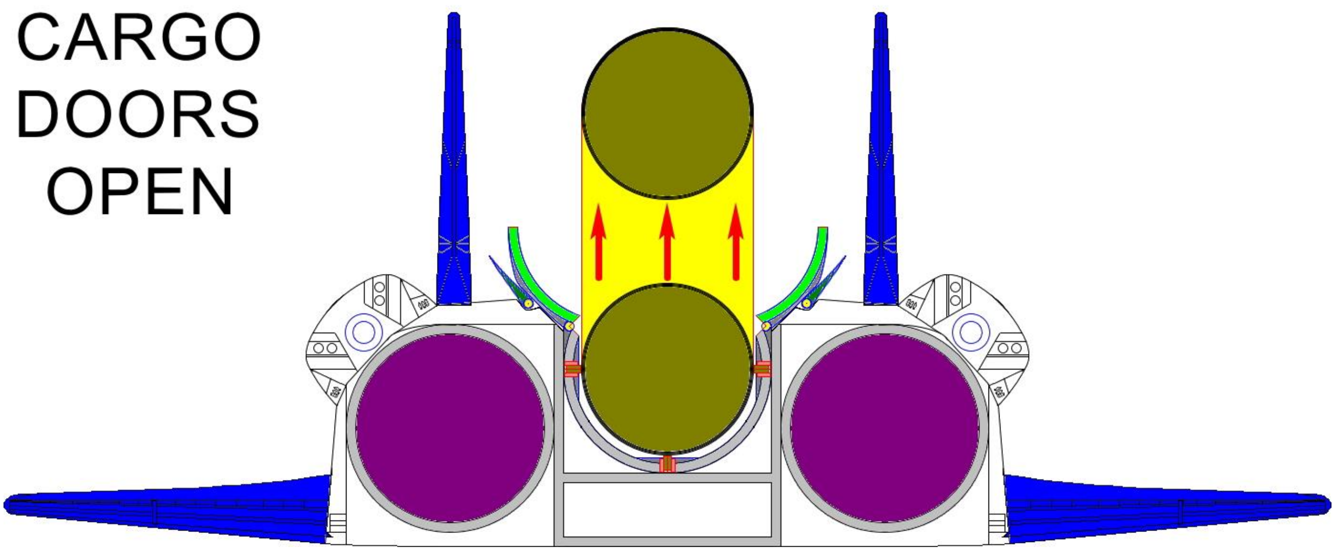
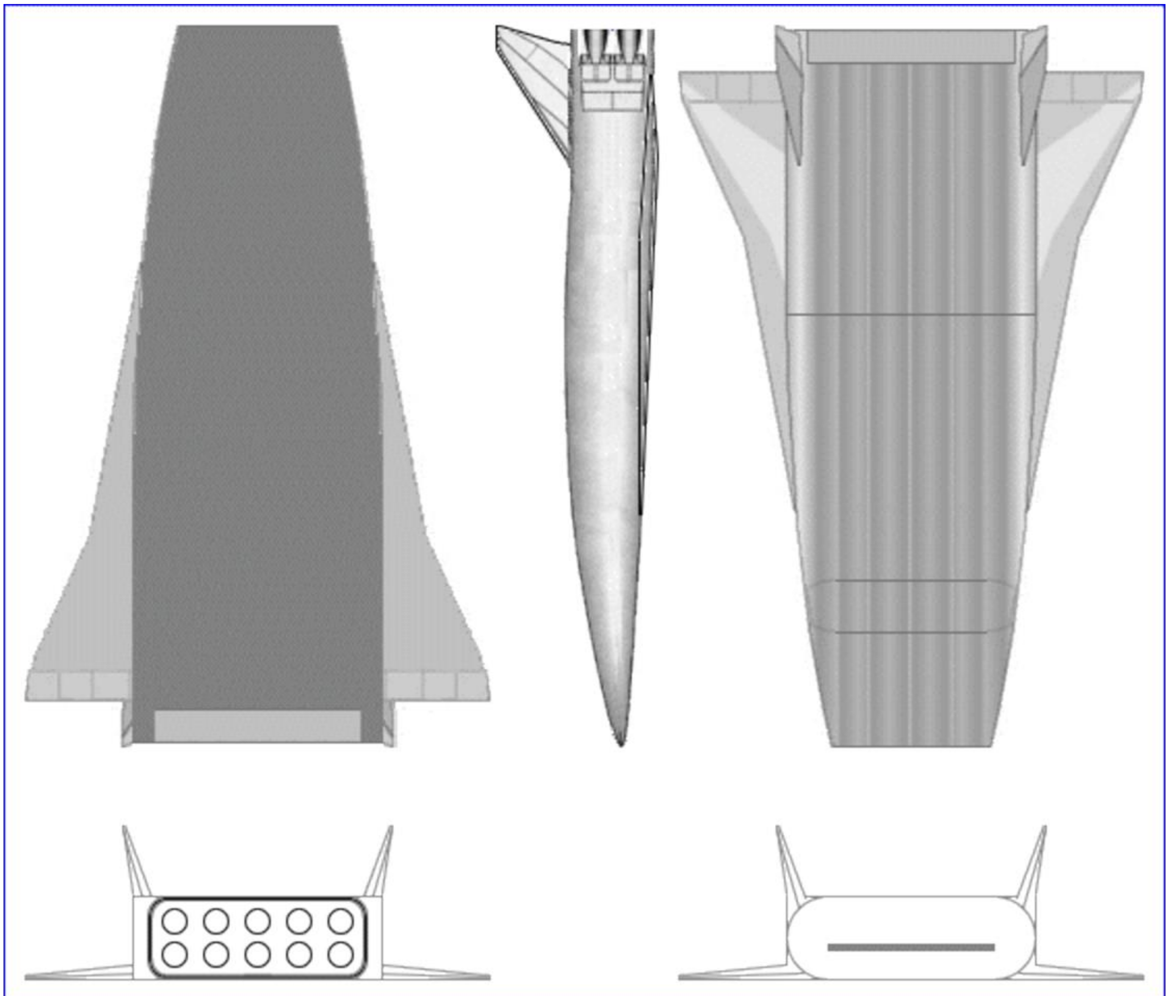
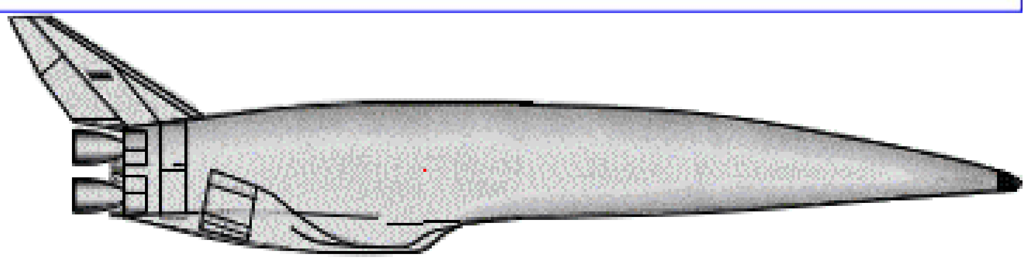
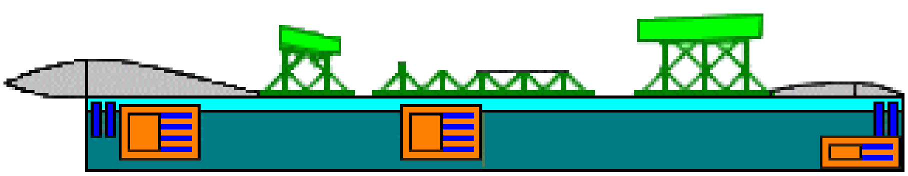
LIFTING BODY
SSTO -&- RSV
SPACE PLANE

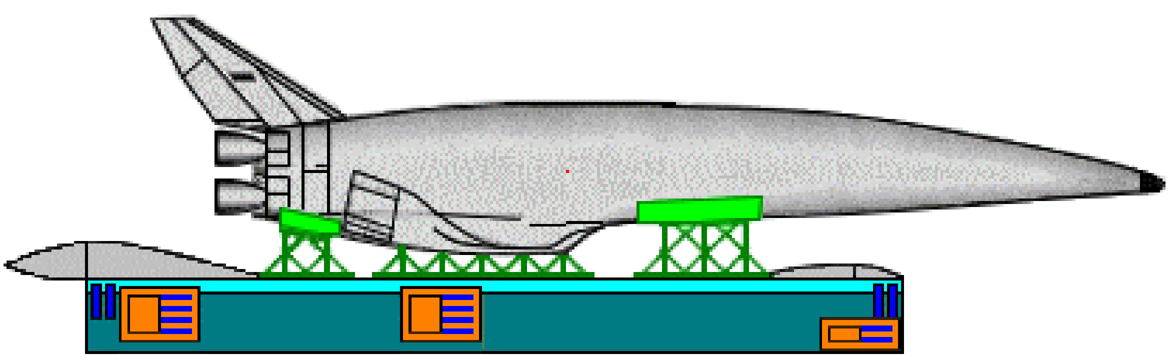
CARGO DOORS OPEN

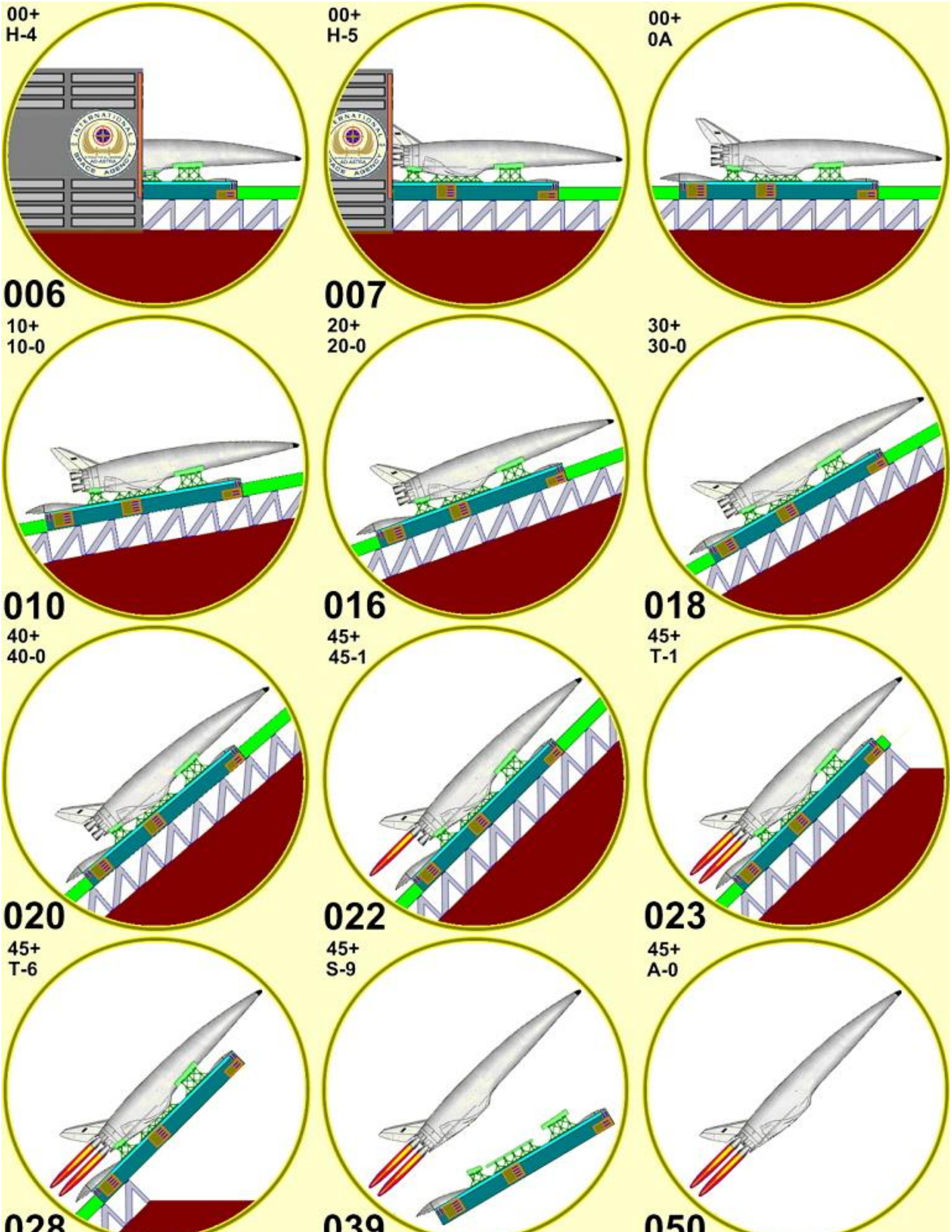











00+
H-4
006
00+
H-5
007
00+
0A
10+
10-0
010
20+
20-0
016
30+
30-0
018
40+
40-0
020
45+
45-1
022
45+
T-1
023
45+
T-6
028
45+
S-9
039
45+
A-0
050


International Space Agency, I. S. A.
International Space Plane (ISP) Program
Electromagnetic Rail Assisted Space Launch System (ERASLS)
Single Stage To Orbit Aerodynamic Re-Entry Capable (SSOARC)
Aerodynamic Lifting Body Multi Purpose Spacecraft (ALBMPS)
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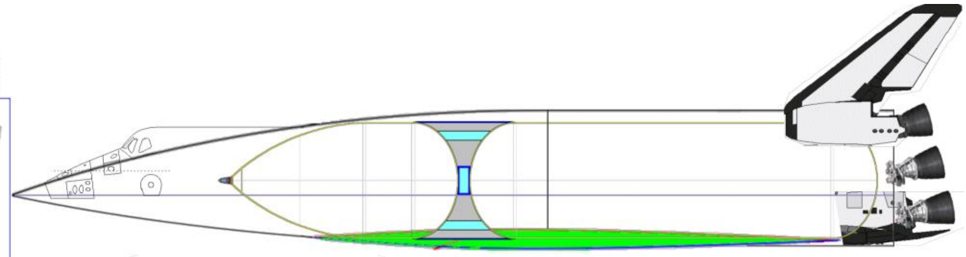
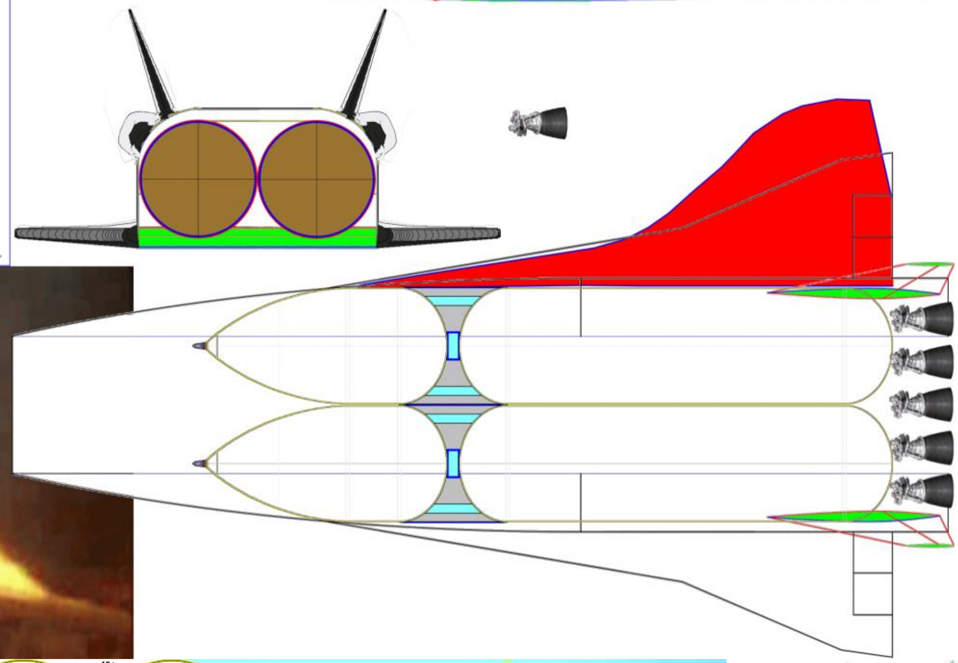
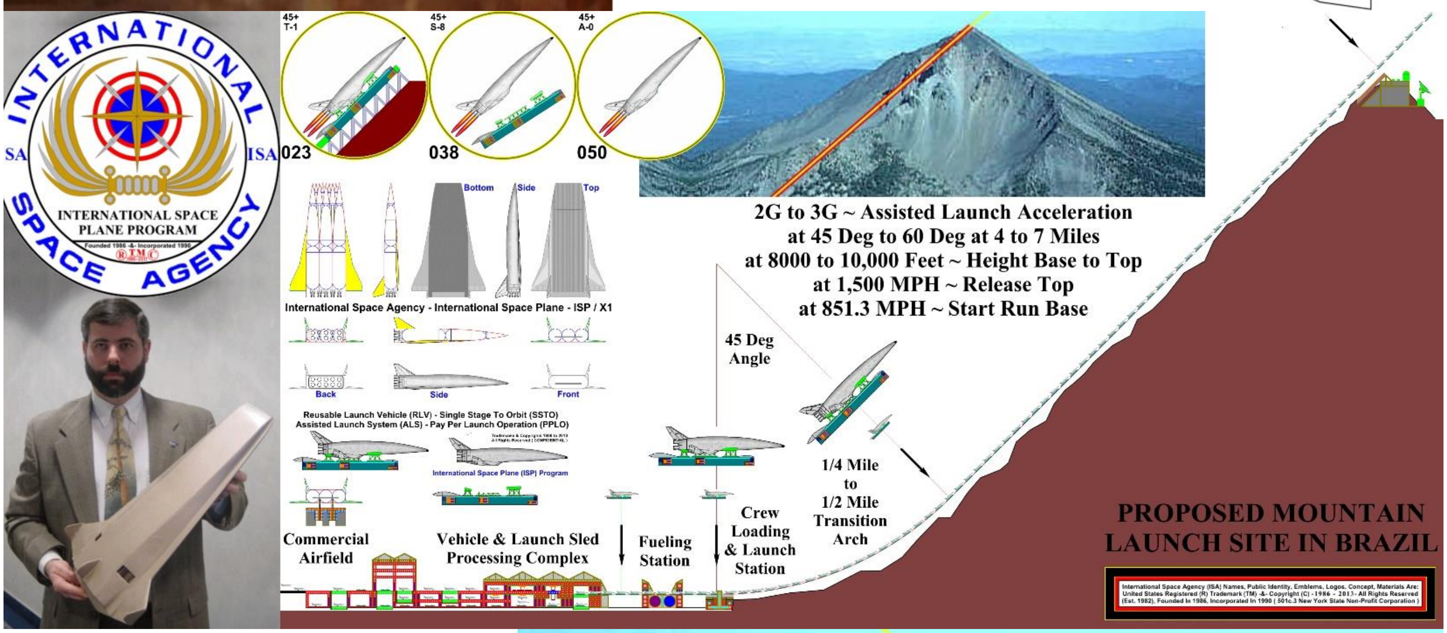
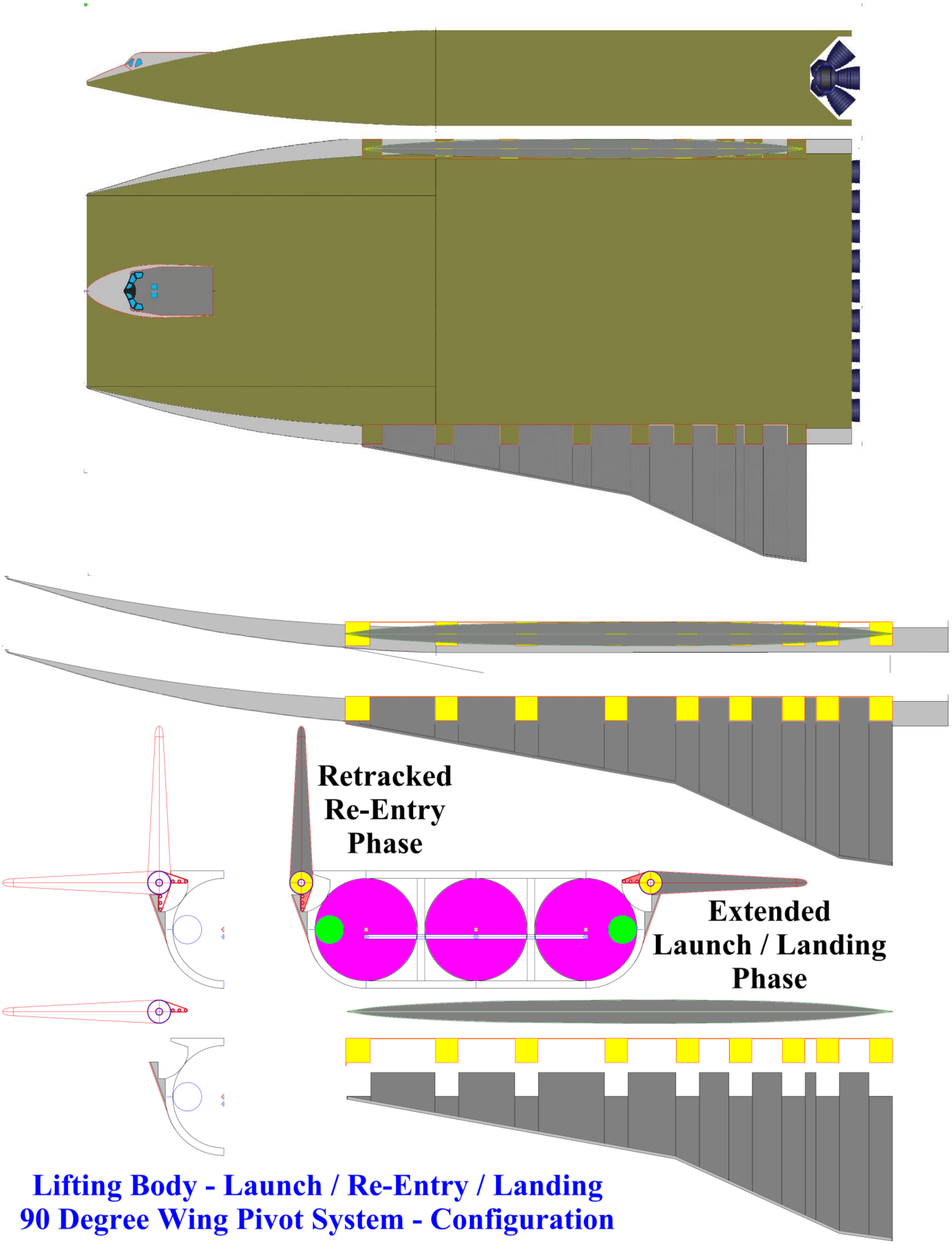
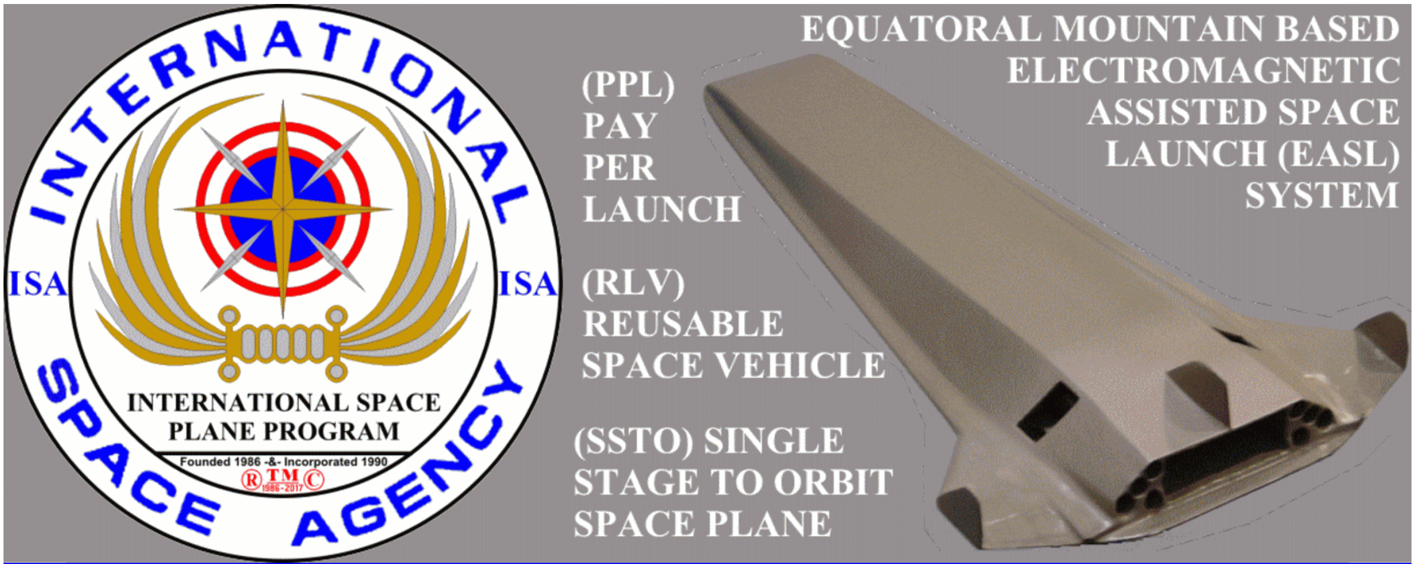





INTERNATIONAL SPACE AGENCY
ISA
INTERNATIONAL SPACE PLANE PROGRAM
45+ T-1
45+ S-8
45+ A-0
023
038
050
Bottom
Side
Top
International Space Agency - International Space Plane - ISP / X1
Back
Side
Front
Reusable Launch Vehicle (RLV) - Single Stage To Orbit (SSTO)
Assisted Launch System (ALS) - Pay Per Launch Operation (PPLO)
International Space Plane (ISP) Program
2G to 3G ~ Assisted Launch Acceleration
at 45 Deg to 60 Deg at 4 to 7 Miles
at 8000 to 10,000 Feet ~ Height Base to Top
at 1,500 MPH ~ Release Top
at 851.3 MPH ~ Start Run Base
45 Deg
Angle
1/4 Mile
to
1/2 Mile
Transition
Arch
Commercial
Airfield
Vehicle & Launch Sled
Processing Complex
Fueling
Station
Crew
Loading
& Launch
Station
PROPOSED MOUNTAIN
LAUNCH SITE IN BRAZIL



Lifting Body - Launch / Re-Entry / Landing
90 Degree Wing Pivot System - Configuration


INTERNATIONAL
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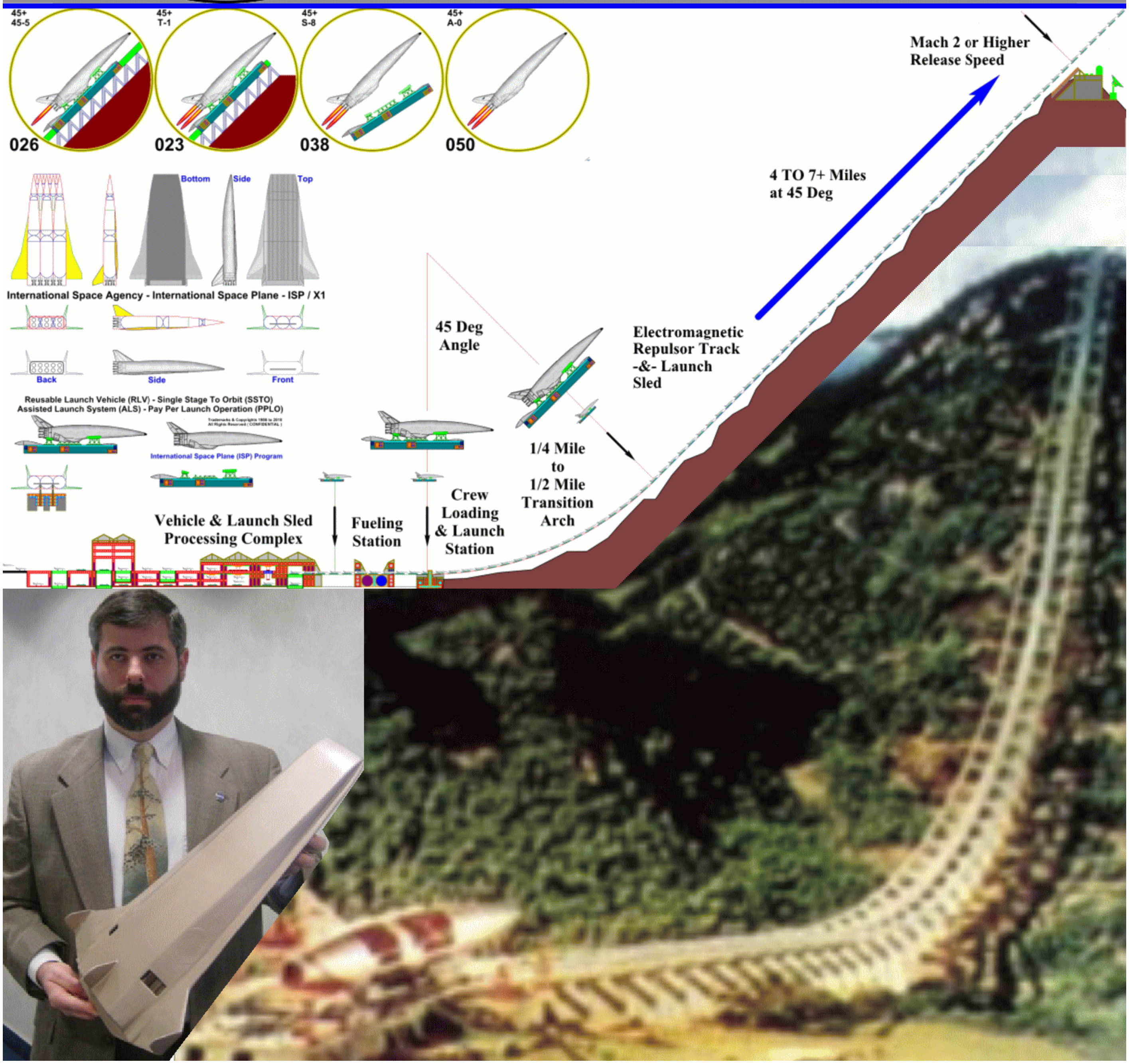
ISA
SPACE AGENCY
INTERNATIONAL SPACE
PLANE PROGRAM
Founded 1986 -&- Incorporated 1990
(PPL)
PAY
PER
LAUNCH
(RLV)
REUSABLE
SPACE VEHICLE
(SSTO) SINGLE
STAGE TO ORBIT
SPACE PLANE
EQUATORAL MOUNTAIN BASED
ELECTROMAGNETIC
ASSISTED SPACE
LAUNCH (EASL)
SYSTEM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023
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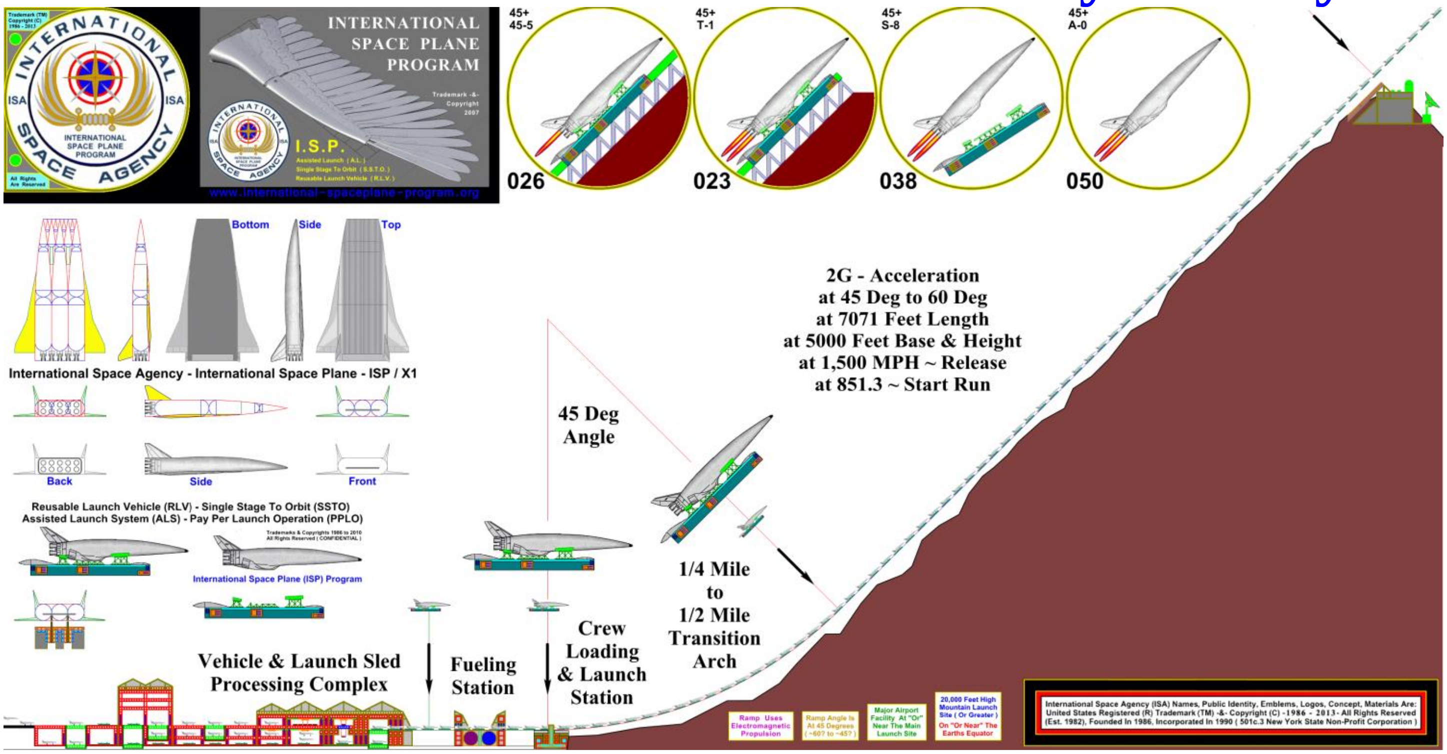
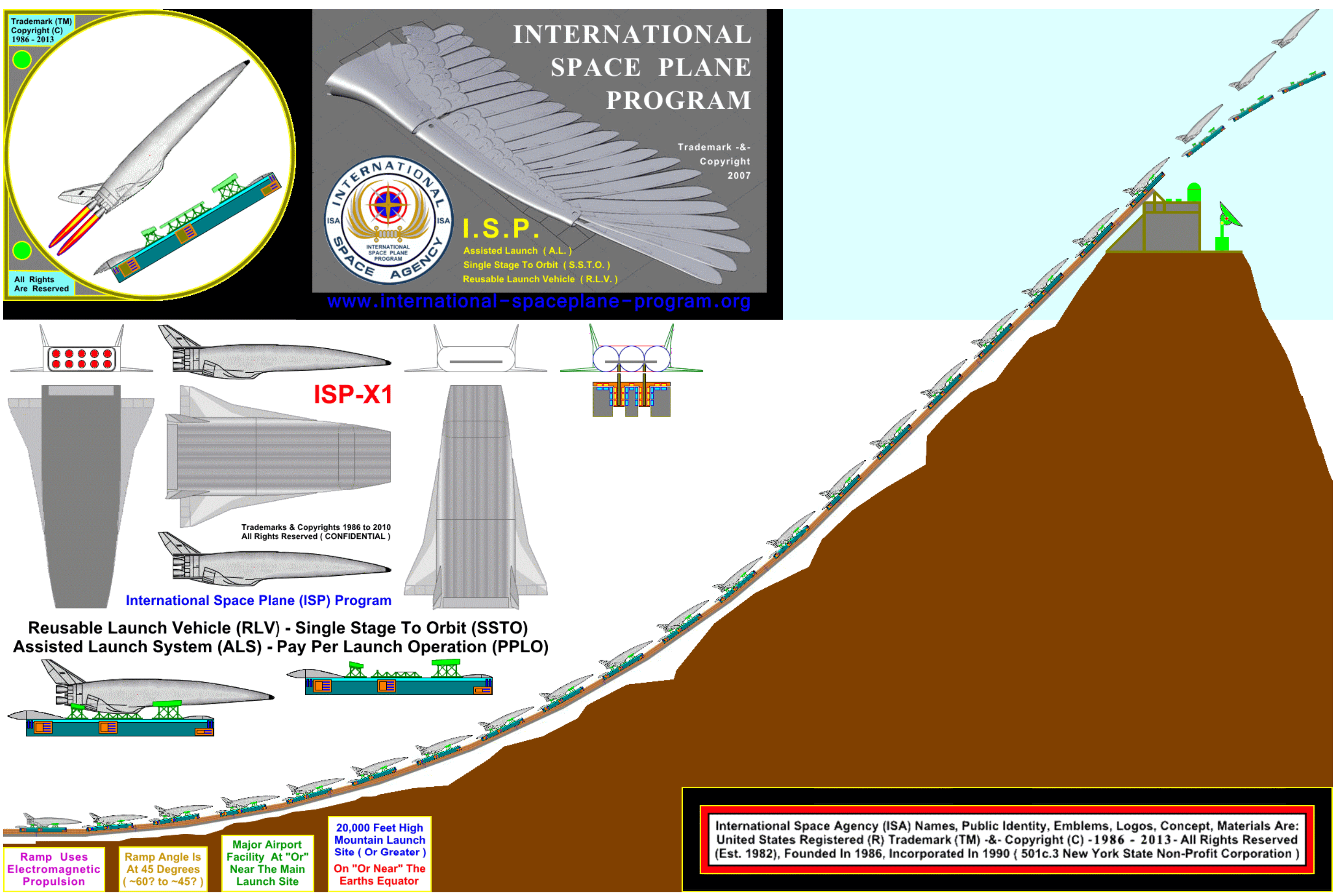
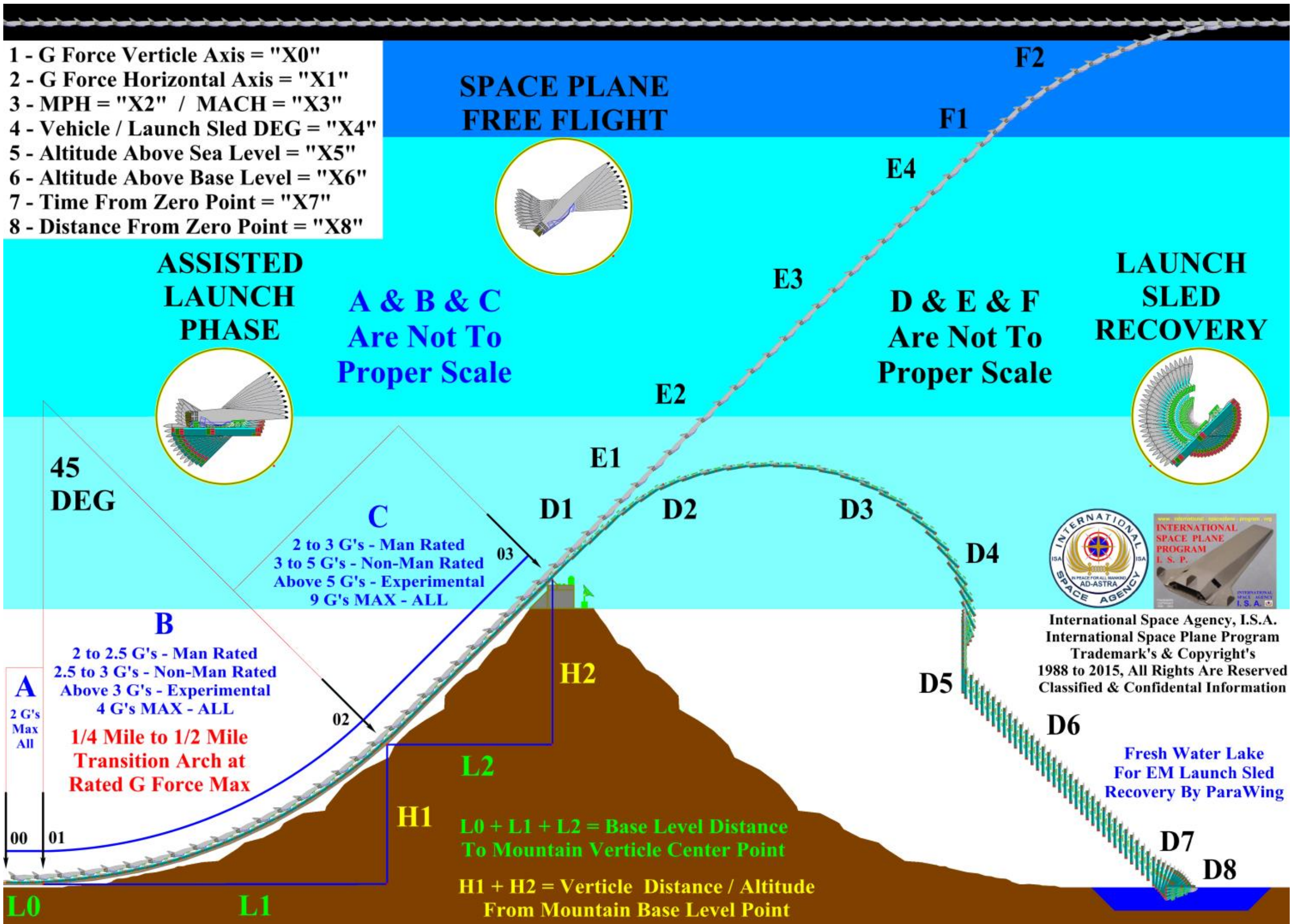
Bottom
Side
Top
International Space Agency - International Space Plane - ISP / X1
Back
Side
Front
Reusable Launch Vehicle (RLV) - Single Stage To Orbit (SSTO)
Assisted Launch System (ALS) - Pay Per Launch Operation (PPLO)
International Space Plane (ISP) Program
Mach 2 or Higher
Release Speed
4 TO 7+ Miles
at 45 Deg
45 Deg
Angle
Electromagnetic
Repulsor Track
-&- Launch
Sled
1/4 Mile
to
1/2 Mile
Transition
Arch
Crew
Loading
& Launch
Station
Fueling
Station
Vehicle & Launch Sled
Processing Complex

International Space Plane (I.S.P.) Program
Mountain Site Launch & Recovery Facility






1 - G Force Verticle Axis = "X0"
2 - G Force Horizontal Axis = "X1"
3 - MPH = "X2" / MACH = "X3"
4 - Vehicle / Launch Sled DEG = "X4"
5 - Altitude Above Sea Level = "X5"
6 - Altitude Above Base Level = "X6"
7 - Time From Zero Point = "X7"
8 - Distance From Zero Point = "X8"
SPACE PLANE
FREE FLIGHT
F2
F1
E4
E3
E2
E1
ASSISTED
LAUNCH
PHASE
A & B & C
Are Not To
Proper Scale
D & E & F
Are Not To
Proper Scale
LAUNCH
SLED
RECOVERY
45
DEG
C
2 to 3 G's - Man Rated
3 to 5 G's - Non-Man Rated
Above 5 G's - Experimental
9 G's MAX - ALL
03
D1
D2
D3
D4
D5
D6
D7
D8
B
2 to 2.5 G's - Man Rated
2.5 to 3 G's - Non-Man Rated
Above 3 G's - Experimental
4 G's MAX - ALL
02
A
2 G's
Max
All
1/4 Mile to 1/2 Mile
Transition Arch at
Rated G Force Max
00
01
H2
L2
H1
L0
L1
L0 + L1 + L2 = Base Level Distance
To Mountain Verticle Center Point
H1 + H2 = Verticle Distance / Altitude
From Mountain Base Level Point
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INTERNATIONAL SPACE PLANE PROGRAM I. S. P.
International Space Agency, I.S.A.
International Space Plane Program
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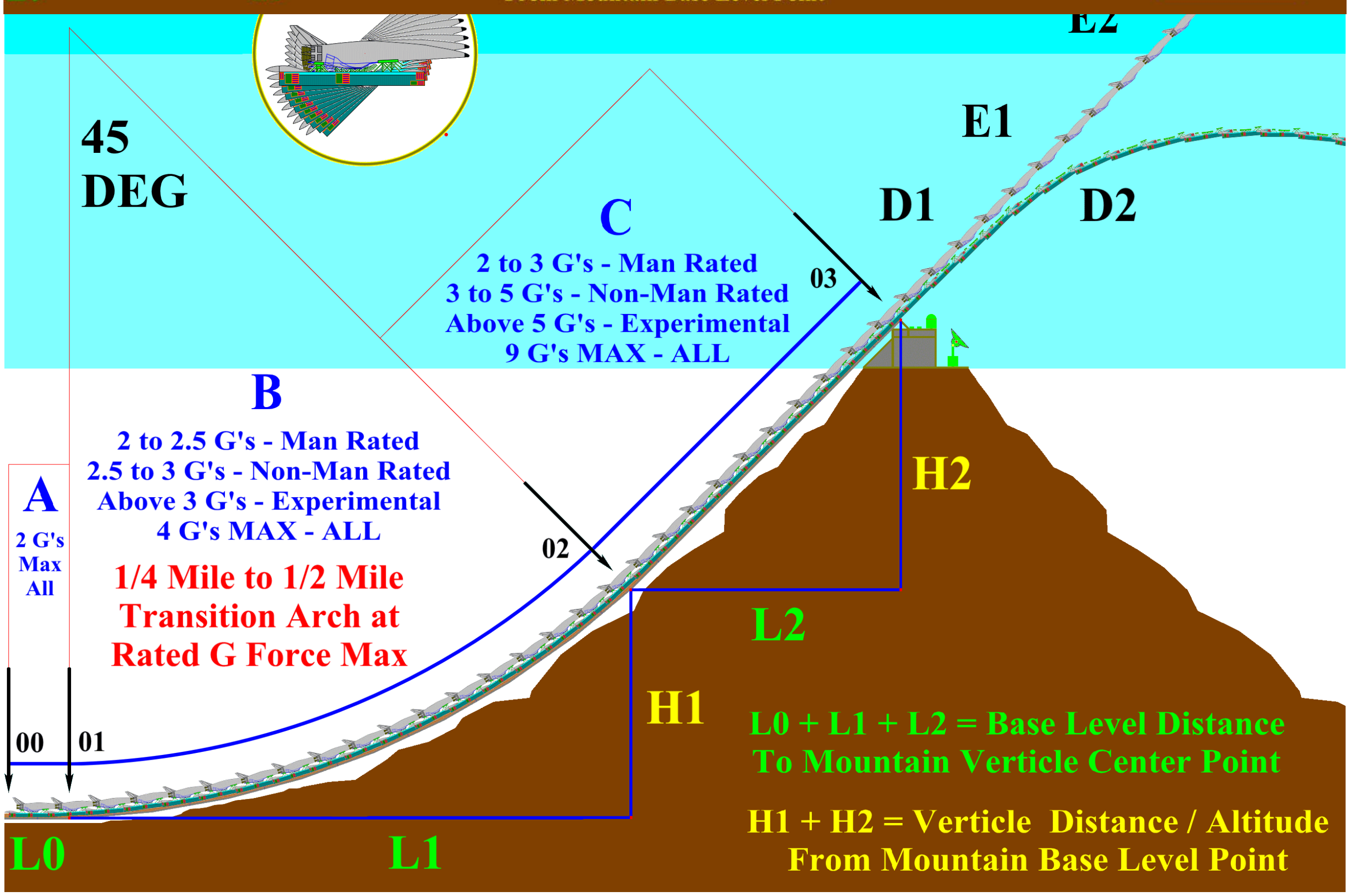
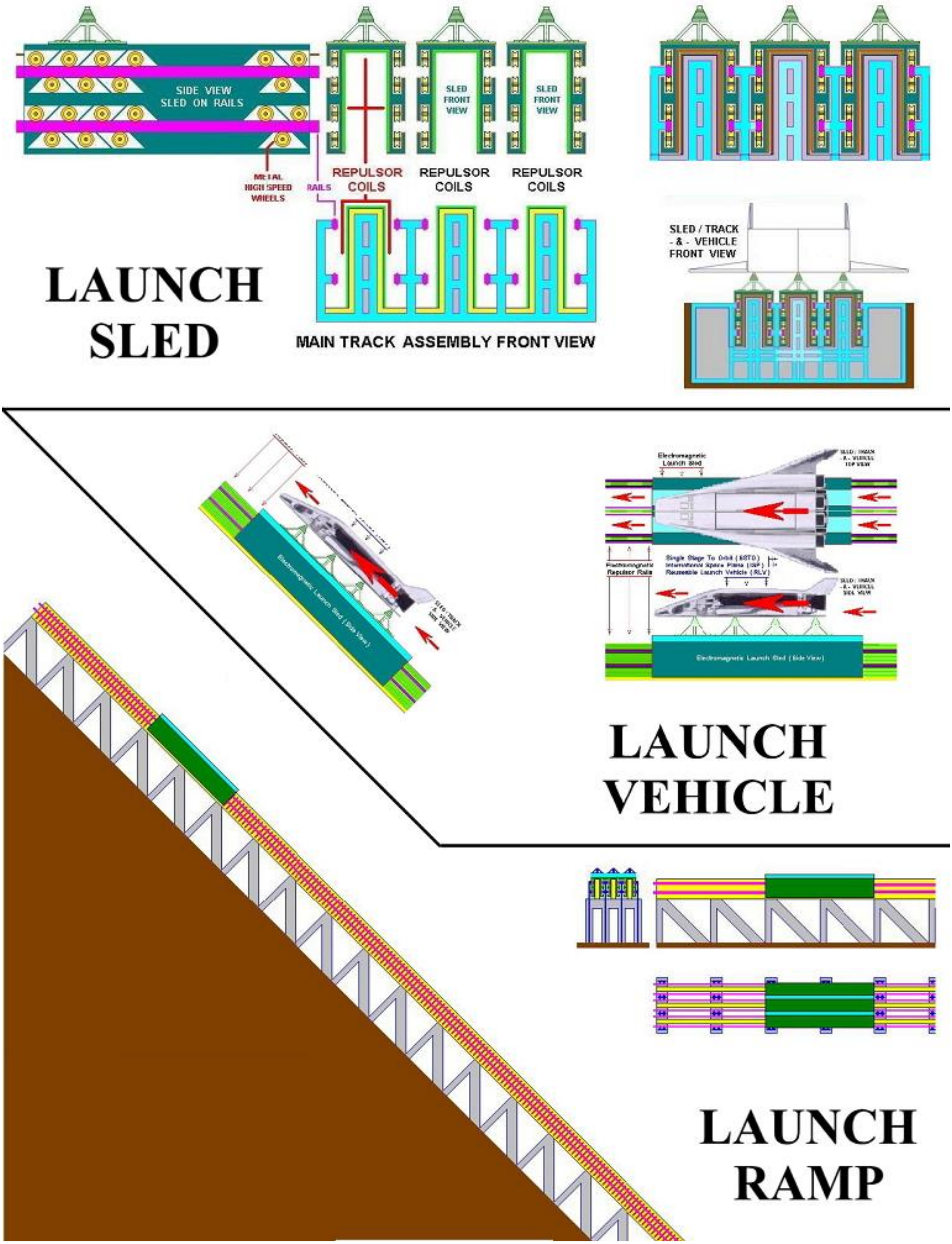
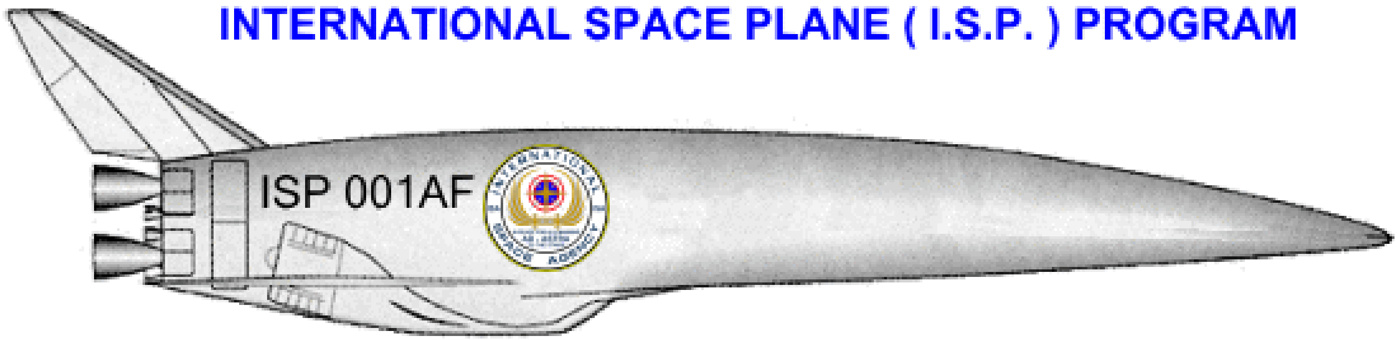
Fresh Water Lake
For EM Launch Sled
Recovery By ParaWing

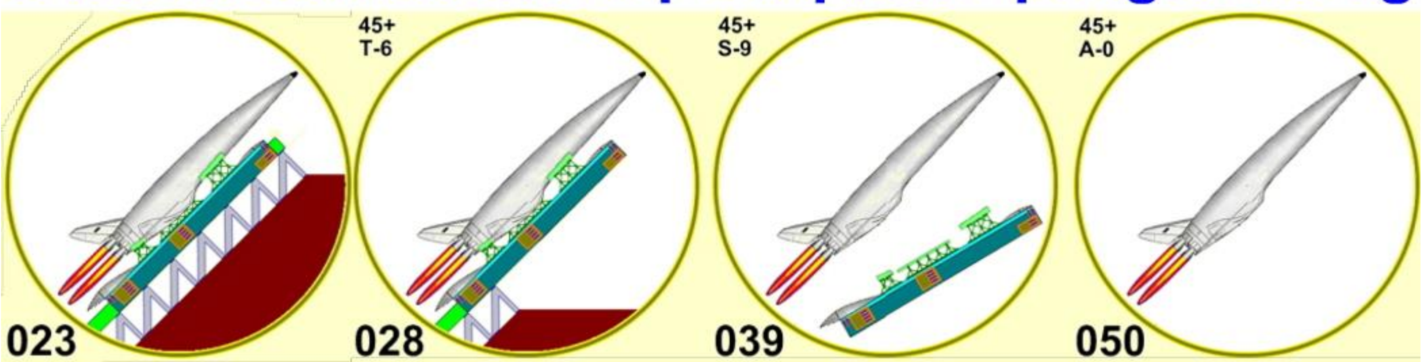

E1
45
DEG
D1
D2
C
2 to 3 G's - Man Rated
3 to 5 G's - Non-Man Rated
Above 5 G's - Experimental
9 G's MAX - ALL
03
B
2 to 2.5 G's - Man Rated
2.5 to 3 G's - Non-Man Rated
Above 3 G's - Experimental
4 G's MAX - ALL
02
A
2 G's
Max
All
1/4 Mile to 1/2 Mile
Transition Arch at
Rated G Force Max
H2
L2
H1
00
01
L0
L1
L0 + L1 + L2 = Base Level Distance
To Mountain Verticle Center Point
H1 + H2 = Verticle Distance / Altitude
From Mountain Base Level Point


LAUNCH SLED
SIDE VIEW
SLED ON RAILS
SLED FRONT VIEW
SLED FRONT VIEW
METAL HIGH SPEED WHEELS
RAILS
REPULSOR COILS
REPULSOR COILS
REPULSOR COILS
MAIN TRACK ASSEMBLY FRONT VIEW
SLED / TRACK - & - VEHICLE FRONT VIEW
LAUNCH VEHICLE
Electromagnetic Launch Sled
Single Stage To Orbit (SSTO)
International Space Plane (ISP)
Reuseable Launch Vehicle (RLV)
Electromagnetic Repulsor Rails
LAUNCH RAMP

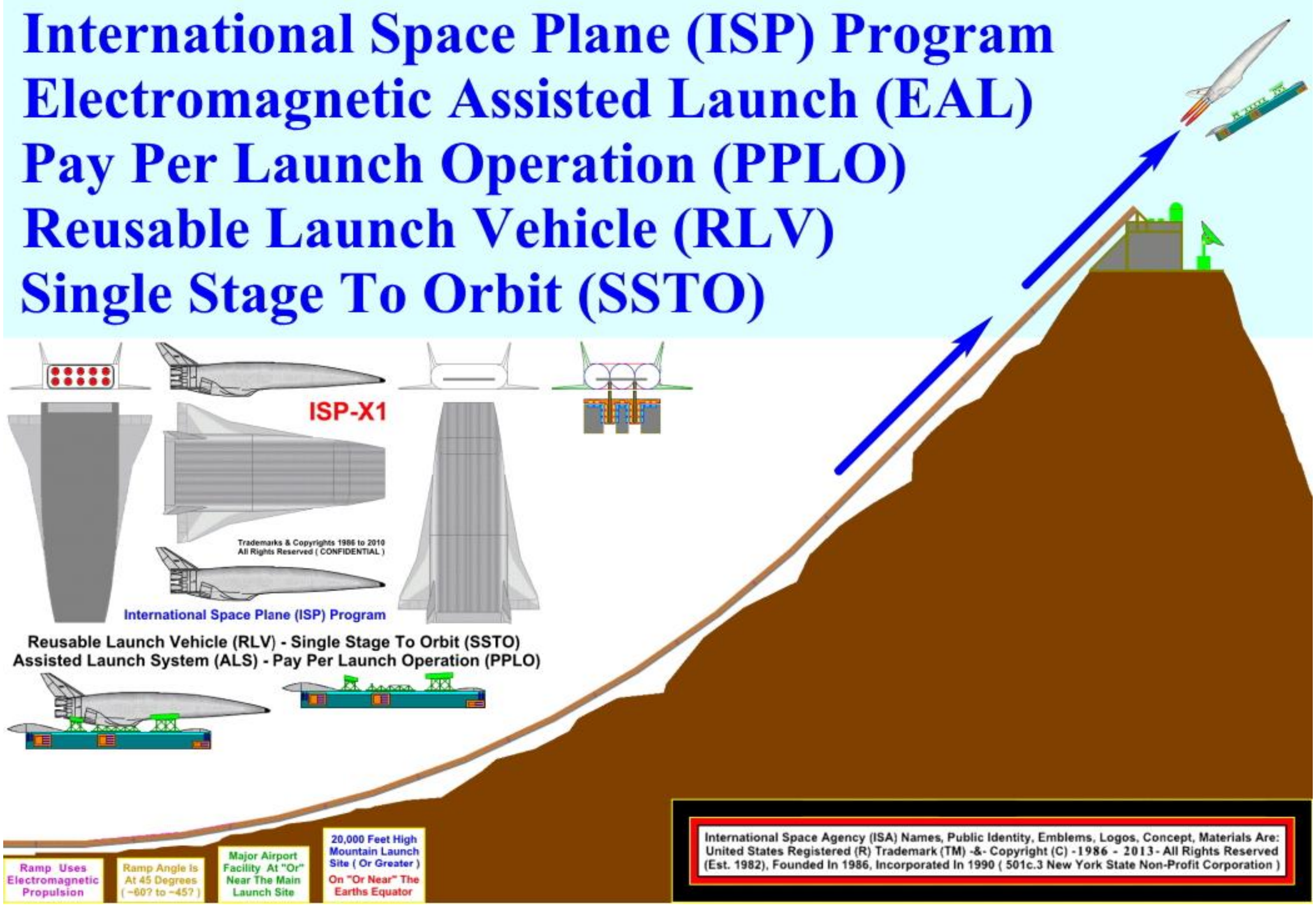
INTERNATIONAL SPACE PLANE (I.S.P.) PROGRAM



www.international-spaceplane-program.org



International Space Plane (ISP) Program
Electromagnetic Assisted Launch (EAL)
Pay Per Launch Operation (PPLO)
Reusable Launch Vehicle (RLV)
Single Stage To Orbit (SSTO)



This is a Historic Record of the Negotiations between: (Dr. R. Gopalaswami of India, and the Chief Designer of the Indian AVATAR Space Plane Program - gopalavatar@123india.com) and **(Admiral, Rick R. Dobson, Jr., Chairman & CEO of the International Space Agency)**. This important and most productive interaction occurred in **2002 and 2003**, with follow up communications for some years later. This was specifically related to the **International Space Plane (ISP) Program** being carried out by the **International Space Agency Since 1988**. It must be noted here, that **Dr. R. Gopalaswami** was instrumental in some of the major core elements of the **International Space Plane (ISP) Program Report/Proposal** included in this **"*1986 to 2013 – 30 Years In History*"** presentation. **Dr. R. Gopalaswami** was also instrumental in providing me with a copy of the ***(INDIA 90th I.S.C. SPACE SUMMIT Speech Presented By: Honorable, Dr. A. P. J. Abdul Kalam, President of India, On The 90th Indian Science Congress, Bangalorem, India, 4th of January 2003)***, which is a most impressive and important document and presentation, and was present previous to this record of events between **Dr. R. Gopalaswami** and **Admiral, R. R. Dobson, Jr.**. For the public and historical record, here are the negotiations and interactions between them.

Note: The following is Letters and Information from Dr. R. Gopalaswami sent to Admiral, R. R. Dobson, Jr.., received at the International Space Agency Administrative Offices in Omaha, Nebraska, USA.

ANALYSIS & COMMENTS ON ISA-INDIA PROGRESS: 20 OCT 2002 to 24 JAN 2003

Dear Rick, **"ie: *Admiral, Rick R. Dobson, Jr.*"** We have been at work these last 3 months and engaged in creative discussions trying to create a long lasting link between the ISA and the GoI for a global space mission in the area of SSTO-RLV and SSP. This mission would the launch the ISA as a new global entity for a variety of missions to bring prosperity and peace for all mankind.

To step back and understand where we were, where are now and where we would like to be in the not too distant future, I have attempted to make a Summary of Events in my communications with you from 20 October 02 to 24 January 03.

The Summary of the ISA-India events is attached herewith. I hope nothing significant has been inadvertently left out, and that you find this Summary thought provoking in retrospect.

As I saw the process of dialogue as a whole it appeared to me that one of the reasons why we are not moving faster is that Rick on 05 November 2002 had suggested that Clause 501.c.3.s of the ISA Charter empowers ISA to work with both governmental and non-governmental entities. Once one or more countries formally sign the ISA Charter, US law will no longer restrict it. Hence Rick emphasized that it is important that up-front formal recognition of ISA by one or more countries is essential.

However I was advised that geopolitical events in 1990's and fears of proliferation had hardened US Government restrictions on transfer of dual-use technology. Many regimes like MTCR etc may be evoked by USG leading to controversy & embarrassment for the GoI. It was prudent to avoid such controversy at all costs.

Hence it is clear even now that ISA expects other countries to sign an agreement up front and this will then enable them to proceed with global space missions duly empowered by US law. But the experience of countries like India has established that this will be a facile assumption at least for India. The USG would certainly oppose and probably penalize any such private initiatives and hence it is best to proceed with USG approval against a specific potential 'business plan'.

Both arguments merit admittance. However 04 January 2002 the situation has changed. The President of India at a Space Summit in Bangalore attended by US Government officials publicly called for not just a cooperative global space mission but also the creation of an International Space Force. The Space Summit Address by the Indian President does indeed provide the required super-ordinate goal for the movement towards a global space mission.

An important and significant response has come from the US Government representatives to the Summit, Dr James Dodge, Director of Earth Sciences in NASA and Dr Kenneth Hodgins, Deputy Director, Office of Space and Advanced Technology in the US State Department. They said at the Press Conference following the Summit the U.S. was eager to help India in all ways in space research. Several areas of co-operation have already been identified including satellite navigation services, environmental monitoring and GPS. An India-US Conference on space technology would be organized in India later this year. A Team from NASA would come again for a discussion about the various elements of co-operation and to plan for an India-US Conference on space technology.

IF THE US GOVERNMENT CAN COME FORWARD WITH SUCH A POSITIVE RESPONSE TO THE VISION STATEMENT OF THE PRESIDENT OF INDIA, IT DOES NOT NOW APPEAR REASONABLE FOR THE USG TO DISALLOW THE US PRIVATE SECTOR FROM RESPONDING TO THE VISION STATEMENT OF THE PRESIDENT OF INDIA ESPECIALLY IF THIS IS DONE IN AN INTEGRATED MANNER WITH GOVERNMENTS' PARTICIPATION.

That is the logic I suggest you may like to use both in the USA and with India.

TO PROCEED WITH THE ISA INITIATIVE WITH INDIA, WE SHOULD WORK FOR BOTH THE UP-FRONT ISA AGREEMENT WITH GOVERNMENT OF INDIA AND THE USG APPROVAL SIMULTANEOUSLY keeping both sides informed.

It is therefore suggested that it may be important to write to India Government officials and above all meet the Indian Ambassador there who is aware of the President's of India's interest in a global space mission. The bare minimum five letters you have to address to GoI officials are to

1. Mr. Lalith Mansingh
Ambassador of India to the United States
Washington DC

2. Dr K.Kasturirngan
Secretary
Department of Space
Anthariksh Bhavan
New BEL Road
Bangalore

3. Dr V.K. Aatre
Scientific Adviser to the Defense Minister
Room 137, South Block
New Delhi-110001

4.Air Chief Marshal S. Krishnaswami
Chief of Air Staff
Indian Air Force
Vayu Sena Bhavan
New Delhi 110001

5.Dr A.S..Pillai
Chief Controller (Research & Development)
Sena Bhavan
New Delhi 110011

With these insights I hope you find the enclosed summary useful
Regards
Gopal "ie: *Dr. R. Gopalaswami*"

Dr. R. Gopalaswami Proposed The Following Communication:

"DRAFT LETTER FROM ISA TO "CORPORATE OFFICERS" OF GOVERNMENT OF INDIA"

To, "Mr. Ambassador/Secretary/Chief Controller, Sir" / "Air Chief Marshal, Sir"

I refer to the Address of the President of India on 04 January 2003 to the Space Summit of the 90th. Session of the Indian Science Congress at Bangalore. In particular, I refer to his historic call to the Global Space Community call for a "Common Minimum Global Space Mission" to address the impending human crises for energy, water and minerals; so also his call for an "International Space Force."

I understand that several areas of co-operation between India and the US have already been identified following the recent visit of the Indian Prime Minister's to the US and his discussions with the US President. These areas included satellite navigation services, environmental monitoring and GPS. Dr James Dodge, Director of Earth Sciences in NASA and Dr Kenneth Hodgins, Deputy Director, Office of Space and Advanced Technology in the US State Department had participated in the Space Summit as representatives of the US Government. In the Press Conference following the Space Summit they affirmed that the U.S. was eager to help India in all ways in space research. They said that a Team from NASA would come again for discussions about the various elements of cooperation and to plan for an India-US Conference on space technology later this year.

I am the Founder and presently the Director of the International Space Agency. This institution was incorporated as a non-profit organization in 1990 in the New York State of the USA. The Charter of the ISA is to promote International Civil Space Projects and missions in the private, quasi-public, and public sectors of peoples of the world community and exclusively for peaceful purposes. While the ISA is restricted from engaging or assisting in military activities of its member nations, it is permitted by Charter and Incorporation to cooperate even with military organizations so long as ISA resources or personnel are not used in military activities or conflicts. Documents relating to the Charter, Mission, Purpose and Organizational Structure of the International Space Agency, ISA, has been enclosed as attachments to this letter.

When I obtained the full details of the historic speech by the President of India to the Space Summit, I was delighted to see that the vision, mission, goals and policies outlined in his address were almost the same being promoted by the ISA since its inception. At the October 2002 World Space Congress I had made a pledge that the ISA would promote, develop and operate an International spaceplane , a fully reusable single-stage-to-orbit system within 5 to 7 years. The work would be based on the management structure and philosophy of Airbus Industries with International support and backing.

India too has been promoting the design and deployment of single-stage-to-orbit spaceplanes and their application as low cost space transportation for space solar power missions. I understand again from published literature that India is keen to promote this Mission as an international space mission to address the impending human crises for energy, water as emphasized by the President of India.

It is in this context that I seek your good offices, guidance and advice to help enable the ISA participate in the emerging Indo-US cooperation in space technology and applications. I submit such cooperation and joint ISA-India global missions would be for the common good, for India, and the International Space Agency. Many institutions in the Government of India and the US Government and its institutions, and other nations would be progressively involved in discussions and negotiations leading to such joint space missions. The ISA is ready to serve as an international space mission management organization , and interface with all nations and institutions in fulfillment of the purpose of the mission.

I shall be grateful for your assistance to identify an Indian Official Team who can be authorized to contact me, or whom I should contact. We can then enter into discussions and negotiations between the International Space Agency and the Indian team to formulate, authorize, support and implement a Global Space Mission in accordance with the historic Vision and missions outlined by the President of India to the Global Space Community on 04th. January 2003.

SUMMARY OF DIALOGUE AND EVENTS WITH ISA

Dear Rick, ***"Admiral, Rick R. Dobson, Jr.",*** This is a Summary of flow of events highlighting the state-of-initiative for a potential ISA-India global space mission:

20 October 2002: I received the ISA's "International Press Release" forwarded by the 'Space News' Correspondent in India, Mr. K.S. Jayaraman.

21 October 2002: My first response to the ISA Press Release bringing out our commonality of goals (SSTO-RLV and international space missions) along with references of my internationally published work on SSTO-RLV design, and a note on my personal background.

24 October 2002: First reply from Rick Dobson graciously offering a position on the ISA Board of Directors as the India Representative and suggesting the incorporation a parallel not-for-profit Corporation in India in support of the ISA. My immediate reply thanking ISA for the offer of a position, but suggesting I need the details of the ISA Constitution and Charter. I also suggest we first engage in creative conversation to synchronize a common vision and mission between the ISA and India. I suggest that the vision and purpose may be "ensuring perennial energy and water security for all nations through space systems and technology missions to harvest the inexhaustible supply of solar energy from outer space" Rick Dobson circulates my letters to his colleagues the same day

25 October 2002: Received the ISA Charter and Certificate of Registration and proceed to study the same with the help of friends who have experience in company law. ISA requests me to sign a formal letter of agreement to work for them, indicating that the ISA relationship may be a reflection of the super-power/developing nation relationship in the United Nations. I suggest that this was unacceptable and premature, that we may continue creative discussions on the basis of the ISA's 1990 Charter, which defines these relationships precisely and well. Also I needed more information about ISA's work and accomplishments since its inception.

28 October 2002: Receive clarifications from Rick. I then promise to come back with a framework of "Business Plan" which would enable our creative conversation proceed to the next step ie a more structured dialogue leading in turn to formal agreements between ISA and interested institutions in India. Discussions with my legal colleague suggested on the basis of papers received from ISA that it would be prudent for ISA to obtain US Gov. approval first for entering into a dialogue with Indian government and other institutions.

29 October 2002: I mail a 5-page note "A Suggested Approach for a Strategic Tie-up Between the Rick Dobson International Space Agency and the Government of India for a Solar Aerospace Initiative" along with a 2-page Chart describing the potential Business Plan.

1 November 2002: Based on the potential Business Plan, and on the theoretical assumption that this Business Plan would call for total Indian financial contribution ie 100% GoI funding for Technology Development I suggest an interlocking structural framework of functional positions described in the ISA Constitution for the Indian presence for the first five years on the ISA as a global mission management organization. Implied here is that if other World Governments and institutions were to share the developmental funding, then the structural positions in the ISA would be based on the principles clearly laid down in the ISA Charter. Steps forward towards a Memorandum of Understanding are also suggested for a measured approach with complete knowledge and approval of both USG and GoI.

02 Nov 2002: Suggest that after ISA studies the approach paper carefully, and the first thing is to get formal permission or a "no-objection" letter from the USG to take up this mission with India.

05 Nov 2002: Rick suggests that the Clause 501.c.3.s of the ISA Charter empowers ISA to work with both governmental and non-governmental entities. Once one or more countries formally sign the ISA Charter, US law will no longer restrict it. Hence it is important that formal recognition of ISA by one or more countries is essential.

Rick cites examples of difficulties in working with bureaucracies without universal vision. However I was advised that geopolitical events in 1990's and fears of proliferation had hardened US Government restrictions on transfer of high technology. Many regimes like MTCR etc may be evoked by USG leading to controversy and embarrassment for the GoI. This was to be avoided at all costs. To help ISA obtain USG clearance for dialogue with India, I bring out facts that several officials in USA, like Lt. Gen. James A. Abrahamson, Director SDI Organization are familiar with the SSTO /SSP work in India. One direct way was to get the USAF interested in the mission. The Phillips Laboratory of the USAF had put out a SSTO Design Competition and the Indian "Avatar" SSTO concept could compete for this.

14 Nov. 2002: Rick confirms his interest in the Approach Paper and says "the magnitude of the decision warrants detailed review". He would try to contact USG officials and Senators. He said the ISA could concede 49% control at the most and structural positions had to be debated. He was getting more information on the Avatar mission from the open literature and prepares to make presentations to USG officials.

17 November 2002: Rick introduces Mike McCarthy to the creative conversations on the potential ISA-India mission. Mike carries out an extensive literature survey on the Avatar mission. He also brings out that such a project may be hindered by USG restrictions like under MTCR as reported in the literature.

18 November 2002: I respond to Mike's observations re. MTCR and its relevance to the SAI (Solar Aerospace Initiative) and a couple of other peripheral points. I wondered how MTCR would be relevant if USA itself were a mission partner! Linking with USAF would potentially be the answer for all USG doubts about SAI mission.

22 November 2002: I formally send the ISA Charter to a GoI Institution which had expressed interest in developing into a Global Company and confirm this to Rick on 23 Nov.02 that I had also mentioned this to the concerned GoI official on telephone.

23 November 2002: Rick advises he is seeking meetings with USG officials , Congress and Senate also Air Force and Space Command. He suggests a story be put in the media about his efforts. I negative the latter suggestion about going to media saying it was premature and would potentially put peoples' back up. Rick consults others and agrees with me.

26 November 2002: Rick feels involving the USAF as "budding space warriors" is a wise and insightful move and he supported the idea.

01 December 2002: Rick conveys his attempt to meet Mr. R.S.Bhatia of the Indian Embassy in Washington. I respond encouraging him to meet the Indian Ambassador in Washington personally, and that the Ambassador was aware of the SSP/RLV initiative. I further suggest he meet the Technology Counselor in the Embassy, Mr. Checker .I update Rick on the evolving story of RLV development in India and why the Avatar / Hyperplane design concept is unique.

05 December 2002: Rick confirms setting up some meetings with reps of Congress and Senate. He also proposed to forward the conversations to his friend in Boeing, Mr. Bob Bocek to which I had no objection as all work on Avatar was published in open literature.

16 Dec 2002: Rick forwards for information letters exchanged with US Congressman Honorable Lee Terry.

27 December 2002: Rick forwards some correspondence from an interested person in Azerbaijan for information. I request Rick to please remain focused on moving towards a dialogue and understanding for working with India.

04 January 2003: The President of India addresses the Space Summit in Bangalore and calls for a Common Minimum Global Space Mission for RLV and SSP" and the creation of an International Space Force". I give Rick full particulars of the Web Site on which the President's address was available. I also advise Rick to download the complete Address and give it wide circulation because the vision of the President of India closely matches that of the ISA. The President had also invited feedback at the Address and I suggested this was an opportunity for ISA to write directly to the President of India.

08 January 2003: Received a letter from Mike hinting that Rick may not have received encouragement from Mr. Checker in the Embassy. I write a letter to Rick and Mike seeking to consolidate the initiatives as follows:
Seek and obtain some kind of authorization from the USG to make out a proposal to the GoI. Write to two US officials who had attended the Space Summit in India. They were Dr James Dodge, Director of Earth Sciences in NASA and Dr Kenneth Hodgins, Deputy Director, Office of Space and Advanced Technology in the US State Department. While moving to consolidate his foundation with the USG, NASA and the USAF, I may suggest that Rick makes out a standard letter to the following officials of the GoI (given below are five key names and addresses out of the 8 suggested)

1. Mr. Lalith Mansingh, Ambassador of India to the United States, Washington DC
2. Dr K.Kasturirngan, Secretary, Department of Space, Anthariksh Bhavan, New BEL Road, Bangalore
3. Dr V.K. Aatre, Scientific Adviser to the Defense Minister, Room 137, South Block, New Delhi-110001
4. Air Chief Marshal S. Krishnaswami, Chief of Air Staff, Indian Air Force, Vayu Sena Bhavan, New Delhi 110001
5. Dr A.S..Pillai, Chief Controller (Research & Development), Sena Bhavan, New Delhi 110011.

14 January 2003: Rick send me a copy of his letter to President of India in which he requests the President that 'it would be to the common good, for India and the International Space Agency that Official dialogue be initiated with the following goals……." I suggest that he follows up with a hard copy by normal mail.

15 January 2003: Acknowledgement from Rick and a request that he should be kept updated on response to his letter to the President of India. He was continuing his work on trying to get official support for ISA from other countries. He was still following on the last contacts I had suggested at NASA and US State Department.

18 January 2003: I suggest to Rick and Mike that the time is propitious to extend the range of his contacts from government alone to include Industry in India. This would synergize his efforts with GoI and USG. GE had set up an inter-disciplinary Technology Center in Bangalore and they could be considered as a Nodal Technology Center by the ISA for India. If the idea was attractive then Rick could contact the Corporate Officers of GE in the USA for advancing the idea. GE would be helpful in synergising ISAs recognition by both USG and GoI as they were already well established in India. Mike supported the idea.

24 January 2003: Rick reminded me that the structural position issue of India in ISA was still open to debate and I agreed. Rick further said he appreciated the GE(Technology Center) idea and would follow up.

END OF SUMMARY OF ISA-INDIA EVENTS OCT 2002 to JAN 2003

NOTE: It must be noted for the public record, that during this time frame, and a few years later, Admiral Dobson was facing dire personal issues, and was struggling just to survive under extreme duress from well funded organized criminal/cult entities targeting of him. In this time, Board Member & Corporate Attorney, Adam Jacobs of Omaha, Nebraska, of International Space Agency died under extremely suspicious circumstances, and it is suspected he was murdered for supporting Admiral Dobson and the ISA Effort. Also around this time an important Board Member and Major Benefactor of the International Space Agency, Jerald Schneider of Omaha, Nebraska had a serious heart attack. The offices of the International Space Agency, in Omaha, Nebraska, where also fire bombed around this time. **This and other nefarious activities against Admiral Dobson, left him fighting just to survive, and the ISA effort terribly suffered. Sadly, this nefarious targeting of Admiral Dobson continues to the present day in 2017, and has been ongoing in a focused manner since 1990. Also the limited funding and ridicule for the ISA Endeavor has been stifling! Much of this negative activity is due to well funded espionage by rivals.**

NOTE: The International Space Agency, International Space Plane Program, DOES NOT Use or Suggest "Horizontal Assisted Launch Configuration or Launch Sled Levitation" As Outlined In This NASA Report! Instead the ISA ISP System & Configuration Uses A Mountain Side Assisted Launch Ramp At or Near 45 Degree Launch Incline Up The Side Of A Mountain On The Earths Equator "Proposed 2 Mountain Sites In Brazil", And The ISP Would Only Use The Electromagnetic Component For Acceleration Only, As The ISP Launch Sled Would Utilize Direct Rail Connection With The Launch Sled. However, This Report Has Critical Insight And R&D Elements That Are Key & Critical To The Concept Of Assisted Electromagnetic Launch Technology And Is Therefore Relevant To The ISA International Space Plane Program Initiative.

NASA Electromagnetic Assisted Launch Report
Short Description (Solving a specific problem) 2004_Mag-Lev_Surface

Reduce the development risk for the following concepts: 1) Power storage and delivery system for Moon/Mars that includes electromagnetic levitation and propulsion for surface transport, habitation and exploration operations, 2) Launch assist from the surface of the Moon, achieve escape velocity for cargo and passenger vehicles, taking advantage of the surface power storage and delivery system above, 3) Horizontal Launch Assist utilizing electromagnetic fields from the surface of Mars utilizing airfoil on flight vehicle to achieve orbit but not being able to take advantage of atmospheric oxygen, which does not exist. These concepts would take advantage of the surface power storage and delivery system. 4) Single Stage To Orbit (SSTO), Horizontal Launch Assist (HLA) from the surface of the earth utilizing the capabilities of the Rocket based Combined Cycle engine to utilize oxygen from the atmosphere to reduce weight by not having to carry oxidizer on board.

The SSTO effort would reduce the number of engines required for a single engine out and still achieve orbit. By utilizing high ground speed (possibly beyond Mach) the size and mass of the wings, steering and landing gear can be greatly reduced. Issues are energy storage, power generation and distribution, electromagnetic levitation and propulsion, stability during acceleration and flight vehicle separation dynamics. The Moon/Mars efforts will mitigate the effects of dust and dirt intruding into moving wheels, rotating seals, etc. on the surface of Moon/Mars. Reliable power distribution that eliminates the movement of commodities (fuel, oxidizer, mono-propellants, etc.) would increase overall safety and reliability of the installed system. Elimination of the emission of contaminants (combustion by-products) and lubricants into delicate planetary atmospheres would reduce the environmental impact for the installed systems.

The overall goal of these efforts would be to raise the TRL level for all concepts proposed by one per year from approximately 2, where they are currently as demonstrated systems. Though the hardware for demonstrating these concepts basically exists as Commercial-Off-The-Shelf, the integrated systems with flight vehicles and travelers do not. The complexity and risk is in the scaling features of each approach. The products produced will be the system operational models and identified risks for future research. At the end of the four-year period it should be clear how feasible and at what cost and risk a system of a specific size, capability and operational scenario might be.

ROM Budget (4 years, $5 – $50 M)
Year-1: $3.5M, Year-2 $4M, Year-3: $4.5M, Year-4: $6M ($18M run-out)

Deliverables
Modeling electromagnetic and electromechanical issues to estimate feasibility
Trade Study to identify likely approaches for each scenario
Experimental verification of critical issues

Resources (CS and Contractor $'s)
Seven CS full-time per year, four years, six NASA Centers, two DOD facilities
Contractors: TBD per year for Four Years

Proposed Partnerships
Glenn Research Center / Ray Beach / Energy storage
Dryden Flight Research Center / Kurt Kloesel / Flight vehicle controls and design
Marshall Spaceflight Center / John Suter, John Cole, Ken House / Separation Dynamics / PRT Maglev Systems Bantam demonstration track to demonstrate low-speed separation dynamics and flight
Langley / Michael Wright / Flight vehicle aerodynamics
Kennedy Space Center / Ric Adams, Bob Youngquist / Electromagnetic modeling, power generation, track / traveler mechatronics / Foster-Miller and Lawrence Livermore National Labs Bantam demonstration tracks
Wallops / Bruce Underwood / EMALS Test Articles
Holloman Air Force Base / Col. David Minto / Utilize High-Speed Test track for launch and high-speed separation dynamics experimentation
U. S. Navy, Lakehurst N.J. / Mike Doyle / Electromagnetic propulsion motor models
KSC has one STTR Phase II contract that requires additional effort and an ongoing partnership with University of Central Florida, Florida Institute of Technology through the Florida Space Institute.

Mag-Lev_Trade_FY-04-VIII - U/D: 02/06/04
(Adams, Lueck, Meinke, Minto, Russell, Schultz, Youngquist, Gutierrez)

Electromagnetic Horizontal Launch Assist (HLA)

Goal

The overall project goal is to develop the concept of Horizontal Launch Assist in order to reduce the cost and complexity of launching single-stage vehicles from Earth to orbit using East-West oriented ground acceleration tracks. The NASA Bantam program funded three prototype concept hardware demonstration projects, and much of the experience with this hardware is reflected in this paper. Part of the reason for designing to Mach, rather than the sub-Mach speeds mentioned in the Bantam program was a comment that pushing through the Mach point on the ground would allow the ground system to perform that "energy-hump" maneuver rather than the flight propulsion system.

The purpose of this paper, including the referenced attachments is to maintain in one place the current thinking of technical experts focused on the topic of high-speed launch assist. Whether the actual application is first used for earth orbit, Lunar escape or Mars horizontal launch is not known at this time. With only 1% of earth atmospheric pressure, HLA on Mars may not make sense. Vehicle configurations will certainly differ from those for earth applications, as the motivation to take advantage of an oxidizing atmosphere does not exist on Mars. Lunar HLA will require sufficient energy to break free of lunar gravity horizontally without relying on aero-surfaces for support in any form.

System Feasibility

System feasibility refers to the overall ability of the technology, flight and ground hardware, to achieve the goals of reduced cost to orbit for a high-rate turn-around launch system. Development of compatible flight vehicle, flight propulsion and ground acceleration systems will require consideration of all components as a system. It is very likely that limitations of flight hardware are going to be the determining factor in the actual requirements for the ground acceleration portion, and will most likely determine the overall pace of progress of the system. It appears concepts of the electro-magnetic propulsion and levitation are sufficiently advanced to be considered to be in the realm of the classical engineering disciplines.

In a focused effort to acquire funding for research, it quickly became apparent that there were a lot of questions regarding how much is currently known about the techniques and methods that might be integrated to achieve a reliable HLA system, including the flight vehicle. Various interested individuals were polled for interest in contributing and for providing ideas and concepts that might be targets for others to focus on and perfect.

Project Management, Scaling and Scope: It has generally been considered that changes in scaling would correspond to orders of magnitude above demonstrated scale models, starting with a first flight vehicle weighing < 100 lbm flying from a current Bantam demonstrator track, followed by an enhanced 1,000 lbm, remote piloted for landing recovery and achieving ~ Mach speed on the ground prior to release. Matched pairs of flight vehicle and ground HLA accelerator tracks would be developed in parallel with each other. While this is a good starting point for scoping development, the overall approach should be verified by analysis. Careful matching of each technology (flight and ground) for each scale of prototype demonstrator will be a key feature guiding the design and development of each phase of the overall project.

Design Team: Participants from many disciplines (Civil, electrical, mechanical, aerospace, chemical engineering, physics, etc.) will be required before this effort can be defined in sufficient detail to perform trade studies, solicit proposals, etc.

Coordination:

Reporting:

Overall System Modeling: Overall systems modeling needs to be performed, so the effect on cost, performance and reliability can be quantified. Given that a key purpose of these studies is to select between competing design options and reliably integrate the options selected (including what can be known of a potential flight vehicle) into a consistent system. An estimate of the energy required to achieve orbit from a horizontal launch perspective, based on realistic flight vehicle concepts, considering all necessary orbits needs to be completely developed before continuing with advanced Horizontal Launch Assist (HLA) effort.

System development is most likely to occur in phases, sub-scaled systems that include both some form of a flight vehicle and a matching accelerator track. Each scale model will consist, most likely of a design integration effort utilizing technology current at the Critical Design Review. New technology will most likely be confined to development of new techniques to model various portions of each sub-scale prototype demonstration version with lab and field testing to verify the modeling effort. Advanced modeling software for electro-magnetic levitation and control may be the major contribution when the overall project is complete. The end result of each phase is likely to be a sequence of test flights, controlled from the ground via "pilot in the loop" technology. The purpose of this testing would be to recover and re-fly each prototype vehicle sufficiently to gauge the performance under various scenarios in order to develop data and information necessary for scaling each demonstrator to the next higher level. With state-of-the-art modeling software it may not be necessary to build complete prototype hardware for each "order of magnitude" phase, as was originally (three years ago) considered.

Training: Individual training on modeling software will be necessary before any team effort can start. Recommend development of a concurrent engineering team to cross-train and work online on a regular basis to define the vehicle as much as possible.

The Woodcock white paper examined five topics that led to the conclusion that Horizontal Launch Assist is a concept worthy of further investigation. It was written by Gordon Woodcock, at the time with the Boeing Defense and Space Group (~1997), to highlight the advantages of HLA, specifically light-weight retractable landing gear, reduction in launch vibration, reduction of wing area of the flight vehicle, feasibility of achieving reasonable orbits from an East-West oriented guideway and the reality that the amount of thrust for HLA is greatly reduced, resulting in fewer and smaller engines. Also, that the number of engines can be reduced while meeting the need for single engine out mission continuation on a reusable vehicle.

Reduction of launch weight by reducing the wing area of the flight vehicle is possible if the launch speed can be made a substantial fraction of the speed of sound. During the launch acceleration time-frame, the vehicle would be fully fueled, the fuel would be accelerated along with the vehicle and fuel would not need to be consumed during acceleration, if top-off fuel is provided on the traveler with the vehicle.

One concern that arises immediately is the perception of a need to horizontally rotate the direction of the track to achieve higher-inclination orbits. According to Mr. Woodcock, achievement of any reasonable orbit, including polar, based on an East-West Horizontal Launch Assist mechanism is possible by using the airframe in flight to direct the movement toward the desired inclination while the vehicle is traveling at slower speeds and accelerating horizontally.

Light-weight retractable landing gear is possible if the requirement for steering the fueled vehicle during launch acceleration along the ground is removed and replaced by a launch track. This should reduce the mass associated with that hardware. Steering gear would be required for landing after return from orbit, or after an aborted launch provided the vehicle can be drained of fuel during the Return to Launch Site landing attempt, but would not be required to support the fully fueled vehicle.

Vibration-induced strain on the vehicle fuselage can be reduced if the levitation and acceleration forces are supplied in a more controlled fashion than if the vehicle were to ride on a paved concrete runway. For the HLA movement along the track would be precisely controlled by a feedback system with appropriate control software and inclusion of leveling devices under the track itself. The need to have a substantial horizontal segment of the runway leveled as for commercial jet liners would be un-necessary.

Vertical launch requires that the engines provide sufficient force to lift and accelerate the vehicle on a vertical path from the launch surface. Acceleration means that the engines provide more force that the weight of the vehicle. Horizontal launch only requires a fraction of the force to maintain lift in flight at low altitude, while the vehicle is orienting itself to orbital inclination while accelerating horizontally and gaining speed and altitude.

Woodcock only considered the manufacturing costs of the HLA vehicle compared to a vertical launch scenario, but considered the vertical launch vehicle to be reusable in his estimates, but had no budget in the weight estimate to cover thermal protection for re-entry. No consideration was given to the operational features, where an HLA vehicle would be recovered and reused, but, in reality, most vertical launch vehicles are designed to be expendable. Reusable engines may prove to be heavier than expendable engines to meet reliability requirements, so that would detract some from HLA, but overall HLA looks pretty good as a starting point, for estimating purposes [1].

Overall Stability: There may be a tendency to presume that resonance is the only mechanism that can lead to catastrophically large vibrations, but there is another item of concern. Resonance is not to be confused with dynamic instability and that the latter is just as capable of producing catastrophic vibrations as the former. Unlike resonance, however, dynamic instability does not require externally-powered time-dependent forcing (e.g. a shaker table) to operate. Indeed, dynamic instability, like wing flutter, will arise as soon as the vehicle-carriage system reaches a critical velocity as it moves down the guide-way. The following paragraphs should clarify these assertions.

Consider a dynamic system consisting (for simplicity) of a rigid body on a compliant suspension system that translates along a straight, rigid guide-way through smooth, nominally-undisturbed air. In the basic state of undisturbed motion the body is in mechanical equilibrium at all times as it translates. Suppose, for simplicity, that the system can undergo disturbances in two degrees of freedom, say plunge and pitch. The body is thus subject to vertical forces from the suspension system and from the air and is likewise subject to a pitching moment from these same two causes (I do not mention the axial forces due to thrust and drag since they do not urge the body to displace in either the plunge or the pitch).

If one develops the differential equations of motion for the plunge and pitch variables (and linearizes for small disturbances) then one can formulate an initial-value problem for the time evolution of the these displacement functions for a prescribed set of initial conditions. The system is dynamically unstable (to small disturbances) if there are some initial conditions which lead to solutions that exhibit exponential growth. Alternatively, the system is dynamically stable only if the solutions are bounded for all initial conditions.

It should be emphasized that the foregoing criterion for dynamic stability or instability of a system involves only free or nominally-unforced motions of the system. Of course the body is subject to time-dependent air loads but these are due to the assumption that the air is nominally smooth and undisturbed: only the body's pitching and plunging (in an otherwise uniform, steady airs-stream) leads to changes in the magnitude and direction of the relative wind velocity to which the body is subject. In this sense the role of the air is passive rather than active. The theory of wing flutter (for example) shows that compliance in plunge and yaw (even with positive stiffness in both degrees of freedom) and passive air loads of the sort just described are quite enough to make a dynamic system unstable (i.e. one in which the disturbance displacements grow exponentially in time). The boundary between the dynamically stable condition and the dynamically unstable condition depends upon the parameters but the speed of the air-stream in which the body is immersed is always a crucial parameter. Airplanes can shake themselves to pieces in flight if they fly too fast even if they are not subject to any externally powered shakers and a body on a compliant suspension system moving down a guide-way can do the same.
Resonance, by contrast, arises when a dynamic system whose free motions are consistent with the notion of dynamic stability is subject to externally powered forcing by a wave-maker, shaker table, or other agency extrinsic to the original dynamic system and when that forcing matches, or nearly matches, one of the frequencies of the free modes. The solution of the initial-value problem for the disturbances in such a case will typically exhibit algebraic rather than exponential growth. To preclude such algebraic growth through careful design in no way prevents exponential-growth of dynamically unstable, unforced modes described earlier.

Bottom line: To rely on a model predicated on the assumption that the only source of catastrophic vibrations is resonance (and which does not include analysis of the flutter hazard) is to miss what may well be the most likely failure scenario. (John Russell, personal communication)

System (Earth to Orbit) Modeling: Modeling the flight path and determining the feasibility of achieving any desired orbit should be included in the scope of this discussion, as early estimates indicate that HLA is not an unreasonable approach for a Single-Stage-to-Orbit flight vehicle.

Re-entry, Landing and Recovery: Flight termination from orbit will require some fuel and oxidizer remain on board after achieving orbit during launch. If cryo hydrogen and oxygen are the fuel and oxidizer of choice, they must remain refrigerated during on-orbit operations. It will be necessary to pressurize the fuel and oxidizer tanks with inert gas during re-entry to maintain integrity as the vehicle descends into the atmosphere during landing.

Source of this purge gas could be atmospheric air if nitrogen is used to initially clear the fuel tank of gaseous hydrogen during descent. Since the vehicle will, in all cases, be landing empty of liquid fuel (hydrogen and oxygen would be alternately vented overboard for Flight Termination After Launch / RTLS abort), the demands on the landing gear will be greatly reduced over what would be necessary were the vehicle to be required to land fully fueled. Scavenging hydrogen from the helium purge through chemical electrolytic processes while the vehicle is in orbit can reduce the mass of the landing vehicle and retain a substantial portion of the helium purge gas for later reuse. Chilling the helium purge in orbit (to avoid venting it) and heating it during re-entry may eliminate the need for adding substantial nitrogen or air during re-entry, further reducing landing mass.

Ground Propulsion, Electromagnetic (motor)

Providing energy to a linearly accelerating vehicle, without direct mechanical contact from ground hardware is the task for the linear motor component of the system. A linear motor is simply a conventional rotating motor with the stator and rotor (armature) sliced and rolled out into horizontal segments. The motor will provide the acceleration force to the vehicle and carrier (attaches flight hardware to the armature) assembly. Two types of motor architectures, synchronous and induction, are generally considered for this type of service.

If the vehicle provides 100% of main propulsion power at separation, the need for linear motor power capability and the amount of stored energy will be greatly reduced, but must be supplemented by the addition of a top-off capability for fuel and oxidizer on the carrier to replace the large amount of fuel that will be required to run the engines at full power. Under the scenario whereby the vehicle propulsion system provides a substantial amount of launch energy, special consideration must be given to decelerating a fully fueled vehicle while shutting down the propulsion engines in a controlled manner to avoid straining the airframe. In this instance the mechanism for removing energy from the system must consider slowing the vehicle down while the propulsion system is still providing substantial thrust, perhaps, few seconds after termination of the decision to continue with launch.

Part of the appeal of electro-magnetic propulsion comes from the ability to take advantage of the existing electrical power grid to transport the energy required for ground acceleration. In one hour's time, at a 28 MW rate, 100 GJ of energy can be stored in some manner, at a recurring cost of ~ $1,500 for electricity. This stored energy would be released in about sixteen seconds to launch the vehicle in a Single-Stage-to-Orbit scenario. No hazardous fuel would need to be transported for each launch beyond what is used for the vehicle. No storage requirements for fuel (and the associated security) or hazardous materials handling beyond current procedures for electrical safety would be required for this approach.

Some of the attraction for the electromagnetic approach to launch assist is that the major components can be designed to operate in a highly efficient, "transient" or pulse mode (on or off) depending on the design. This would relieve the design of the need for exotic cooling methods (water, active refrigeration, etc.). This design feature can be utilized to improve overall system reliability by sealing power components against weather intrusion and not having to transfer large amounts of thermal energy through these barriers. No hazardous waste would be associated with the use of the launch site, and current procedures for providing pollution abatement would be adequate for controlling release of emissions to the state utility power plants. The ability to retract, repair and re-launch after a launch attempt terminated by technical concerns will be a key factor in providing reliable overall success with minimum maintenance. The only time the system might be considered to be in a hazardous state would be during charging of the energy storage mechanisms, vehicle launch and post-launch shut-down.

If energy storage is Superconducting Magnetic Energy Storage (SMES) or flywheels, they can't be fully discharged during launch because they have a peak power requirement toward the end of acceleration. Zero rotational velocity in a flywheel would require infinite torque, zero current in a SMES would require infinite voltage. Therefore, the velocity and current reductions are held to about a factor of two, so that the peaking factors on torque and voltage are held to similar factors. Then, after a launch, there is no reason to discharge either the flywheel or the SMES system to zero.

The flywheel could have a small motor or alternately use a single set of stator windings to both charge and discharge the device. In the SMES system a small auxiliary power supply could be used to begin recharging the system to full stored energy, so that it would be ready in a couple of hours for the next shot. Either the auxiliary supply or the main storage device or an independent supply could be used for the modest motor needs of retrieving the sled to the tractor position. Manned access to the guideway between shots requires only that the energy storage device's connection to the guideway be switched off. It is only necessary to discharge the energy storage system to access that system, which is only needed during maintenance periods.

Segments of the system could be charged and operated independently of other segments, for troubleshooting purposes. Dummy loads could be fitted to the carrier for troubleshooting or launch preparation tests where the entire track performance requires verification. Low-power operation of the entire track, at full or reduced speed, under operator control would be possible, perhaps for a variety of smaller launch vehicles, at reduced hazard and increased flexibility and reliability.

Synchronous motors utilize permanent magnets on the traveling component and use a linear stator (typically with three phase windings) to generate a traveling magnetic field. The stator provides the magnetic force on the moving magnets that propel the carrier and flight vehicle assembly. In the region centered on the nominal zero-force (0 degrees) point the force is approximately linear with the phase displacement from the null alignment. One might think that it would operate at 90 degrees, because that is the angle with the maximum thrust. However, at 90 degrees, there's no controllability, because thrust doesn't change with phase angle for small perturbations. Therefore, one would probably operate at 60-70 degrees, where you can get ~ 90 % of maximum thrust with only a slightly nonlinear control curve.

The linear motor never operates anywhere close to zero phase-angle, even when pulling a light load. For that mode, power to the windings would be reduced and the 60 – 70 degree angle maintained. It should be pointed out, that since the same linear motor, whether synchronous or inductive is used for launch and sled retraction, they both have to be able to generate negative thrust and, therefore, zero thrust, so the concern about having no accelerating force under some operating conditions is certainly not a major one.

Some concern directed against the use of synchronous motors for linear vehicle acceleration is associated with the fact that the motor has modes where there is no accelerating force for certain angles of displacement. This is primarily a control issue and is not considered cause to rule out consideration of the synchronous motor at this stage in the system development.

An advantage of the synchronous motor is that permanent magnets can be also used for electrodynamic levitation, providing a lifting force which is a function of velocity. A separate advantage of using a synchronous motor is the possibility that high electrical efficiency can be achieved because of the need to provide only partially shaped sine-waves, but the use of modern power switching electronics developed for high-power DC power transmission will greatly reduce the influence of this concern. Since less power is required at the beginning of the track, motor segments for propulsion can be light duty (lower power capability) at the start and become more substantial near the middle of the track, where launch and separation from the carrier occurs. Energy delivered to the carrier plus vehicle increases linearly (Joules per meter) along the track, small at the beginning (to get it moving) to full energy just prior to separation. Energy delivered with time will increase as the square of the velocity, so the same amount of energy per meter is delivered in a shorter amount of track as the vehicle speeds up (time over a meter of track reduces linearly with speed). Power delivered as a function of distance is a square root function of distance.

One concept, that of distributing DC power along the track with distributed storage and three-phase sine wave inverters powering distributed motor segments plays to the concept of modular construction and the elimination of segment switches, whereby parts of the ground propulsion system could be readily isolated for service and troubleshooting. Use of hot, online redundancy of propulsive components during operation, where all would be contributing, so if one dropped out here or there the others in its drive circuit would pick up slack to maintain propulsive force and whatever fraction of levitation or stability control is required. In this mode, components would have to only operate on an intermittent duty cycle, reducing the need for cooling. For increased reliability there would be more active circuits and motor segments online than required for each launch.

Although it is true that there is a large variation in power, during a launch, from start to peak acceleration, the variation in thrust from a square-root function (with distance down the track) will be primarily caused by aerodynamic drag on the vehicle and carrier. At constant acceleration, thrust is nearly constant, except for drag. Thrust is the product of the current in the on-board magnets, which is absolutely constant during a launch and the current (times the sine of the phase angle) which is nearly constant in the guideway. If guideway current is nearly constant (rising only to compensate for drag), then the voltage and frequency feeding the guideway will be changing by large amounts as the vehicle accelerates, as noted in the recent report on Maglev Launch Assist / Technology Demonstrator produced by CEM, U/T Austin, TX.

Improvement in motor efficiency has little to do with the shape of the current waveform due to the nature of modern high-power switching design and fast switching and synthesis techniques. This way of thinking may be a holdover from intercity Maglev design, which tends to be dominated by the long guideway and relatively light vehicle. In the HLA case, the high real power needed for the vehicle and the low reactive and resistive power guideway will make all options relatively efficient. One estimate is that there is a factor of two between the best and worst motor winding / power conditioner waveform, but it would probably work out to something like 2 % losses vs. 4 % losses, so that all linear motors will be over 90 % efficient.

Induction motors take advantage of the fact that dragging lines of magnetic flux through a conducting medium produces a force that rises with increasing relative velocity and which peaks at a velocity that is an inverse function of the resistivity of the conducting medium. In the induction motor, the currents in the rotor are induced by "slip" between the speed of the electrically traveling fields and the physical speed of the rotor / carrier assembly. The "rotor" can be simply a sheet of conducting material, usually copper or aluminum. In order to increase overall electrical efficiency the conducting plate can be broken into segments to reduce eddy-current losses and loaded with magnetic material to achieve the same result but require less conducting mass.

The peak in drag force as relative speed between the magnetic field and the conductor is increased is caused by the fact that flux lines are pushed out of the conductor as their relative speed in the conductor starts to exceed their characteristic speed, the maximum rate they can travel in a conductor with that degree of electrical conductivity. The faster the speed, the less penetration into the conductor, the less interaction angle in the conductor, the fewer number of them that are in contact with or contained within the conductor, the less force (or drag) they produce on the conductor.

In the induction motor, currents induced in the rotor conducting material interact with the currents creating the induced field providing the propulsion force. Because of the requirement for inducing operating currents in the armature there is less clearance required between the rotor and stator in an induction motor, compared to the synchronous motor with the same capability. The stator winding arrangement for an induction motor is similar to that for the synchronous motor. Laminated iron is used in both cases to reduce induced currents in the conducting iron material in order to reduce electrical losses which result in heating and magnetic effects which also lead to reduced operational efficiency.

Control of power accelerating the vehicle is designed to carefully limit forces induced by acceleration and jerk on the airframe and flight components. This is a major concern in the overall system design, and in part, the main reason for using the electro-magnetic approach for HLA. Currents and voltages can be precisely controlled, at high speed, in order to achieve the level of performance required for this application. Modern power switching electronics and computer technology is believed to be capable of meeting this need without additional advance development.

Deceleration of the carrier after a successful launch (or flight vehicle and carrier on launch abort) is a key feature intended to increase system reliability and decrease the cost of launching payloads to orbit. If a launch is terminated with a fully fueled vehicle, all the energy supplied by the propulsion effort must be removed from the traveling hardware. The linear motor portion downstream of the center release point must be operated in a "generator" mode to extract and either dissipate or store this energy.

Low-speed, controlled return of the carrier or carrier plus flight vehicle to the base station is necessary, and one of the key reason for development of electro-magnetic launch assist. After launch, when the traveling carrier has stopped, the downstream portion of the linear motor would switch from "generator" mode to "motor" mode for retraction of the sled to the charging base station for re-launch. This activity requires much less power and energy, but this portion of the motor must still have capacity to remove and dissipate the energy contained in the carrier and fully fueled vehicle in case that scenario arises during a launch attempt. Rapid recovery of the carrier, after a successful launch allows timely return to launch-ready status for the next flight. Recovering the flight vehicle and carrier after a terminated launch attempt allows rapid and timely troubleshooting to be performed on a fully fueled vehicle. In this case the fueled vehicle could be levitated and returned to the base station and the engines fired horizontally, for instance, in a static test to determine cause of an engine problem that terminated the launch.

Levitation: Levitation refers to the process of isolating the carrier and flight vehicle from the ground track by "floating" the vehicle/carrier assembly on a magnetic field during acceleration, launch and recovery. This eliminates physical "wear and tear", reducing life-cycle maintenance, improving reliability by eliminating moving parts (high-speed wheels and support bearings) and the periodic maintenance associated with inspection, lubrication, etc. of moving parts.

One critical feature of a system that is tightly coupled is the mechanical clearances between the propulsion motor components and the levitation system components must be similar in scale, i.e., an induction motor is incompatible with a superconducting levitation system since the clearances are significantly different unless some method can be devised to de-couple the levitation and propulsion system components from each other.

Levitation Technology can be separated into two main parts. Active levitation refers to an actively powered magnetic levitation approach (attractive or repulsive) vs. passive (pseudo-attractive or repulsive) electrodynamic suspension, where currents induced in fixed conductive plates or assemblies (null-flux coils) by magnets which move along with the carrier and induce currents, which result in the levitation forces by virtue of the movement of the carrier.

For passive (electro-dynamic) levitation, once the carrier speed drops below some pre-determined rate, the levitation forces rapidly disappear and some alternate method must be used to levitate the carrier at low speeds so it can be moved along the track. Air bearings are considered a likely candidate for this purpose, but wheels and active magnetic levitation may also be considered. In all electromagnetic levitation cases, some means must be provided to control and contain the carrier assembly or limit its travel in sway (side) or plunge (vertical) movement, as there is almost no vertical or horizontal damping force inherent in any scheme.

Active electromagnetic suspension requires electrical power and an active control system to both lift and control the clearance between the moving and fixed components of the system. Attractive forces created by electrically actuated magnets on the sled consisting of iron pole pieces and coils powered by direct current (D.C.) can be quite strong, and are used in the German Transrapid Public transportation system installed in Germany in (TBD) and recently licensed and already operating in China. The air gap (clearance between the sled and the guideway) in attractive systems is typically limited to less than one inch.

The gap size can be controlled and power required to levitate can be decreased when permanent magnets are used to supplement the active levitation forces, as in the Magnemotion system. In that arrangement, permanent magnets provide the primary attractive levitation force. This permanent attractive force is modulated by currents circulating in windings wrapped around the permanent magnets to modify the fixed flux to maintain a constant air gap. When the weight of the supported hardware matches the attractive force of the permanent magnet and the sled floats at the nominal distance above the track (force greatly increases as the gap distance is reduced), no electrical power is required to levitate the load. This system is inherently unstable and requires active sensing and control to maintain a constant air gap, even under static conditions. If the two parts of the system are allowed to touch, the control system must supply sufficient power to effectively disable the permanent magnet until the air gap can be restored.

Levitation technology of the attractive type utilizes iron poles which are attracted to electromagnetic actuators using direct current (DC). Active iron or ironless levitation technology utilizes the changing flux of alternating current (AC) in the magnet coils to induce currents in conductive plates that interact with the inducing currents to produce the repulsive forces that perform the levitation function.

Stability is a major concern in the design of any dynamic system, and has various implications depending on the portion of the system under discussion. The stability of conventional control systems is not really the issue here, as this technology is well developed. Controlling the air or clearance gap of the levitated sled with active feedback falls under this category. One would simply apply adequate force when the gap is not centered, when the velocity is non-zero at the gap centering reference point or sensors indicate acceleration between the components forming the air-gap (before too much energy has been imparted, from whatever source). Controlling different portions of the gaps (fore, aft and side extremes) in heave and sway and maintaining a controlled pitch and constant heading for the traveler can be done with 8 actuators each capable of providing force in two directions along each axis located on the traveler (six degrees of freedom, overall) at the distal points.

Control: Control of the forces acting on components of attractive or repulsive levitation systems will be required in all instances where contact between fast-moving hardware components must be avoided. The main point is that the forces used to create the air-gaps are under system control and readily modulated to achieve stable operation in the classical sense. In the PRT Maglev Systems track located at Marshall Space Flight center, an active repulsive levitation system was operated in an open-loop mode, with no feedback or levitation force control recently indicated its limitations when the traveler achieved sufficient speed to literally fly off the track as there was no force designed in to restrict upward movement. In this, and many other instances, small tracks developed under the NASA/Bantam program (Foster-Miller, Lawrence Livermore National Labs & PRT Maglev Systems) are providing valuable experience & concept testing on a regular basis.

Passive Electrodynamic levitation: Passive electrodynamic levitation is achieved simply by moving a permanent magnet along a group of null-flux coils or over a strip of conductive material. Interaction of the flux lines from the magnet with flux lines created when currents are induced in the coils or conductor create repulsive forces that are capable of lifting the carrier during movement along the track. The only requirement is that the carrier must be moving relative to the fixed conductor at a speed that exceeds the “lift-off speed” for the levitated portion of the system.

Null Flux coils are a specific arrangement of vertical, figure-eight shaped of current loops designed to provide both vertical lift and horizontal centering forces as a permanent magnet passes in the influence region around each coil assembly. They provide discrete “levitation regions” along the length of the acceleration track with well-defined performance and repeatability. Part of the problem with null-flux coils is their discrete nature. In between two coils there is some loss of support to the traveling magnet which creates a periodic force, which varies in three dimensions with a frequency that is a function of the spacing of the coils and the speed of the carrier containing the magnet. At certain frequencies vibration resonates depending on the mechanical design and can induce instabilities in horizontal centering and levitation. The nearly complete lack of damping in the modes of vibration where resonance occurs is a major concern for system design. In early tests on a segment of the Holloman High-Speed Test Track, periodic induced vibration by the null-flux coils caused the superconducting magnets to quench, leading to test failure. Hector Gutierrez will address this concern as he studies the Foster-Miller track, currently located at FIT under a Young Investigator Achievement grant from the Naval Research Labs.

Flat-plate conductor: The latest (third) Holloman High Speed Test Track design utilizes an arrangement of four flat plates to eliminate the excitation of vibration modes by eliminating the periodic structure of null-flux coils. The levitation blade design does not use null flux coils but provides vertical support and centering using split copper plates on the wall of the blade slot. There is central space between the plates where propulsion coils could be mounted.

There was a magnet quench prior to launch at the first attempted test in September-03 and the cause is under investigation. The first dynamic test is now scheduled for February-04. In the case of the new Holloman design, the system has a rotational degree of freedom that is a slight degree of concern to HLA due to roll motion and the lack of damping in the roll axis. None of the modes in the Holloman design are actively damped. The magnet wing design incorporates an aluminum plate to provide some passive damping. A dynamic Maglev test is planned to see if there are any stability issues. The 6-DOF design implies that no catastrophic instabilities are anticipated. The Holloman design team does not believe active control is required for their specific application due to expense, complication, and large additional mass required for the application to solve this problem. There should be more data after the planned demonstration testing. Spreading the load support points out horizontally would eliminate rotational degrees of freedom may help reduce the concern for HLA.

The guideway proposed in the CY2000 AML/MIT study is not flat plate, but curved guideway, the same as the classic Kolm/Thornton Magneplane design. This allows banking without loss of track/vehicle clearance, yet has a powerful magnetic keel force to prevent roll. It also provides some mechanical protection against derailment.

The distinction being made concerning the use of null-flux coils is discrete vs. continuous guideway. The advantage of null-flux is that the losses can be an order of magnitude less than those of a continuous guideway. In return for that advantage, there are several disadvantages beyond vibrations caused by discretization. These include low clearance, stiff suspension; and, MIT believes, higher cost of guideway and guideway structure (null-flux benefits from more uniform current density than continuous guideway, but a figure-8 is clearly a worse structural concept than thick plate).

The advantage in efficiency is less significant for HLA than it is for intercity transit, because of the high mechanical load in a 2 g system. For the AML/MIT CY2000 reference design, using a continuous copper guideway, the worst-case drag/acceleration force was only 1.4 % at 30 m/s, dropping to ~ 0.7 % at 250 m/s. The use of null-flux coils will undoubtedly reduce the magnetic drag to well under 1 %, but this is clearly less important than their ability to reduce losses for intercity travel from 20-30 % down to a few per cent. Incidentally, null-flux coils may be most competitive as a method for reducing control power for the "minor" vibrational modes (e.g. pitch, yaw).

Since all stable modes are under-damped in a magnetic suspension system, it should always be necessary to have active damping of at least 5 of the 6 degrees of freedom, in order to guarantee flight control. Spreading the load support points reduces the variation in the roll degree of freedom, but active control will still be required to remove kinetic energy before it can rise to the level to cause collisions between the track and the carrier. The benefits of a guideway with lower passive excitation of vibratory modes should ultimately show up in the probability of success (the 7-8 9's), so ideas for eliminating or reducing discontinuities are probably still worthwhile.

The issue of flat plate vs. curved guideway deserves an independent design study. If it is decided, as MIT believes it will be, that continuous guideway is superior to null-flux coils, there are several guideway shapes that deserve consideration, including Blade (Holloman), Tee, U, and Curved (MIT/Magneplane). The MIT preference for the curved guideway in the Magneplane is, in large part, influenced by its ability to bank on curves, allowing tighter radius of curvature, use of highway rights of way, and greatly reduced cost. This is not a factor for HLA, so one of the flat-plate alternatives might be preferred.

The main tradeoff is that the Tee and the U should have the best orthogonal control geometry, but the greatest difficulty in achieving high clearance from both walls. They are almost certainly the topology of choice for attractive systems. The Blade has the advantages of low drag and significant operational experience at Holloman. It has the disadvantage of depending on a form of null-flux for vertical control and competing with the propulsion coils for central space. The advantages of the curved guideway are discussed above. The main disadvantage is that it has the highest tendency to develop cross-coupled modes in large perturbations. A flat horizontal plate by itself shouldn't be considered, because it gives no mechanical backup to magnetic restoring forces against derailment.

Fixed Permanent Magnets: Permanent magnets that interact with the linear motor used to propel the carrier along the track can be used simultaneously to levitate the carrier, provided there is enough velocity along the track to induce sufficient levitation currents. Currently the availability of neodymium-iron-boron magnets provide adequate flux at a reasonable distance to be effective for small prototype demonstrator systems. A typical application for these magnets has been the synchronous motors driving high-speed entertainment rides. For more specialized applications, in order to increase the flux of the permanent magnet, use of the Halbach arrangement with a group of magnets allows the forces on one side of the magnet to be substantially larger than those on the other side and increases the flux on one side by approximately a factor of two compared to a single magnet. The General Atomics "Low Speed Maglev Technology Development Program" (people transporter) prototype developed for the Federal Transit Authority uses Halbach Arrays for both levitation above a re-arrangement of Inductrack-type coils and propulsion with a synchronous motor.

Another advantage of permanent magnets is that they can be distributed through the length of the sled, while superconducting magnets may have to be confined to the fore-aft compartments of the sled or moved into outrigger pods. This has nothing to do with any intrinsic badness in superconducting magnets, but simply reflects the fact that the motive for using them is to operate at higher magnetic fields, which can't be as effectively shielded by lightweight iron backing plates. The lower field of the permanent magnet option also makes it easier to satisfy the stray field requirements. A disadvantage of permanent magnets is that they are brittle and, if they take advantage of not needing a cryostat to reduce the air gap, they are more likely to be damaged by a grazing collision.

Superconducting magnets in persistent mode operation: Where larger flux is required, as in full-sized demonstrators or operational systems carrying passengers or large vehicles, it is perceived that the air gap must be larger, primarily due to the belief that small air gaps cannot be maintained using current control methods with permanent magnets for large, high-speed (~Mach) vehicles. Larger clearance between the sled and the guideway is likely to increase the reliability of a system and reducing the maintenance effort of the track. With small air-gaps, frequent, time-consuming survey and alignment of the track would be necessary. Superconducting magnets with flux up to ten times greater than those available with permanent magnets have been proposed, and several have been built precisely for this service. They weigh less than permanent magnets even when producing significantly larger fields.

By achieving greater air gaps, the clearance concern is perhaps somewhat reduced, but the same overall problem exists. With a sufficient amount of stabilizing copper in the superconductor magnets, they can be very stable and behave almost like permanent magnets. With such magnets, an acceleration cycle can still be completed, even in the unlikely event that the superconducting magnet quenches during a launch. Such superconducting magnets behave like permanent magnets, but with the additional benefit that they can be switched off (there is some concern in the community that large permanent magnets, as required for Maglev, could be extremely dangerous under some operational scenarios).

MIT advocates active ride control for all degrees of freedom. In the AML/MIT CY2000 design, the reference air gap between the sled and the guideway was 7.5 cm with 9.5 cm from the guideway to the coil. In the most recent design for the Holloman track, the gap between the sled and the guideway is 3 cm.

NbTi is far and away the most extensively used superconductor. It's inexpensive and ductile and it only tends to "lose" to Nb3Sn or other more advanced conductors in high field or high current density applications. For 5 T design with stringent stray field requirements, it would almost always be chosen. However, the unique driving factor for this design is the "7-8 9's" desired for reliability, putting a premium on superconductors with energy margins so high that they can absorb any conceivable perturbation without quench.

The A15 low temperature superconductors, Nb3Sn and Nb3Al, with zero field critical temperatures of 17-18 K are an order of magnitude better than NbTi in this regard. The high Tc superconductors can be two orders of magnitude better. Nb3Sn has the advantage of the second largest amount of experience, use in state-of-the-art high-energy physics and fusion magnets, and commerical NMR. Nb3Al has the advantage of higher strength and lower strain sensitivity with similar performance, except for the most advanced HEP Nb3Sn strands. Nb3Al is more expensive and harder to fabricate in long lengths. This has always led to Nb3Sn being selected for fusion and HEP, but may not be decisive for HLA, which only uses a modest amount of superconductor. BSSCO-2223 is the most widely used high temperature superconductor. If operated at 20 K, it should be possible to design with it to 5 T. However, it is very expensive and only exists in 100-200 A tapes. BSSCO-2212 has the same extremely high energy margin as 2223, can be made in strands and cabled, and has recently been used to add 5 T as an insert in the world's highest-field steady-state solenoid at 4 K. It is also very expensive and is only sold for research purposes, at present. MgB2 is the least mature, but is developing rapidly, and should have very high energy margins. It has a small benefit for this application that it is the only superconductor with a low mass density, that of aluminum. It is brittle and very expensive, but should have very low intrinsic material costs, if it becomes developed.

There are so many considerations in selecting a magnet topology they can't all be discussed in a paragraph. It seems clear that the overall shape of the windings should be racetracks. However, the winding type could be cable-in-conduit conductor (CICC), Rutherford cable or monolithic conductors, cooled in a helium bath or by an on-board cryo-cooler, or there could be a minimal bath, with refill or detachable cryo-cooler cold head before a shot. There are also several different options for joints, internal structural supports, gravity supports, thermal isolation, electrical isolation, and instrumentation feed-throughs, and on-board controls or telemetry.

Inductive Charging of Superconducting Magnets

The superconducting magnets on the sled should operate in a persistent mode to avoid the necessity of locating a power supply to drive the magnet on the sled. If the terminals of a superconducting magnet are connected with a superconducting "short", the magnet will operate in a persistent mode after being charged. The charging can be achieved by inductively inducing flux into the coil with the help of a second magnet, located at the charging base station. Calculations made by MIT/AML have shown that the superconducting magnet would maintain its flux for more than ten hours.

Flux-trapped (superconducting) permanent magnets: High-temperature superconductors (HTS) can be used to build so-called flux-trapped magnets. For this purpose, a block of HTS in the normal conducting state is placed inside of a strong magnetic field. When the HTS material is cooled down, the flux that penetrated the HTS is "trapped" and the HTS block behaves as if it were a permanent magnet when the exciting field is removed. The flux-trapped field remains as long as the HTS block is kept cold. Flux-trapped magnets with fields up to ten Tesla have been produced. The advantage of the "block" form of HTS is that no windings are required or utilized.

Charging of flux-trapped Superconducting Magnets: Similar to the inductive charging of superconducting magnets, flux-trapped magnets require extra magnets for the charging process. If fields of several Tesla are required for flux-trapped magnets, superconducting charging magnets will (most likely) be required. These magnets would be located in the charging base station and brought into close contact with the flux-trapped magnets located on the sled. The flux-trapped HTS magnets would be in a normal conducting state when the charging current is ramped up to the nominal field. In this state the flux lines from the charging magnet can penetrate the HTS material. When the charging field has reached the nominal value, the HTS material is cooled down and the flux-lines are trapped.

Detachable leads: An alternate approach, where wound coils are used, would be the use of retractable power leads, like those used on NMR magnets. There is some experience, based on the Levitated Dipole Experiment, where the use of inductive charging vs. retractable power leads was selected, due to reliability concerns. A lot of experience and insight into the difficulties in inductive charging was acquired during the experiment, and the situation might prove to be more difficult for Horizontal Launch Assist.

By contrast to the difficulty of inductive charging, the use of retractable or detachable leads in experiment proved to be much more straightforward. Under this scenario all of the levitation coils would be wired in series with each other, as would all of the propulsion coils, so a single pair of leads would be adequate for each subsystem. The only disadvantage of using retractable leads is that the current capacity and relatively high number of cycles hasn't been qualified for this application. However, there is no reason why they shouldn't be feasible. Size-scaling is neutral (i.e. if the coil and its current requirements double in size, the area and contact area of the leads double in size). Even if it isn't possible to reuse a detachable lead 20,000 times (if this is still the specified number of current excitations for the HLA system), it is easy enough to detect failure, before the beginning of launch. One could then either postpone launch or simply charge the coils with spare pair of leads.

The easiest geometry for inductive charging is a single, large aspect ratio solenoid. The HLA sled, however, proposed in the AML/MIT 2000 Design Report, had 8 levitation coils and 30 propulsion coils. The levitation coils were long and thin and all coils were close to each other, making it difficult to couple flux in from outside. The design could be improved for inductive coupling, if this were selected. However, coupling efficiency must always be less than one, and in this case, much less than one. Therefore, the inductive charging coils must have higher field and current than the coils on the vehicle and be more expensive. It may even push the limits of present magnet technology to achieve the fields and current densities needed, if the coupling coefficient is very low, as it would be in the AML/MIT 2000 Design, where the levitation coils are long and thin with opposed polarities. Furthermore, since the fields must be higher than those generated by the vehicle magnets (which themselves must go significantly beyond the best permanent magnets to be worthwhile), these coils must also be designed for difficult flux leakage requirements.

The most likely thing, in fact, is that the contacts will start to wear out while the detachable leads are still functioning, and that this will be obvious through visual inspection or resistance measurements and the lead could be refurbished or replaced by a spare with no effect on a launch. It is anticipated that detachable leads would be at least two orders of magnitude less expensive than charging coils, as it appears that lead failure could be addressed by periodic maintenance procedures, a normal mode of operation in an operational environment.

Charging coils with detachable leads and superconducting switches has been done successfully with NMR and MRI magnets and experimental levitated dipoles. A pair of current leads with flexible contacts on the surface are used to charge a string of levitation or propulsion coils in series to guarantee equal currents. A heater is used to keep a superconducting switch between the terminals in the normal state. After charging, the switch is allowed to cool down to the superconducting state and the leads are retracted. These leads can be inspected for wear between shots and the stationary on-board contact areas can be inspected frequently. The main advantages of detachable leads over inductive charging are assumed to be cost, size, feasibility, and the absence of stray field. The disadvantage is the use of sliding contacts that may require periodic inspection and maintenance. Development of higher current superconducting switches (than currently available?) would also be required.

A less important point: inductively charged and flux-trapped superconducting magnets are basically the same thing. They are both charged in the manner described in the flux-trapped magnet section (i.e. flux is linked by an external magnet while they are normal, they are cooled down and the external magnet is ramped to zero, trapping flux and current in the on-board magnet). The above discussion implies that there is a difference between the two concepts, and that there may be a difference between low temperature and high-temperature superconductors in this regard. They really are all the same mechanism. The time needed for heating and cooling of all the coils is another disadvantage, compared to the highly-localized heating of a single superconducting switch needed with detachable leads.

Finally, a third option that may be worth exploring is the use of fixed leads and an on-board battery supply. All propulsion coils and levitation coils would still be wired in series, so there would only be two active power supplies needed. It would have the reliability advantage of fixed leads without the need for a superconducting switch. It would have the disadvantage of the weight and space needed for the power supply and additional refrigeration requirements from the lead losses. On-board power supplies may already be required, because of the need for active stability / vibration control.

Stability: Vertical and horizontal stability of the carrier as it interacts with the propulsion and dynamic separation forces is the real issue for concern. These comments apply primarily to passive suspension systems. With active control, the controller is the mechanism that removes vibration and displacement energy from the system, eliminate system resonances, and keep the vehicle out of the large displacement zones corresponding to hazardous conditions. It is obvious that passive suspension systems by themselves are incompatible with the goal of 7-8 9's, but in adding active control to a passive suspension, the goal is becoming to appear achievable.
There is a restoring force, to some degree, in all electro-dynamic levitation systems, when in normal operation the restoring force gets larger as the gap distance increases or decreases from its nominal centered position. In an automobile, when shock absorbers are worn out, energy added to the suspended load by the road in a periodic manner (only two or three cycles are necessary) can rapidly cause deflections that lead to the suspension system

"bottoming out" produce large, transient forces that can produce metal fatigue over time. In an electrodynamic levitation system, where there may be no hard-point designed into the system to restrict movement of the sled, the levitation magnet may simply leap out of the confining gap and lose all suspension and restoring force in the process.

There is no mechanism inherent in these passive levitation systems to remove energy that might be entered in a periodic or non-periodic manner and dynamically stored in the hardware components that might lead to operation outside the region where restoring forces are effective. At slow speeds, the kinetic energy in the moving hardware is small and restoring forces of the levitation system can provide sufficient force as to keep the levitation magnet in the "groove". Provided there is no resonance effect, where energy is added to the system in a periodic manner that might excite modes of vibration in the hardware components, restoring forces of the levitation system will likely adequate to maintain system integrity during low-speed acceleration. As speed increases, aerodynamic and other forces begin to act and depending on local resonance opportunities can create moments when hazardous conditions might exist.

In all likelihood, in a system of fixed dimension and mass of critical components, when the propulsion frequency increases from low tens of Hertz through hundreds of Hertz, there will likely be points where cross coupling between modes of vibration between orthogonal axes caused by misalignment during operation will possibly induce vibration that might cause components to become sufficiently unstable as to exceed the linear range of restoring forces. Precisely how these incidents will occur will be a function of the system design, control of tolerances and other factors may be visible only through modeling or test. Eliminating one resonance may shift the frequency to another unknown one, and the hazard may still exist at a different frequency. These concerns can be readily addressed by modeling the hardware.

The decisions at this point are resolved to a choice between different suspensions, all of which are in principle controllable. The attractive suspension will be unstable toward heave, the repulsive suspension will be stable but under damped. It will also be stable, but under damped, with respect to pitch, jitter, sway, yaw, and roll. Unstable motions will require a faster response time from the control system, as will small gaps and stiff suspensions. Each mode should be independent, if not orthogonal, for small perturbations with cross-coupling increasing for larger perturbations. Similarly, control systems should be orthogonal for small perturbations, but not for large perturbations.

Control: The probability of a controller failure that is nominally operational is a function primarily of wind shear patterns, tolerances, including diurnal track/ground/sled shifting, and changes in load distribution. It is assumed that there will be adequate redundancy in sensors, electronics, and controllers. Analysis at this level of detail will only be possible after a design is specified and adequate modeling experience, including model validation by experiment is complete.

It appears that modal analysis will provide adequate design insight. A dynamic control system must and can always eliminate all resonances, when the active controller is included in the equations, and the design solution will be deterministic, not stochastic. Since resonant, even nonlinear coupled, frequencies are a function only of mass, stiffness, and magnetic load, there's no excuse for having an "unknown" resonance frequency. Frequently, some of the higher harmonics (100's of Hz, rather than Hz) are the hardest to control; because even if they are known, it's difficult for any controller to have a rapid effect on a large vehicle.

Active control against perturbations has to select between pulsed control magnets, ailerons, or jets (including hydrogen, water, fans, and gas guns?). Hybrids are, of course, conceivable, but it will probably be simplest to choose one. One imagines that ailerons are simplest and require the least power, but may have the slowest response time and the fastest metal fatigue. They are also less effective at low velocity. Jets may be the most expensive and complex, but the most powerful. Magnets could be the heaviest, requiring auxiliary pulsed power supplies. They would also be the most vulnerable to saturation in large deflections, due to cross-coupled modes. Internal, smart shock absorbers have also been proposed as a method to damp vibrations in high-speed Maglev.

Theoretically, there have to be at least eight controllers in addition to the use of the linear motor for propulsion and jitter control of heave through phase adjustment in the LSM driver during acceleration. There would be 2^3

controllers, whether ailerons, jets, or magnets, on the sled: horizontal and vertical in the fore-port (FP), fore-starboard (FS), aft-port (AF), and aft-starboard (AS) positions. Alternatively, one could also conceive of having a large number of control "cushions" in the guideway that would be triggered by proximity signals.

Aerodynamic Levitation (Russell, Sepri)

Advantages of HLA, additional information on the likely flight vehicle speed on the ground, dynamic instability (flutter) of the vehicle and the carriage and components. Wet fueling possibly during acceleration along the ground [4].

Stability: Historic wind patterns, at say, Cape Canaveral are well known, and the effect on reliability of different "launch scrub" policies can be modeled. Tolerances can be handled by Monte-Carlo techniques. Load distribution for different types of rockets, cargo, and passenger can be calculated. Therefore, the probability of a vehicle going out of range can be calculated, and different design options will be calculated to have different probabilities of derailment, bottoming, overheating of the track by rocket exhaust, etc. When quantitative results are available, they will reveal the relation between stable vs. unstable, soft vs. stiff, maximum deflection to derailment or bottoming, etc. and the probability of failure. Until these tools are available and calibrated, anecdotes about individual events of hopping the track or bumping into it are of very limited design utility, especially if no system has ever attempted to achieve active control of all modes of freedom.

Control

Low-speed return to Launch Position

Energy Storage (~ 100 GJ)

Substantial stored energy will be required to launch a vehicle with a fueled mass of 1,000,000 lbm. According to a recent study by the Center for Electro-mechanics, University of Texas, Austin, approximately 23 GJ would be required for the vehicle (including drag). An estimate of an additional 27 GJ for the added mass of the carrier sled, potential extra hardware that might be required to ride on the sled (top-off fuel tanks), allow for system redundancy (to provide sufficient reserve to achieve high reliability (seven nines) during acceleration), system inefficiency, etc. This gives a rough system requirement of 50 GJ for the planned vehicle. Schultz [1] offers several suggestions for reducing the stored energy and launch peak power.

Chemical: Storing energy in chemical bonds

Static (Batteries): A standard car battery, 80 AH, 12 volts stores 3.5 MJ. If 20% is available over a ten second timeframe, it would require 72,500 batteries to operate the system (50 GJ) for one launch. At one cubic foot per battery (allowing for access and maintenance), the batteries would require a cube 42 feet on a side. Distributed along the length of the track (2.3 km / 7,545 ft) would require ~ 3 ft square housing running the entire length of the accelerating portion of the track to contain adequate energy for launch.

Dynamic (Combustion, MHD)

Mechanical

Static (Compressed air, weight / gravity, etc.)

Dynamic (Flywheels): Overall the system would require flywheels with ~ 100 GJ stored energy, as ~ 50 – 75 % of the energy in a flywheel can be extracted at high power. As the rotor slows down the induced voltage drops and load current must increase to maintain rated power output, leading to excessive IR heating of the output stator windings.

The issue of power distribution (for power sources distributed along the track) was addressed by Youngquist [2]. It turns out that power demand is a square root function of distance along the track, for a linear, constant acceleration model. For identical storage devices, this translates to a varying number of storage devices, greater toward the release point, less at either end. In the case of flywheels of the same size, they will have a rated power capability, leading to an issue for distribution of fixed-size flywheels along the track for the purposes of reduction of losses, power redundancy, etc. The power equation can determine the density of flywheels to minimize losses due to line resistance. How much of this will be a major factor in the final design will be determined during trade studies for the system.

Electrical

Static (Super-capacitors)

Dynamic / SMES A SMES system stores energy in the magnetic field produced by a direct current flowing in a superconducting coil. The stored electrical magnetic energy is transferred into and out of the coil through a solid-state power conversion system. The intrinsic speed of the solid-state system enables almost instantaneous delivery or absorption of electrical energy.

It is generally accepted that SMES units are preferable to capacitive storage devices, rotating electromagnetic generators, and battery packs. The US Department of Defense reviewed existing technologies potentially capable of providing the required services and chose SMES as the most promising technology because of its virtually instantaneous response, the almost loss-free storage of energy in the magnet coil, and the extremely low environmental impact of the system. It also can be assumed that a larger fraction of energy can be removed from a SMES storage device compared to mechanical flywheels, reducing storage requirement to ~50 GJ.

Flywheels (with superconducting bearings) and SMES are probably fairly-evenly matched contenders for the HLA energy storage system. In the first place, while SMES can do better than charging down to ½ of its original stored energy, it can't possibly discharge to anything close to 100 %. In a study for the NAVY aircraft launcher system, the SMES system was determined to be able to be reliably discharged down to ¼ of its original stored energy, but it comes at some cost. If you charge down to ¼ of the original energy, the current in the SMES magnet is down by a factor of 2. If it were a uniform power system, this means that the terminal voltage would be up by a factor of two.

Unfortunately, a constant acceleration HLA system is at peak power at the moment of minimum current, further exacerbating the voltage requirements. For example, a SMES system with an initial current of 60 kA, accelerating a 590 tonne load at 2 g to a final velocity of 268 m/s with an overall system efficiency of 70 % would require a peak power of 3 GW to the vehicle and 4.4 GW from the SMES coil. If the SMES coil had discharged to ¼ of its original energy, it would require 40 GJ of magnetic storage. The problem is that the current has reduced to 30 kA at this point, so that the terminal voltage is a very high 150 kV. If the current were reduced by another factor of two in order to extract more energy, the voltage would double again. This, of course, is not such a bad tradeoff, in that one can extract most of the energy without a very large voltage riser, but it means that the practical superiority of SMES to flywheel energy extraction ratio is probably closer to 1.5 than 2.0. Several flywheel systems have been fatigue tested down to ¼ energy and 10,000 cycles, so it is possible that flywheels will be significant player in HLA design trade studies for various scale model systems.

Flywheels have other features superior to SMES, which is why they were originally selected for (Electromagnetic Aircraft Launch System) EMALS and why they are so much more common than SMES today for other applications. They don't require cryogenic refrigerators, they can be made of advanced composites and therefore tend to be more lightweight than SMES systems and they can directly drive the shaft of a commercial three-phase generator. On the other hand, they are subject to fatigue and require qualification for 20,000 cycles. (Although the literature indicates that several materials have been tested to 10,000 cycles to ½ speed for space applications.) They are also harder to operate with very rapid response time than SMES.

The losses in a flywheel system will be, in all likelihood, relatively unimportant, when the analysis is completed. In any event, the cost of electricity is not a dominant factor. At 10 cents/kW-h, the electricity cost of a 50 GJ launch is $1,400. Superconducting bearing developers claim that 2 % loss/day is achievable, corresponding to $1.17/hour in a system that is specified to be 75 % discharged at up to 6 launches per day. Superconducting magnets and flywheels have comparable thermal and pulsed losses; losses shouldn't be a dominant concern for either system.

Single magnet, centrally located on the track: At the beginning of the 90's an EBASCO team developed a conceptual design of a very large SMES unit, which was scalable in energy storage from 21 MWh (75.6 GJ) to 5000 MWh (18,000GJ). The high-end system with a storage capacity of 5000 MWh was meant for diurnal load leveling applications. The low-end unit of this design effort was the so-called Phase-I SMES-Engineering Test Module (ETM), which had the dual purpose of demonstrating the use of a SMES device for the Strategic Defense

Initiative and to perform load-leveling functions for commercial electrical utilities. It was based on a 60 kA conductor in a solenoid coil configuration.

Distributed storage magnets: Advanced Magnet Lab, Melbourne, FL (AML) has recently developed the concept of a "Distributed SMES". In this concept a string of simple solenoid magnets is operated along the guideway, possibly inside or under the guideway support structure. The magnets are sized in such a way that they store the necessary amount of energy needed in the section of linear motor adjacent to the magnets. A connection between adjacent magnet cryostats allows transfer of cryogens from magnet to magnet. The energy for sections of the guideway is extracted from the magnets close to the point where it is needed for the linear motor system. The size and complexity of the power transmission between the SMES system and the linear motor is significantly reduced, and power losses are much smaller.

A Distributed SMES (DSMES) system for energy storage of the MagLifter would offer significant advantages. The superconducting magnets that are needed are simple in their construction and can be mass-produced for low cost. The magnets would have an aperture of about 1.35 m and would operate at a modest magnetic field of about 7 Tesla. The magnets are built with a NbTi superconductor, which is significantly less expensive than Nb_3Sn and also the coil construction with this type of conductor is much less expensive.

The technology of solenoid magnets is well established. The magnet design could be highly optimized by building and testing a few prototypes, for relatively little money. As in accelerator applications a short string of such magnets could be set up and would allow a thorough qualification program before the actual MagLifter system is being built. It may be assumed that a large amount of helium might be required to support a SMES storage device, but it should not require much of a drain on the National Helium Reserve as most of it will be contained or recovered during operations.

From an operational point of view the DSMES would also offer significant advantages. A large experience base exists from the high-energy physics accelerators, where these magnets are continuously operated for many months without any interruption. If any repair work is needed at the system, the DSMES system is far superior to a large toroidal magnet. The warm-up and cool-down time for a large magnet, which stores 36 GJ could take several weeks. The magnet cryostat can only be opened for repair work, if the inside has reached room temperature. For a string of small magnets, the individual magnet needing repair work or a group of magnets can be brought to ambient temperature and cooled down again within a few days.

Although, the probability of a quench in a large toroidal coil is extremely low, if a quench does occur, it would lead to a significant down time of the whole system to allow cool-down of the magnet coil. For magnet strings the quench can be localized to one or a few magnets and the operational temperature can be restored more rapidly. Also, quench protection system would be much simpler for the DSMES system than for a large toroid.

It would be advantageous, but not necessary to install the DSMES system in some kind of tunnel structure or extended building. This enclosure could at the same time serve as a very robust support structure for the MagLifter guideway. As a long string of solenoid magnets, the stray magnetic field would be extremely low and would meet stringent requirements.

The proposed novel DSMES system for MagLifter energy storage has a very low technical risk. The necessary magnet technology is fully developed and the reliability of such system has been proven at several laboratories. Since a standard NbTi superconductor without special requirements can be used and magnets can be produced in a large series, the overall system cost should be less than a single SMES unit, which has to be assembled in-situ. A DSMES system could easily be extended in length and therefore has intrinsic scalability features.
Certainly, enough modularity to operate with one magnet system out would give a quantum jump in availability. There are several potential disadvantages to the distributed storage concept. The first point is that that the overall system mass of magnets and cryostats can't be better than a single magnet system and cryostat and is almost certainly worse. The virial theorem places fundamental limits on the amount of structure needed per unit energy, less mass is needed in the conductor or lower current density for the same mass, and the surface area/volume ratio is best for a single, large cryostat. The theoretical and historical benefits of large magnets are discussed in the

literature, e.g. F. Moon's 1981 monograph, "The Virial Theorem and Scaling Law for Superconducting Magnet Systems."

There are also system problems in paralleling and seriesing an array of small magnets. No matter how many segments the track is divided into, the real power requirement of a 2 g x 590 tonne x 268 m/s vehicle will be at least 3-4.5 GW from the coil system, requiring peak total currents and voltages on the order of, for example, 60 kA and 150 kV. If the output of the coils is paralleled, special care has to be taken in order to ensure that each coil contributes the same current and lead losses can become prohibitive, using independent cryostats. If they are seriesed, care has to be taken to insulate and float some of the coils off of system ground. Of course, since coil currents have to be processed through power electronics before reaching the track, in which massive parallelism of solid-state switches is already necessary, a systems study may show that the incremental complexity of multiple magnets is not that important.

Another point; if the small coils are in individual cryostats, the cost of cryostats and vapor-cooled leads and the vapor-cooled lead losses will increase enormously. However, if the small coils are in a common Dewar, then the time to cool down and warm-up the system will be little better than a large magnet in a common Dewar. In between, (i.e. a larger number of coils than cryostats by a factor of 2, 3,…n), there is a continuous tradeoff in maintenance and cool down time vs. complexity, parts count, and radiation and lead losses.

The comparison with accelerator magnets can be viewed another way, and may require more detailed analysis. The HLA SMES system has to do up to 6 deep discharges a day, allocating only ~ 12.5 s/discharge. This is much more highly pulsed than any accelerator magnet, and many accelerator magnets have exhibited severe ramp-rate limitations. The SMES systems ought to be able to ramp down more rapidly than ramping up, but units of this size still have to be qualified for HLA SMES operation. The more expensive fusion CS Model Coil concept, using Nb3Sn and Cable in Cable in Conduit Conductor (CICC), has achieved higher rampdown performance than required for HLA SMES.

There is some difference of opinion on how well NbTi is understood and there might be a need for additional research in this area. Commercial use of NbTi is steady-state, low current, and low energy. The only other application, using large numbers of magnets – accelerators – are perhaps similar in some ways to the sort of magnets needed for HAL SMES, in terms of using cables, moderately high current, and high-quality strand. However, they are very different in other ways in that they are multipoles (dipoles, quadrupoles, hexapoles,…etc.), rather than solenoids or toroids, their cold mass is dominated by iron yokes (to reduce stored energy and tightly contain conductor motion), while an energy storage magnet must be air core, and can't be as tightly clamped. It is true that NbTi is less expensive than A15's or HTC superconductors, but it's energy margin against the heat generated during deep discharge is an order of magnitude less than Nb3Sn and orders of magnitude less than HTC, so that the probability of quench during discharge is much higher.

Finally, in the absence of an iron shield, the best configuration for eliminating leakage is a toroidal magnet. A system of alternating +/- solenoids in a "magnet farm," might be next, but it doesn't have the reliability gain of operating with one magnet out. A string of same-polarity solenoids with shunts could be operated with one magnet out, but it will be very difficult to satisfy the requirement for < 2 mT at the loading ramp and < 10 mT at 1 m below the coil, especially if the coil tunnel is part of the guideway supports, as suggested above. It does appear that while either the "big" SMES or DSMES can be made to work, it is a new application that needs to be qualified and does not have an adequate data base.

Electrical Power Conditioning and Delivery (10GW, pk)

Approximately 3.7 GW peak is required to meet the energy needs for the vehicle itself. Extra capability will be required to include power for accelerating the carrier and whatever hardware is included on that item. More will be required for some level of redundancy to meet the needs of high reliability during acceleration. If the carrier is 100 meters long (it might tow a section of covered material to protect the track while the engines are being fired, for warm-up and health monitoring purposes, prior to separation), and this power is available to accelerate the vehicle, it amounts to 100 MW per meter of linear motor drive capability at the peak or release point. At Mach, one meter of motor would be illuminated for approximately 300 milliseconds.

Power distribution between storage and load circuits: Depending on the specific approach to powering the propulsion coils, some arrangement for transferring energy from the storage mechanism and the load is required.

Semiconductor power switching for sine wave generation
Room temperature versus tailored low temperature semiconductors to improve performance

IGBT (Insulated Gate Bipolar-junction Transistor)
SCR (Silicon Controlled Rectifier)
GTO (Gate Turn-Off SCR)

Semiconductor power switching for segment isolation: If a central three-phase (alternately 6 or 9 phases) source is provided, some mechanism must be provided so as to switch on only the segments directly under and immediately ahead of the traveling carrier and vehicle. These frequencies and power levels are of a magnitude that currently available SCR's can handle.

SCR
Other
Direct transfer, Flywheel to track (Glenn approach)
Dedicated segment / power driver (no transfer switches): Pairing each propulsion segment with its own dedicated inverter, synchronously linked to the master propulsion frequency and connected to a D.C. power distribution bus will eliminate the need for segment switches. Use of steering diodes will allow sharing the D.C. feed lines for redundancy purposes. Fuses will protect the system from diode short circuits.

There is some concern that segmenting the track will give few benefits and that a system trade will reveal that no more than one or two sections are called for. In an intercity Maglev system, there may be segments every few kilometers in order to limit inductive effects, reduce resistive track losses and allow for the use of multiple traveling vehicles on the same track. However, in this case, the acceleration is so high and the entire track only 4 km, that it is possible that it is not necessary to segment the track to enhance efficiency, but may prove necessary to achieve the desired reliability. There is some thought that the acceleration profile might be tailored to reduce peak power for personal transportation systems (i.e. acceleration is higher at low velocity, lower at high velocity). Since the peak/average power ratio is only 2:1 with constant acceleration, this will probably reduce peak power by ~ 1.4:1 at most.

If there is more than one dedicated power driver with no transfer switches, each driver would require access to a shared (both feed and load, for reliability) DC bus. Development of power drivers at a standard power rating compatible with all segment requirements could lead to economies of scale. Integrating the propulsion winding with the power driver, would reduce the number of segment leads at each interface. In this instance the trade study will have to be done, but it should at least be presented as a design option, not a fait accompli. Except for reliability concerns it is likely that a single segment Y-connected, three-phase winding may turn-out to be the simplest, least expensive, most reliable alternative.

Separation Dynamics
Separation of the vehicle at launch will transfer all levitation and propulsion forces from the carrier / vehicle combination to the flight vehicle alone. Sufficient momentum must exist in the flight vehicle for the propulsion system to come up to flight power without losing significant altitude, or alternately, the propulsion system must come up to speed from takeoff (separation) power to full propulsion power without significant loss of altitude. There is a bit of disconnect here, since, if full engine power were applied while the flight vehicle is still on the track, the electro-magnetic propulsion system would not be necessary. Under this scenario, fuel would be required to be fed to the vehicle while it is accelerating under its own power and levitated either actively or passively.

It was initially assumed that flight propulsion system would provide 2 g's acceleration but some comments have indicated this may be more like 0.5 g. Under those conditions, the acceleration must be reduced from 2 to 0.5 g, with an acceptable level of jerk, while traveling near Mach, just prior to release. The Woodcock paper refers to 0.25 g with the balance of power (to achieve 0.625 g max) supplied by the vehicle propulsion system, but he also mentioned a 1,400 ton accelerated load (carrier and vehicle?), but only needing to achieve 100 m/s then the flight propulsion system would add to the acceleration force (~ 0.5 g) for a liftoff speed less than 200 m/s.

Dynamic Wind loads: Depending on the launch site, direction of winds at the moment of launch may be predictable or quite random, requiring some abatement for nominal to extreme conditions. A local weather mesonet (20 mile coverage around the launch site) containing wind speed and direction, humidity and other critical measurements would meet the needs for installation. These are standard techniques at KSC.

Clearance and vehicle acceleration: It is possible that if the full power of the on-board vehicle propulsion system were to be applied for the entire trip along the ground, and fuel were added to the vehicle as it accelerates, until separation, no propulsion power from the ground would be required at all. The hitch here is that no oxidizer is available to the engines (ramjet) until ~ Mach-1 is achieved, unless LO2 is supplied along with fuel during the run-up on the ground. Carrying sufficient LO2 could add substantial mass to the traveling sled assembly. This unlikely scenario should be pursued further since the electromagnetic ground propulsion system is most likely to prove to be the least reliable and most expensive component of the overall system, excluding the civil engineering and construction portions.

The process by which the vehicle engines fire or warm up during acceleration down the track (starting at perhaps 10% power) and then achieve 100% power at separation will require close coordination between the track real-time controller and flight vehicle. It is possible that the track will not necessarily provide all the energy necessary to achieve Mach on the ground, and that much of it could be provided by the vehicle engines near the separation point. In any case, to reduce hardware damage by transient separation forces, careful attention to the vehicle and appropriate response by the ground side propulsion system will be required. In order to reduce flame damage to the track during vehicle powered operation, the traveler can pull a covered tail segment behind it, perhaps covered with some ablative material.

There is something to be said for the case when the ground speed might substantially exceed Mach in order to reduce the size of the engines, or for some other reason, primarily associated with the flight vehicle. These are all vehicle concerns that will play critical roles in the development and design of any launch assist mechanism.

Traveler recovery: The carrier must be stabilized and slowed immediately after separation. Unless the propulsion system is at full power (able to immediately maintain speed when released from the ground) the vehicle will slow rapidly from aerodynamic drag once it is released from the carrier. The dynamics of separation must be carefully designed to make sure the vehicle is clear to make sure the two do not collide with each other.

Drag to halt, retract to Start / Charging Station after launch scrub: Slowing the carrier, which may weigh a large fraction of the fueled flight vehicle, perhaps maintaining it underneath the flight vehicle, after separation, to protect the track during the launch timeframe, bringing it to a dead stop and returning it to Start / Charging Station position, in preparation for the next launch will be part of the overall linear propulsion system design.

The authors of this paper generally agree that Separation is the single most critical transient in the launch process and deserves a separate Level 4 design study. However, there are three known jolts to the system, in order of importance: 1) Separation, 2) Rocket Firing, and 3) Magnetic Liftoff. Rocket firing and liftoff are more critical transients than traveler recovery, retract to start, etc. and they are unmentioned in this Work Breakdown Structure (WBS).

The issues of dynamics, wind loads, etc. are common to all of the sudden transients. Therefore, I would reorganize this section with perhaps a Level 4 title of "Rapid Transients", Level 5 of "Vehicle-Sled Separation," "Rocket Firing/Vehicle Interaction," and "Sled Magnetic Liftoff." These would include all design/analysis issues needed to be considered for these events, along with design tradeoffs, such as static vs. traveling ablating shields, rate of separation, sled surface shaping, etc. Both common issues, such as response to wind dynamics, and separate issues (wheel retraction for magnetic liftoff, relative rate of sled/vehicle horizontal and vertical separation for separation, etc.) would be treated as Level 5 studies. However, all issues of unattached sled propulsion: braking to a halt, retraction after normal and aborted launches (subdivided into aborted launches, with and without vehicle separation) should be treated in an entirely separate Level 4 study.
System Reliability

System reliability requirements will be extreme for operation during charging, acceleration, launch separation and drawdown after launch.

7 or 8 nines during launch operation or recovery can be obtained by adequate design margin and powered, on-line redundancy.

Civil Engineering (Estimated to be 70% of installed cost)

Terrain / Scope

Track siting

Noise abatement (supersonic on the ground)
Location and right of way

Alignment survey and maintenance

Alignment refers to the placement of the system, within its local natural environment, to meet the needs of the flight vehicle and other potential users of the same general area. An east-west alignment at KSC is the only item of interest here, with launch in the easterly direction. A launch track of this size may be partially located above level terrain to allow traffic to pass underneath parts of the track on the western end. The track would not necessarily have to be flat over the extent, but could partially follow the curvature of the earth in order to prevent the entire track from being located high over terrain.

Stability over time (Bedrock, location)

Ground shift with time will be an issue with each installation location. Whether there is a need to drive pilings to bedrock along the path of the track, for maintaining a stable acceleration path versus building in some mechanism to compensate for ground shift in real time during acceleration. One might compensate for ground shift in real time during acceleration, but this may prove to be difficult. Alternate approaches may be narrowed to automated motorized overnight guideway level adjustment prior to each launch day and periodic adjustment between launches to re-center the automated portions where they may approach their physical limits due to continuous ground shifting.

Initial construction issues

State construction guidelines,

Design
Construction
O&M

Dynamic Interaction (During Launch) will be a concern as a substantial force will be transferred to the support system, slowly during the initial acceleration and more rapidly just prior to liftoff. In addition, the entire horizontal propulsion force (~ 4M lbf) will be applied to the track supports on a transient basis by the mounting hardware that retains the motor stator iron segments. Coils will have forces on them tending to squeeze the coil turns together, but no relative force with respect to the stator iron, in cases where stator iron is present to carry the lines of flux close to the rotor components. The linear synchronous motor option is air-core with no iron in the stator for either the superconducting or permanent magnet options. Even in the case of a linear induction motor, the windings will experience a reverse thrust load that gets transmitted to the iron.

Ground loading
Protection of Asset throughout life
Protection During Launch

Side wind One serious problem with high-speed HLA is wind. Although side-winds are clearly more dangerous than headwinds or tailwinds, they shouldn't be singled out. The problem is wind or variable wind patterns. If side winds cause some yaw in the vehicle, then the headwinds will exacerbate the perturbation. Since winds/side-winds are identifiably a major concern, there should be a separate study on baffle design. The baffle could also include lightning rods, etc.

Protection in Standby
Hurricane
Lightning

Earthquakes Earthquakes are not usually a problem in Florida, but may be an issue in other locations. They would, of course, be extremely rare, but they give less notice than hurricanes or lightning, effectively none, and are capable of doing extensive damage unless the system is designed to take them. Presumably, while all of these protection studies have to be done, the main response to other unusual natural conditions is to scrub the launch. There should be very few hurricanes, or lightning storms that don't give you 12 seconds notice. In a system designed to handle the 4 Mlbf horizontal loads characteristic of normal launch scenarios, earthquake consideration may not be as large an issue as might be imagined.

2.6.9.8.7.2.2.) Side-winds Side-wind during standby would be handled by the baffle system with maximum suppression of side-winds without excessive Bernoulli or wind tunnel interactions between the baffle and vehicle.

Weathering / Sunlight
Corrosion
Protection / Security (DOD)

There is a "quantum" issue related to the fundamental limits of electromagnetic propulsion. Protection/security against vandalism, let alone terrorism, is much easier if the guideway is contained within a fenced government-operated facility, in particular Cape Canaveral. As I understand it, there are only 4 km of straightaway available at the Cape and this dictates the 2 g requirement for 268 m/s, leaving space for deceleration at the same rate on a flight abort. This is such an important consideration, that it should be imposed as a constraint on design studies. The comments above on Separation lead to a factor of eight uncertainty in the length requirements for the track. There are already too many options to allow thorough vetting of the topological alternatives, so it would make sense to live with the constraint of Cape Canaveral, allowing protection against uncleared civilians, while using all of the available straightaway.

Alternatively, if it is impossible to simply impose the original mission (i.e. 2 g to 600 mph, no more than 4 km of guideway, and other sites have to considered, one could limit the infinitude of possibilities by doing only 2 studies: 1) an optimized system for Cape Canaveral/4 km/2 g, and 2) and an optimized system for a 30 km reservation (the Holloman track is 15.5 km, can it be extended?) with only 0.25 g acceleration. This might give enough insight to select either option or go to something in-between.

It may also turn out to be the case that the last "9" can only be achieved by permitting aborts on a flat-runway, a major contingency feature that would require the vehicle to vent liquid oxygen and massive amounts of liquid hydrogen (not simultaneously) after engine shutdown during final approach to the landing strip. A west-east southerly launch would still be dictated, but perhaps it is possible to convert Holloman or Rocky Flats or wherever to a site that is more compatible with controlled landing on abort. The guideway would, of course, be designed so that controlled abort can be achieved by the linear motor, even after the beginning of rocket firing, but before separation. However, after separation, if there is any reason for abort in the next few seconds, then a Cape Canaveral launch would have to be designed for safe retrieval from the Atlantic Ocean, which doesn't seem as easy as controlled landing on a flat. The political concerns of launching experimental flights over populated areas will eliminate that option, based on the recent Columbia incident.

Summary and Recommendations:

Concern: The most important design problems are the extremely high reliability requirement, the high propulsion acceleration, and the need for guaranteed active control during acceleration, separation and launch or abort scenarios. The requirements are, of course, interrelated.

Recommendation: Rapid development of overall system simulation tools and experiment design to validate the various models.

Concern: The magnet and vehicle design philosophies needed are somewhat different than those used in the past for either big science magnets or maglev travel designs. They are different from big science magnets because those magnet requirements are so modest and very different from maglev travel, because the track lengths are so modest. They are similar to maglev travel in that the design is dominated by the need for extreme reliability.

Therefore, one expects that decisions that magnet engineers have made in the past to reduce cost will be incorrect for this application and that any technology that improves reliability at reasonably higher cost will be selected.

Recommendation: Suggest that the design go in the direction of advanced superconductors, CICC, redundant active controllers, high clearance, continuous guideway, permanent or quasi-permanent magnet operation, elaborate wind baffles, and SMES that can launch with one coil out. However, intuition is frequently wrong, leading to the need for developing accurate tools for reliability and failure analysis.

Concern: As pointed out by Larbalestier, in this October's Magnet Technology conference (MT-18), the last year has demonstrated sufficient technical developments in new superconductors, that there are now several serious candidates that could be sufficiently mature for the HLA application. These include NbTi, Nb3Sn, Nb3Al, BSSCO-2223, BSSCO-2212, and MgB2.

Recommendation: For both the levitation and propulsion magnet systems, there should be a design study to select the correct superconductor and magnet technology. There is some mention of a distinction between NbTi and HiTc superconductors, but the need for a tradeoff is more extensive than that.

CELT Gas Gun / Alternate Horizontal Launch Assist

System Feasibility, Woodcock Study, System (Earth to Orbit) Modeling, Landing and recovery, Propulsion, CELT Gas Gun, Supersonic Turbo-fan, Control (vehicle limits of acceleration, jerk), Deceleration of traveler or flight vehicle on launch abort, Low-speed return to battery position, Levitation, Technology (Active vs. electrodynamic suspension, aerodynamic), Active Electromagnetic suspension, Levitation technology (attractive, iron or ironless), Stability, Control, Passive Electrodynamic levitation, Null Flux coils, Flat-plate conductor, Fixed Permanent Magnets, Superconducting magnets with persistent switch, Stability, Control, Aerodynamic Levitation, Stability / Control, Low-speed return to battery, Energy Storage, Mechanical, Static (Compressed Air), Power Conditioning and Delivery, Pressure / Flow control, Separation Dynamics, Dynamic Wind loads, Clearance and vehicle acceleration, Traveler recovery, Drag to halt, Retract to Battery after launch scrub, System Reliability, 7 or 8 nines during launch operation or recovery, Civil Engineering, Terrain / Scope, Stability over time (Bedrock, location), Initial construction issues, Design, Construction, O&M, Dynamic Interaction (During Launch), Ground loading, Protection of Asset throughout life, Protection During Launch, Side wind, Protection in Standby, Hurricane, Lightning, Weathering/Sunlight, Corrosion, Protection/Security

Ducted-Fan Propulsion / Aerodynamic Levitation

System Feasibility, Propulsion, Levitation, Energy Storage, Power Conditioning and Delivery, Separation Dynamics, System Reliability, Civil Engineering

Water-Jet Propulsion and Levitation

System Feasibility, Propulsion, Levitation, Energy Storage, Power Conditioning and Delivery, Separation Dynamics, System Reliability, Civil Engineering

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16) Joel H. Schultz, MIT Plasma Science Fusion Center, Fusion Technology Engineering Div, Cambridge, MA

17) Rainer B. Meinke is with the Advanced Magnet Lab, Melbourne, FL

18) Robert C. Youngquist is with NASA, Kennedy Space Center, FL

19) David Minto, Technical Director, 46th Test Group, Holloman Air Force Base, NM, Senior Member AIAA

20) John Russell Associate Professor of Aerospace Engineering, Florida Institute Technology, Melbourne, FL

21) Hector Gutierrez is

22) Gordon Woodcock

International Space Agency, ISA

International Space Administration

Founded In 1986 -&- Incorporated In 1990

Presently Seeking International Treaty -&- Charter Status

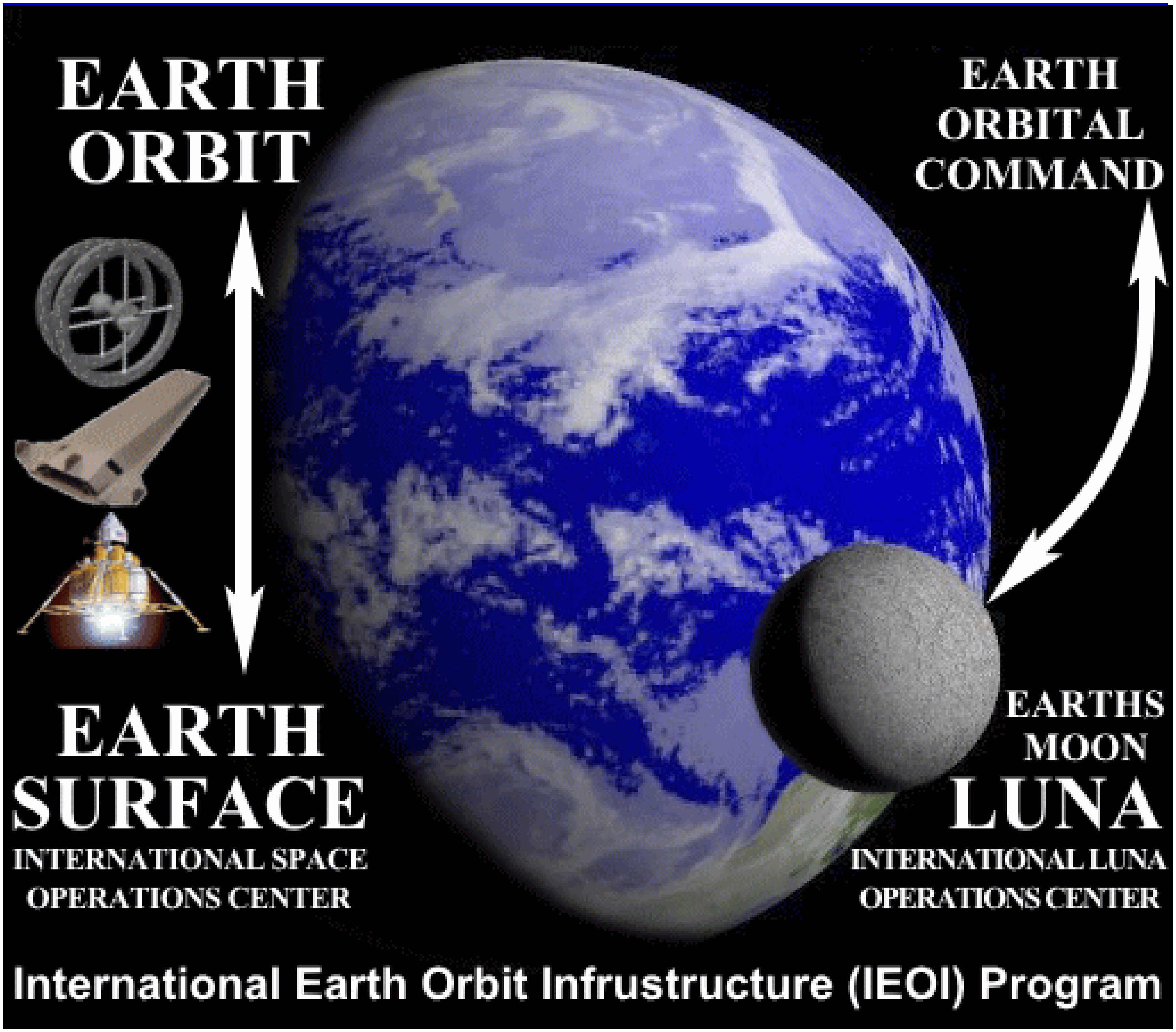
2013 - PROPOSAL

International Earth Orbit Infrastructure

(I.E.O.I.) Program / Office

International Space Agency - I.S.A.
International Space Administration

PURPOSE: The International Earth Orbital Infrastructure (I.E.O.I.) Program / Office will function as the Core/Central Knowledge and Expertise Base and Focal Point of Excellence and Standards for all Earth Orbital Infrastructure, Facilities, Stations, Satellites, Space Craft, Operations, Programs, Projects, and Missions of the International Space Agency, I.S.A.. It will be the Key Initiator, Enabler, Conduit, Promoter, and Organizational Instrument for all endeavors specifically related to the Earths Orbit Transits From Earths Surface To Earths Orbit, and from Earths Orbit to Points Beyond Earths Orbit. This will include (but is not limited to) Planning, Establishing, and Operation of Orbital Space Facilities for Space Craft & Station Construction in Earths Orbit, Fuel & Materials Storage in Earths Orbit, Earth Remote Censing & Communication Infrastructure in Earths Orbit, Stations and Space Craft "Support Infrastructure" to Shuttle Personnel, Supplies, Materials, and Equipment “to” & “from” Earth Orbit from the Earths Surface, and To Points Beyond Earths Orbit, such as Planets/Moons/Asteroids, and Interstellar Space.



International Space Agency, ISA

International Space Administration

Founded In 1986 -&- Incorporated In 1990

Presently Seeking International Treaty -&- Charter Status

2013 - PROPOSAL

International Space Station

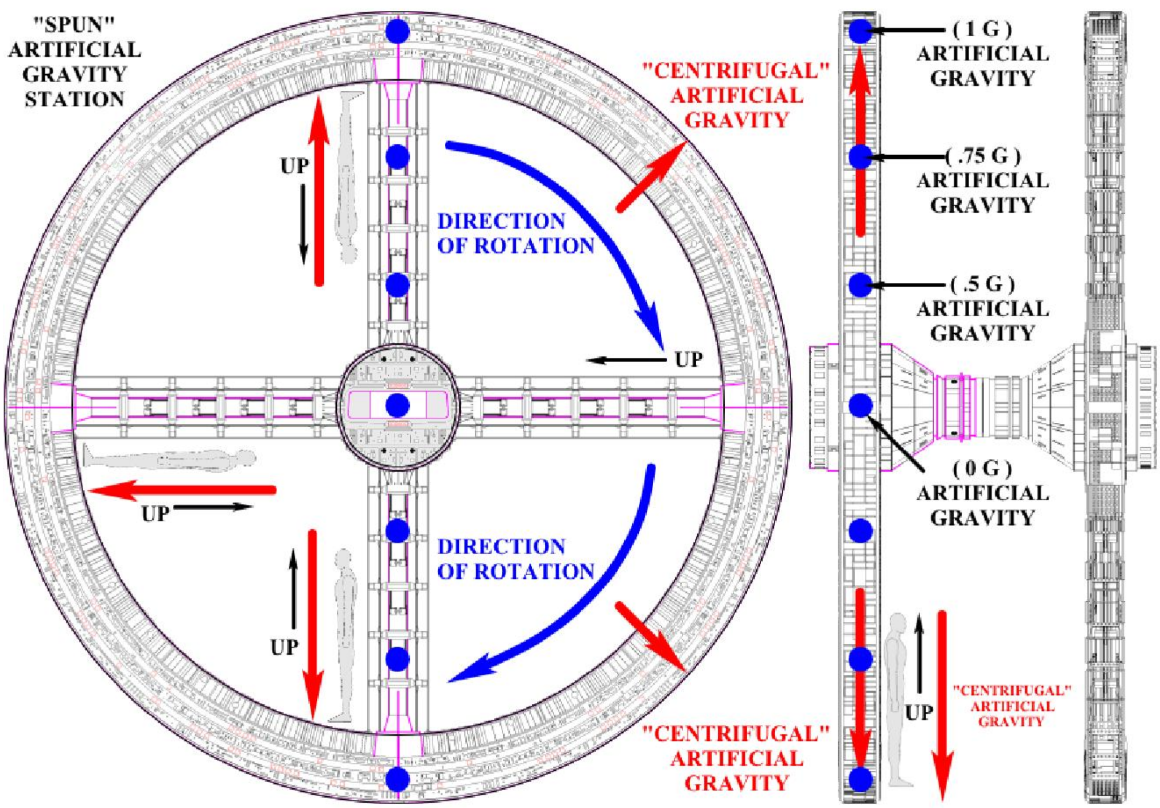
(I.S.S.) Program / Office

International Space Agency - I.S.A.
International Space Administration

PURPOSE: The International Space Station (I.S.S.) Program / Office will function as the Core/Central Knowledge and Expertise Base and Focal Point of Excellence and Standards for all Earth Orbital Manned: Facilities, Stations, Operations, Programs, Projects, and Missions of the International Space Agency, I.S.A.. It will be the Key Initiator, Enabler, Conduit, Promoter, and Organizational Instrument for all endeavors specifically related to Maaned Facilities & Stations in Earths Orbit. This will include (but is not limited to) Planning, Establishing, and Operation of Artificial "Spun" Gravity and Micro-Gravity Orbital Space Facilities for Space Craft & Station Construction in Earths Orbit, Fuel & Materials Storage in Earths Orbit, Earth Remote Censing & Communication Infrastructure in Earths Orbit, Stations and Space Craft "Support Infrastructure" to Shuttle Personnel, Supplies, Materials, and Equipment "to" & "from" Earth Orbit from the Earths Surface, and To Points Beyond Earths Orbit, such as Planets/Moons/Asteroids, and Interstellar Space.

INTERNATIONAL SPACE STATION (I.S.S.) PROGRAM

"SPUN" ARTIFICIAL GRAVITY STATIONS / MICRO "0" GRAVITY STATIONS / FUEL SUPPLY FACILITIES
ORBITAL SHIP YARDS -AND- MANUFACTURING FACILITIES / LARGE SPACE STRUCTURES "COLONIES"



MICRO "O" GRAVITY STATION

SPACE COLONY

International Space Agency, ISA

International Space Administration

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2013 - PROPOSAL

INTERNATIONAL PLANET / MOON (ASTEROID) LAUNCHER / LANDER (I.P.M.L.L.) PROGRAM / OFFICE

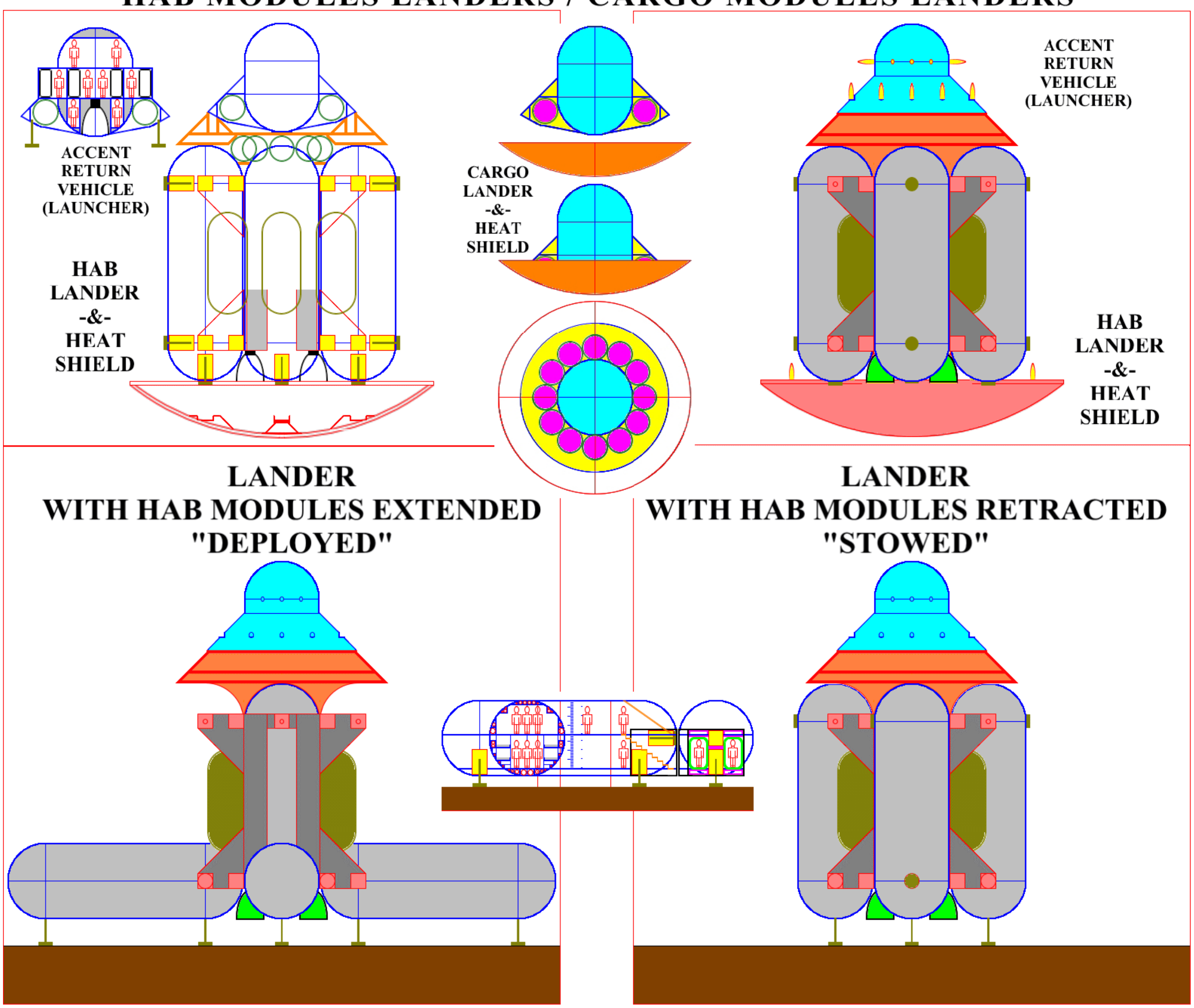
International Space Agency - I.S.A.
International Space Administration

PURPOSE: The International Planet / Moon (Asteroid/Comet) Launcher / Lander (I.P.M.L.L.) Program / Office will function as the Core / Central Knowledge and Expertise Base and Focal Point of Excellence and Standards for all Planet, Moon, Asteroid, or Comet: Launch and Landing Ships, Spacecraft, and Vehicles, and related Operations, Programs, Projects, and Missions of the International Space Agency, I.S.A.. It will be the Key Initiator, Enabler, Conduit, Promoter, and Organizational Instrument for all endeavors specifically related to Manned and Robotic Ships , Spacecraft, and Vehicles specifically designed for Landing and Launching from the surface of Planets, Moons, Asteroids, and Comets, from Space or Orbit. This will include (but is not limited to) Planning, Establishing, and Operation of Ships. Spacecraft, and Vehicles capable of shuttling and carrying Personnel, Cargo, and Materials, and Habitat Modules, Vehicles, Equipment, and Tools from/to the surface of any Planet, Moon, Asteroid, or Comet from/to Space or Orbit.

INTERNATIONAL PLANET / MOON (ASTEROID) LAUNCHER / LANDER PROGRAM

SURFACE TO ORBIT - LAUNCHERS / ORBIT TO SURFACE LANDERS

HAB MODULES LANDERS / CARGO MODULES LANDERS



International Space Agency, ISA

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2013 - PROPOSAL

INTERNATIONAL SOLAR CRUISER
(I.S.C.) PROGRAM / OFFICE

International Space Agency - I.S.A.
International Space Administration
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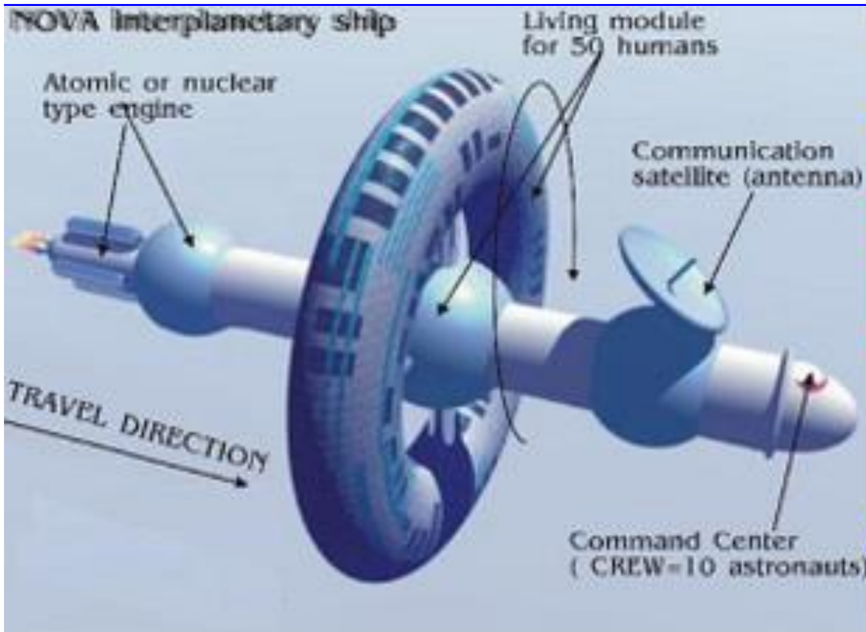
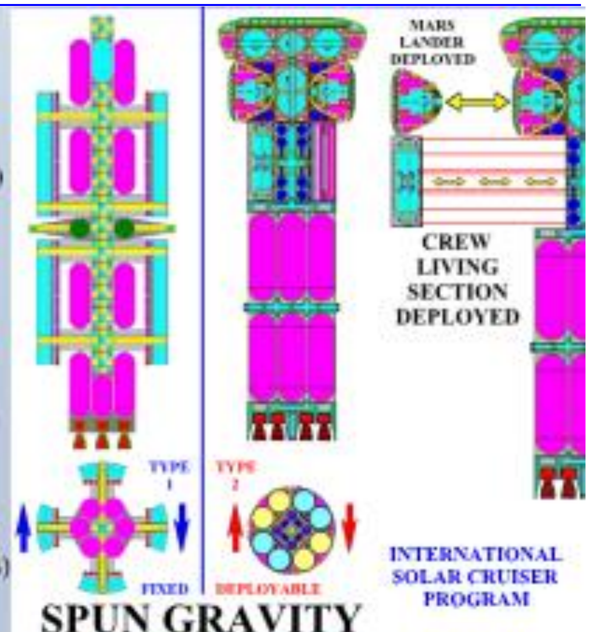
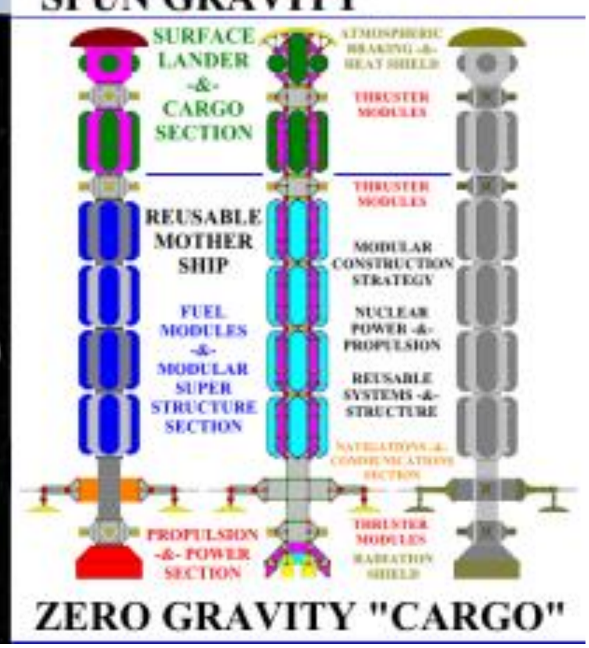
2013 - PROPOSAL
INTERNATIONAL SOLAR CRUISER (I.S.C.) PROGRAM / OFFICE







International Space Agency, ISA

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Presently Seeking International Treaty -&- Charter Status

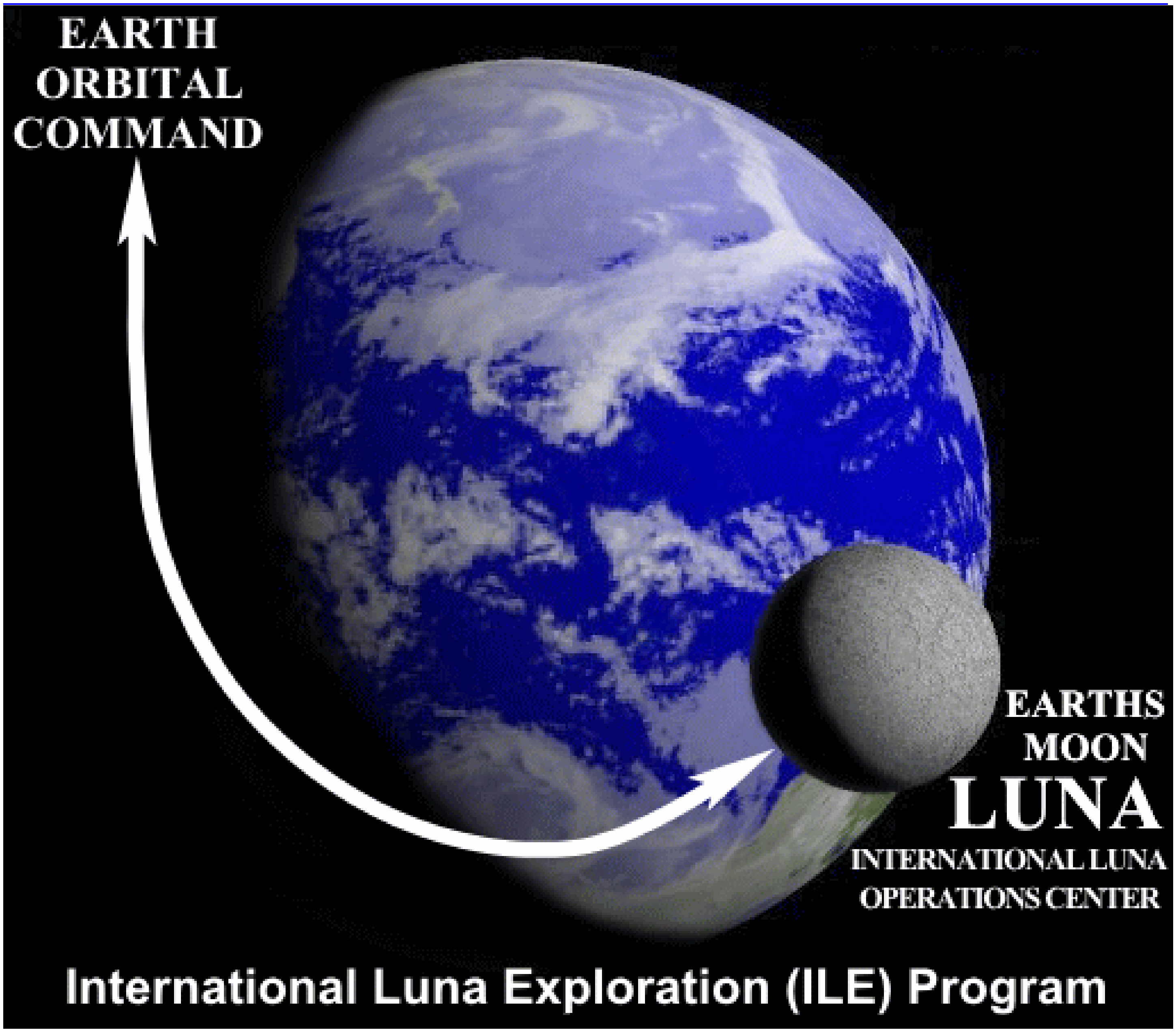
2013 - PROPOSAL

INTERNATIONAL LUNA EXPLORATION

(I.L.E.) PROGRAM / OFFICE

International Space Agency - I.S.A.
International Space Administration

PURPOSE: The International Luna Explorations (I.L.E.) Program / Office will function as the Core/Central Knowledge and Expertise Base and Focal Point of Excellence and Standards for all of Earths Moon "Luna" Infrastructure, Operations, Projects, Missions, and Programs of the International Space Agency, I.S.A.. It will be the Key Initiator, Enabler, Conduit, Promoter, and Organizational Instrument for all endeavors specifically related to the exploration, utilization, and human settlement and activities of Luna "Earths Moon". This will include (but is not limited to) coordination of the mapping of Luna surface (initially planning robotic lunar rovers to map Luna, Google Maps is a good example of what I.S.A. should be looking to achieve.) to identify suitable landing sites, and possible locations for Luna Bases and Facilities, planning and execution of a Luna Orbital Space Station and Space Craft "Infrastructure" to shuttle Personnel, Supplies, Materials, and Equipment from the Luna Orbit "to/from" Luna Surface; and various Surface & Subsurface activities and facilities on Luna "Earths Moon".



A. General Information

Project Title:	*International Luna Exploration (I.L.E.) Program / Office (of the International Space Agency, I.S.A.)*
Brief Project Description:	The **I.L.E. Program / Office** will, Firstly, Promote, Organize, Design, Build, Support, Operate, and Maintain all International Space Agency Infrastructure, Stations, Space Craft, Bases, Facilities, Vehicles, Assets, Personnel, Activities, Missions, Projects, and Programs on the Earths Moon "Luna" Surface, Subsurface, and In Orbit; and, Secondly to act as an Enabler, Bridge Head, and Focal Point for all National Space Agency and Private Tourism, Commercial, Scientific, and Mining activities on Earths Moon "Luna", in achieving their Non-Military and Peaceful Civil Objectives and Endeavors, in regards to their own independent Luna activities and missions. The International Space Agency will be the Key Core/Central Administrator & Management, Quality Control & Safety, Search & Rescue, Medical & Health Services, Research & Development, Navigations & Communications, and Infrastructure & Assets umbrella organization on the Surface, and In Orbit Around, Luna "Earths Moon". The International Space Agency will provide the Core/Central Infrastructure, Personnel, and Operations on the Surface, Subsurface, and In Orbit Around, Luna "Earths Moon", and all End Users will provide independently, or approved to be contracted through International Space Agency networks, all support services, materials, personnel, consumables, and equipment for independent activities outside the direct control or charter of the International Space Agency.
Prepared By:	**Mr. Tony James - United Kingdom - Director, International Luna Exploration Program / Office** **Dr. Sergio Cabral Cavalcanti - Brazil - Assistant Director, International Luna Exploration Program / Office**
Date:	**20 October 2013**

B. Project Objective:

Purpose: The **International Luna Exploration (I.L.E.) Program / Office** will function as the Core/Central Specialized Knowledge & Expertise Base and Focal Point of Excellence & Standards for all of Earths Moon "Luna" Infrastructure, Operations, Projects, Missions, and Programs of International Space Agency. It will be the Key Initiator, Enabler, Conduit, Promoter, and Organizational Instrument for all endeavors specifically related to the exploration, utilization, and human settlement & activities of Luna "Earths Moon". This will include (but is not limited to) coordination of the mapping of Luna Surface (initially planning robotic lunar rovers to map Luna, Google Maps is a good example of what I.S.A. should be looking to achieve.) to identify suitable landing sites, and possible locations for Luna Bases and Facilities, planning and execution of a Luna Orbital Space Station and Space Craft "Infrastructure" to shuttle Personnel, Supplies, Materials, and Equipment from the Luna Orbit "to/from" Luna Surface; and various Surface and Subsurface activities and facilities on Luna "Earths Moon".

Areas of Operations, Programs, and Missions Authority:

- Building a Knowledge & Expertise Base related to all things required for the Exploration, Utilization, Human Settlement.
- Researching & Planning Most Effective & Best Possible Locations to Enable Landings, Launch, Surface/Subsurface Activities.
- **Explore Possible Transportation Systems "from/to" Luna to Earth / Luna to Mars / Luna to Solar System**
  - Conventional Chemical Propulsion/Power Technologies / Nuclear "Fission & Fusion" Propulsion/Power Technologies
  - Ion Thrusters Propulsion Technologies / Solar Cell Based Propulsion/Power Technologies
  - Hybrid, Non-Conventional, and Closed Loop Propulsion/Power Technologies
- **Explore Possible Transportation Infrastructure and Systems "from/to" Luna Surface to Luna Orbit**
  - Conventional Chemical Propulsion/Power Technologies / Nuclear "Fission & Fusion" Propulsion/Power Technologies
  - Ion Thrusters Propulsion Technologies / Solar Cell Based Propulsion/Power Technologies
  - Hybrid, Non-Conventional, and Closed Loop Propulsion/Power Technologies
  - Electromagnetic Rail Launch & Recovery Systems, Mechanical Leverage Launch, Equatorial Space Elevator
- Soliciting & Selection of Suitable Government & Private End Users & Costumers for Robotic & Human Exploration & Activities.
- Design of suitable space craft, vehicles, and equipment for Robotic & Human Exploration & Activities
- **Design and Planning of Suitable Structures, Buildings, Facilities, and Utilities on the Surface & Subsurface.**
  - Personnel Living Quarters / Tourist & Hotel Accommodations / Special Purpose Accommodations & Facilities
  - Suitable Structures & Facilities to support a wide range of working and living requirements on the Surface & Subsurface.
  - Environmental structures & buildings to grow food and keep animal livestock for consumption, store & process water & waste.
  - Structures & Facilities to House: Environmental & Atmosphere, Heating & Cooling, Water & Waste, Systems & Infrastructure.
  - Structures & Facilities to House: Commercial & Industrial, Scientific & Research, Academic & Training, Infrastructure.
  - Structures & Facilities to House: Power Systems, Navigations Systems, Communications Systems, and Computer Systems.
  - Structures & Facilities to House: Medical & Health Services, Search & Rescue Services, and Security & Judicial Services
- Initial explorers will require laboratories in which to experiment with life support systems to enable humans to live on Luna, and the Primary Focus of Materials & Personnel will be on Construction & Natural Resources Exploration & Utilization.

Benefits: The **International Luna Exploration (I.L.E.) Program / Office** will be the Core/Center of Specialized Knowledge, Expertise, Excellence, Standards, Personnel, Space Stations, Space Craft, Vehicles, Equipment, Structures, Bases, Facilities, Programs, Projects, Missions, and Human Activities In Orbit, On The Surface, and Under The Surface, able to supply its Infrastructure, Resources, and Operations to National "Government & Civil" and Private Space Exploration Agencies, Organizations, Companies, Institutions, Foundations, Societies, and Private Individuals. Enabling them to Benefit Symbiotically, Collectively, and Co-Operatively on the Promotion, Planning, Building, Operation, and Maintenance of a Robust, Extensive, and Long Duration Transportation & Support Infrastructure of **Scale & Scope** ***"Out Side The National Domain Or Capability"***, which is easily accessed, with all costs optimized, and enhanced and rapid technology development. The **(I.L.E.) Program** will work very closely with, and in tandem, with the **(I.M.E.) Program** and **(I.S.E.) Program** as all elements of these **"3"** ***KEY(*** **I.S.A.) Programs**, will collectively depend on each others existence to ensure overall broad program operation, advances & success.

Funding: Costs for all International Space Agency infrastructure & operations on Luna "Earths Moon", will be obtained primarily through a pay for use strategy ***"Toll or Fee"*** by all end users, whether they be National Governments or Non-Governmental Entities, Organizations, or Persons; and, augmented by approved Multi-National & Joint Programs Participants, Government & Private Grants, and Private Philanthropy. A proposed initial amount of ($7 Billion) U.S. Dollars is sought for ILE Program start up funding.

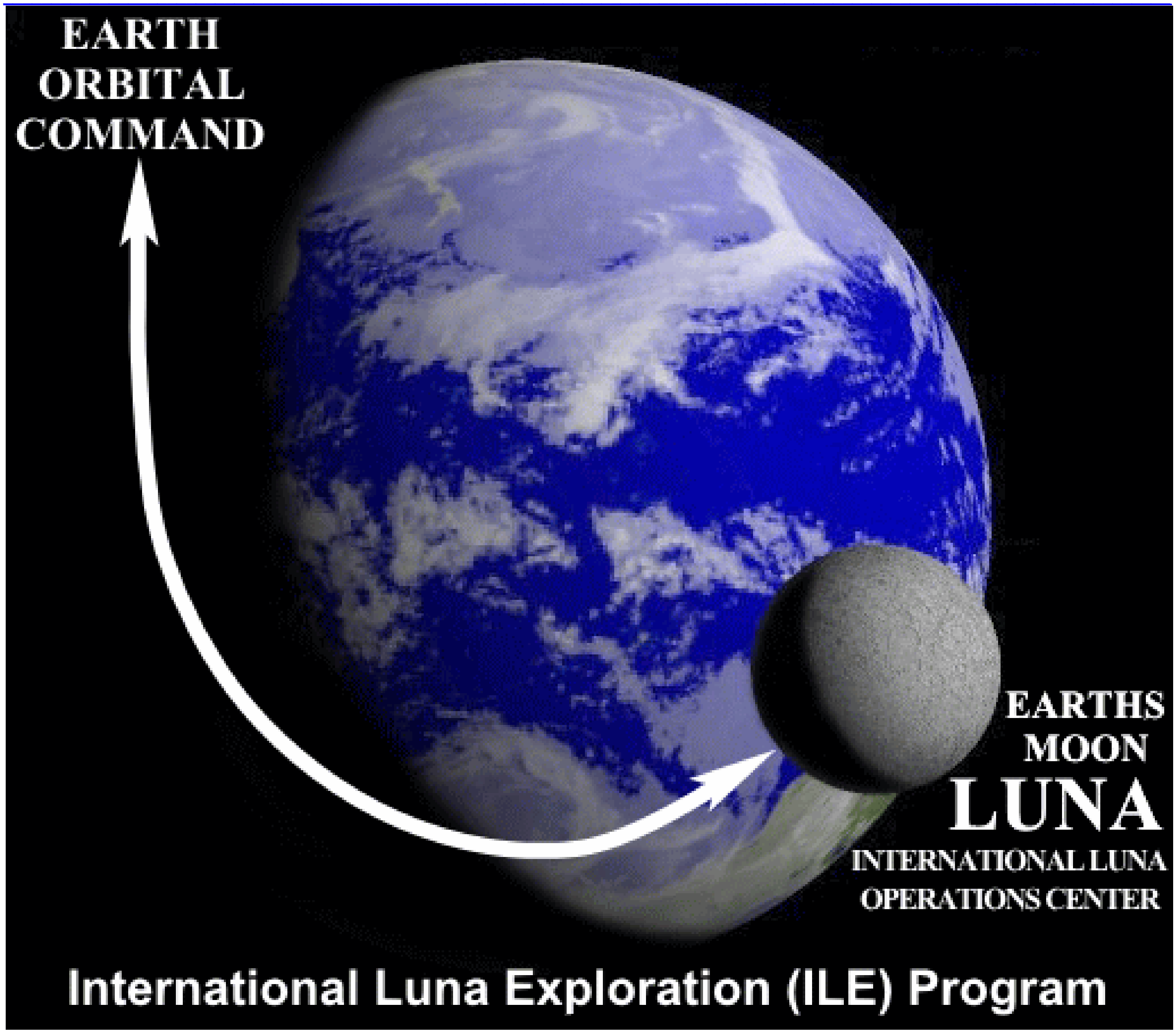
International Space Agency, I.S.A.
International Space Administration

Founded In 1986 -&- Incorporated In 1990

Presently Seeking International Treaty -and- Charter Status

2013 - PROPOSAL

INTERNATIONAL LUNA EXPLORATION (I.L.E.) PROGRAM / OFFICE



International Space Agency, ISA

International Space Administration

Founded In 1986 -&- Incorporated In 1990

Presently Seeking International Treaty -&- Charter Status

2013 - PROPOSAL

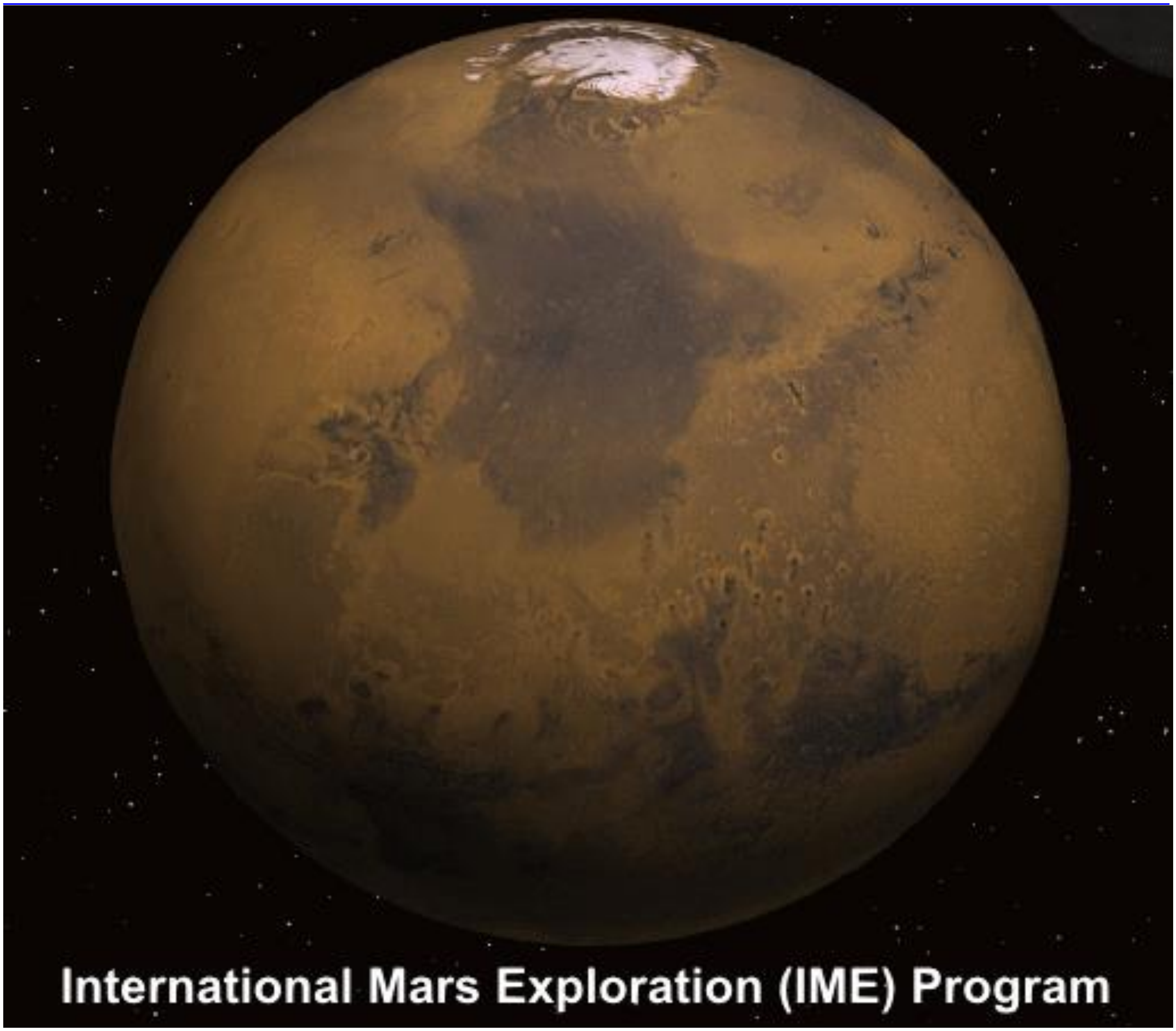
INTERNATIONAL MARS EXPLORATION

(I.M.E.) PROGRAM / OFFICE

International Space Agency - I.S.A.

International Space Administration

PURPOSE: The International Mars Explorations (I.M.E.) Program / Office will function as the Core/Central Knowledge and Expertise Base and Focal Point of Excellence and Standards for all of Mars (And Mars Moon Phobis) Infrastructure, Operations, Projects, Missions, and Programs of the International Space Agency, I.S.A.. It will be the Key Initiator, Enabler, Conduit, Promoter, and Organizational Instrument for all endeavors specifically related to the exploration, utilization, and human settlement and activities of Mars. This will include (but is not limited to) coordination of the mapping of Mars surface (initially planning robotic surface rovers to map Mars, Google Maps is a good example of what I.S.A. should be looking to achieve.) to identify suitable landing sites, and possible locations for Mars Bases and Facilities, planning and execution of a Mars Orbital Space Station and Space Craft "Infrastructure" to shuttle Personnel, Supplies, Materials, and Equipment from Mars Orbit "to/from" Mars Surface; and various Surface and Subsurface activities and facilities on Mars.



A. General Information

Project Title:	*International Mars Exploration (I.M.E.) Program / Office (of the International Space Agency, I.S.A.)*
Brief Project Description:	The **I.L.E. Program / Office** will, Firstly, Promote, Organize, Design, Build, Support, Operate, and Maintain all International Space Agency Infrastructure, Stations, Space Craft, Bases, Facilities, Vehicles, Assets, Personnel, Activities, Missions, Projects, and Programs on the Mars Surface, Subsurface, and In Orbit; and, Secondly to act as an Enabler, Bridge Head, and Focal Point for all National Space Agency and Private Tourism, Commercial, Scientific, and Mining activities on Mars, in achieving their Non-Military and Peaceful Civil Objectives and Endeavors, in regards to their own independent Mars activities and missions. The International Space Agency will be the Key Core/Central Administrator & Management, Quality Control & Safety, Search & Rescue, Medical & Health Services, Research & Development, Navigations & Communications, and Infrastructure & Assets umbrella organization on the Surface, and In Orbit Around, Mars. The International Space Agency will provide the Core/Central Infrastructure, Personnel, and Operations on the Surface, Subsurface, and In Orbit Around, Mars, and all End Users will provide independently, or approved to be contracted through International Space Agency networks, all support services, materials, personnel, consumables, and equipment for independent activities outside the direct control or charter of the International Space Agency. It's highly advised, that no Earth Government be allowed to have Sovereign control of Mars, like Antarctica.
Prepared By:	**Mr. Robert D. McGown, MSci - United States - Director, International Mars Exploration Program / Office** **Dr. Deepak Kapadia - India - Assistant Director, International Mars Exploration Program / Office**
Date:	**20 October 2013**

B. Project Objective:

Purpose: The **International Mars Exploration (I.M.E.) Program / Office** will function as the Core/Central Specialized Knowledge & Expertise Base and Focal Point of Excellence & Standards for all of Mars Infrastructure, Operations, Projects, Missions, and Programs of International Space Agency. It will be the Key Initiator, Enabler, Conduit, Promoter, and Organizational Instrument for all endeavors specifically related to the exploration, utilization, and human settlement & activities of Mars. This will include (but is not limited to) coordination of the mapping of Mars Surface (initially planning robotic lunar rovers, Aircraft, and Satellites to map Mars, Google Maps is a good example of what I.S.A. should be looking to achieve.) to identify suitable landing sites, and possible locations for Mars Bases and Facilities, planning and execution of a Mars Orbital Space Station and Space Craft "Infrastructure" to shuttle Personnel, Supplies, Materials, and Equipment from the Mars Orbit "to/from" Mars Surface; and various Surface and Subsurface activities and facilities on Mars.

Areas of Operations, Programs, and Missions Authority:

- Building a Knowledge & Expertise Base related to all things required for the Exploration, Utilization, Human Settlement.
- Researching & Planning Most Effective & Best Possible Locations to Enable Landings, Launch, Surface/Subsurface Activities.
- **Explore Possible Transportation Systems "from/to" Mars to Earth / Mars to Luna / Mars to Solar System**
  - Conventional Chemical Propulsion/Power Technologies / Nuclear "Fission & Fusion" Propulsion/Power Technologies
  - Ion Thrusters Propulsion Technologies / Solar Cell Based Propulsion/Power Technologies
  - Hybrid, Non-Conventional, and Closed Loop Propulsion/Power Technologies
- **Explore Possible Transportation Infrastructure and Systems "from/to" Mars Surface to Mars Orbit**
  - Conventional Chemical Propulsion/Power Technologies / Nuclear "Fission & Fusion" Propulsion/Power Technologies
  - Ion Thrusters Propulsion Technologies / Solar Cell Based Propulsion/Power Technologies
  - Hybrid, Non-Conventional, and Closed Loop Propulsion/Power Technologies
  - Electromagnetic Rail Launch & Recovery Systems, Mechanical Leverage Launch, Equatorial Space Elevator
- Soliciting & Selection of Suitable Government & Private End Users & Costumers for Robotic & Human Exploration & Activities.
- Design of suitable space craft, vehicles, and equipment for Robotic & Human Exploration & Activities
- **Design and Planning of Suitable Structures, Buildings, Facilities, and Utilities on the Surface & Subsurface.**
  - Personnel Living Quarters / Tourist & Hotel Accommodations / Special Purpose Accommodations & Facilities
  - Suitable Structures & Facilities to support a wide range of working and living requirements on the Surface & Subsurface.
  - Environmental structures & buildings to grow food and keep animal livestock for consumption, store & process water & waste.
  - Structures & Facilities to House: Environmental & Atmosphere, Heating & Cooling, Water & Waste, Systems & Infrastructure.
  - Structures & Facilities to House: Commercial & Industrial, Scientific & Research, Academic & Training, Infrastructure.
  - Structures & Facilities to House: Power Systems, Navigations Systems, Communications Systems, and Computer Systems.
  - Structures & Facilities to House: Medical & Health Services, Search & Rescue Services, and Security & Judicial Services
- Initial explorers will require laboratories in which to experiment with life support systems to enable humans to live on Mars, and the Primary Focus of Materials & Personnel will be on Construction & Natural Resources Exploration & Utilization.

Benefits: The **International Mars Exploration (I.M.E.) Program / Office** will be the Core/Center of Specialized Knowledge, Expertise, Excellence, Standards, Personnel, Space Stations, Space Craft, Vehicles, Equipment, Structures, Bases, Facilities, Programs, Projects, Missions, and Human Activities In Orbit, On The Surface, and Under The Surface, able to supply its Infrastructure, Resources, and Operations to National "Government & Civil" and Private Space Exploration Agencies, Organizations, Companies, Institutions, Foundations, Societies, and Private Individuals. Enabling them to Benefit Symbiotically, Collectively, and Co-Operatively on the Promotion, Planning, Building, Operation, and Maintenance of a Robust, Extensive, and Long Duration Transportation & Support Infrastructure of **Scale & Scope *"Out Side The National Domain Or Capability"***, which is easily accessed, with all costs optimized, and enhanced and rapid technology development. The **(I.M.E.) Program** will work very closely with, and in tandem, with the **(I.L.E.) Program** and **(I.S.E.) Program** as all elements of these **"3" *KEY* (I.S.A.) Programs**, will collectively depend on each others existence to ensure overall broad program operation, advances & success.

Funding: Costs for all International Space Agency infrastructure & operations on Mars, will be obtained primarily through a pay for use strategy ***"Toll or Fee"*** by all end users, whether they be National Governments or Non-Governmental Entities, Organizations, or Persons; and, augmented by approved Multi-National & Joint Programs Participants, Government & Private Grants, and Private Philanthropy. A proposed initial amount of ($9 Billion) U.S. Dollars is sought for IME Program start up funding.

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