

Russian-Ukrainian Dnepr Program's Opportunities For Commercial Space Projects

Presented by Dr. Ighor K. Uzhinsky
ATK Launch Systems
April 13, 2007



An advanced weapon and space systems company



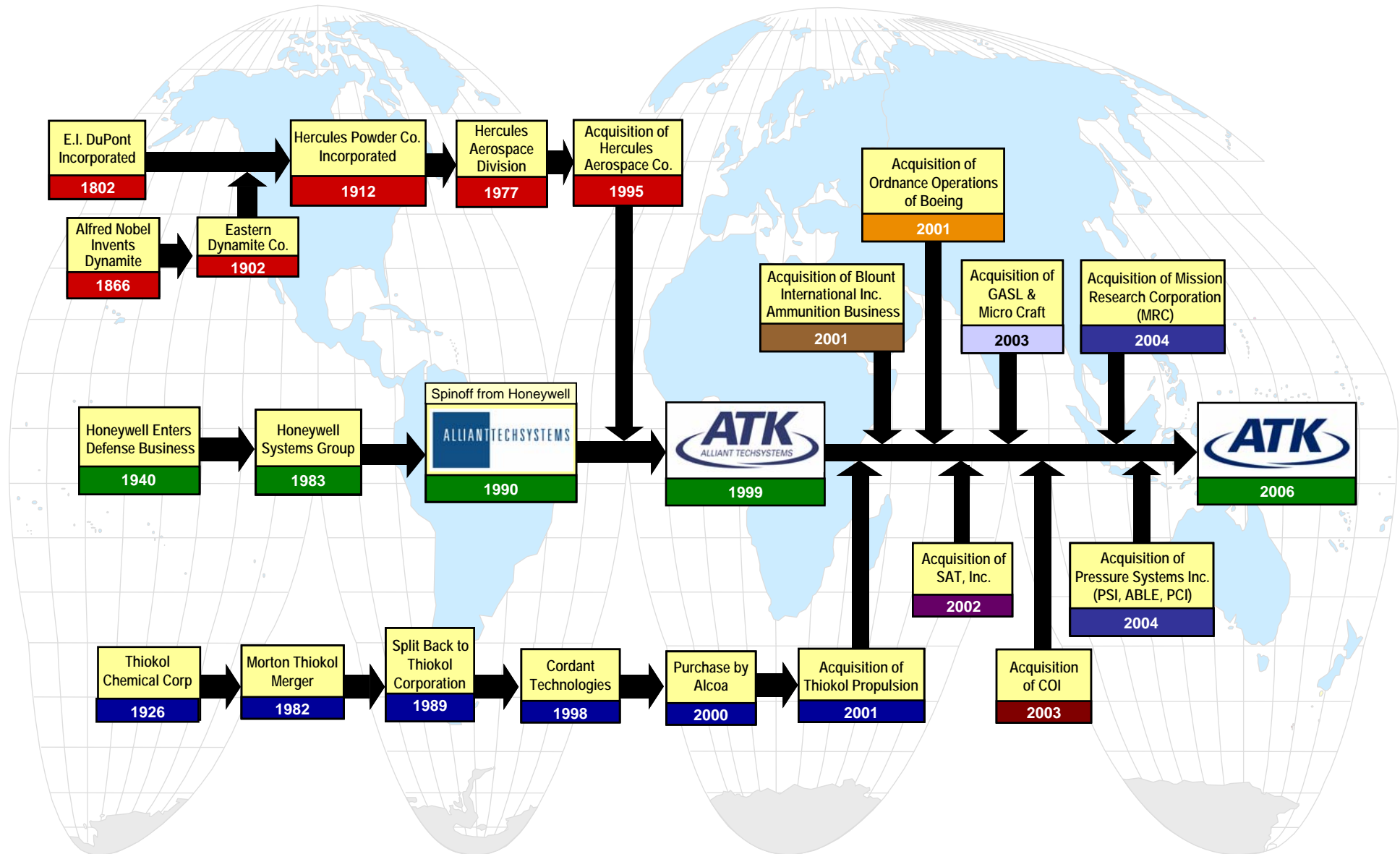
The world's leading supplier of solid propulsion systems and the nation's largest manufacturer of ammunition.

An Advanced Weapon and Space Systems Company

ATK History



An advanced weapon and space systems company



ATK Corporate Profile



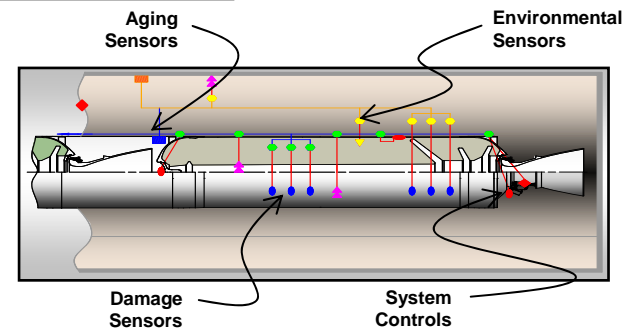
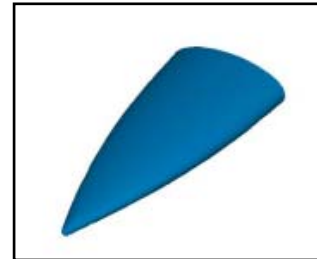
An advanced weapon and space systems company

- **\$3.5 billion aerospace and defense company**
- **~15,000 employees**
- **Headquarters in Edina, MN**
- **Ranked 13th largest U.S. defense contractor by *Defense News***
- **Ranked 10th largest world space company by *Space News***
- **Operations in 21 states**
- **Diversified customer base**
- **Leading positions in...**
 - Launch systems
 - Space systems
 - Munitions
 - Precision capabilities
 - Composite structures

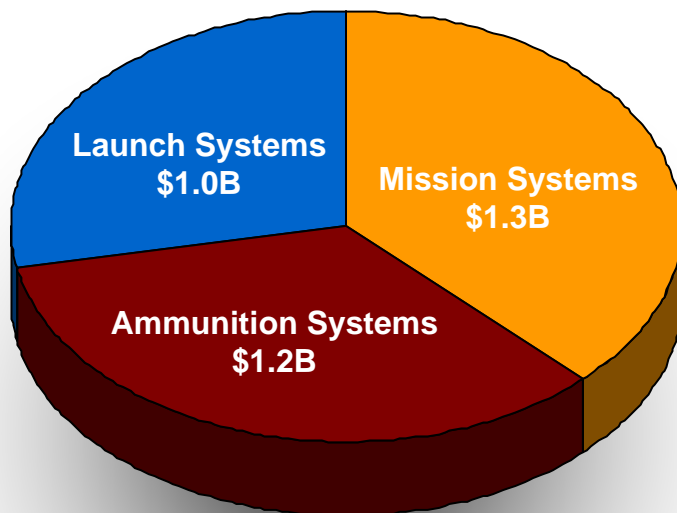


ATK is investing in new technologies that will help meet forward looking challenges

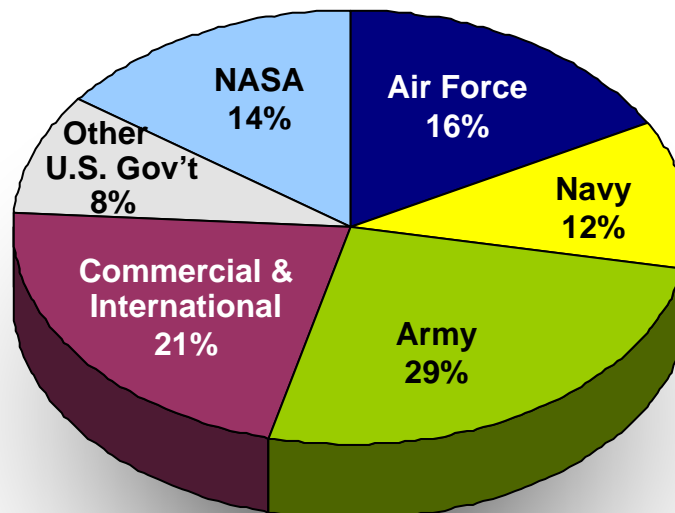
- Advanced Thermal Protection
- Advanced Composites
- Solid Rocket Propulsion Technology
- Advanced Air-Breathing Propulsion
- Space Sensor and Data Technologies
- Reactive Materials



Sales by Business Group



Sales by Customer

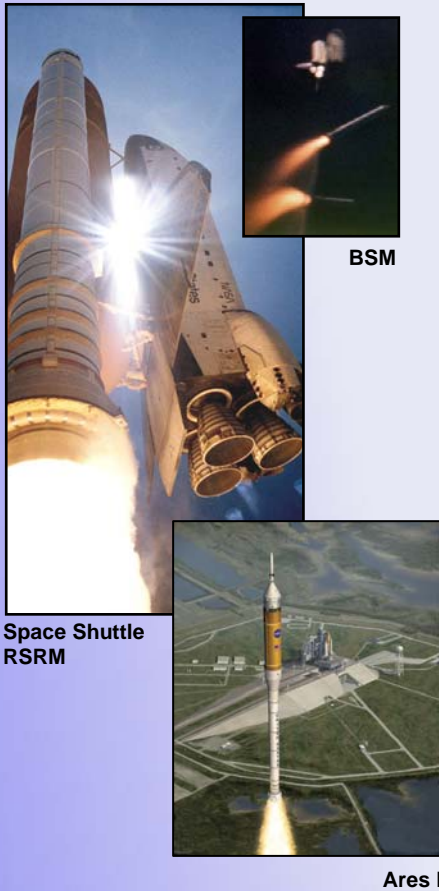


Launch Systems Product Lines



An advanced weapon and space systems company

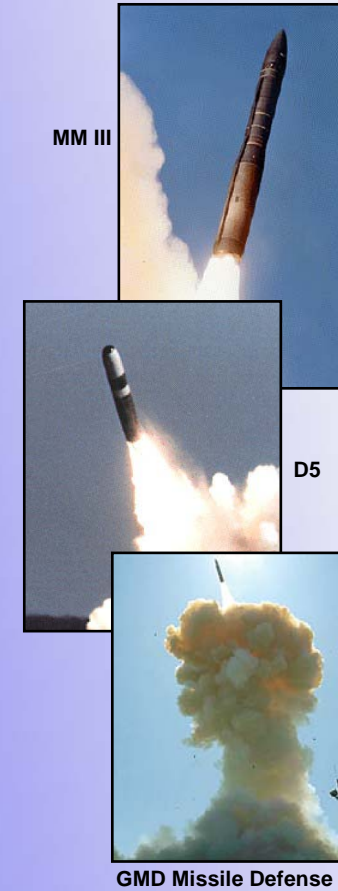
Human Space



Unmanned Launch Vehicles



Strategic Propulsion



Launch Systems Specialty Products

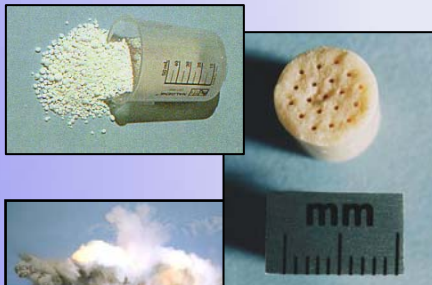


An advanced weapon and space systems company

Energetics



Pilot Plant



Explosives

Specialty Ordnance



Decoys



Ordnance



Illumination Flares



LUU-2/LUU-19

Tech Services



Demil



Launch Support



KSC



VAFB



Kodiak

About Bigelow Aerospace*



Mission and Vision

Vision Statement: Near Term

- Develop Pathfinder demonstrator spacecraft that can validate spacecraft hardware and systems. Our near term vision for Bigelow Aerospace is to play a major role in drastically altering the current cost and availability surrounding commercial and public use of non-habitable and habitable space complexes.

Mission Objectives

- **Primary Objectives**
Validate expandable structures as a certified spaceflight technology. Provide a low-cost, low earth orbit (LEO) human-rated space complex that is accessible to the commercial sector. Develop an affordable and flexible space complex architecture that can be adapted for any manned or unmanned mission requiring a large pressurized volume. Provide a ground-based infrastructure that the commercial and public entities sector can utilize for developing low-cost, space-based missions.
- **Secondary Objectives**
Create new ways of generating revenue through the use of these demonstrators that lead to full-scale business development engaging the public in fun and interesting pilot revenue generating programs.

*Source: <http://www.bigelowaerospace.com/>

Excerpts from Mr. Bigelow Message*



“If Bigelow Aerospace is successful, we should be consuming a significant number of vehicles each year. But we have the schedule responsibility that dictates for us the necessity of predicting when the flights will occur. Therefore we may need to either participate in some form of ownership in these transportation systems or at the very least to broker them for our customers.

It is possible that the primary use of space complexes has yet to be discovered. So much of our technological development has been a result of happenstance, brought about by simple trial and error. Our goal is to get humanity into space so we can experiment, toy with ideas, try new and different things, and eventually make that miraculous mistake leading to a discovery that will change life forever.

In 2000, I announced our original goal of 2015 (and \$500,000,000 later) as being the year we would have our first commercial space complex (CSC) in orbit. We might be ahead of schedule. The problem is transportation. We expect to fly two spacecraft this year in 2006 that we are referring to as Genesis I and Genesis II. By 2010, Bigelow Aerospace hopes to have flown 6-10 pathfinder/demonstrator spacecraft. By 2012, Bigelow Aerospace may be ready to fly its first full-scale habitable structure.

With only two modules (BA 330's) in orbit the flight rate demand in the third year of operation alone is 16 rockets the size of the Atlas V-401s or Falcon 9s to transport people and cargo. Perhaps, we will even use a foreign transportation system if a domestic alternative is not available or is too expensive. We just don't know. I have recognized all along that we may be ready with a destination but must wait for the progress of affordable, available transportation to catch up.”

*Source: <http://www.bigelowaerospace.com/>

Atlas V Could Be Used to Launch Passengers to Bigelow-Built Commercial Space Complexes*



- LAS VEGAS, NV, September 21, 2006 - Lockheed Martin has entered into an agreement with Bigelow Aerospace to pursue the potential of launching passengers on human-qualified Atlas V rockets. The destination would be a Bigelow-built space complex assembled from expandable modules. Bigelow's first launch of a prototype expandable module, Genesis I, took place on July 12th atop a Dnepr rocket from Russia.
- "LM Atlas V is one of the most reliable launch vehicles serving the expendable Launch vehicle markets today. We appreciate the opportunity to work with the entrepreneurial and innovative company of Bigelow aerospace to evaluate the market of space tourism and research to determine if Atlas could be a part of this potential new market area." said George Sowers, Atlas Business Development and Advanced Programs Director.
- Initially, the two companies will focus on exploring the technical requirements for the human-qualified launch services needed to transport commercial crew and cargo to expandable orbital space complexes. Bigelow and Lockheed Martin will examine the production and supply of Atlas rockets and comprehensive data describing flight safety and performance. Potential business models and business plans will also be discussed. Following this initial stage, each company will evaluate the feasibility of proceeding with a program to develop a human-qualified Atlas to meet the expected demand.

*Source: http://www.bigelow aerospace.com/multiverse/BA_and_Lockheed.php

Kistler K-1 Could Be Used to Ferry Passengers to Bigelow's Modules*



SATURDAY, MARCH 24, 2007

Kistler K-1 to Boost Passengers to Bigelow Space Hotels in 2012?



Rocketplane-Kistler (RpK) and Bigelow Aerospace have executed a *Letter of Intent* to ferry space passengers to and from a Bigelow Space Habitat at some future point.

George French III announced the Letter of Intent to those attending the *Space Access '07* in Arizona Friday morning. Jeff Foust writes at *Personal Spaceflight* that "once Rocketplane's K-1 is ready to carry passengers, and once Bigelow's modules are in orbit, they'll do business to ferry passengers to and from the facilities" and "by 2012" notes Rand Simberg at *Transterrestrial Musings*.

It was noted that Rocketplane-Kistler are still looking for an orbital spaceport within the domestic United States to launch and land the K-1 booster. At this point the commercial space firm plans to use the spaceport in *Woomera*, Australia.

One launch expert noted recently that the K-1 will have difficulty obtaining a launch spaceport within the United States with the current configuration unless the K-1 designers are willing to splash and "get wet."

*Source: <http://spaceports.blogspot.com/2007/03/kistler-k-1-to-boost-passengers-to.html>

Bigelow Aerospace Launch Campaign in Russia*



- May 2004 - Bigelow Aerospace and Kosmotras have executed a Non-Technical Framework Agreement, that, pending U.S. Department of State approval of a Technical Assistance Agreement, will allow Kosmotras to launch a BA spacecraft in 2006 aboard the Dnepr Launch Vehicle. The Framework Agreement also provides BA with the option to purchase several additional launches aboard the Dnepr in the future.
- On July 12th 2006 at 18:54 Moscow time, the US manufactured Genesis-1 spacecraft was successfully launched into the customer's predetermined orbit, aboard a Dnepr rocket from Yasny launch base. The launch was prepared and performed by specialists of RF Ministry of Defense and industrial enterprises of Russia and Ukraine under the leadership of International Space Company Kosmotras.
- The Dnepr launch vehicle is a converted SS-18 ICBM. This was the inaugural launch from the new Yasny launch base, located in the Orenburg region of Russia, and was also the first launch for Bigelow Aerospace.
- Las Vegas, NV 03/27/07 – Bigelow Aerospace announces its second pathfinder space complex module Genesis II has been shipped to a launch site in Russia and is expected to be lofted into orbit in mid-April. Genesis II will be enclosed in a payload shroud and put atop a Dnepr rocket at the ISC Kosmotras Space and Missile Complex near Yasny, Russia for a launch window that begins on April 19.

*Source: <http://www.bigelowaerospace>, <http://www.kosmotras.ru>

Russian Dnepr Rocket Carrying The Bigelow Aerospace Pathfinder Mission*

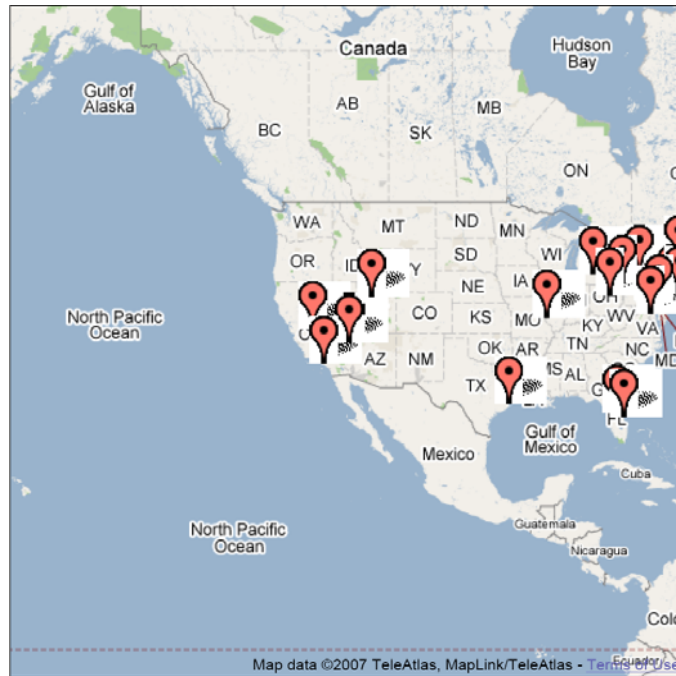


Photos from July 12, 2006 Launch
Spaceport Yasny, Russia

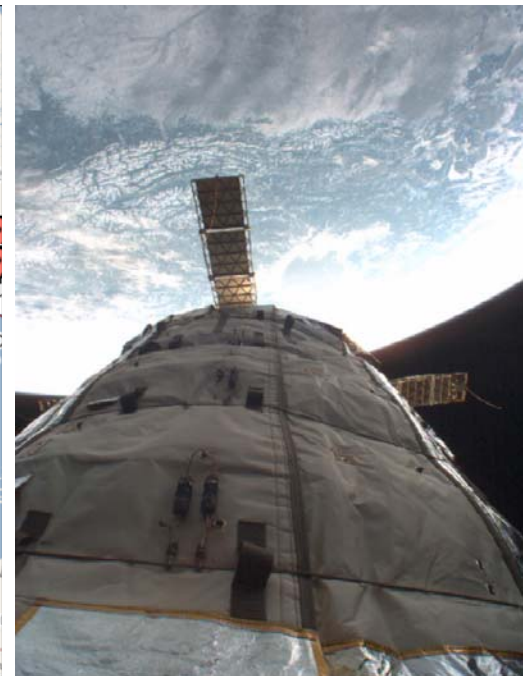


*Source: <http://www.bigelow aerospace.com/>

Photos from Genesis I Orbit



88 people have reported that they have seen Genesis I as of 4/11/07 - 10:56 PDT



*Source: <http://www.bigelowaerospace.com/>

ITAR Issues



- While Bigelow Aerospace is making strides in the development of its modules, one ongoing headache is the export control and regulatory process, be it International Traffic in Arms Regulations (ITAR) or telemetry issues, Gold said. “If anything, the regulatory procedures have been more difficult for Genesis 2 than Genesis 1. It rivals, if not exceeds, the technological difficulties that we face.”
- While improvements in dealing with ITAR are sorely needed, Gold saluted the Defense Technology Security Administration’s Spacelink system — a newly overhauled Internet portal that is simple, easy to use and responsive to space companies like Bigelow Aerospace.
- “Export control and ITAR are a barrier to entry for small entrepreneurial firms. Particularly in aerospace, in this day and age, you can’t have a cost-effective and innovative operation without international participation,” he added.*

*Source: http://www.space.com/spacenews/070326_bigelow_businessmonday.html

On the U.S. Export Control System:

- The current system is no longer suited for national and economic security
- It’s imperative that industry and government come together to make the system more predictable, efficient, and transparent.
- While our industry is becoming increasingly global, our export control system still reflects a bipolar, Cold War view of the world – and this is counterproductive.**

**Source: American Aerospace Industry Association Executive Report, Q1 2007

Excerpts from Announcement at the National Space Symposium 4/12/07*



- While seeing the suborbital tourism market as a viable private industry, “we can’t count upon any kind of business model that has some dependency upon NASA” in regards to supporting orbital business growth, Bigelow said.
- BA believes that Space Tourism is a beginning, not an ending, and, ultimately, it will be microgravity research and development that sustains space commerce. Tourism will be an important part of a new space industry, particularly in the beginning, but, again, it’s just a part of a much larger field.
- BA will be targeting ‘Sovereign Clients’, nations such as India, Canada, Germany, etc., that have an interest in developing a human space-flight program and astronaut corps, but, don’t want to pay an unrealistic or exorbitant price to do so. BA intends to open up the frontier of space to all of humanity, currently, there are only about 225 astronauts, we would like to see this number in the thousands or tens of thousands. For these customers BA will offer ‘hang-time’ opportunities, wherein, a Sovereign Client will be able to send an astronaut to a BA complex module for a period of four weeks.
- The cost of this experience, including transportation to and from the BA station, inclusive of training, will be approximately \$12 million in today’s dollars. Moreover, an additional four weeks on the station will be offered to future astronauts for only an additional \$3 million. BA hopes this service will be available by 2012, and, the experience will include, at no additional cost, the opportunity to conduct an EVA

*Source: Mr. Bigelow announcement 4/12/07, http://www.space.com/news/070410_nss_bigelow.html

Excerpts from Announcement at the National Space Symposium 4/12/07*



- “What we’re out to do is try and identify maybe 50 or 60 countries...to provide them “hang time” – a term he identified as the activity of foreign nation’s astronauts flying for four weeks in a Bigelow Aerospace-provided orbital complex, conducting that nation’s experiments or other activities and returning those individuals to Earth after their respective missions.
- “Our forecast for this service to be available is 2012. Obviously, the long pole in the tent is transportation...a major, major thing.”
- Bigelow Aerospace business plan evolves from the orbiting in 2010 of the company’s first habitable complex called Sundancer, outfitted to accommodate three people. Once in orbit, a propulsion bus and node would be lofted to attach to Sundancer in 2011.
- In 2012, Bigelow Aerospace would loft the first standard, 6-person module, substantially bigger than Sundancer. By ganging modules together and associated hardware, larger complexes can be crafted in Earth orbit to house upwards of 13 to 15 people.
- The projected cost for transportation and living onboard a Bigelow space complex for a four-week period is \$14,950,000 in 2012 dollars.
- Up to now, Bigelow Aerospace has spent about \$95 million. “It’ll take a lot more money to get us into the 2012 time frame,” Bigelow said, indicating that he is putting together an investment strategy that will make possible the establishment of commercial space complexes, not only for low Earth orbit, but other destinations too.
- The Genesis 2 is now in Russia, with a target launch date of April 26, Bigelow said.

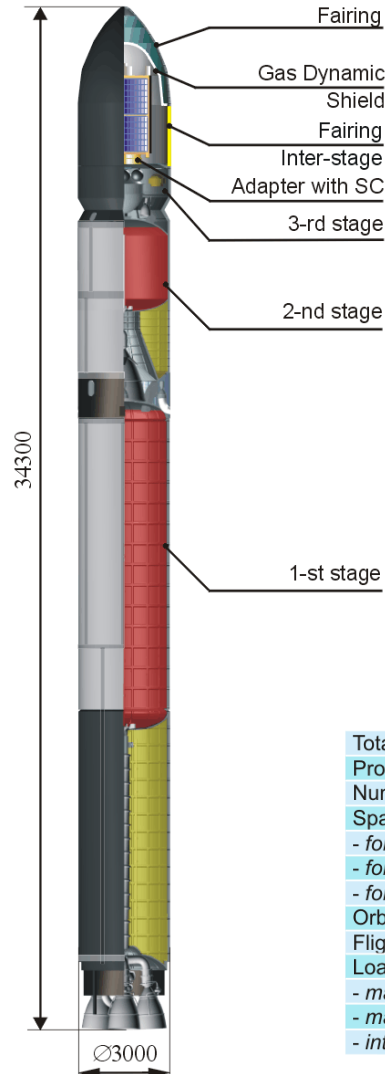
*Source: Mr. Bigelow announcement 4/12/07, http://www.space.com/news/070410_nss_bigelow.html



Dnepr Program



Main Specifications of Dnepr LV



- 1st and 2nd LV stages are unmodified standard SS-18 ICBM stages.
- 3rd stage is a standard SS-18's 3rd stage with the modified control system flight software.
- Space Head Module design is based on the SS-18 front section with several design variations.

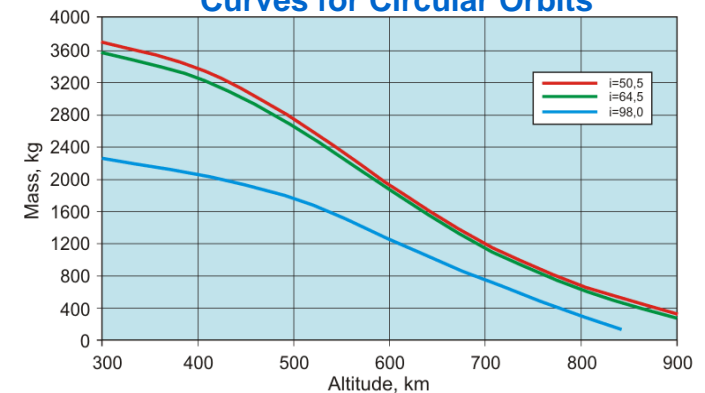


Dnepr Payload Envelope

Dnepr LV Basic Data

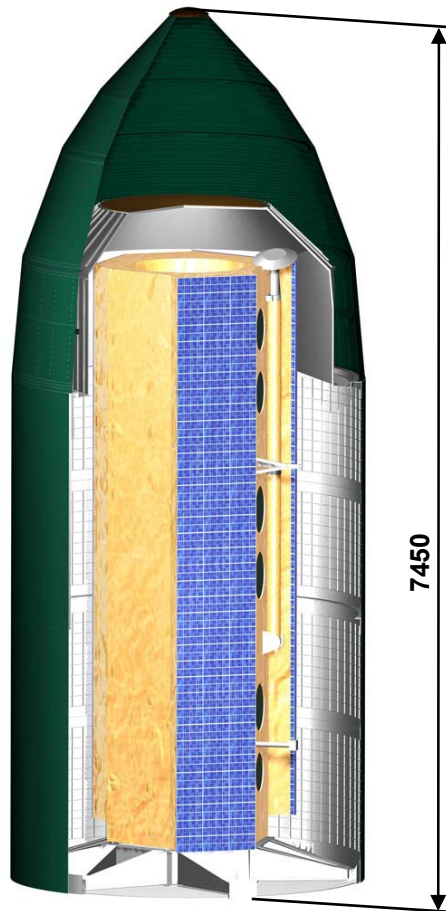
| | |
|---|-------------------|
| Total launch weight | 210 tons |
| Propellant components for all stages | amil+heptyl |
| Number of stages | 3 |
| Spacecraft injection accuracy (H=300 km): | |
| - for altitude | ± 4.0 km |
| - for inclination | ± 2.4 ang. min. |
| - for the right ascension of the ascending node | ± 3.0 ang. min. |
| Orbit inclination | 50.5°, 64.5°, 98° |
| Flight reliability | 0.97 |
| Loads affecting the spacecraft: | |
| - maximum axial quasi-static g-load | 7.5 |
| - maximum lateral quasi-static g-load | 0.8 |
| - integral level of sound pressure | 140 dB |

Dnepr LV Performance Curves for Circular Orbits





Available Configurations of Dnepr Space Head Module (SHM)



Extended SHM for a large-size satellite



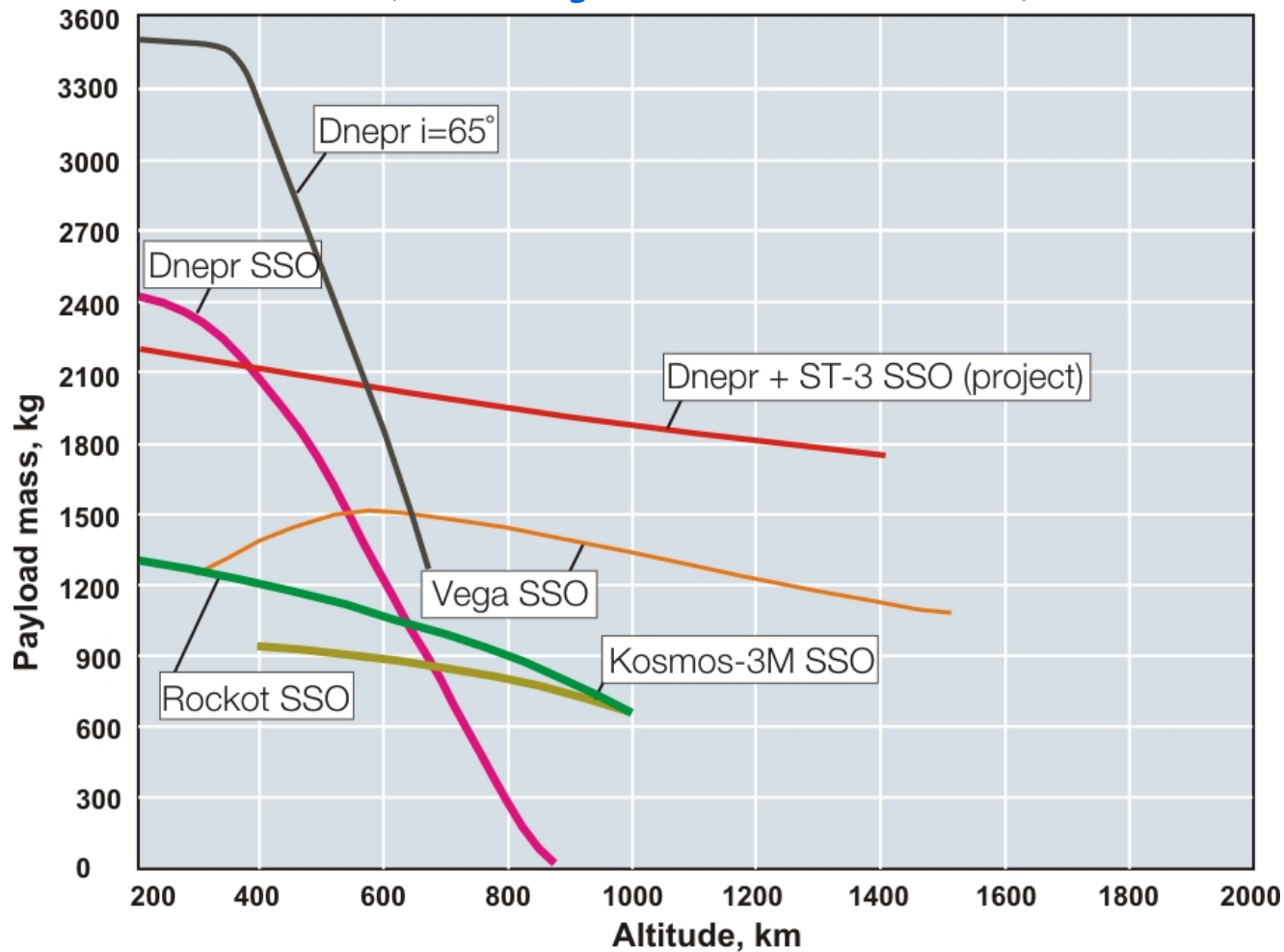
SHM for a multiple small satellite mission (cluster launch)



SHM for mid-size satellites



Light Class Launcher Performance Chart (Sun-Synchronous Orbit)





Ground Tests of SHM with Satellite Mock-ups

- SC mock-up/ SHM fit-check
- Vibration tests of assembled SHM
- SC mock-up/ SHM elements separation tests
- Separation shock tests
- SC adapter static tests
- Test runs of LV control system and checkout equipment
- Tests of SC electrical interface
- Tests of mechanical ground support equipment (MGSE)



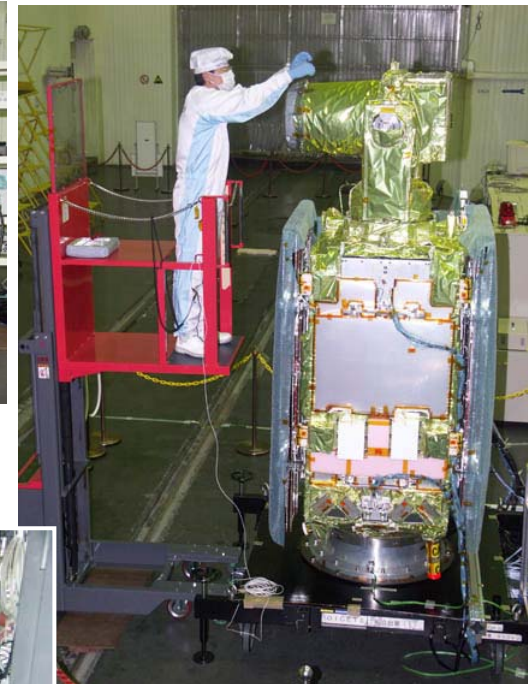


SC and GSE Delivery to Launch Base (Baikonur, AITB, site 31)





SC Processing and Fuelling



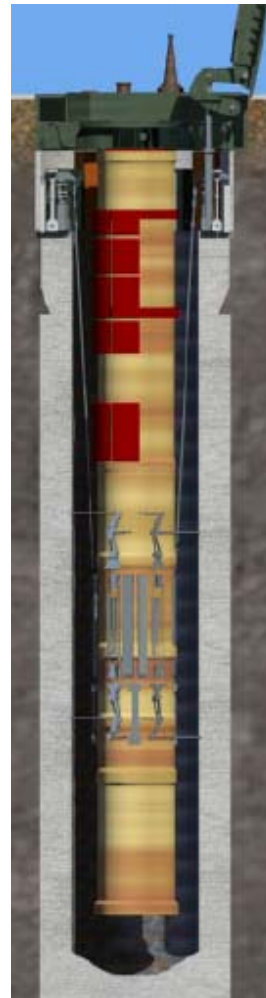
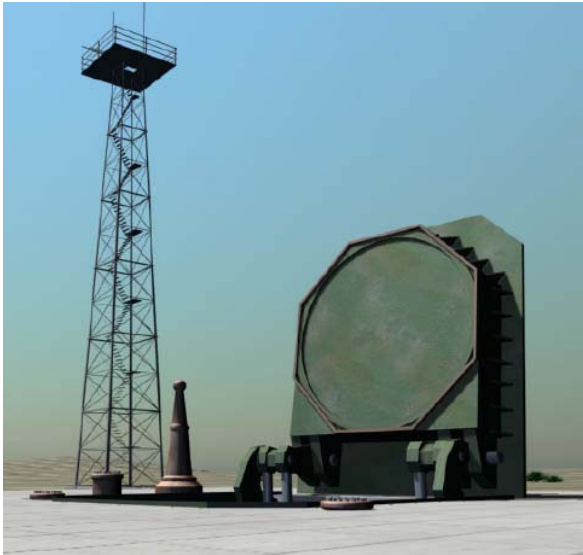


LV Loading into Silo and Preparation





Launch Silo





SHM Integration and Mating with Launch Vehicle

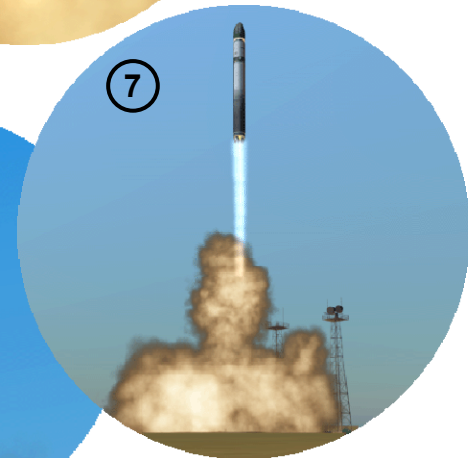
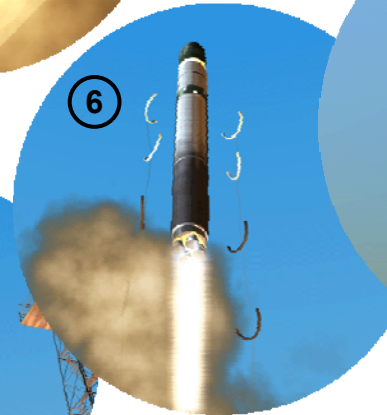
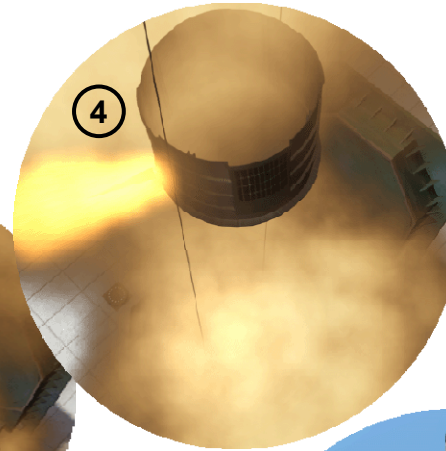
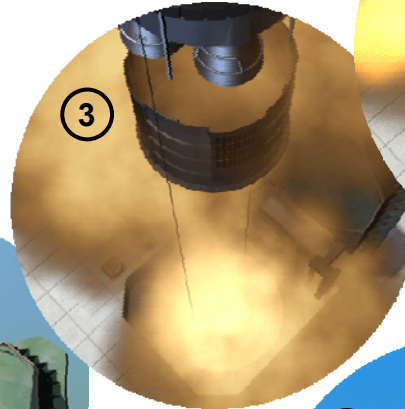




Dnepr Steam Ejection from Silo



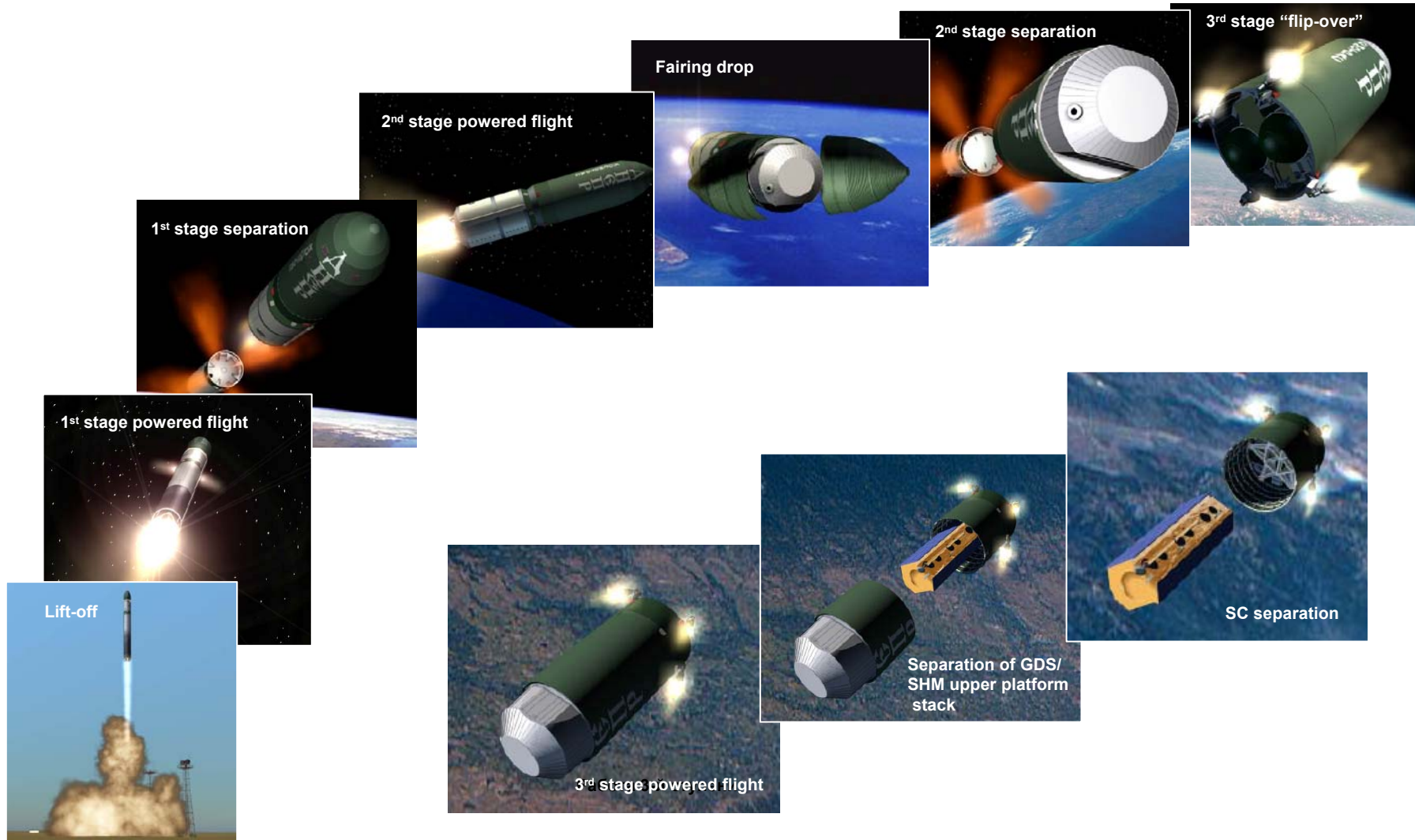
1. Black powder gas generator activated
2. LV expelled from silo
3. Protective tray separated
4. Protective tray jettisoned



5. First stage motor ignited
6. Sealing rings dropped
7. LV powered flight started

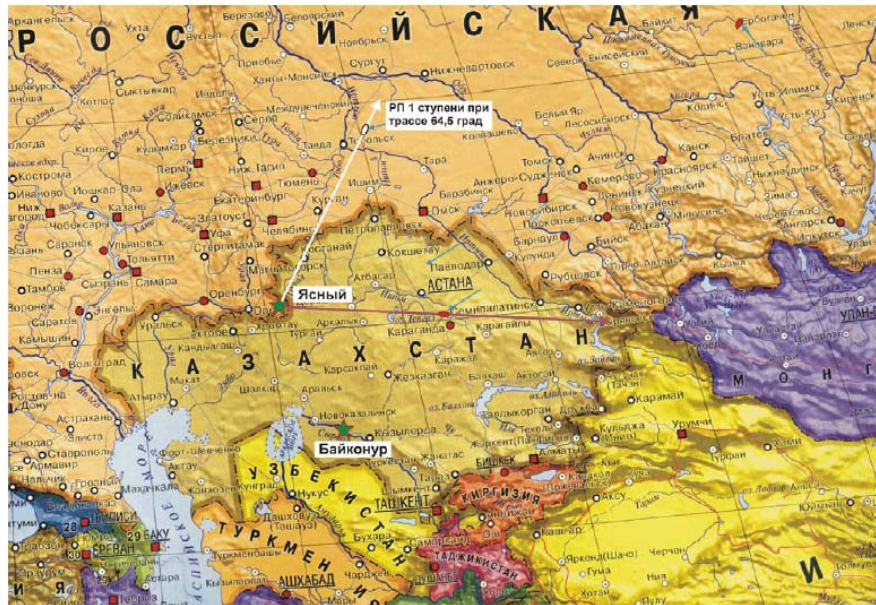


Typical Mission Profile for a Large Size Satellite





Yasny Space Launch Site



- **Yasny Launch Base** is a new Russian space launch base dedicated to SS-18/Dnepr Launch Vehicle. The first Dnepr launch from Yasny was conducted here on 12th of July, 2006. The Dnepr took off from launch silo carrying a Genesis 1 Spacecraft for Bigelow Aerospace in the U.S.
- **Geographical Location** of Yasny Launch Base is about 120km west of Orsk city, Orenburg Region, Russia, near Kazakhstan.
- <http://www.npointercos.jp/Yasny.html>



Dnepr Flight Reliability Before Last Mission Failure

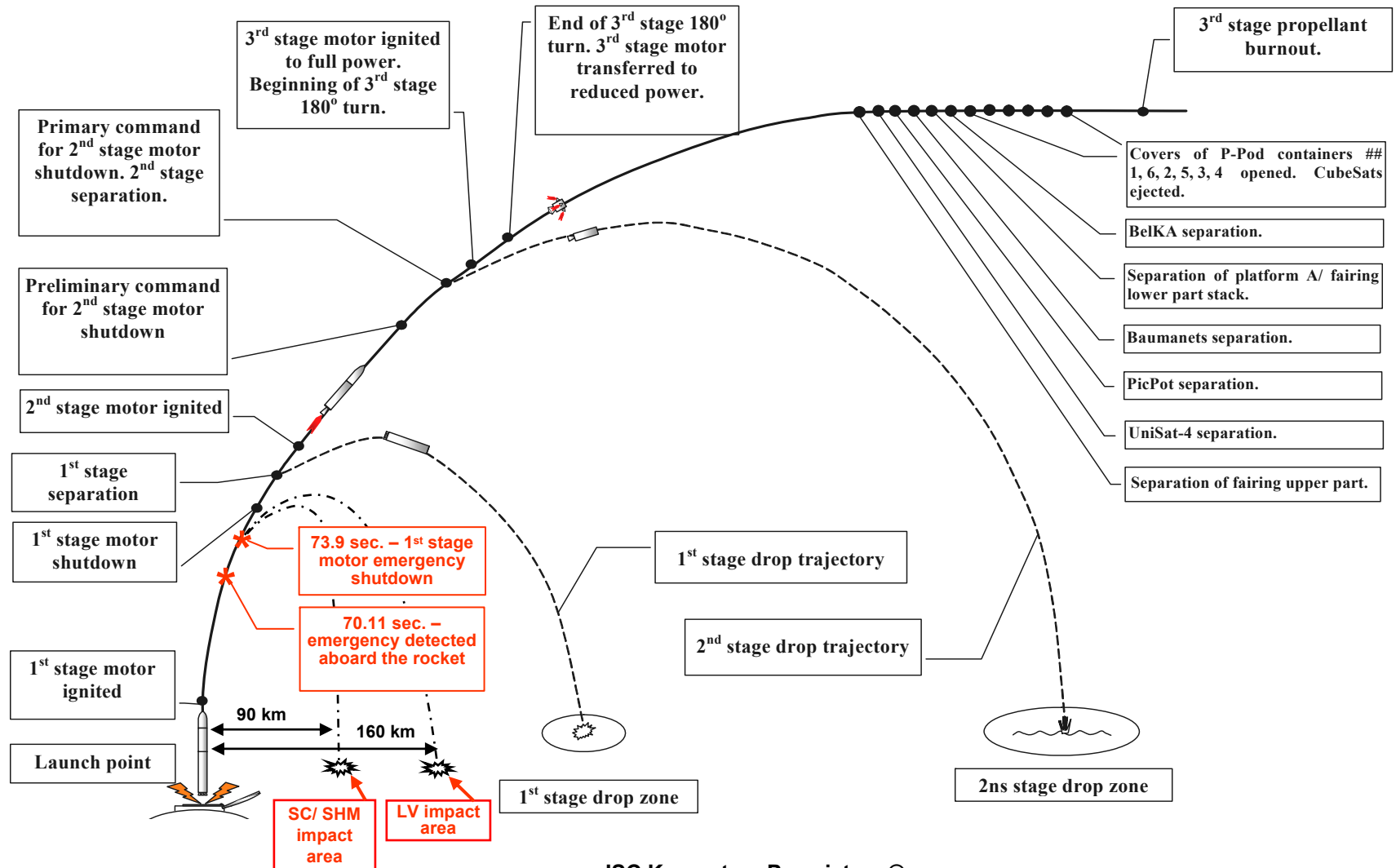


- SS-18 in its basic configuration has been in operation since mid-70s.
- Total of 163 flights of all generations of SS-18 ICBM were carried out (including Dnepr commercial flights).
- Total of 86 launches have been performed since SS-18 ICBM became operational.
- Four launch failures were encountered throughout SS-18 system operational lifetime.
- The causes of four failed missions were undoubtedly established and relevant corrective measures were introduced.
- 22 successful mission have been performed since August 1988.

Before the last failure 6 successful commercial Dnepr launches have been performed, which deployed 23 satellites of UK, Malaysia, USA, Germany, Saudi Arabia, Italy, France and Japan.



Launch #7 Injection Profile





Main Conclusions of the Failure Investigation Commission

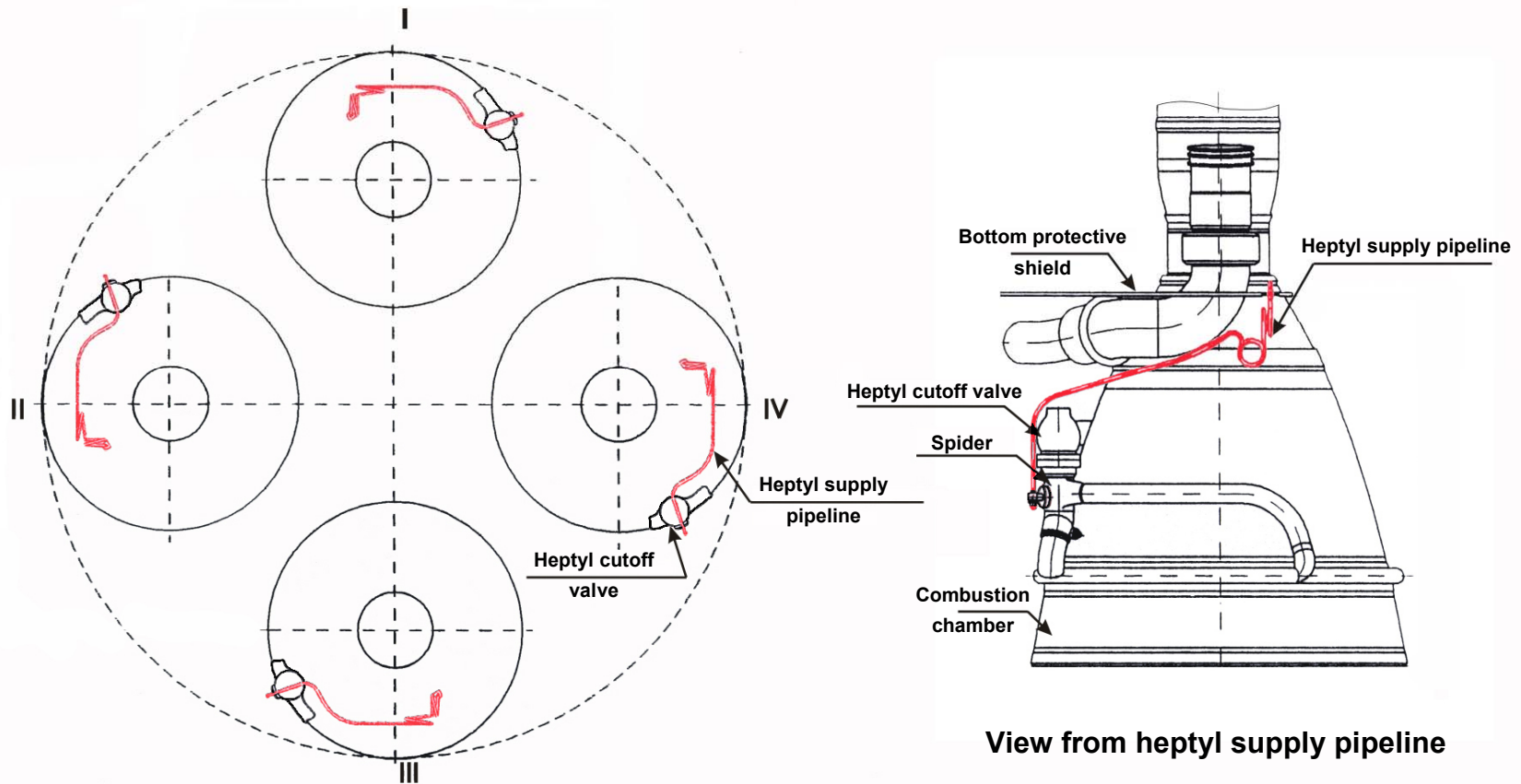
The Commission has conducted analysis or tests with respect to more 15 potential causes of abnormal operation of the hydraulic drive.

Basic conclusions made were as follows:

- The short-time malfunctioning of the hydraulic drive was caused by overheating of heptyl in the pipeline that carries it to the hydraulic drive during the flight.
- Heptyl overheating was the consequence of the heat insulation damage during the flight due to the probable deviation from the manufacturing and process related documentation, which was confirmed by the checks of integrity of thermal insulation installed on hydraulic drive heptyl supply pipeline performed on rockets manufactured before 1985.
- The launch failure investigation has not detected any flaws due to the service life duration of this type of the rockets.



Location of Hydraulic Drive Heptyl Supply Pipelines



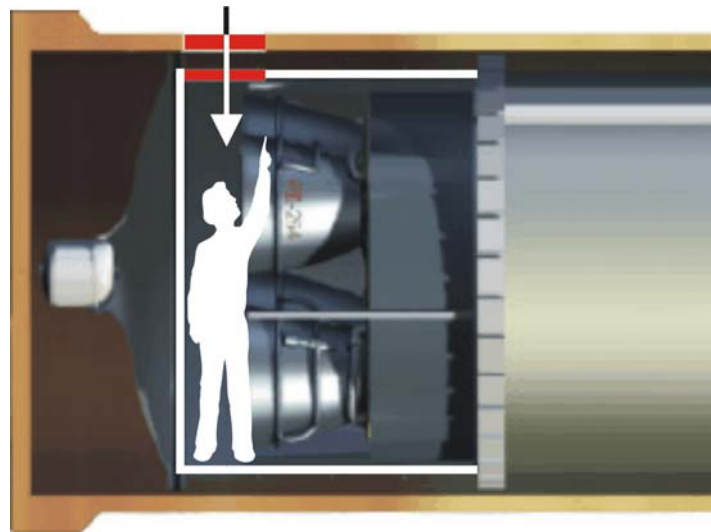
View from bottom protective shield

View from heptyl supply pipeline



Recommendations of Failure Investigation Commission

- To verify the condition of the heat insulation of heptyl pipelines of SS-18s manufactured before December 1984 to be used for spacecraft launches for the compliance with the manufacturing and process related documentation and, if necessary, to modify it.
- SDOY and Yuzhmash to develop relevant documentation that will govern performance of thermal insulation checks and its modification.





Implementation of the Failure Investigation Commission Recommendations

- Procedures are being developed for inspection and, if necessary, modification of the thermal insulation of hydraulic drive heptyl supply pipeline.
- Thermal insulation inspection and modification procedures will be validated at Surovatikha ICBM elimination base in October 2006.
- Inspections and, if necessary, modification of the thermal insulation of the rockets to be used for commercial launches are foreseen to be performed at launch bases and/ or storage facilities during rocket processing for launch.

Dnepr LV flight reliability

0.967



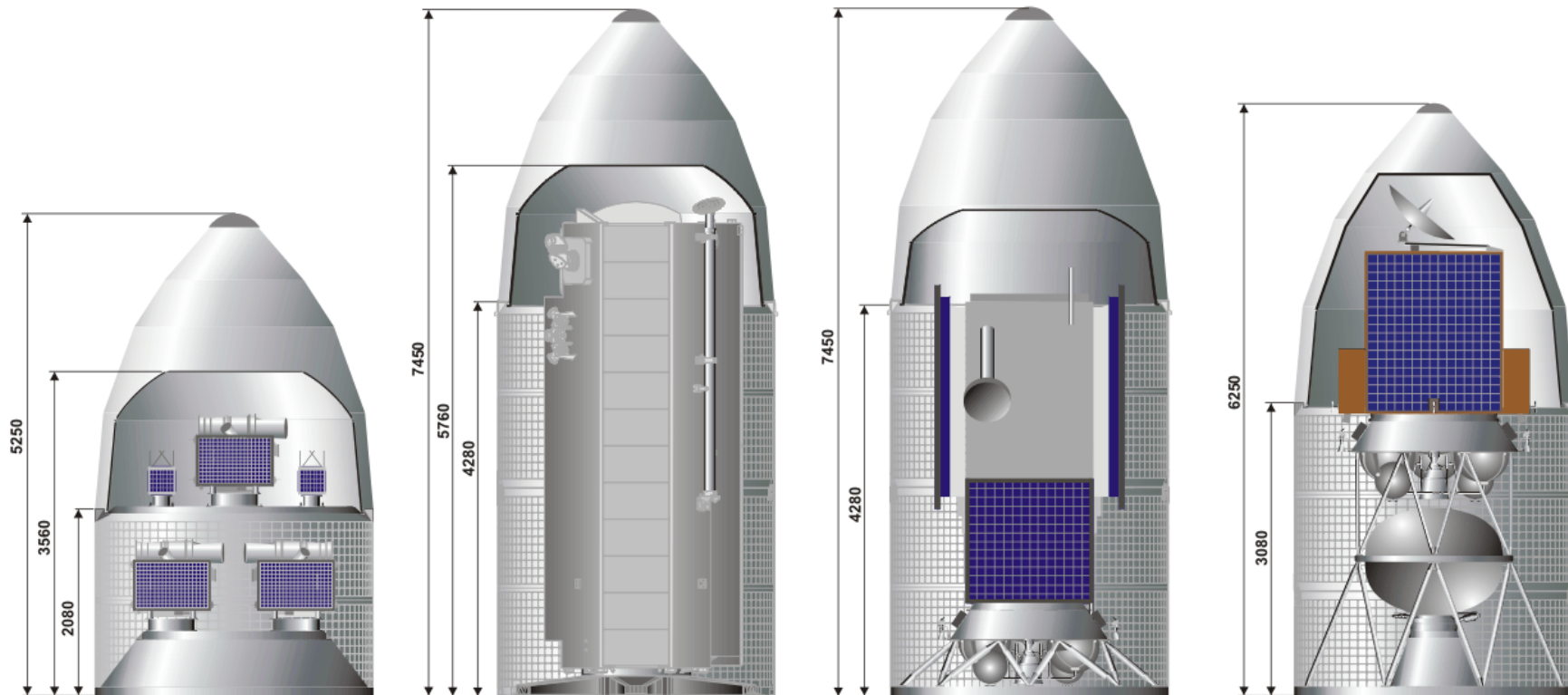
Projected Dnepr Launch Manifest for Late 2006 - 2007

| | |
|-------------------------|--------------------------------------|
| TerraSAR-X | May 2007 (Baikonur) |
| Genesis-2 | April 2007 (Yasny) |
| Small SC cluster launch | April 2007 (Baikonur) |
| Theos | October 2007 (Yasny) |
| RapidEye | January-Feb 2007 (Baikonur or Yasny) |

Subsequent projected launch rate: 2 to 4 launch missions per year

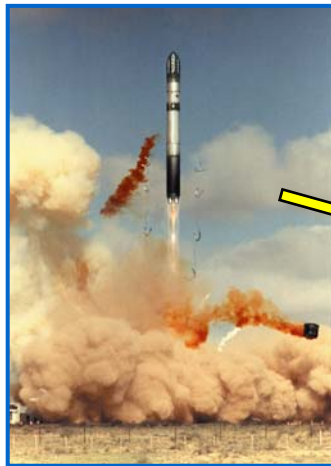


Dnepr LV Space Head Configurations





Heritage of ST-3 systems and elements



Adapter and separation system



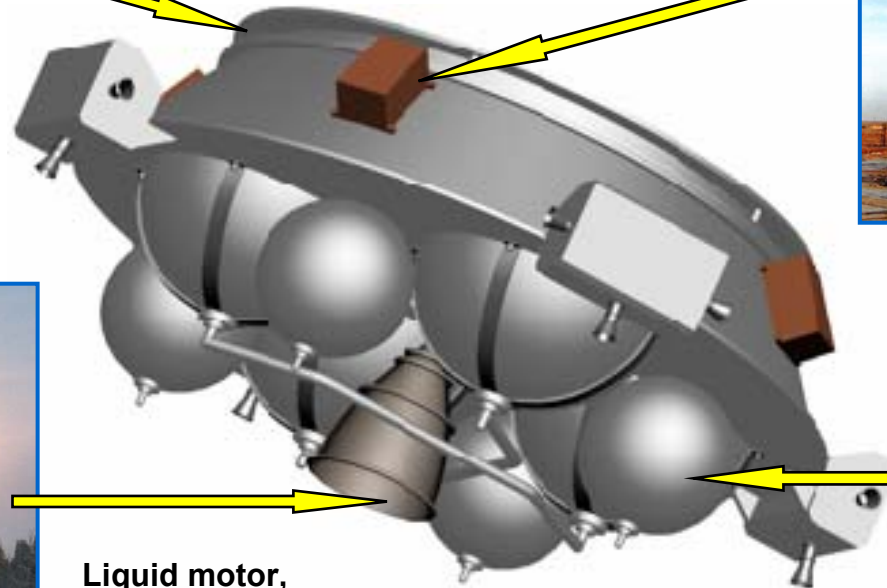
Main elements of control system



Liquid motor, orientation and attitude control thrusters



Propellant tanks and helium vessels





ST-3 Principal Characteristics

- Space Tug dry mass.....400 кг
- Propellant..... oxidizer N₂O₄ + fuel NSDH
- Propellant mass150-500 кг
- Liquid motor thrust.....4500 N
- Liquid motor specific impulse.....322.5sec
- Number of liquid motor restarts Up to 10
- Thrust of liquid thruster..... 110 N
- Separation system type and mass.....clamp band, 40 kg



ST-3 Engineering Model



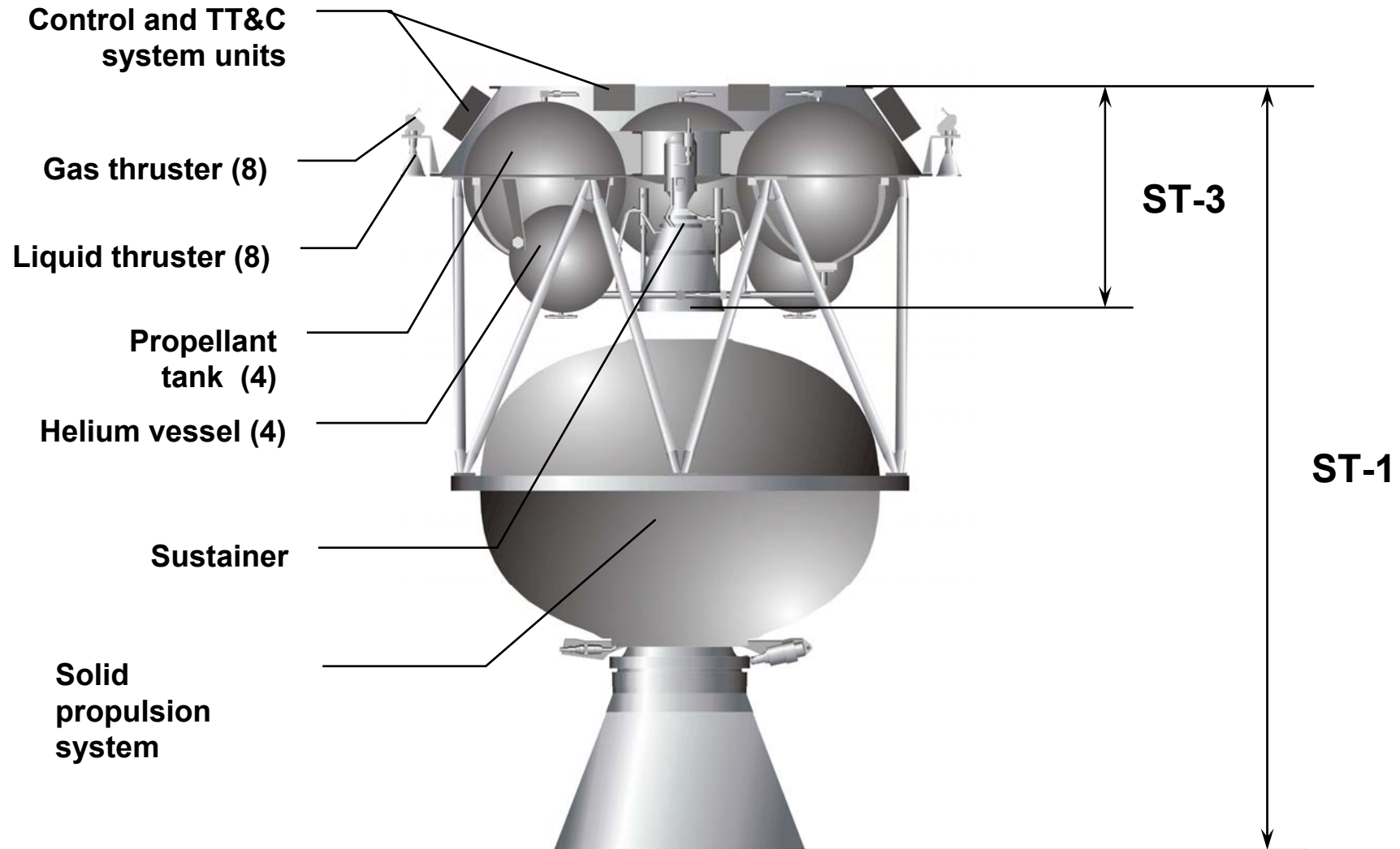


Liquid Propulsion System (bottom view)





Space Tug-1 for high energy orbit missions



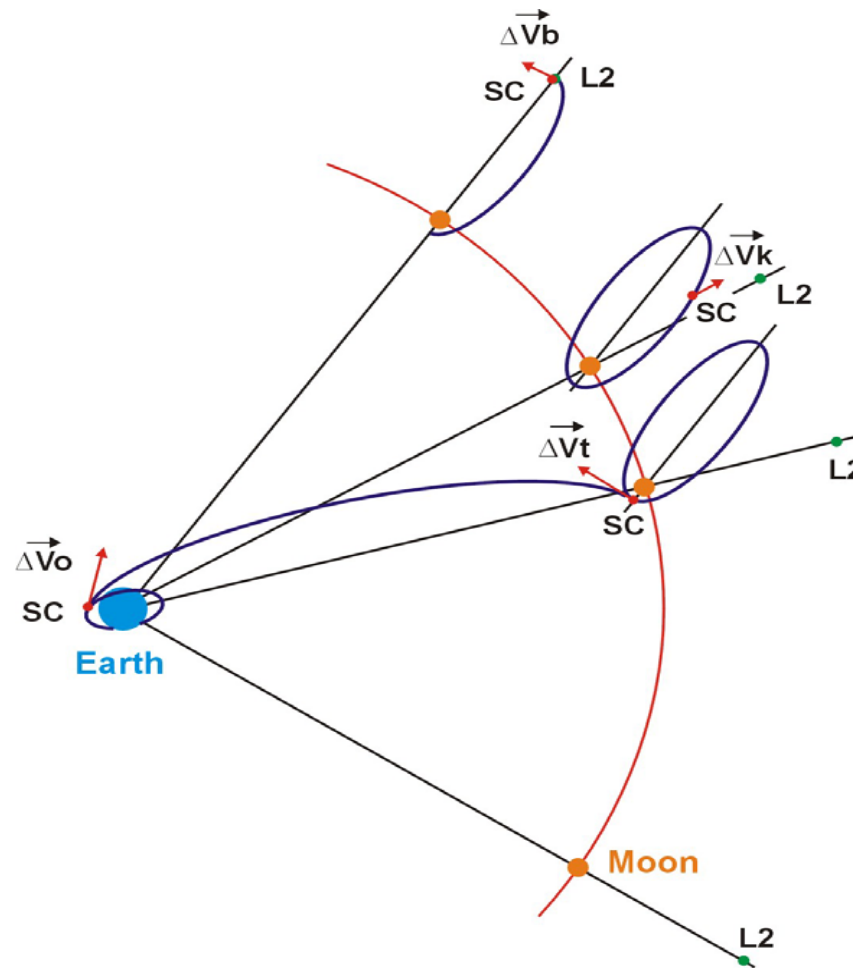


Performance of Dnepr LV with Self-contained Booster Stage (SBS)

| Mission | SBS Type | Payload Mass, kg |
|---|----------|------------------|
| Escape trajectory to Mars | SBS-1 | 440 |
| Martian orbit | SBS-1 | 250 |
| Geostationary orbit | SBS-1 | 300 |
| Escape trajectory to Moon | SBS-2 | 750 |
| Lunar orbit | SBS-1 | 400 |
| 600 km circular orbit inclined 12-17 degrees | SBS-1 | 200-320 |
| Libration point L2 (L1) of "Sun-Earth" system | SBS-1 | 620 |
| Libration point L2 (L1) of "Earth-Moon" system | SBS-1 | 430 |
| High-elliptical orbit, 40000 km apogee | SBS-2 | 700 |
| High-elliptical orbit, 71000 km apogee | SBS-2 | 650 |
| 800 km Sun-synchronous circular orbit | SBS-3 | 1750 |

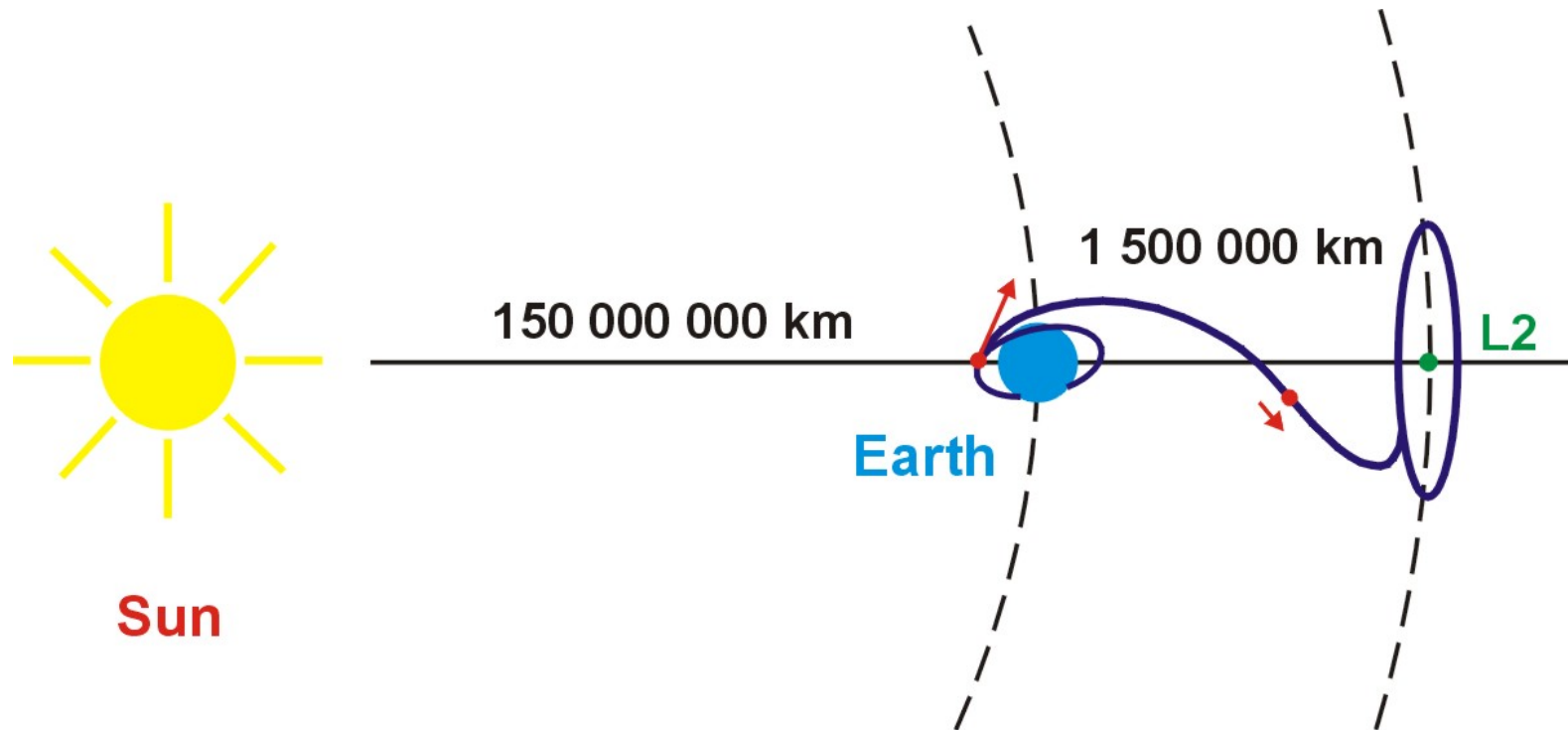


L2 Libration Point Mission Profile (Earth-Moon)



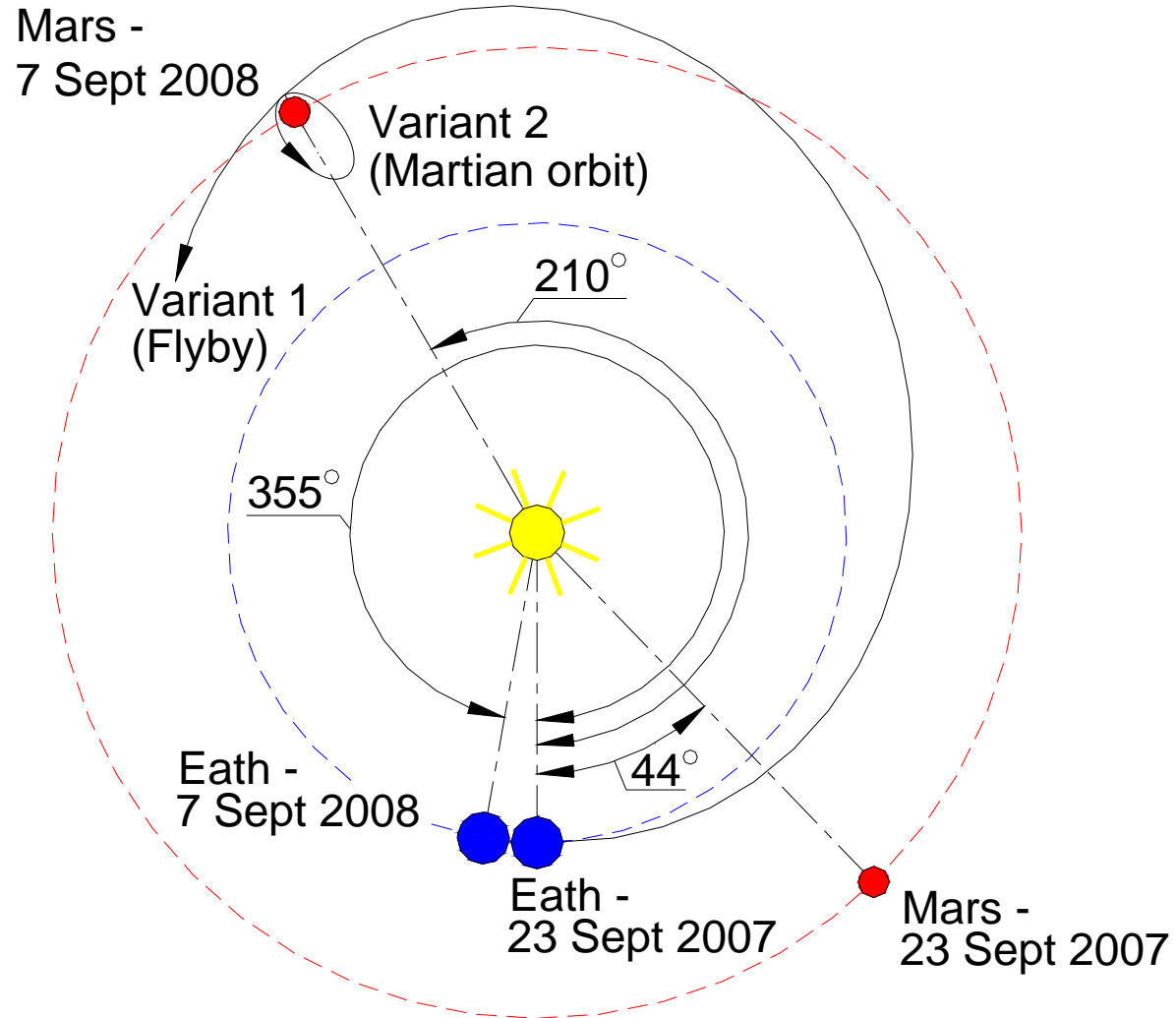


L2 Libration Point Mission Profile (Sun-Earth)



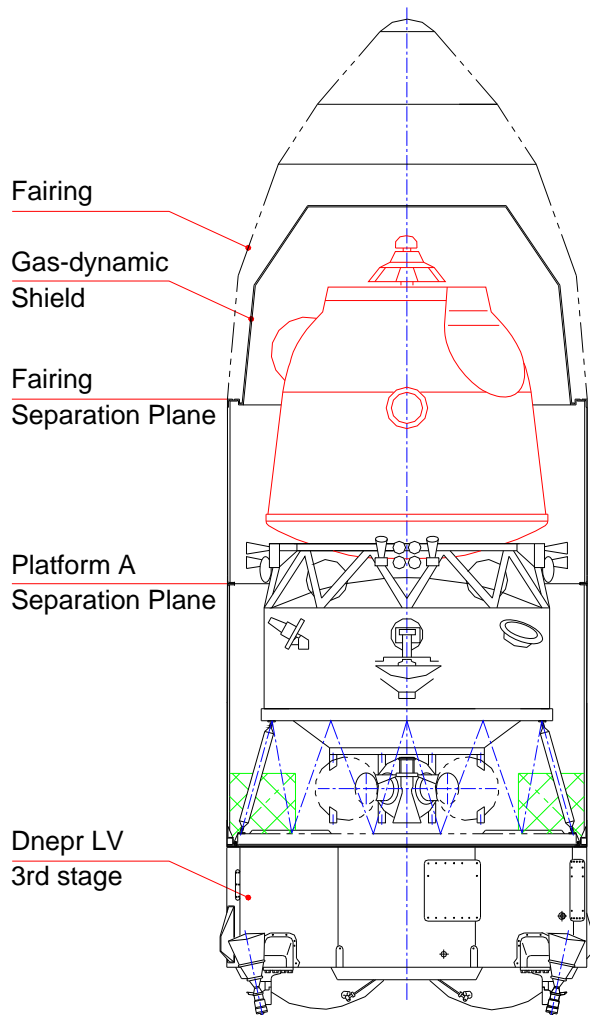


Martian Mission Profile

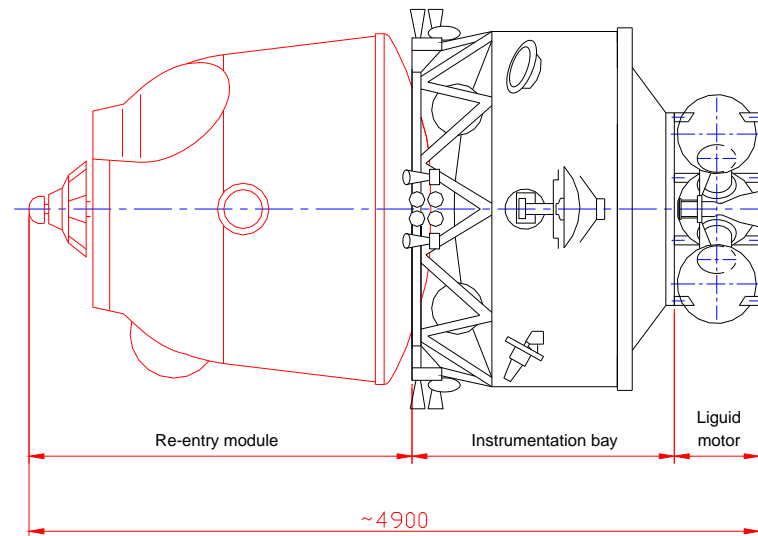




Dnepr LV is capable of delivering a recovery vehicle into the ISS orbit



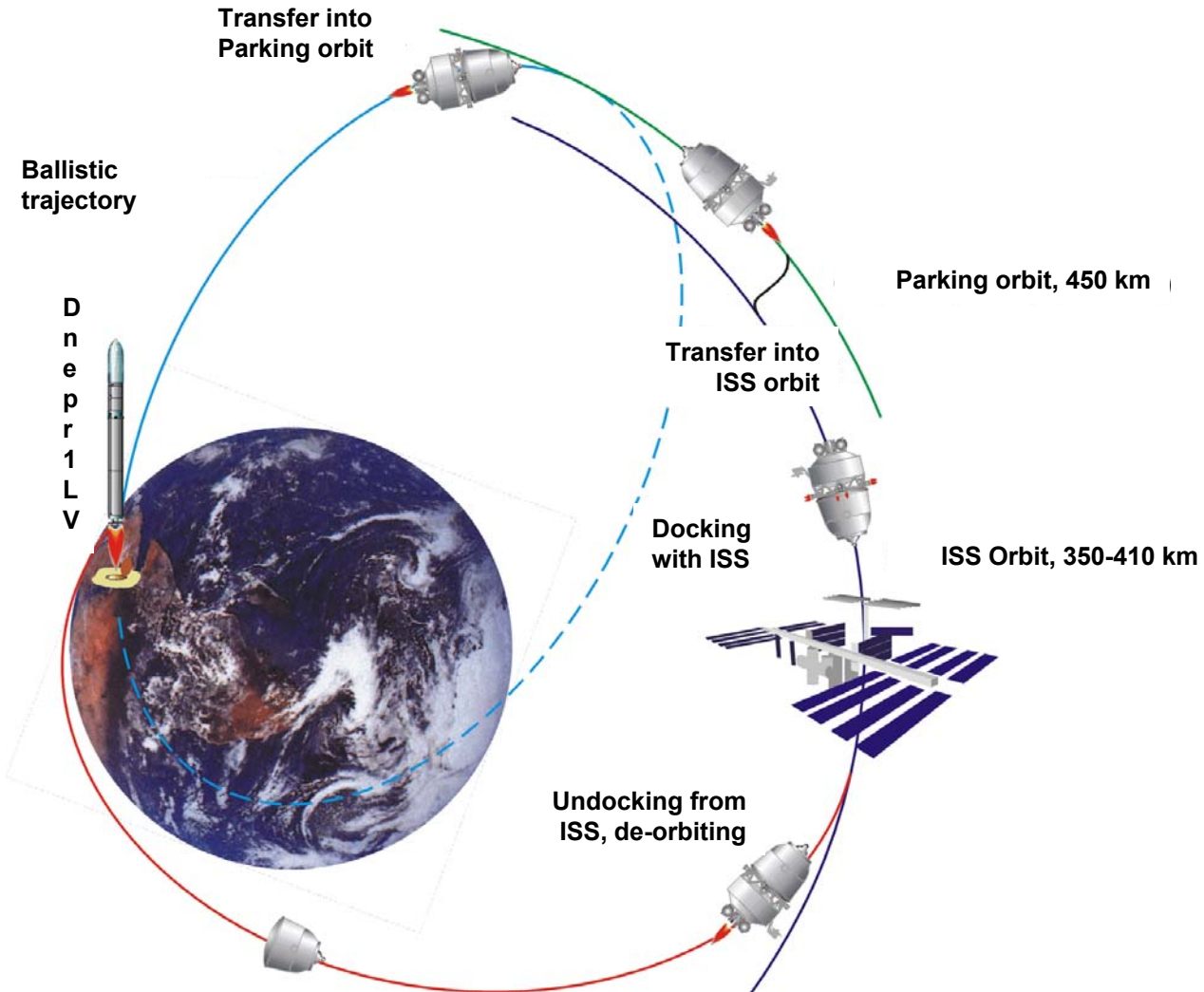
Recovery vehicle



- Recovery vehicle is designed to return the ISS crew back to Earth
- The weight of the fuelled recovery vehicle is 4.5 metric tons.

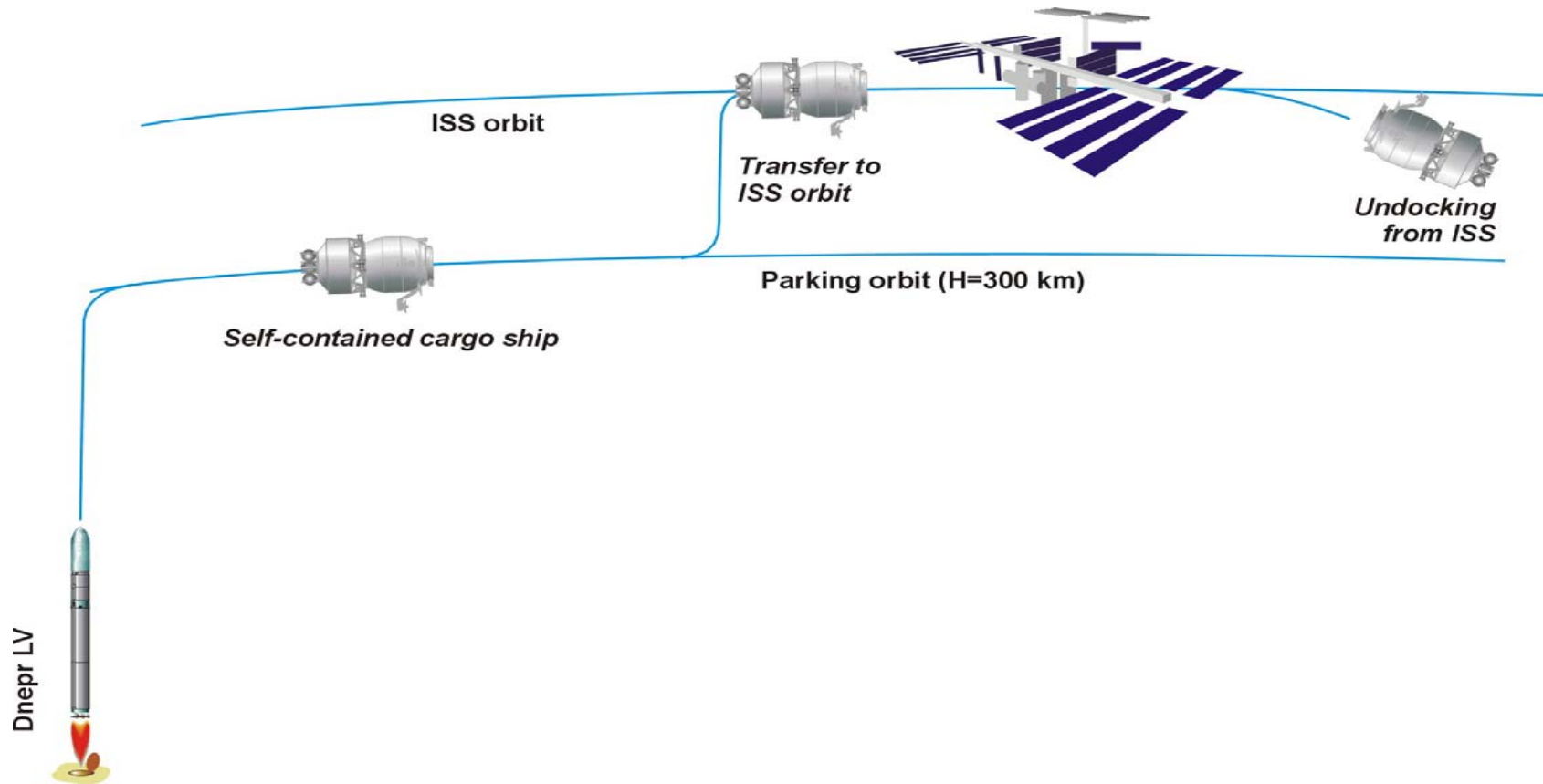


Recovery Mission Profile



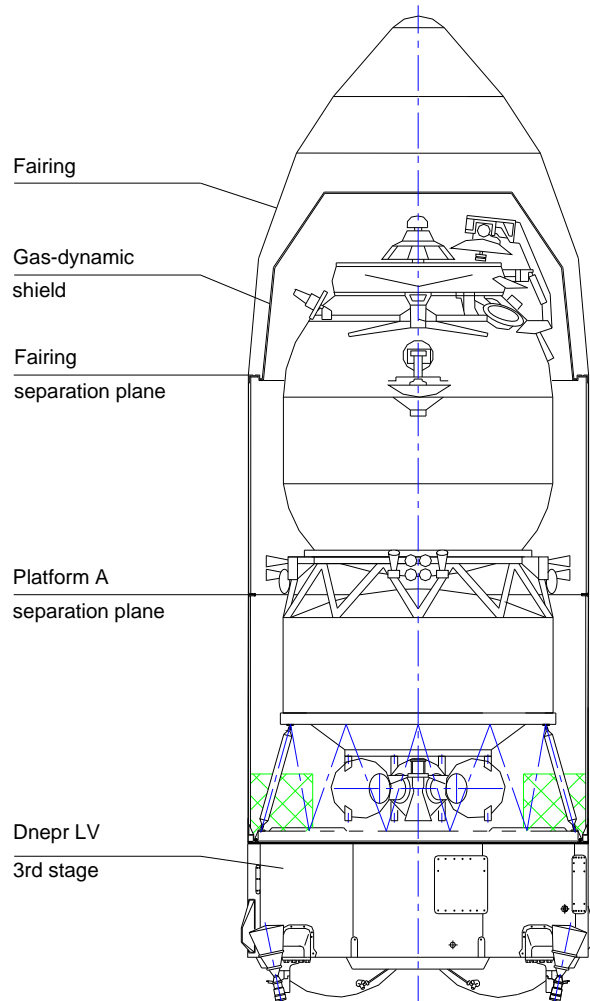


ISS Re-supply Missions Using Self-contained Cargo Ship and Dnepr-1 LV

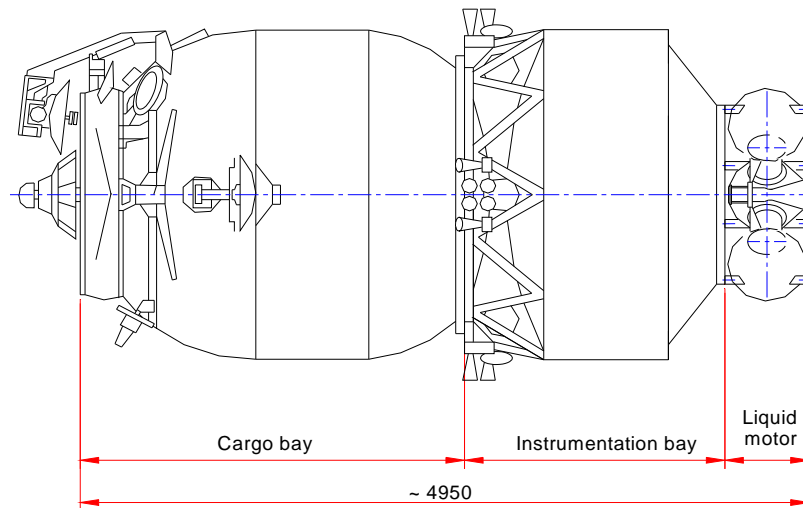




ISS Re-supply Missions Using Self-contained Cargo Ship and Dnepr-1 LV



Self-contained Cargo Ship



- **Cargo ship payload capability - 1.2 MT**
- **Projected per kilogram cost to ISS - \$10,000**



***ISC Kosmotras Mail Address:
7, Sergey Makeev str., bld. 2,
Moscow, 123100, Russian Federation***

Phone +7(495) 7457258

Fax +7(495) 2323485

E-Mail: info@kosmotras.ru

http://www.kosmotras.ru