Architecture for Reusable Responsive Exploration Systems: ARES - Platform and Reusable Responsive Architecture for Innovative Space Exploration: PRAISE (Part 1)

PATENT PENDING

Abstract

A comprehensive Modular Reusable Responsive Space Exploration Platform (Architecture) composed of multiple modular reusable elements such that the assemblies can be flexibly configured into systems for low earth orbits launches and for long-range exploration such as orbits to moon, Lagrange points and others. This platform & architecture is named as Architecture for Reusable Responsive Exploration System (acronym ARES) / Platform and Reusable Responsive Architecture for Innovative Space Exploration (acronym PRAISE), in short ARES/PRAISE or simply ARES. It is also known as Alpha Spaces Architecture and Platform (acronym ASAP), in short as "αPlatform" or "αArchitecture", or "αAres".

As an example, the configuration involves reusable lightweight wing, core stage, (optional booster stages) combination of expendable upper stage and reusable crew capsule. Further, the expendable upper stage can be re-used to serve as in-orbit fuel depots and for other innovative uses.

This is first part of the multi part patent application.

Inventor: Atreya, Dinesh S.

US Patent References

US Patent 6158693 - Recoverable booster stage and recovery method

US Patent 4878637 - Modular space station

US Patent 6726154 - Reusable space access launch vehicle system

US Patent 6113032 - Delivering liquid propellant in a reusable booster stage

US Patent 4557444 - Aerospace vehicle

US Patent 4880187 - Multipurpose modular spacecraft

US Patent 4452412 - Space shuttle with rail system and aft thrust structure securing solid rocket boosters to external tank

US Patent 4802639 - Horizontal-takeoff transatmospheric launch system

US Patent 4884770 - Earth-to-orbit vehicle providing a reusable orbital stage

US Patent 4265416 - Orbiter/launch system

U.S. Patent 3,285,546 - Multi-cell wing type aerial device, filed October 1964, issued November 1966

Claims:

What is claimed is:

1. This invention describes a Reusable Responsive Space Exploration Platform (Architecture) composed of multiple modular reusable and responsive spacecraft elements, which are sub-inventions on their own. The modular reusable spacecraft elemental sub-inventions, attachments to such elements, combinations of such elements in different configurations making the configurations into combined inventions/elements (assemblies/clusters/sub-systems/systems), and support systems for the spacecraft elements and (space systems) configurations constitute the Space Exploration Platform (Architecture) that provides a constellation of space exploration capabilities, that include low earth orbit (LEO), geo stationary orbit (GSO), near earth orbit (NEO), moon and others as per this claim. It is named as Architecture for Reusable Responsive Exploration System (acronym ARES) / Platform and Reusable Responsive Architecture for Innovative Space Exploration (acronym PRAISE), in short ARES/PRAISE or simply ARES.
2. A reusable exploration capsule (modular element according to claim 1) where the capsule provides Versatile Exploration Comprehensive Technologies including Orbital Reconnaissance (acronym VECTOR) invention is claimed. The capsule (vehicle for exploration by crew) comprising attached external air lock supports astronauts' extravehicular activities in space. This claimed capsule has the following copyright names: VECTOR, αVECTOR, VEC, αVEC.
3. In this invention, the crew exploration vehicle in claim 2 with detachable external air lock (modular element according to claim 1) is claimed.
4. The crew exploration vehicle in claims 2 and 3 having various sizes both including and excluding the external air lock is claimed. These sizes which provide different volumes include (a) Apollo class capsule size approximately 4.3 m (14 feet) in diameter with a narrower inclination (15 – 30 degree range) (copyright name αVEC-Apollo) (b) Orion capsule size with a narrower inclination (15 – 30 degree range) (copyright name aVEC- Orion) (c) standard (Orion bloc 2) and recommended size of approximately 610 cm (20 feet) in diameter (copyright name αVEC-Standard, αVEC etc.). This size is also termed as VECTOR class, or proposed ORION class (or ORION Block 2 class).
5. The invention of a reusable core (main) stage (modular element according to claim 1) where the core (or main) stage is reusable is claimed. This reusable core stage in one realization of this claim is composed of LH tank, LOX Tank, modular engine bracket. This reusable core stage in this instance can support multiple configurations, 2 engines, 3 engines or a single main engine. The engine(s) may be SSME (Space Shuttle Main Engines) initially followed later by RS-68 engine(s) (after they are qualified to be man-rated) for human use. The cargo core stage (reserved for only launching cargoes) is an alternative embodiment of the core stage. This core stage instance has a minimum size of 610 cm (20 feet) in diameter. The core stage in different sizes and different engine configurations in a reusable form is also part of this claim (in another instance a larger core stage with minimum size of 760 cm (25 feet) in diameter with 4 engines or 5 engines). In another embodiment of this invention the core stage can have integral fly-back engines.
6. As per this claim, this invention enables the enhancement of Solid Rocket Booster rendering the SRB to be fly back reusable. The SRB (currently used as a part of space shuttle) is designed to be integrated and serve as an auxiliary booster with the core stage described above. These solid

rocket boosters may be of initially composed of 4 segments. These solid rocket boosters may be modified later to have 3, 5, 5.5 segments or similar sizes.

7. As per this claim, enhanced Liquid Rocket Boosters (modular element according to claim 1) are designed to work with other modular elements (such as the core) and be flown back.
8. A reusable wing (modular element according to claim 1) is invented according to this claim. The elements claimed in claims 5 (core), 6 (Solid Rocket Booster), 7 (Liquid Rocket Booster) can be attached to this reusable wing element making the combination to be flown back for reuse. The wing embodiment is designed with different sizes to suite the different launch system configurations.
9. The reusable and responsive element in 8 and the element combinations (claim 5, 8), (claims 5, 6, 8), (claims 5, 7, 8) are embodiments of the combined first stage of the ARES space exploration platform (architecture). In accordance with Claim 1, this is represents a fly back clustered first stage system.
10. According to this claim, the redundant attachments of multiple recovery devices such as parachutes inflatable airbags, landing gears, retro-rockets and others are modular elements according claim 1. The spacecraft elements in claims 2 through 9 are designed to land in either liquid surface (water) or solid surface (land) with the aid of these attachments. Some examples (not exhaustive) include (a) Multiple redundant parachutes attached to element in claim 8 deployed to slow the flight (b) inflatable rafts attached to element in claim 8 deployed after landing of space craft element in water.
11. According to this claim a versatile thrust stage containing multiple Common Extensible Cryogenic Engines (CECE) or RL series (RL10A-4-2 or RL10B-2) engines or other engines belonging to this class constitute a modular spacecraft element as per claim 1. This stage provides a high degree of flexibility with throttling range from 100% (all engines at 100%) to 4-5% (one engine at 20-25%). This stage comes in different instances/embodiments with different number of engines, for example engines in cluster of 3, 4, 5, 6, 7 or other similar groups.
12. According to this invention/claim, the service module is designed to be powerful and has a minimum diameter of about 6.1 m (20 feet). The service module is a modular spacecraft element according to claim 1. It is designed to be flexible to be integrated with different classes of capsules (both crew and cargo). The integrated service module and modular capsule is a sub-system according to claim 1.
13. As per this claim, the upper stage (a modular element as per claim 1) is designed/invented to have double hulls and a minimum diameter of about 6.1 m (20 feet). The upper stage launches the spacecraft elements (sub-systems) that include crew modules (capsules) and cargo modules into space orbit.
14. The first stage as per claim 5 and 9 combined with an upper stage constitutes the reusable (responsive) space launch system (RLS). This system (and components thereof in claims 5 through 14) used for launching the capsule element claimed in 2, 3 and 4, provides a versatile human exploration capability. The various embodiments are classified as systems forming a part of the Architecture for Reusable Responsive Exploration System (ARES) according to claim 1. Following are the different embodiments (systems) of this invention:
    a. Experimental Launch System
    b. Medium Human Reusable Launch System – Medium HRLS
    c. Medium Heavy Human Reusable Launch System – MH HRLS

d. Heavy Human Reusable Launch System – Heavy HRLS
e. Ultra Heavy Human Reusable Launch System – Ultra HRLS

15. As per this claim Earth Departure Stage (a modular element as per claim 1), is designed as double hull module with a common inner fuel-oxidizer bulkhead capable of launching large objects into space. In this embodiment, the Earth Departure Stage is designed for use both with a single engine and with multiple engines depending on the sizes of the objects to be launched into space.
16. In the precious cargo embodiment of this invention (modular element as per claim 1), the human rated modules/capsules adapted with increased mass carrying capacity and designed to serve as cargo capsules is claimed. As an adjunct embodiment (another modular element as per claim 1), the cargo capsule has an extension that can be mated as required for supporting higher loads (cargo carrying capacity). The assembly is a sub-system according to claim 1.
17. This claim involves the invention of enhanced payload bay for holding and transporting cargo and is integrate-able with upper rocket stages (as per claim 11 and 12). This invention is a modular element as per claim 1.
18. The Earth Departure Stage (EDS) Cargo System invention/claim (classified as a system according to claim 1) consists of (a) Three core stages (each with 3 cargo RS/68 based engines), (b) 5 segment solid rocket boosters, (c) Earth Departure Stage (EDS) module with cargo and launch shroud for the cargo (as per claim 15). In the preferred embodiment, EDS has multiple engines and in an alternative, it has one engine.
19. The preferred Precious Cargo System embodiment (classified as a system according to claim 1) consists of (a) Wing, (b) 3 engine core stage containing engines meant for cargo use such as RS-68 based ones, (c) Auxiliary first stage 4 segment solid rocket boosters, (d) enhanced upper stage, (e) cargo capsule VECTOR-C (as per claim 16) and service module according to the claims of this invention.
20. The preferred Cargo Payload System embodiment (classified as a system according to claim 1) consists of (a) Wing, (b) 3 engine core stage containing engines meant for cargo use such as RS-68 based ones, (c) Auxiliary first stage 5 segment solid rocket boosters, (d) enhanced upper stage, and (e) payload bay αPAYLOAD (as per claim 17) according to this claim/invention.
21. As per this claim, heat resistant shields/shrouds (modular elements according to claim 1) are designed-invented for protecting the core stage and booster from hot gasses exhaust from the upper stage rockets and high temperatures during return flight.
22. According to this claim, the attachment of air breathing aircraft engines (modular element as per claim 1) to the wing element claimed in 8 will aid in fly back of spacecraft systems. The attachment of air breathing aircraft engines in other means to the elements claimed in 5, 6, and 7 will aid in fly back of space craft elements as well. (This is an alternative to having fly back engines at the bottom of core stage).
23. As per this invention, the design and attachment of liquid strap on boosters to the elements claimed in 5, 6, 7 that aid in fly back of space craft elements constitute another modular element according to claim 1. (This is yet another alternative to having fly back engines at the bottom of core stage or aircraft engines as per above claim).
24. One of the salient claims of this architecture is the design for reusability and responsiveness of modular elements, sub-systems and complete systems. In the principal embodiment, the integrated first stage and upper stage systems are launched vertically and the first stage sub-

system consisting of the core, auxiliaries and wing after launching of upper stages at the edge of atmosphere, are flown back and land. In this embodiment, the capsules are recovered from landing sites (land or water) and are reused. These recovered systems are made reusable in a highly responsive manner through support systems. As an adjunct to this invention, the upper stage rocket is reused as a part of in-orbit fuel depots.

25. The elements modules, sub-systems and systems claimed herein (in this document) in isolation or combination (that comprise a platform-architecture according to claim 1) are usable in a flexible manner for a variety of space exploration operational profiles as per this claim for low earth orbit (LEO), geo stationary orbit (GSO), near earth orbit (NEO) exploration and so on. This use can constitute light lift (10-15 tons), medium lift (15-20 tons), medium heavy lift (20-30 tons), heavy lift (30-60 tons), ultra heavy lift (60 to 120 tons), and super ultra heavy lift (more than 120 tons). Some embodiments of the flexible exploration profiles include the following and similar and other ones are part of this invention.
    a. Low earth orbit exploration embodiment
    b. Geo Stationary orbit exploration embodiment
    c. Near Earth Orbit exploration embodiment
    d. Lunar Exploration embodiment
    e. Precious cargo launches and return embodiment
    f. Space station construction, support and service embodiment
    g. Fly back embodiment using passive/powered and crewed/tele-operated means.

Description

CROSS-REFERENCE TO RELATED APPLICATIONS

Continuous Space SAFETY in process patent application: Continuous Space Safety Architecture that Fix Exploration Exceptions through Technology (SAFETY).

BACKGROUND

Field of the Invention

This invention relates to the field of space exploration both human and cargo/robotic.

Description of the Prior Art

The Apollo program was designed to land humans on the Moon and bring them safely back to Earth. Six of the missions (Apollo's 11, 12, 14, 15, 16, and 17) achieved this goal. In the Apollo program, the astronauts came back in the Apollo capsule. Rest of the Saturn vehicle used to launch the astronauts was expendable.

The Space Shuttle **Space Transportation System** (**STS**) is the first orbital spacecraft designed for partial reusability. It carries payloads to low Earth orbit (LEO), provides crew rotation for the International Space Station (ISS), and performs servicing missions. Each Space Shuttle is a partially reusable launch system that is composed of three main assemblies: the reusable Orbiter Vehicle (OV), the expendable external tank (ET), and the two partially-reusable solid rocket boosters (SRBs). While parts of the Space Shuttle are re-usable, it is not adaptable for long-range exploration missions.

The evolved expendable launch vehicles (Delta IV and Atlas V) can provide medium range exploration capability, however they cannot be used for human exploration. They cannot be used for long-range human space exploration of the order presented in this patent application. Also they do not provide any of the reusable characteristics of Space Shuttle and will be quite expensive in the long run.

While the Energia re-architecture, i.e., Energia II had plans proposed to make the core system completely reusable; the Energia system itself was never a fully functional system. In addition the Energia-2 core stage was not modular in nature and the entire core was meant to reach orbit and fly back and land (inspired by the Shuttle orbiter). Since Energia system (consequently Energia-2) was not well designed neither launch vehicle has been used for regular launches. Also Energia system was not meant for exploration beyond low earth orbit.

While the Shuttle II study had the concept of a fly-back booster, it was not versatile enough to handle both SRBs and Liquid Boosters (that this invention is capable of). The Shuttle II study also proposed an expendable Heavy Lift Launch vehicle to reach beyond low earth orbit. This invention on the other hand invents a reusable and responsive vehicle that can be used for both low earth orbit and for missions beyond low earth orbit.

While the reference patents listed above may suggest some modular elements, none of them suggest a completely modular architecture. Some of them propose certain elements such as fly back boosters to be re-usable while the core is expendable. For the first time this invention and architecture proposes a completely modular platform where the entire first stage (including the core and the boosters) can be flown back and re-used and is a re-invention of existing functional systems. The first stage core and the boosters reach the edge of the atmosphere – beginning of space and are flown back after launching the upper stages. The upper stages can be enhanced as a part of this invention's extensions to make a completely reusable Two Stage to Orbit and Landing (TSOL-TSTOL) system.

SUMMARY

In accordance with the present invention a modular reusable responsive space exploration platform (architecture) is presented which has the following components:

- Different classes of versatile exploration capsule(s) that can serve multiple roles: (a) initially serve as a Crew Escape Vehicle (CEscV) (b) Crew Exploration Vehicle (CEV) (c) support Extra Vehicular Activity (EVA) through use of integrated external air-lock.
- Modularly attachable wing.
- The core stage that is highly configurable
    - Can be used stand-alone
    - Can be outfitted with one or two or three engines as needed
    - Can be used with strap on boosters
    - Can be used together with auxiliary core-stages
- The expanded diameter core stage can be equipped with 4 engines.

- Solid rocket strap-on boosters that can come in various segments
    - 3 segments
    - Standard 4 segments
    - Auxiliary standard 5 segments
    - 5.5 or 6 segments as needed
- Upper stage can consist of
    - Upper stage having J2X engine(s)
    - Versatile stage that has Extensible Cryogenic Engines (CECE) or RL Series of engines.
- The complete rocket assembly in two flavors (a) 2 stages (b) 3 stages.

OBJECT AND ADVANTAGES

The invention satisfies a number of objectives. It is designed to be highly modular, reusable and responsive.

It provides appropriate configuration capability for various classes of missions, from low earth orbit (LEO) to long range exploration.

The high degree of re-usability involves:

- Reuse of exploration capsules
- Reuse of both core stage and solid boosters

After a designated number of uses for human exploration, the platform can be re-used again for cargo. The core and booster stages can be re-used for satellite launches as well.

The high degree of modularity and re-usability enhances the responsiveness of the platform. Instead of procuring new sets of hardware for every launch, the platform elements after one mission can be turned around and used for the subsequent missions in a highly responsive manner.

DRAWING FIGURES

Various diagrams that illustrate the invention embodiment(s) are shown below:

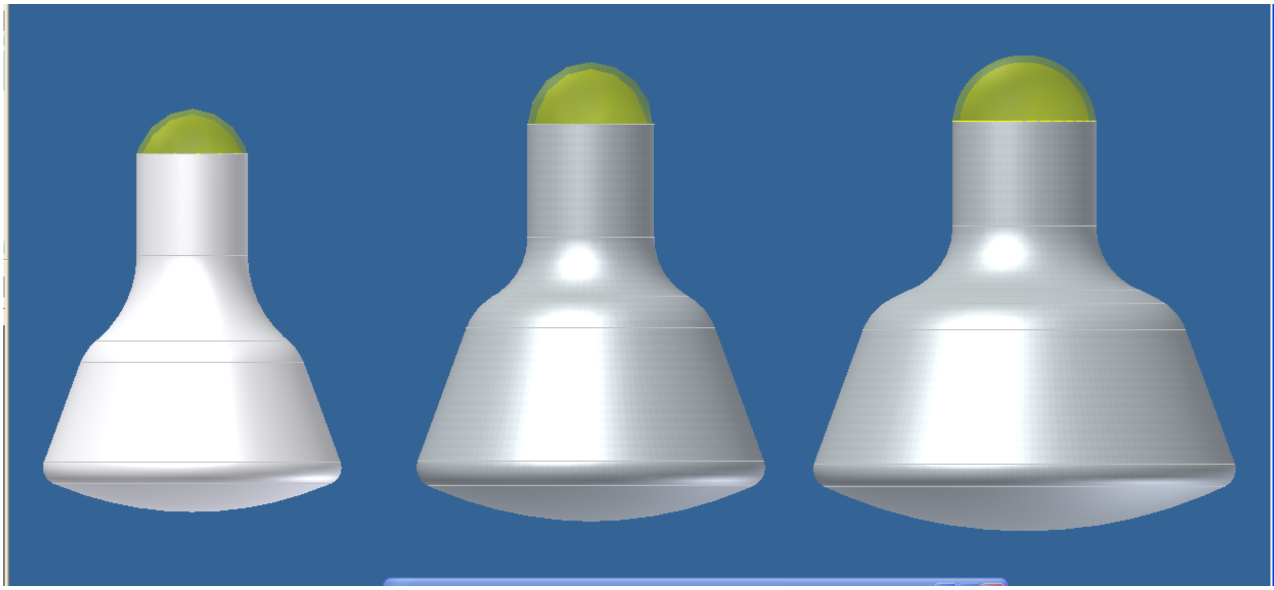

Figure 1: Three classes of Capsules (a) Apollo (b) Old-Orion (c) Standard - Proposed new Orion (VECTOR) or Orion Block-2 with integrated airlocks.

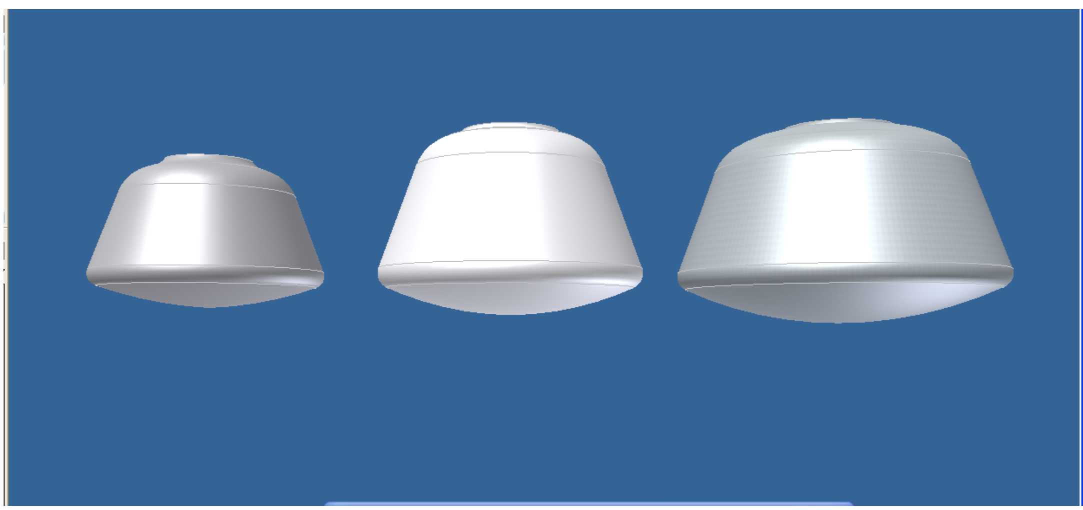

Figure 2: Three classes of Capsules (a) Apollo (b) Old-Orion (c) Standard - Proposed new Orion (with air-locks removed)

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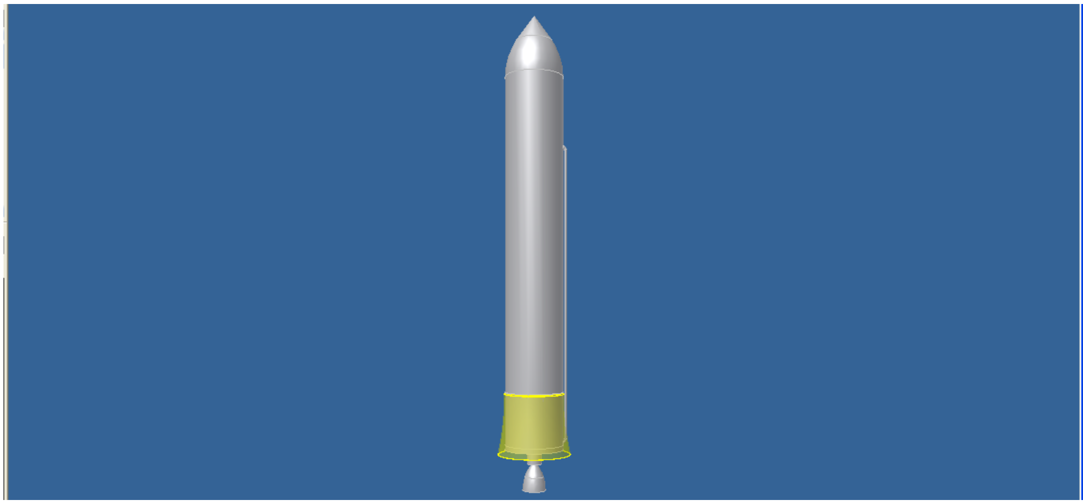


Figure 3: Core Stage configured with single engine.

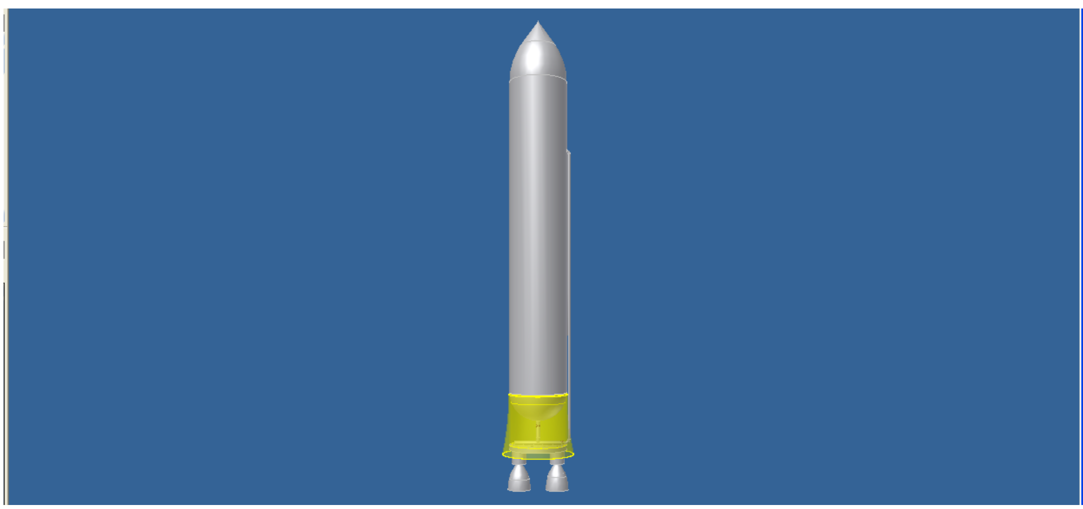


Figure 4: Core Stage configured with two engines.

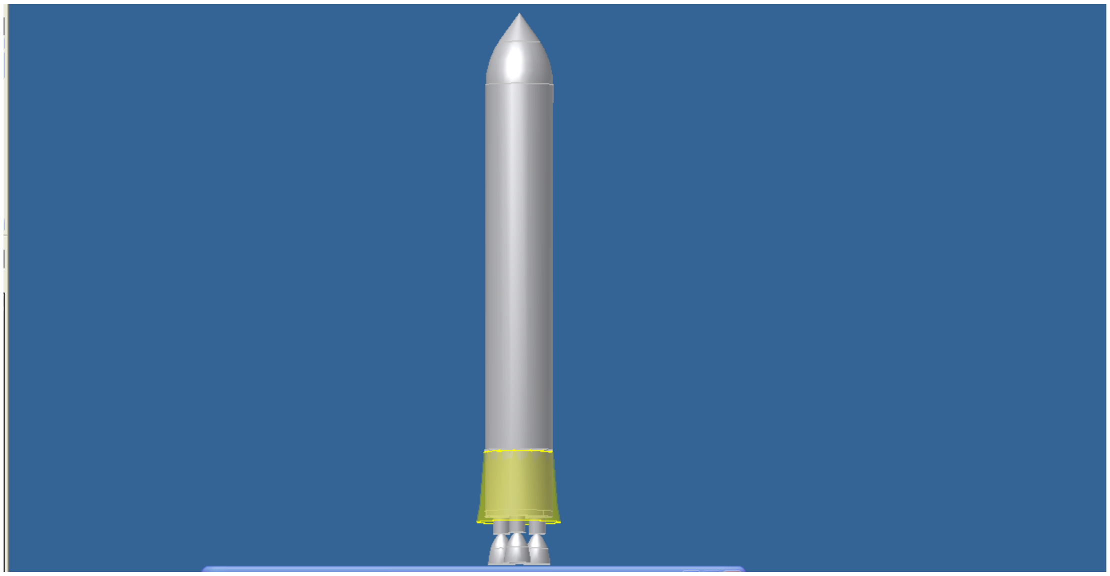
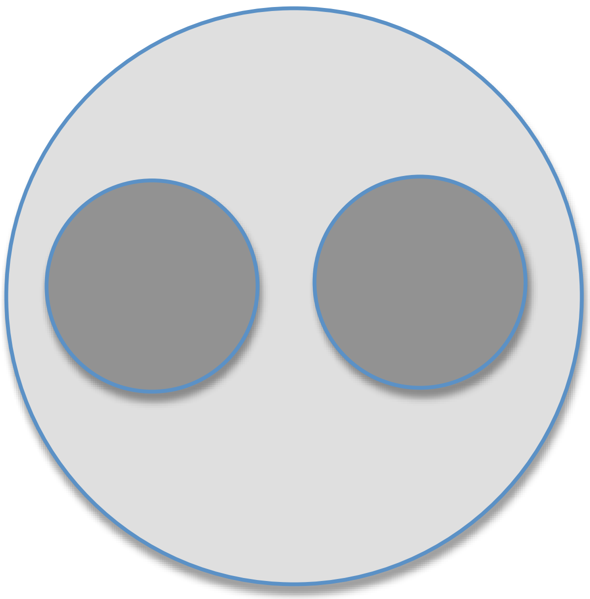
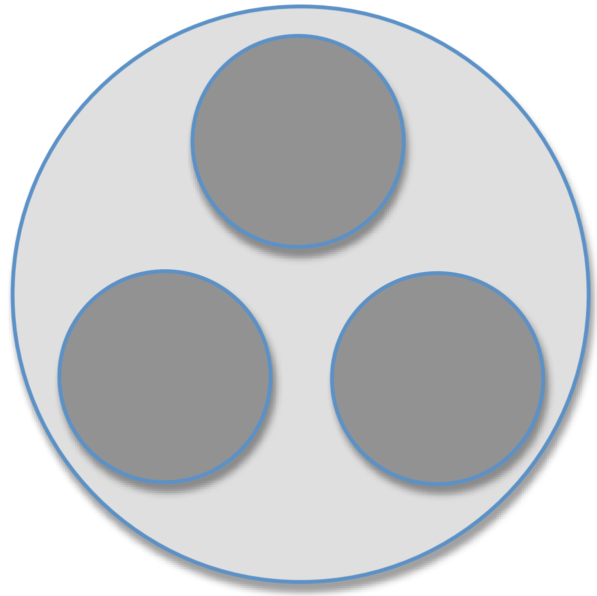


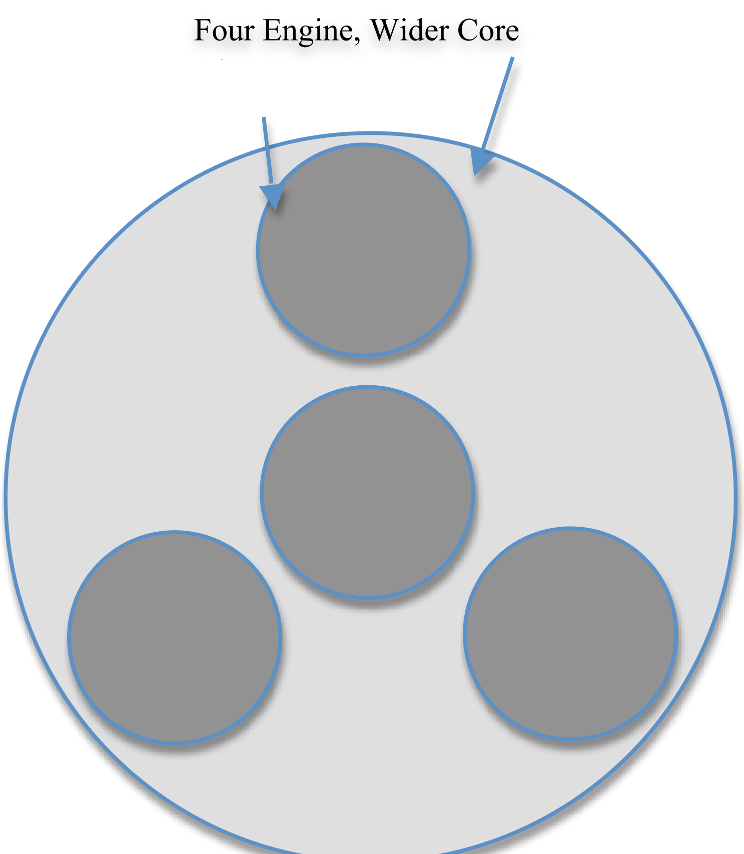
Figure 5. Core Stage configured with three engines (enhanced space shuttle design).



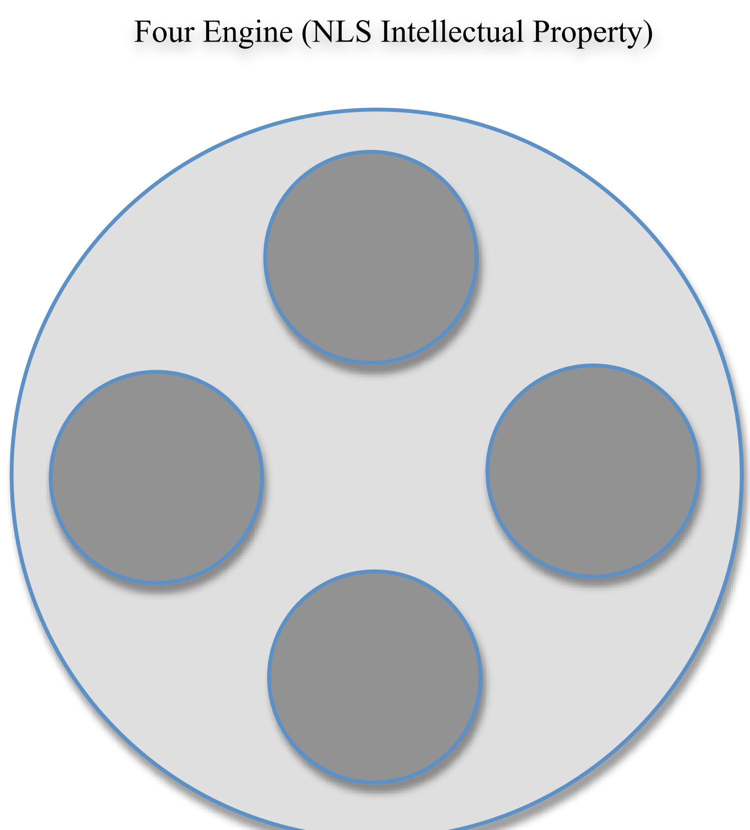
(a) Two Engine



(b) Three Engine



(c) Four Engines



(d) Four Engines (Enhanced NLS)

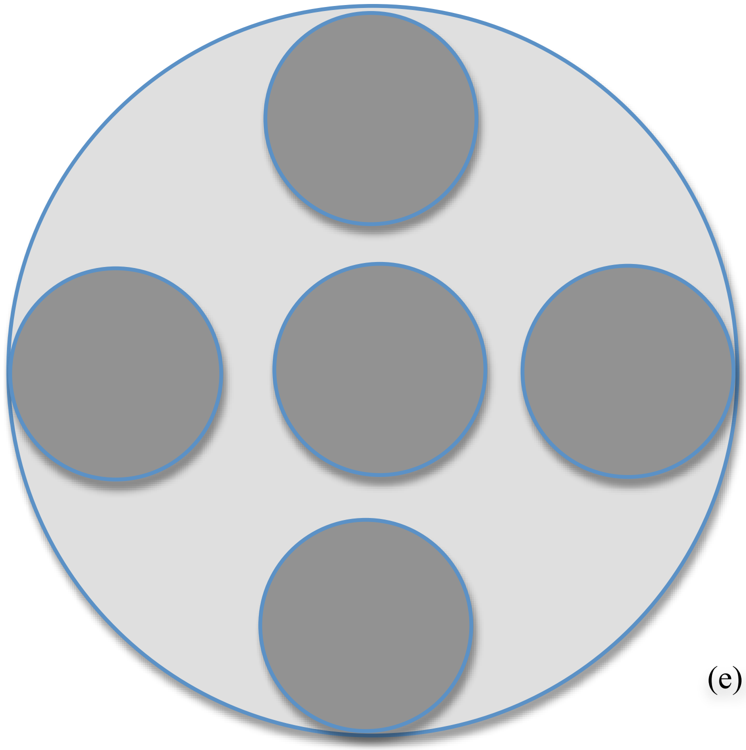
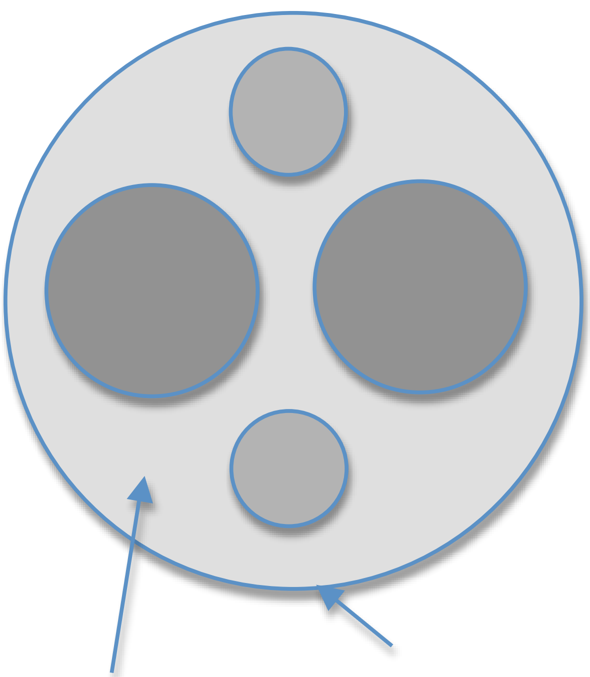
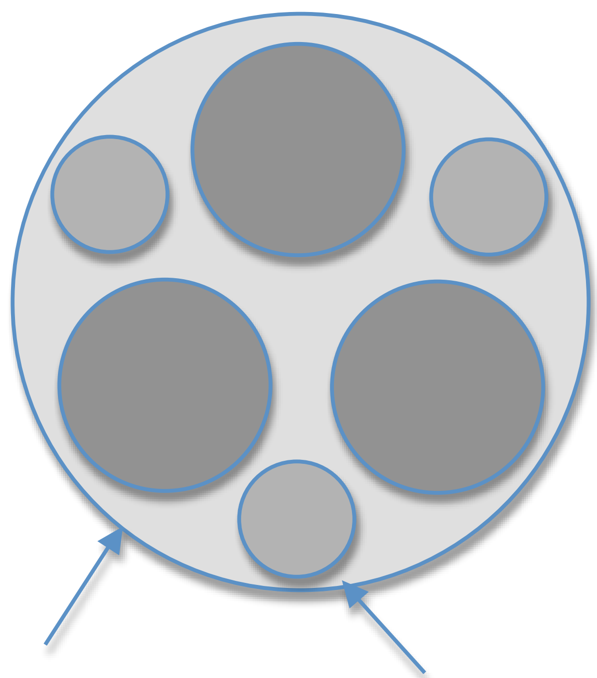


Figure 6. Different possible engine configurations





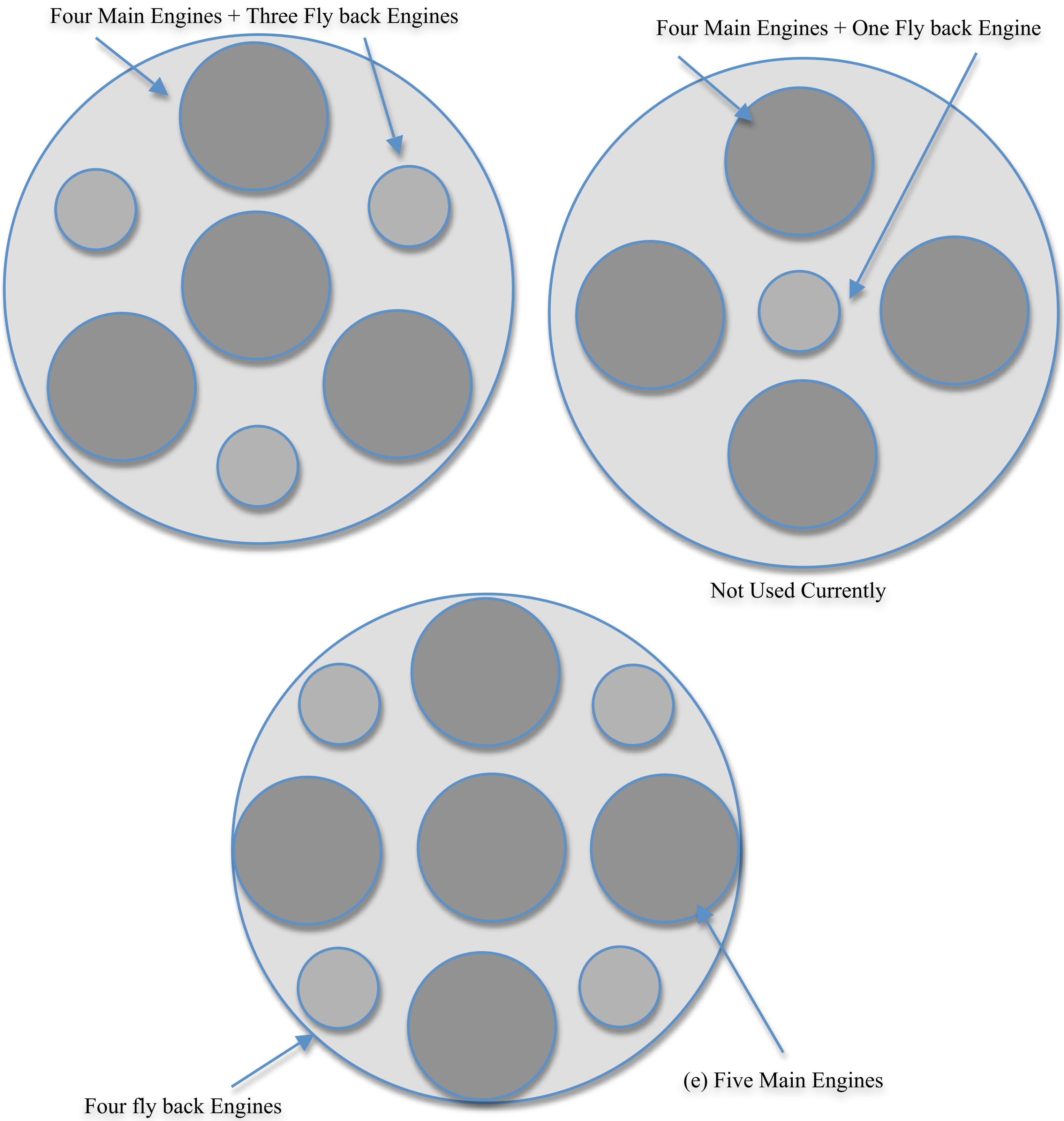


Figure 7. Different possible engine configurations (including fly back rocket engines)

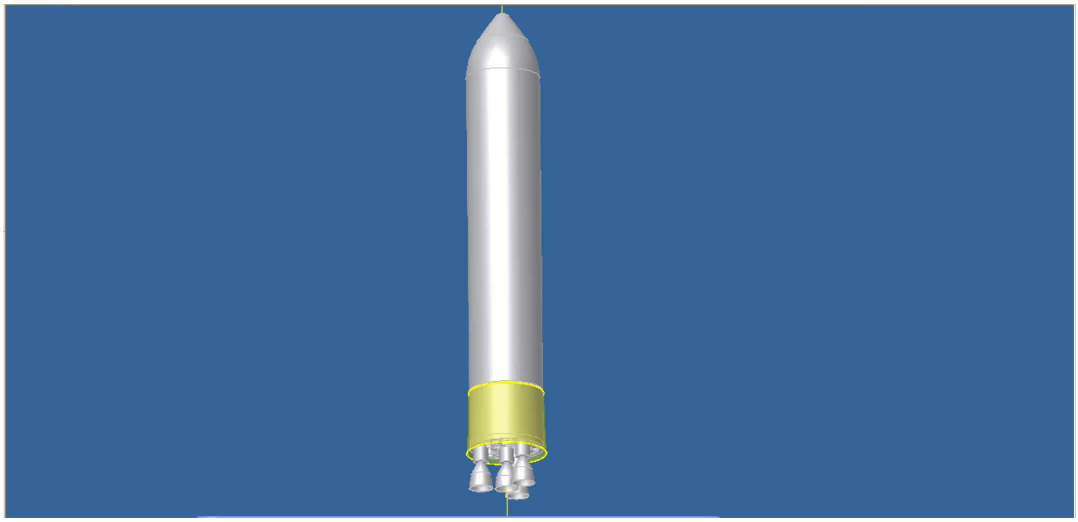


Figure 8. Large Diameter core stage with 4 engines (different from NLS design)

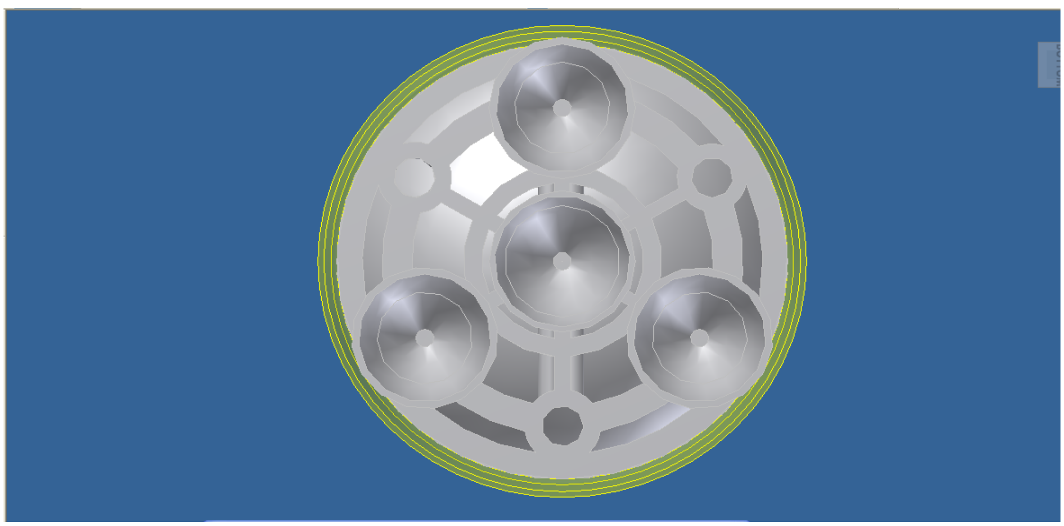


Figure 9: Large Diameter core with visible engine layout as per Figure. 6 (c)

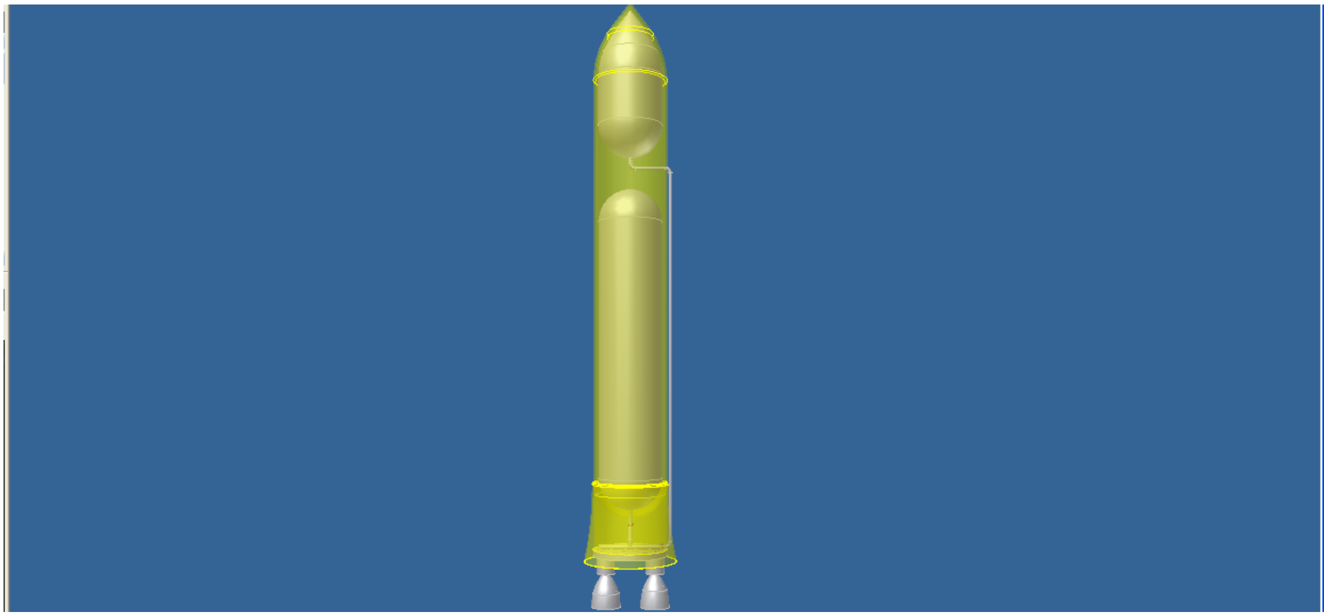


Figure 10: Core stage with internal details visible (LH Tank, LOX Tank, Engine Bracket etc)

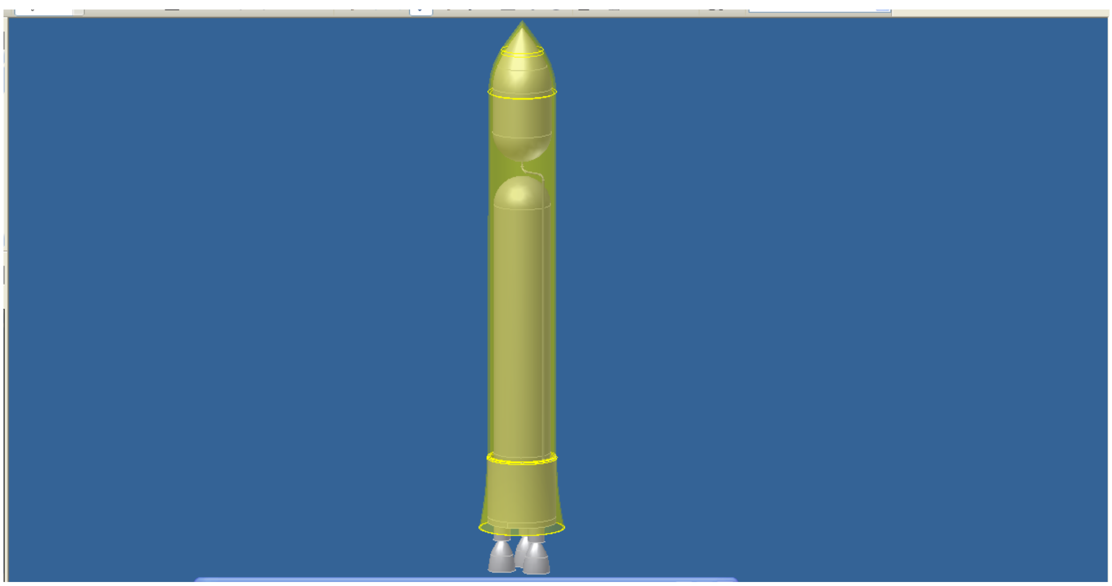


Figure 11. Double Hull (3 engine) Core Stage (Note the LOX piping is now inside outer hull).

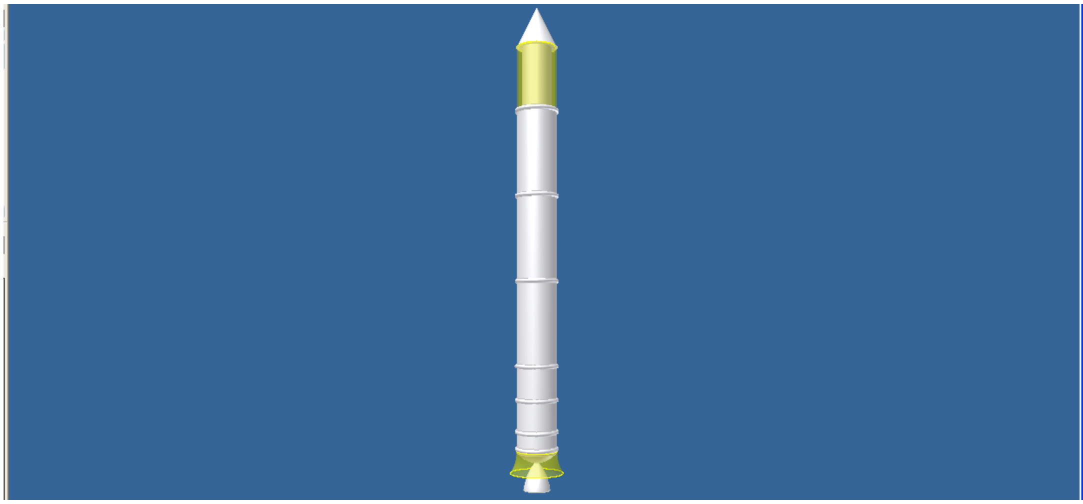


Figure 12: Solid Booster (shown with standard 4 segment)

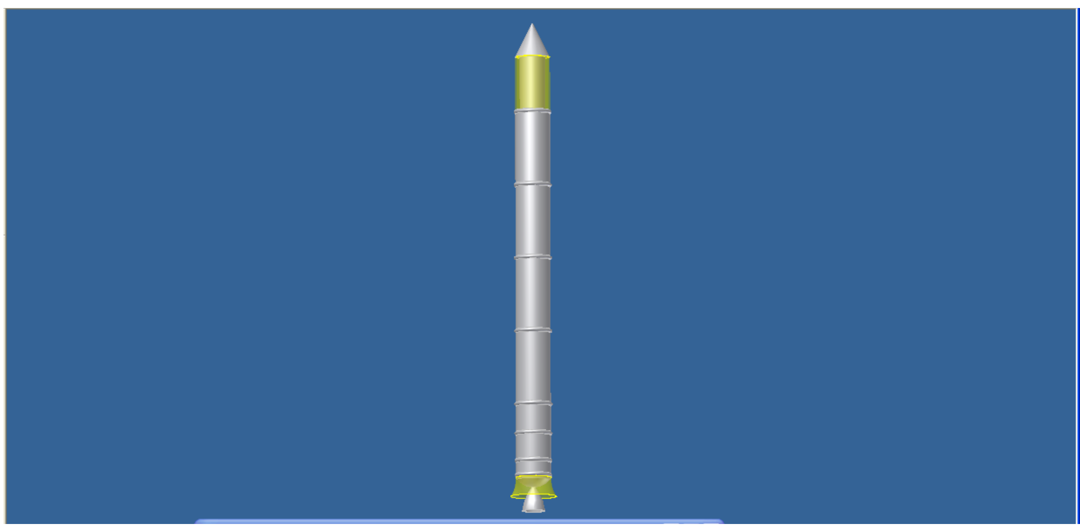


Figure 13: Solid Booster (shown with 5 segments)

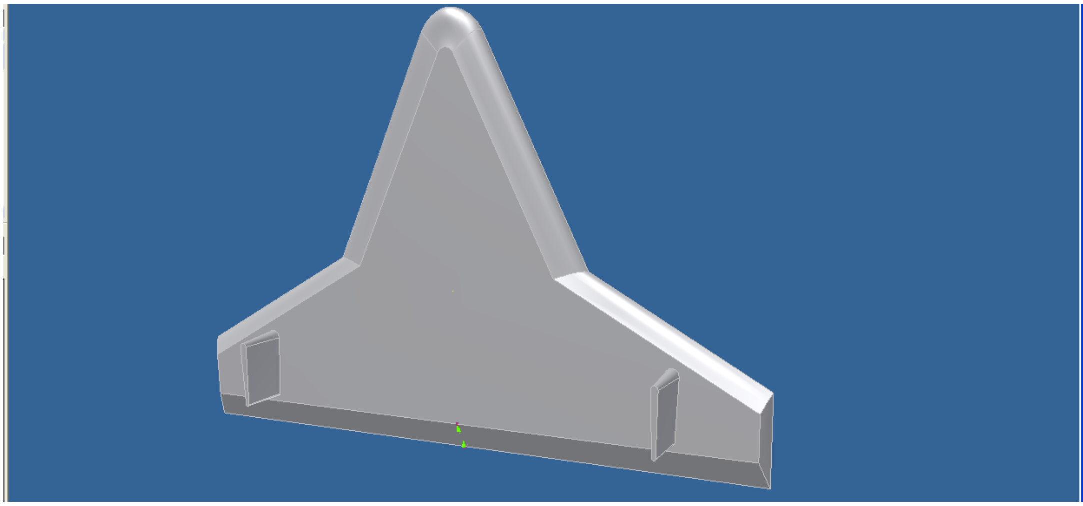


Figure 14: Wing (Light weight, Delta shaped)

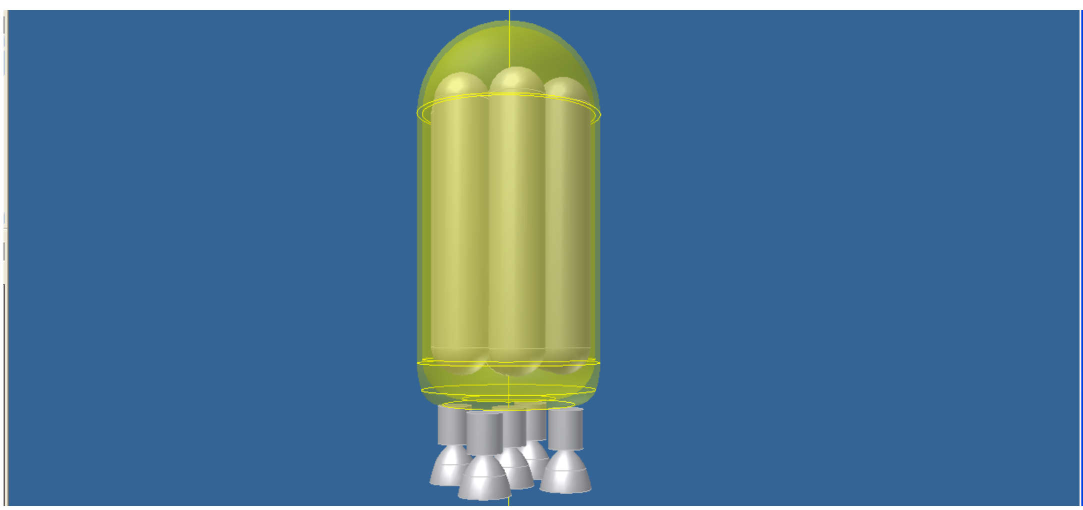


Figure 15: Versatile Stage (also known as kick stage, 3rd stage, moon landing stage etc.)

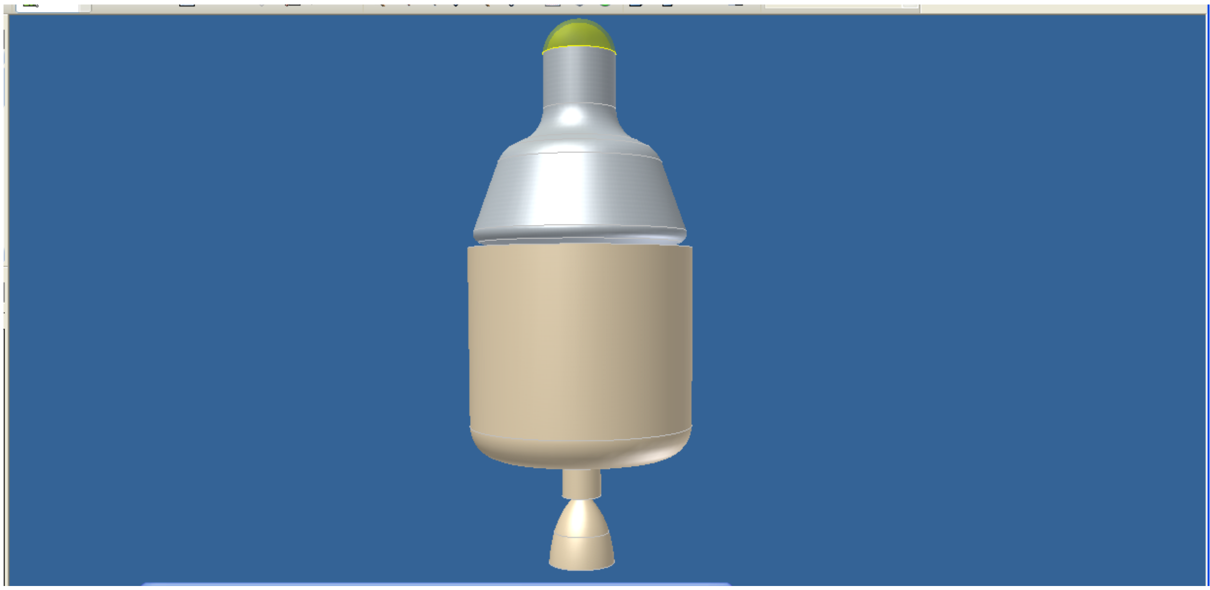


Figure 16: Service Module with VECTOR (Orion block 2) class CEV.

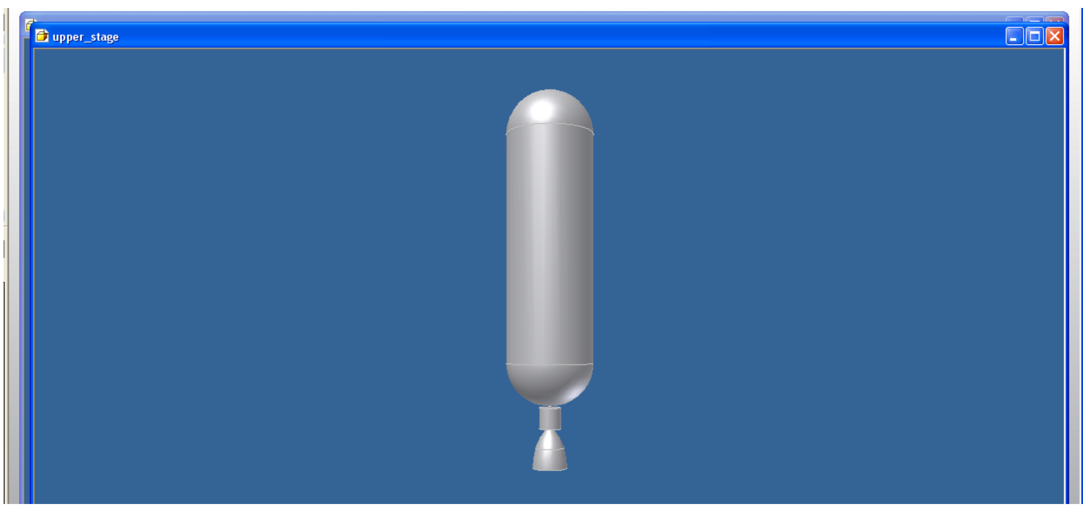


Figure 17: Upper Stage

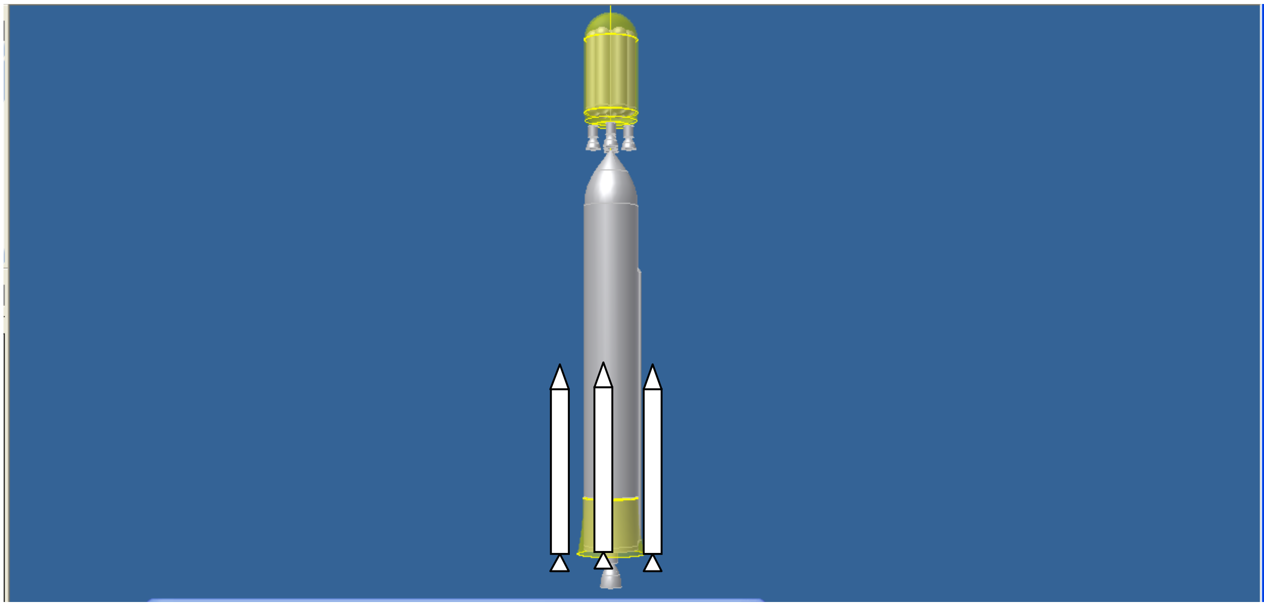


Figure 18: Experimental or Small Lift embodiment (with RS-68 evolved expendable LV engines)

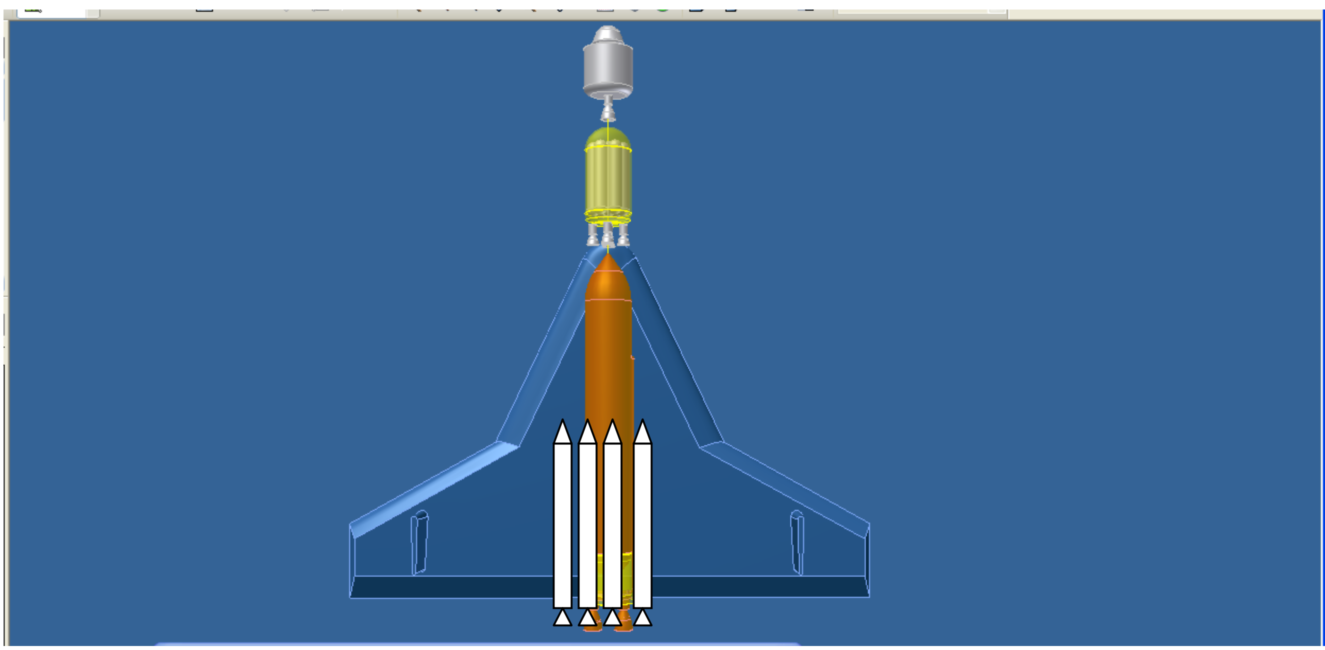


Figure 19: Medium Lift embodiment (for Apollo class vehicles without the air-lock)

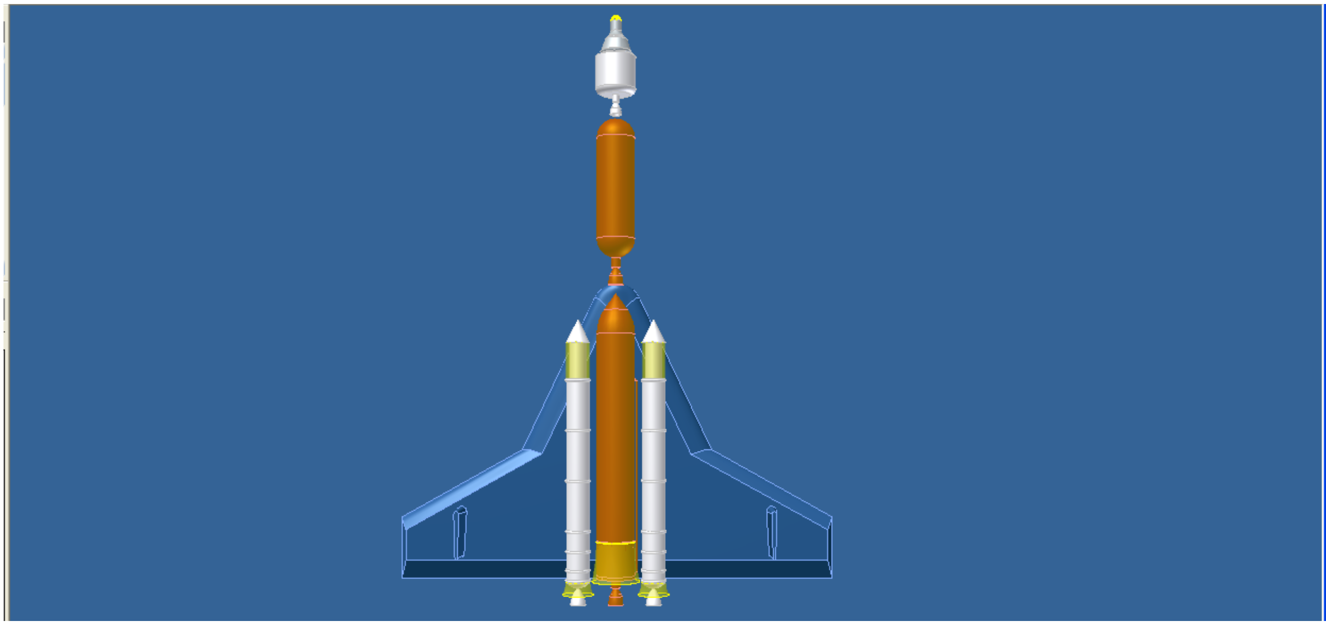


Figure 20: Standard Lift embodiment (for vehicles having old ORION level weight)

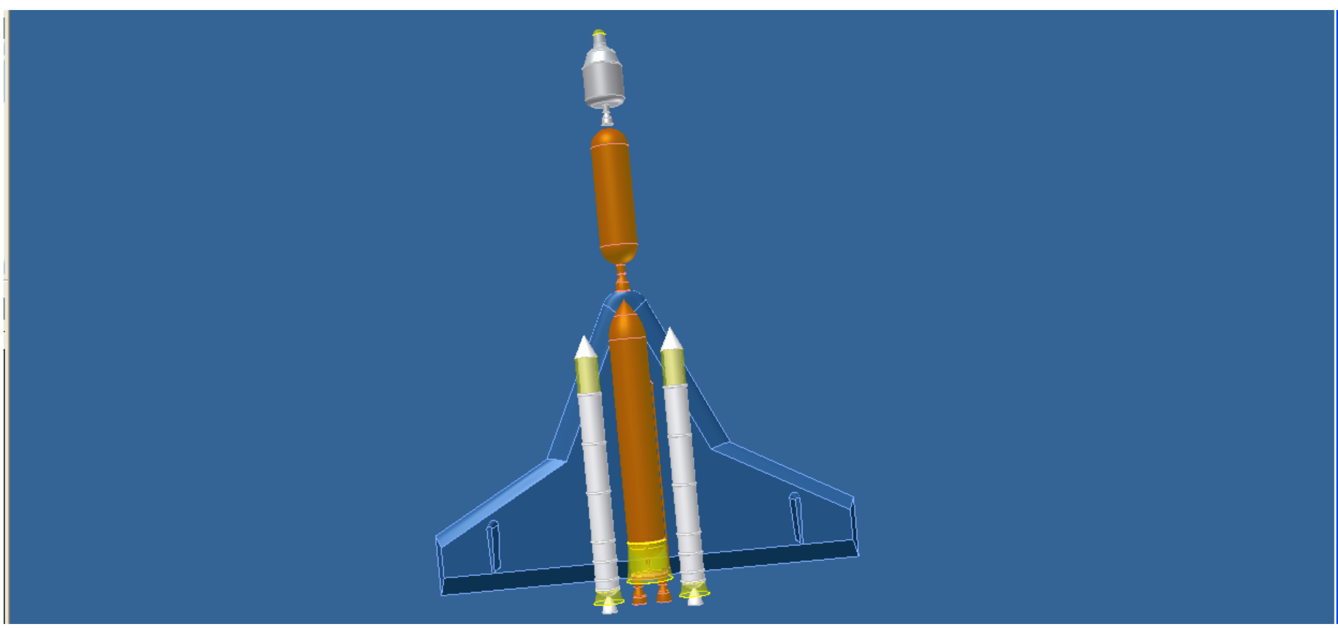


Figure 21: Heavy Lift embodiment (to launch VECTOR class - ORION Block 2 class CEVs)

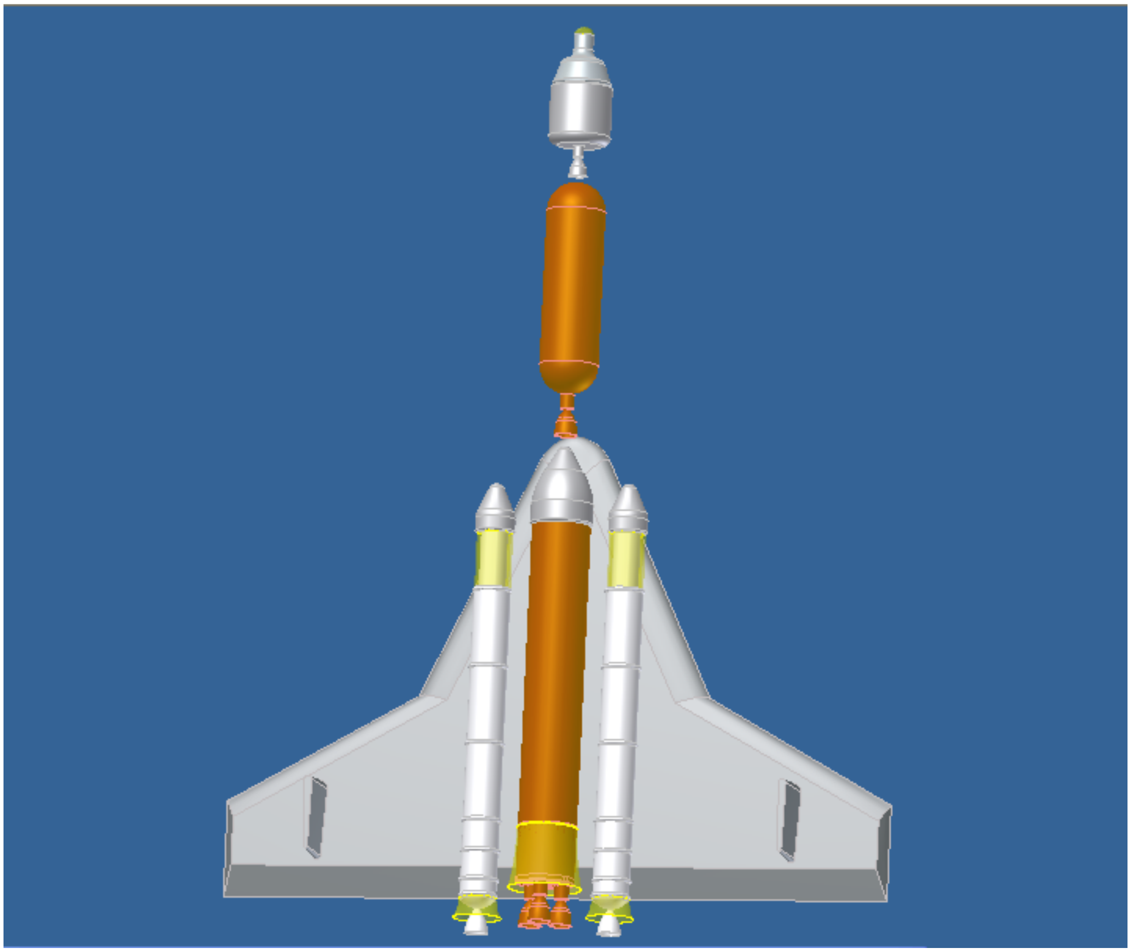


Figure 22: Enhanced STS configuration (3 engine) Heavy Lift embodiment

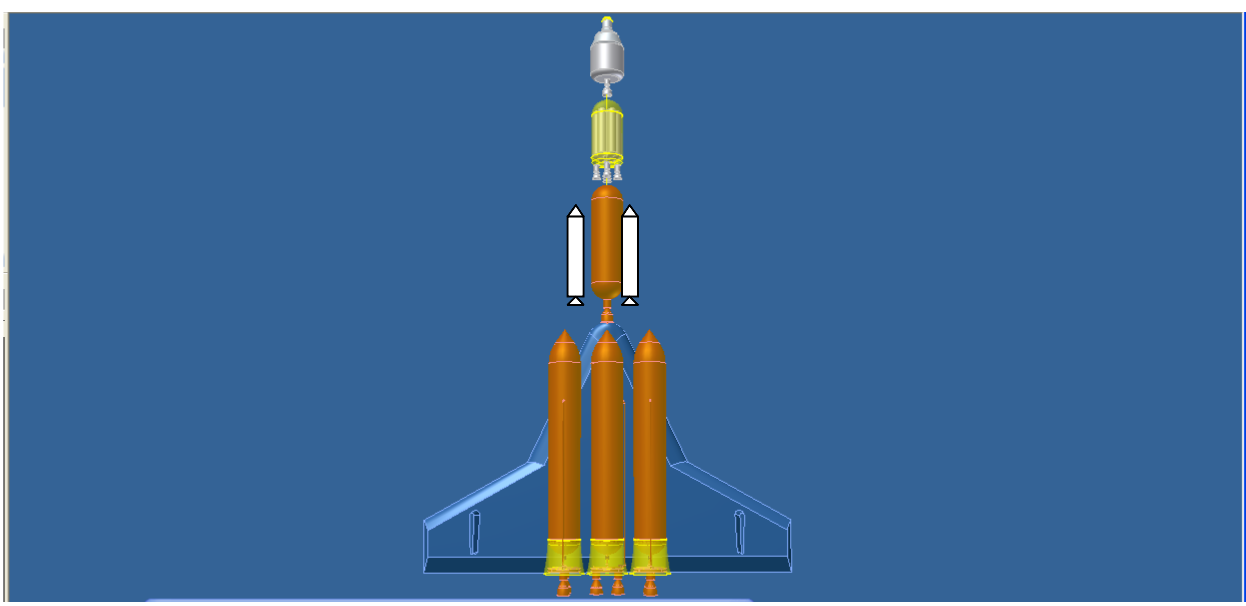


Figure 23: Ultra Heavy Lift embodiment (for Lagrangian Points explorations)

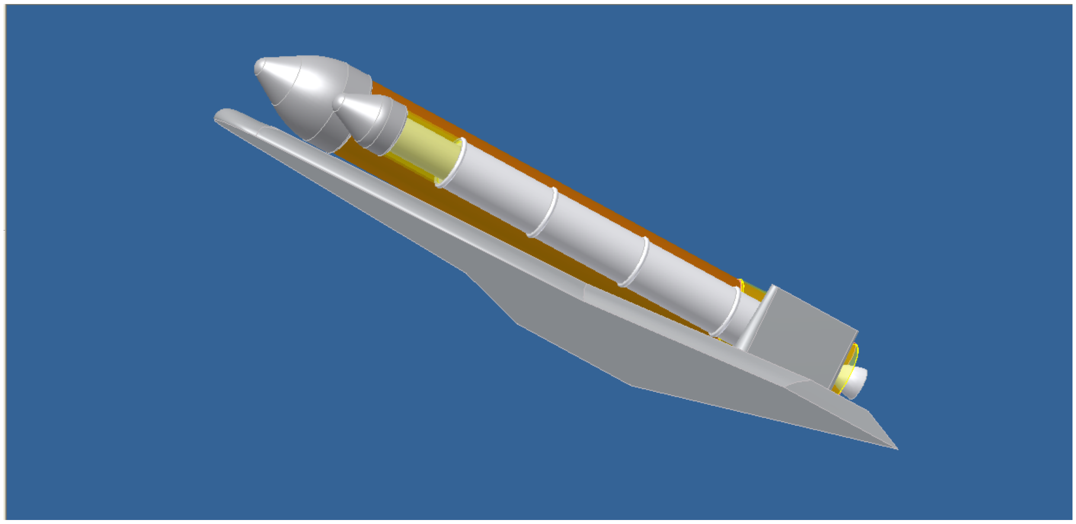


Figure 24: Landing approach of first stages (after launch of space craft)

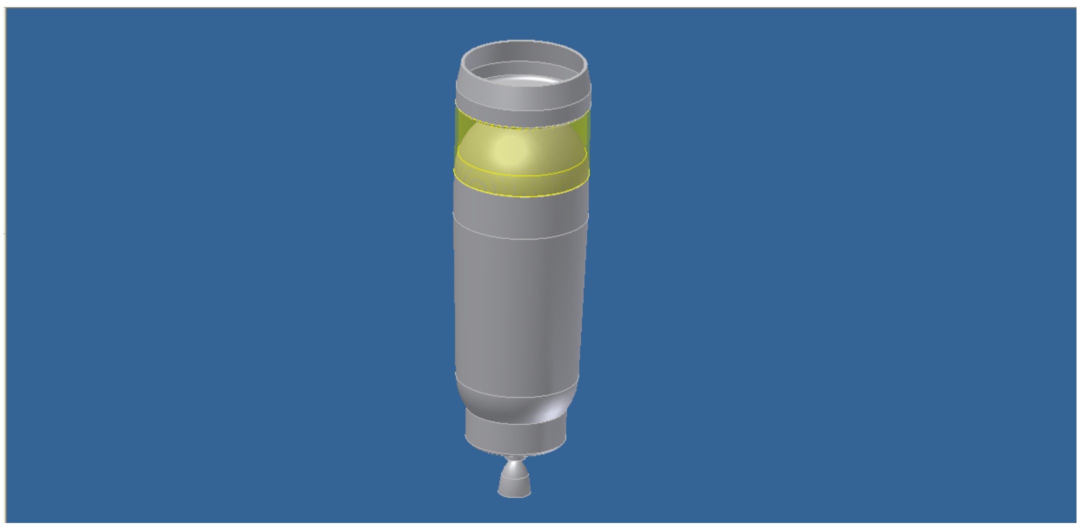


Figure 25: Earth Departure Stage - EDS (1 engine)

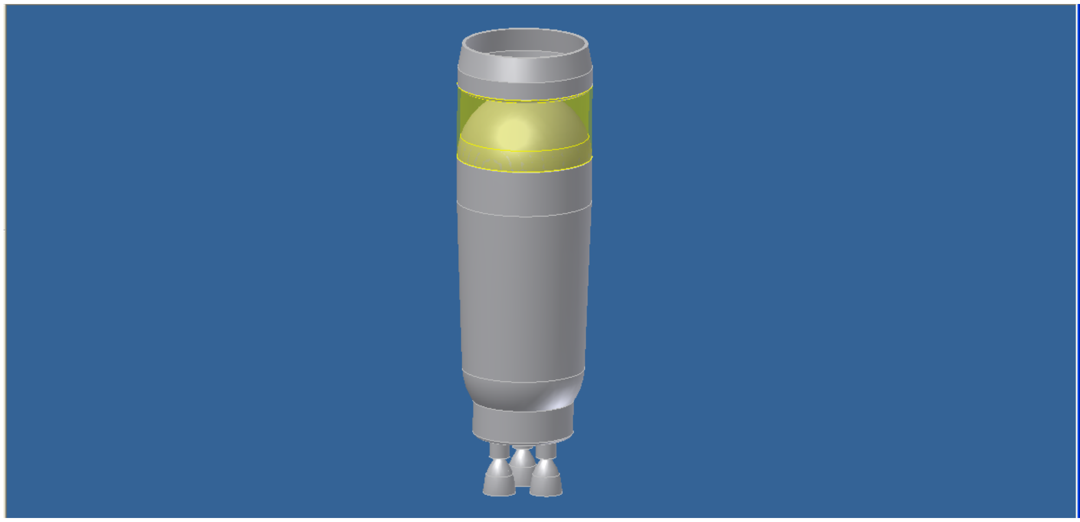


Figure 26: Earth Departure Stage – EDS (3 engine)

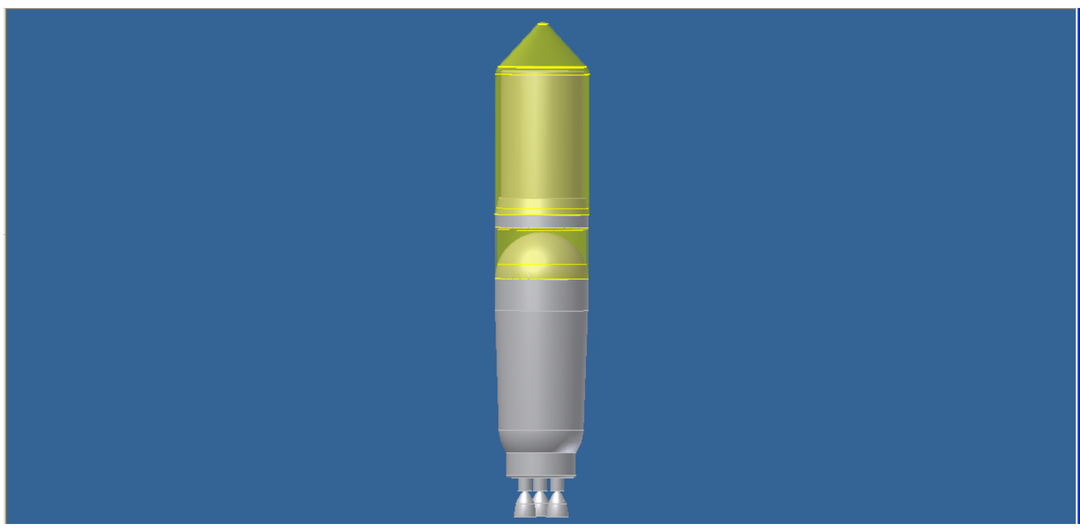


Figure 27: Earth Departure Stage – EDS (3 engine) + Cargo

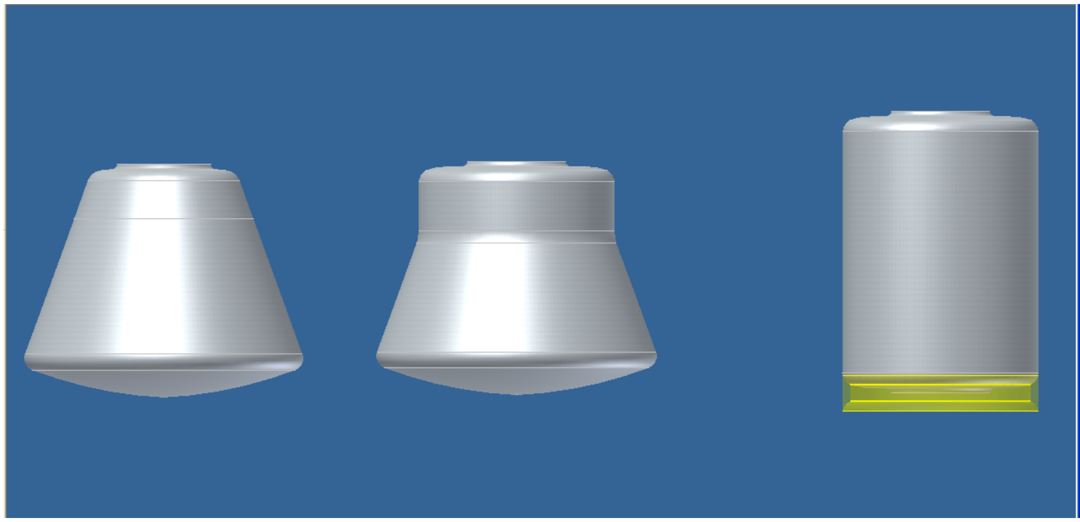


Figure 28: VECTOR (Orion Block 2) Cargo Capsule + Cargo extension capsule

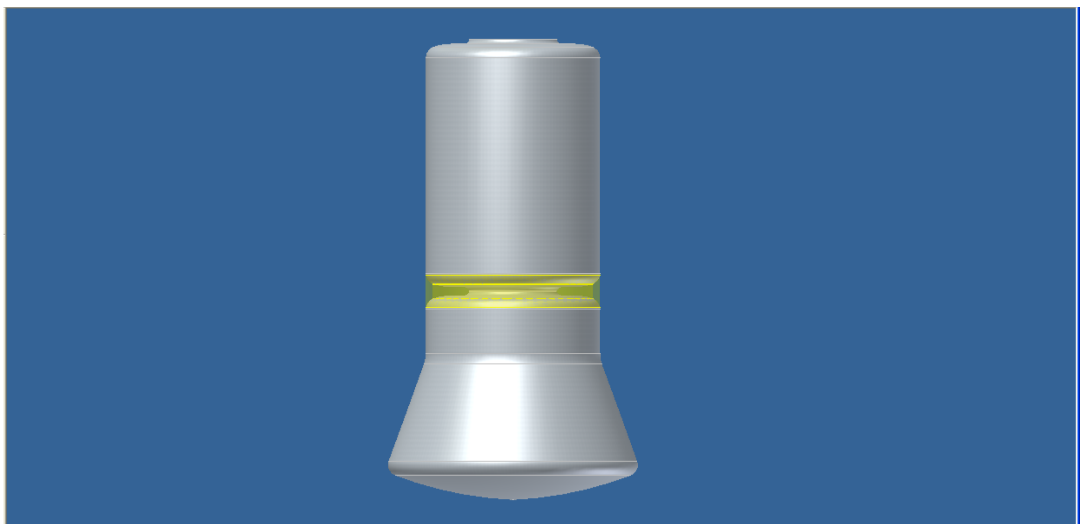


Figure 29: VECTOR (Orion Block 2) Wide Cargo Capsule and Extension Assembly

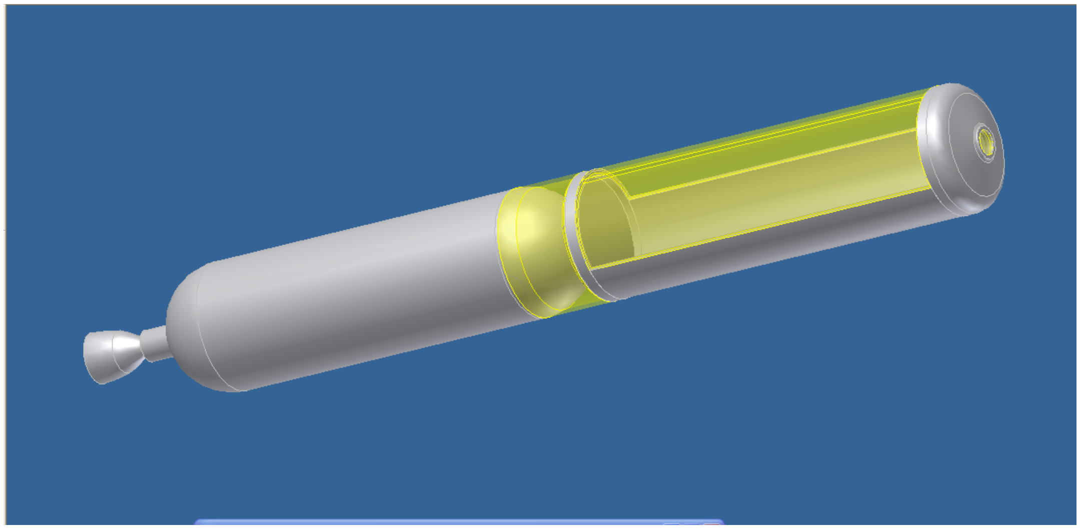


Figure 30: Cargo Payload Bay with Upper Stage Engine

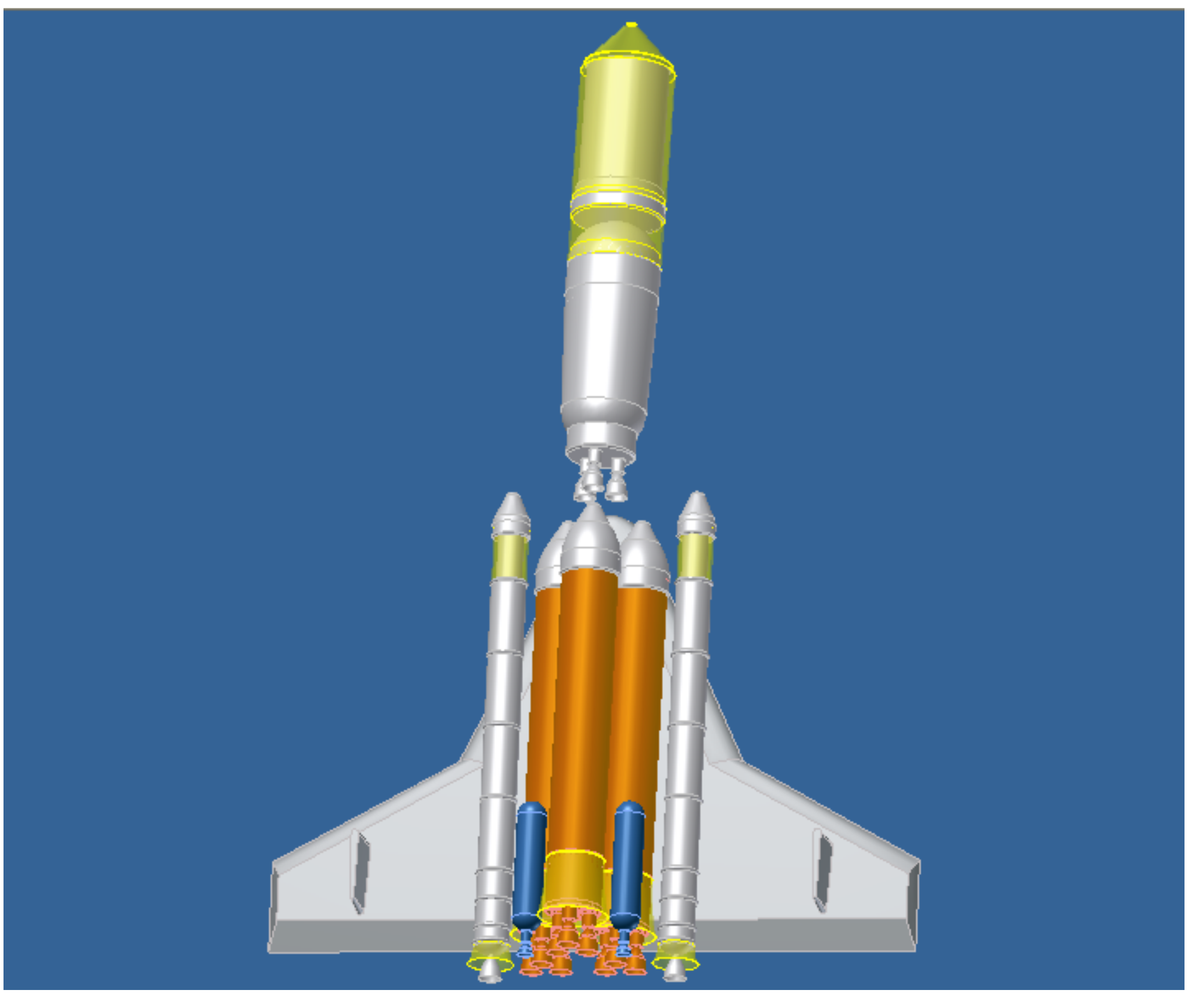


Figure 31: Super Ultra Heavy Lift embodiment (for Transfer Lunar Injection – TLI show here with 3 engine EDS upper stage, clustered 3 core stages each having 3 cargo engines)

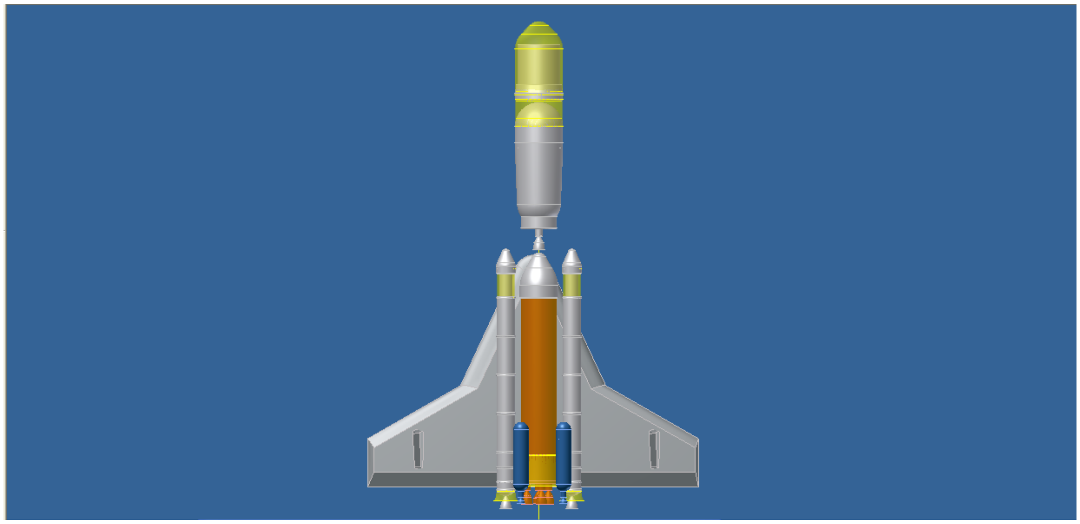


Figure 32: Ultra Heavy Lift embodiment (four engine core + 2 5 seg SRBs + 1 engine EDS + Cargo)

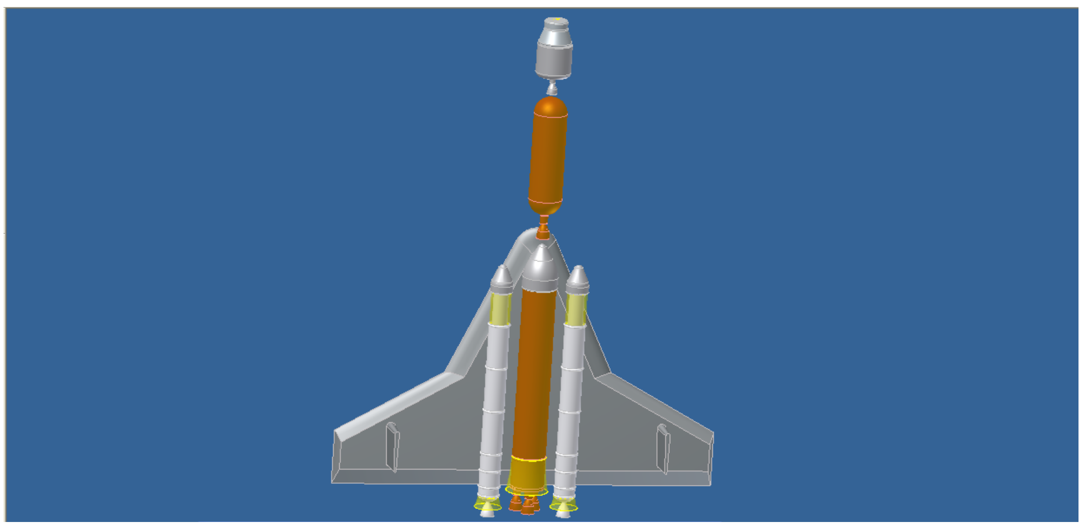


Figure 33: Return (Precious) Cargo Lift Embodiment (3 RS 68 cargo engine core)

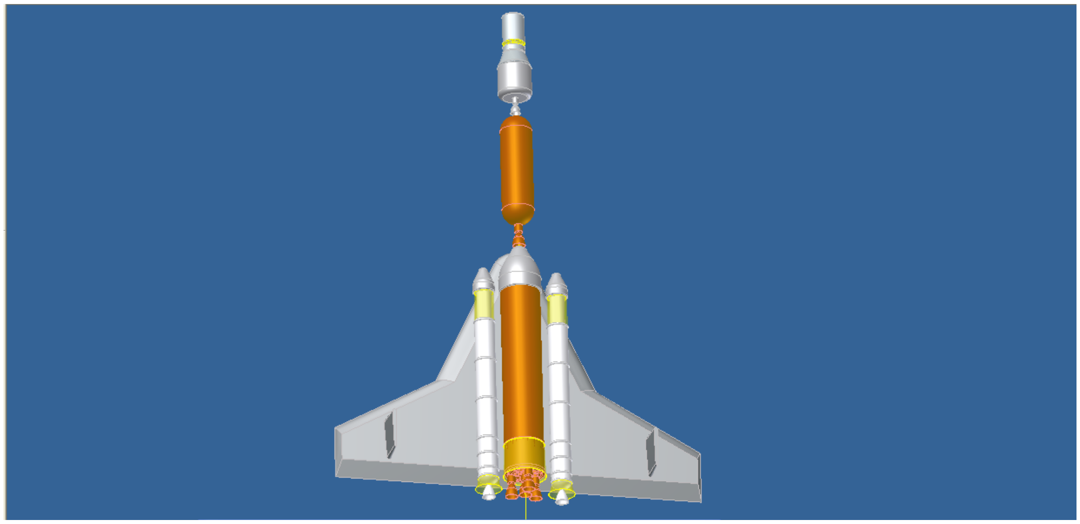


Figure 34: Return (Precious) Cargo and Extension Assembly Launch Vehicle (4 engine core)

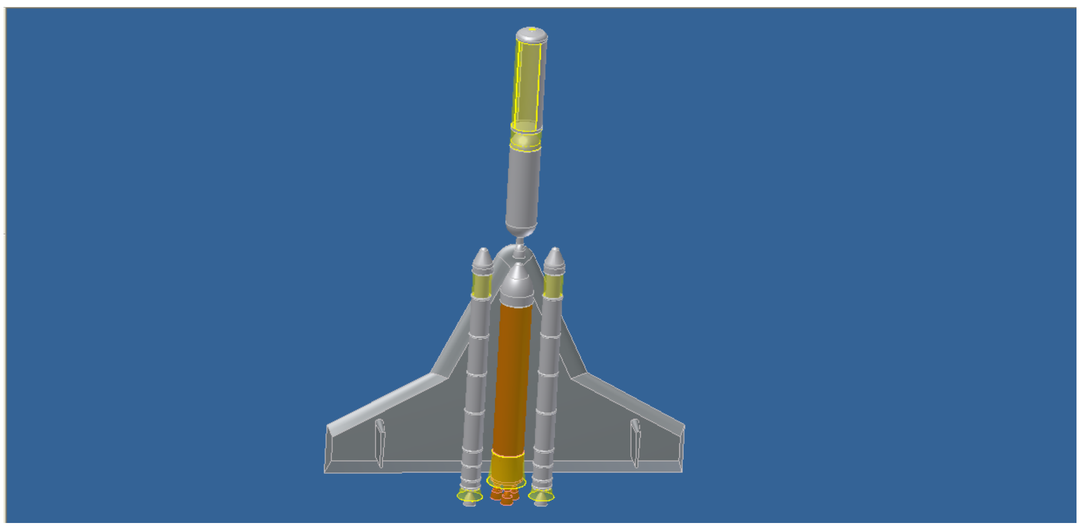


Figure 35: Payload Bay Cargo Lift Embodiment (3 engine core + two 5 segment boosters)

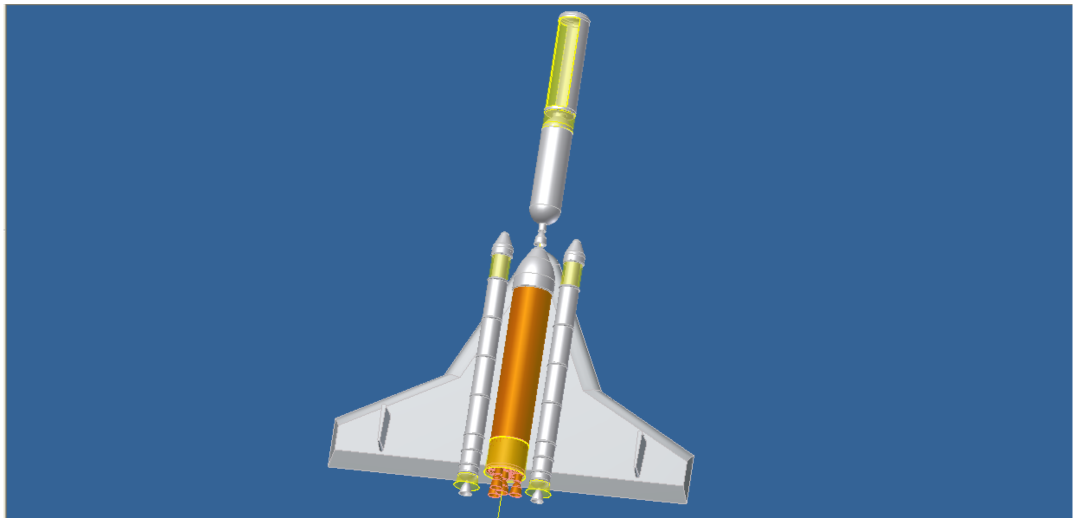


Figure 36: Payload Bay Cargo Lift Alternative (4 engine core + two 5 segment boosters)

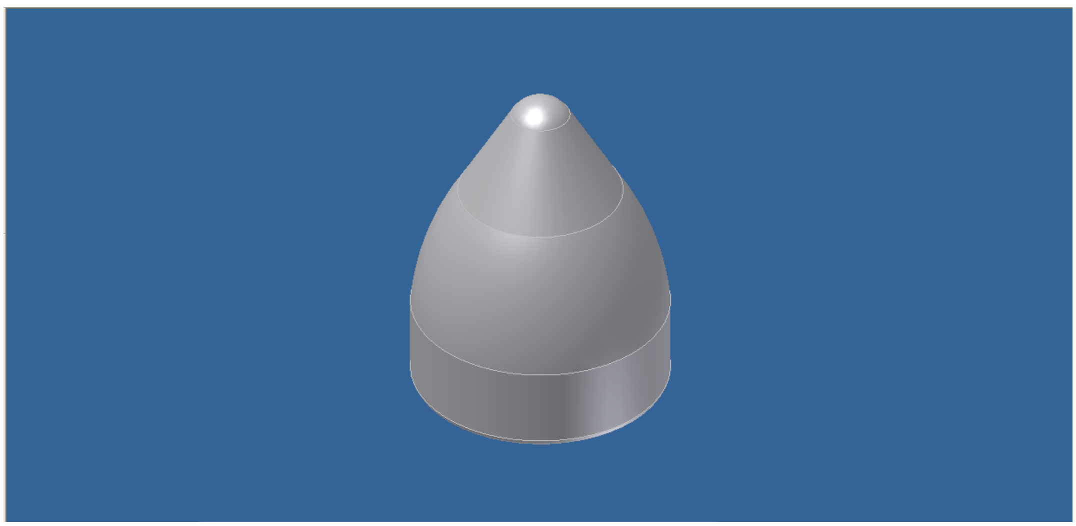


Figure 37: Shield-Shroud for Core Stage

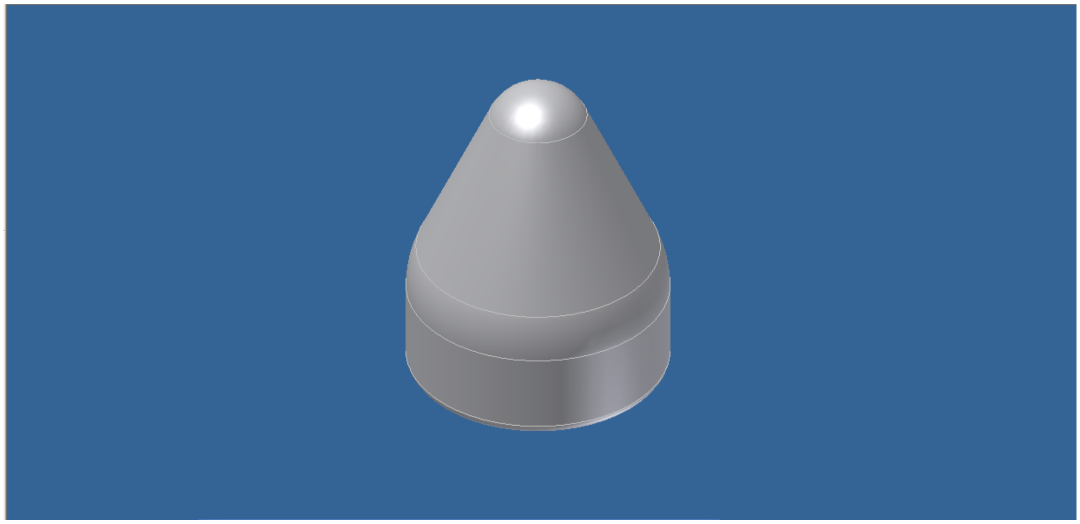


Figure 38: Shield-Shroud for Solid Booster

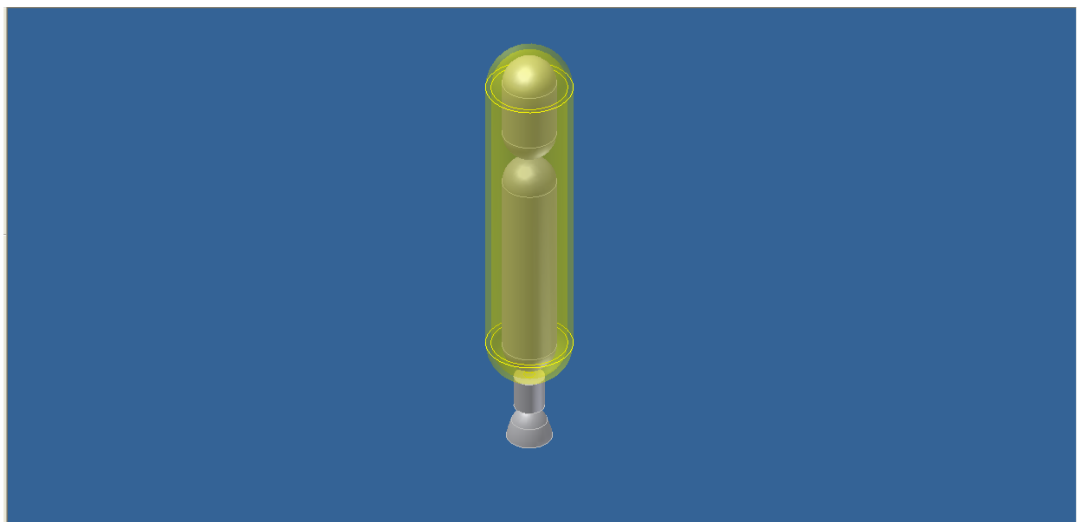


Figure 39: Fly-back Strap-On Engine

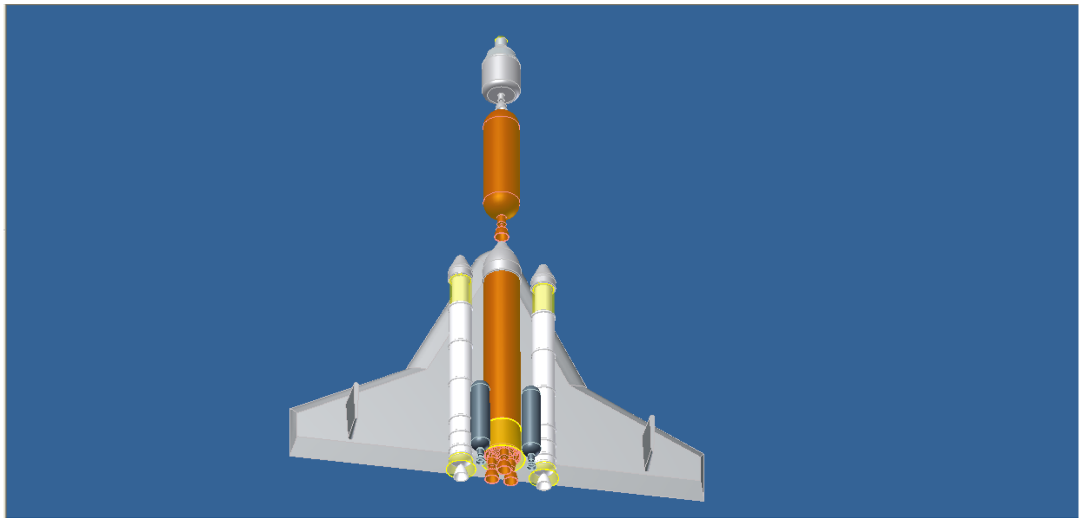


Figure 40: Fly-back Strap-On Engines integrated with Launch Vehicle

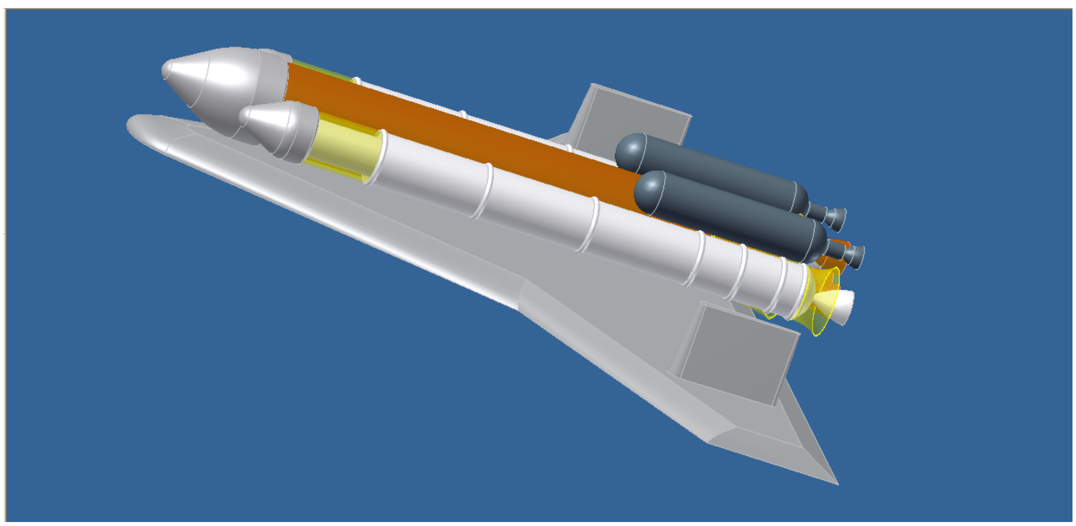


Figure 41: Returning first stages with fly-back strap-on engines.

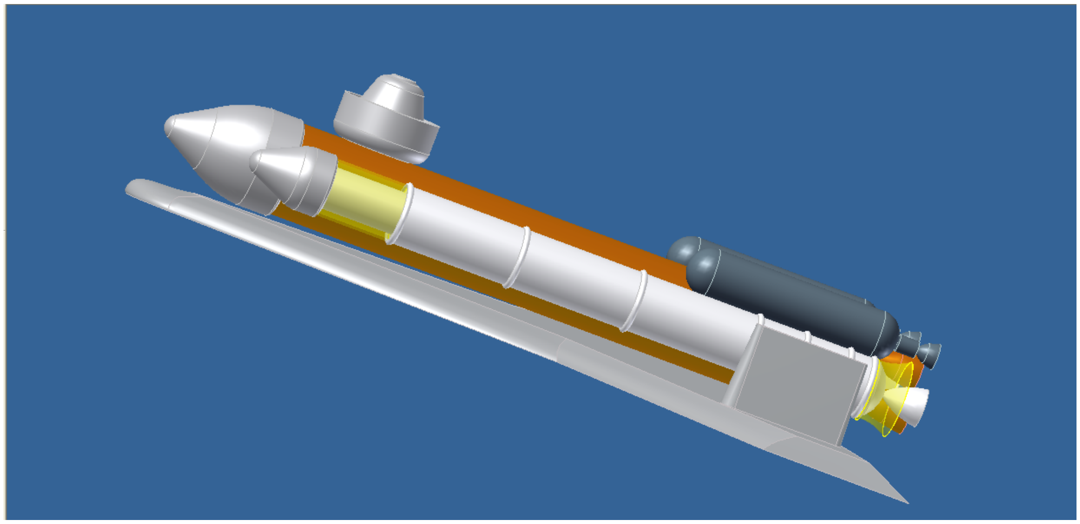


Figure 42: Returning first stages with (Apollo class) crew capsule on the top.

DETAILED DESCRIPTION OF THE INVENTION (EMBODIMENTS)

Overview and Applicability

One of the principal characteristics of this invention is the de-composition of prevalent monolithic space exploration architectures into modular group of sub-inventions and re-composition of these inventions into variety of configurations to form new space exploration launch vehicles and systems.

The modularization of space exploration systems allows the modular inventions to be enhanced and improved both independently and in combination while keeping risks low and safety margins high.

Space exploration is a very high-risk enterprise. The modularization enhances the development of new space exploration technologies at a faster pace. Modularization of new technology development leads to development of proven sub-systems. Integrative sub-systems are developed in the same process and allow invention of combination of the modular elements into a variety of space exploration systems.

Thus sub-systems can be developed and proven, and the process of using proven sub-systems for complete systems development allows the development of new systems soon, in a safe and simple way. This modularization lays the foundation for acceleration of space exploration progress.

- Extensive modularization of space exploration is one of the principal components of this invention. In the process several sub-inventions are described.
- Instead of conceiving launch vehicles as monolithic artifacts, they will now be developed as a combination of highly modular elements (sub-systems). The architecture of these sub-systems into a variety of exploration systems to form a space exploration platform is another significant contribution of this invention.

This invention presents an entirely new way of thinking about space exploration and the space system inventions presented herein to form an architectural platform are also new and have not been included even in extensive studies done so far such as

(a) http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19850015556_1985015556.pdf , and

(b) http://www.cbo.gov/ftpdocs/76xx/doc7635/10-09-SpaceLaunch.pdf

Some embodiments of the invention have been diagrammed in Figures 1-41 and are outlined in the claims and described in the details below.

It is named as Architecture for Reusable Responsive Exploration System (acronym ARES) / Platform and Reusable Responsive Architecture for Innovative Space Exploration (acronym PRAISE), in short ARES/PRAISE or simply ARES. The platform is also alternatively named as αPegasus, αAres, αPlatform, αArchitecture, αAresMajor, or Winged Horse to function as a workhorse as a part the new space exploration capabilities. It is also named as αEagle or αPhoenix since it flies higher and further than any other space system designed until now.

This platform can be useful as a basis for re-architecting the current US Constellation/Ares program, providing it with new (constellation of) capabilities and direction. The newly introduced acronym ARES can stand for the following detailed description and as such these and other such descriptions are considered equivalent:

- Architecture of Reusable Exploration Systems
- Advanced Reusable Exploration Systems
- Advance Reusable Exploration of Space
- Architecture for Reusable Exploration of Space

Each aspect of the invention is described below. While some modular sub-inventions can be considered as systems in their own right, modular elements are distinguished by their usage in relation to other elements. When modular sub-inventions are found usually as a part of a bigger system, they are classified as modular elements. The following categories are used to classify each claim:

- Modular element/sub-invention/sub-system: These are usually combined to form stages of a Launch System or an in-orbit system. They are usually
- System: These include complete launch vehicle configuration or a complete stage of the launch vehicle. This is usually composed of multiple modules into an assembly and/or cluster.
- Architecture / Platform: Coherent combination of systems in such a way that each system in the architecture complements and enhances other systems.

Architecture/Platform (Claim 1)

This invention describes a Reusable Responsive Space Exploration Platform (Architecture) composed of multiple modular reusable and responsive spacecraft elements, which are sub-inventions on their own. The modular reusable spacecraft elemental sub-inventions, attachments to such elements, combinations of such elements in different configurations making the configurations into combined inventions/elements (assemblies/clusters/sub-systems/systems), and support systems for the spacecraft elements and (space systems) configurations constitute the Space Exploration Platform (Architecture) that provides a constellation of space exploration capabilities, that include low earth orbit (LEO), geo stationary orbit (GSO), near earth orbit (NEO), moon and others as per this claim.

It is named as Architecture for Reusable Responsive Exploration System (acronym ARES) / Platform and Reusable Responsive Architecture for Innovative Space Exploration (acronym PRAISE), in short ARES/PRAISE or simply ARES.

This architecture/platform invention has the following characteristics:

- Extensive modularization of space exploration elements. In the process several sub-inventions are described that support this claim.
- Composition of highly modular elements into space (launch or in-orbit) sub-systems and systems.
- Coherent combination of spacecraft elements, sub-systems, systems to serve a variety of purposes.
- Support systems for space systems.

Support systems aspects will be expanded upon in other patents/inventions.

COMMON MODULES

Crew capsule (Claim 2)

A reusable exploration capsule (modular element according to claim 1) where the capsule provides Versatile Exploration Comprehensive Technologies including Orbital Reconnaissance (acronym VECTOR) invention is claimed. The capsule (vehicle for exploration by crew) comprising attached external air lock supports astronauts' extravehicular activities in space.

This claimed capsule has the following copyright names: VECTOR, αVECTOR, VEC, αVEC.

The exploration capsule has a variety of redundant safety sub-elements:

1. Parachutes to break the descent into atmosphere.
2. Retro-rockets to serve as breaks to slow down the speed when the capsule drops separately into gravity wells (earth, moon, mars etc).
3. Air bags that allow the capsule to permit solid ground landing.
4. Floatation devices that permit water landing

The older generation capsules such as Apollo and Orion (being designed currently) never have had enough safety sub-elements (sub-systems) and capabilities. This design rectifies things. For example, while none of the previous capsules have had external air locks, this invention provides air locks. This prevents the crew-cabin of the capsule to be opened up into space for any extra-vehicular activity and ensures safety in space.

Crew capsule with detachable air-lock (Claim 3)

In this invention, the crew exploration vehicle in claim 2 with detachable external air lock (modular element according to claim 1) is claimed.

The crew exploration vehicle has a capability to detach the external air lock. External air lock ejection may be useful during earth landing (to reduce the weight of the capsule).

Since the invention described here in proposes the use of modular elements, capsule modules without the air locks may be used for certain specific missions that do not involve crew EVA.

In one embodiment of the invention, external air lock is ejected during earth landing (to reduce the weight of the capsule). In this embodiment the air lock has a separate set of parachutes. Double set of parachutes provides the crew capsule with required redundancies in case the first set associated with the integrated capsule-airlock fails.

In another embodiment, the air lock is expendable and is ejected early in the landing approach.

In yet another embodiment, the capsules are used separately without the external air lock integrated with other systems (sub-systems).

Crew capsules in different modular sizes (Claim 4)

The crew exploration vehicle in claims 2 and 3 having various sizes both including and excluding the external air lock is claimed. These sizes which provide different volumes include (a) Apollo class capsule size approximately 4.3 m (14 feet) in diameter with a narrower inclination (15 – 30 degree range) (copyright name αVEC-Apollo) (b) Orion capsule size with a narrower inclination (15 – 30 degree range) (copyright name aVEC- Orion) (c) standard (Orion bloc 2) and recommended size of approximately 610 cm (20 feet) in diameter (copyright name αVEC- Standard, αVEC etc.). This size is also termed as VECTOR class, or proposed ORION class (or ORION Block 2 class).

These different modular sizes are shown in Figure 1 and 2. Note that these configurations permit higher internal volume due to the narrower inclination of the capsule walls.

The αVEC-Apollo class capsule allows a crew size of 1 to 2 members. During emergencies it is designed to carry higher number as well. The αVEC- Orion class crew capsule can permit 3 to 5 members. The VECTOR class can carry a full crew contingent of 6 to 9 members.

The αVEC-Apollo class capsule without the external airlock is small enough and can be used in a broad variety of embodiments of this invention.

Modular Core (Main) Stage (Claim 5)

The invention of a reusable core (main) stage (modular element according to claim 1) where the core (or main) stage is reusable is claimed. This reusable core stage in one realization of this claim is composed of LH tank, LOX Tank, modular engine bracket. This reusable core stage in this instance can support multiple configurations, 2 engines, 3 engines or a single main engine. The engine(s) may be SSME (Space Shuttle Main Engines) initially followed later by RS-68 engine(s) (after they are qualified to be man-rated) for human use. The cargo core stage (reserved for only launching cargoes) is an alternative embodiment of the core stage. This core stage instance has a minimum size of 610 cm (20 feet) in diameter. The core stage in different sizes and different engine configurations in a reusable form is also part of this claim (in another instance a larger core stage with minimum size of 760 cm (25 feet) in diameter with 4 engines or 5 engines). In another embodiment of this invention the core stage can have integral fly-back engines.

In one instance of the invention of this modular component, the core stage will be an enhancement of the External Tank (ET) used in the Space Shuttle System. Currently the external tank utilizes an integrally machined stringer system that is not a true isogrid. Since the structure is arranged at right angles it is considered an "orthogrid" rather than an isogrid with triangular stiffeners of an isogrid. The new invention will be based on true isogrid panels.

In one instance the panel hull will be designed to be strong enough to support not only the weight of the engines, but also the weight of the upper stages.

In other instance, the design will have double hulls and be based on the parallel invention application “Continuous Space SAFETY” referred to above.

In one instance (initial experimental configuration), the core stage with one engine is shown in Figure 3. In another instance, the core stage with two engines is shown in Figure 4. In another embodiment, the double hull core stage with three engines is shown in Figure 5.

As different embodiments of this invention, the core stage can be configured with different number and types of engines. Layout of core stage with different number of engines is also shown in Figure 6:
[1] Figure 6(a) shows a 2 engines embodiment. [2] Figure 6(b) shows a 3 engines embodiment.
[3] Figure 6(c) shows a large diameter 4 engines embodiment. [4] Figure 6(e) shows a 5 engines embodiment.

As additional embodiments of this invention, the core stage can be configured fly-back engines in addition to the main engines. Layout of the core stage with different number of fly-back engines is shown in Figure 7: [1] Figure 6(a) shows a 2 engines embodiment with 2 fly-back engines [2] Figure 6(b) shows a 3 engines embodiment with 3 fly-back engines. [3] Figure 6(c) shows a large diameter 4 engines embodiment with 3 fly-back engines [4] Figure 6(e) shows a 5 engines embodiment with 4 fly-back ones.

The fly-back engines in one embodiment may be ignited along with the main engines. In another embodiment, the fly-back engines may be lighted during fly-back phase. When the fly-back engines are present, it assists in the fly-back of the first stage (core + boosters) back to the launch site.

In a large diameter embodiment (with a minimum diameter of 7.5 meters), the double hull core stage with 4 engines is shown in Figures 8 and 9 (as well).

The different classes of core stages based on number of engines are referred to as follows:

Embodiment	Name and Description	Number
Core stage with 1 engine	ARES 1X-C where X stands for experimental or expendable. (This is the only embodiment that can be used in expendable Launch Vehicle configurations). Only for cargo use and hence the letter 'C' is used as a suffix.	ARES 110-C
Core stage with 2 engines	ARES 1M where M stands for medium	ARES 120
Core stage with 3 engines	ARES 1S where S stands for standard and space shuttle derived	ARES 130
Core stage with 4 engines	ARES 1U where U stands for Ultra/Upgrade	ARES 140
Core stage with 5 engines	ARES 1SU where S stands for Super/Saturn and U means same as above	ARES 150

In a primary embodiment, the core stage has Space Shuttle Main Engines (SSME). It has double hull design and internal LOX and LH2 tanks. In one instance the tanks are made from Al-Li Alloys. In another instance the internal tanks are made from composites.

Core Stage Launch Profile and Reusability

Reusable core stages are usually launched with auxiliaries (either solid rocket boosters) or (liquid boosters) configured together with a wing along with upper stages. They take the upper stages up to a height between 50 and 62 miles (edge of space or more precisely up to Kármán line which is "100 km altitude boundary for aeronautics"). The core stage flies back to the launch site after giving the boost to the upper stages (which go into space).

Cargo Core Stage

Cargo Core Stage is an embodiment of the module (element) where it is only used for launching cargo. Core stages with 4 or 5 engines until qualification for human space flight are classified as cargo stages. Core stages containing (only) RS-68 derived engines until the engines are qualified for human use are classified as cargo stages.

Further, after a specific number of uses for human space flight, the core stage is classified only for cargo use. Cargo classification is indicated with an additional character 'C'. For example, the above systems in cargo mode are named as follows

Embodiment	Alphabetic Name	Numeric Name
Cargo Core stage with 1 engine	ARES 1X-C	ARES 110-C
Cargo Core stage with 2 engines	ARES 1M-C	ARES 120-C
Cargo Core stage with 3 engines	ARES 1S-C	ARES 130-C
Cargo Core stage with 4 engines	ARES 1U-C	ARES 140-C
Cargo Core stage with 5 engines	ARES 1SU-C	ARES 150-C

Additional Embodiments

Additional embodiments of this invention include use of Liquid Methane or RP1 tank instead of Liquid Hydrogen (LH2) tank. These enhancements are particularly applicable to 4 and 5 engine configurations.

Fly Back Solid Rocket Boosters (Claim 6)

As per this claim, this invention enables the enhancement of Solid Rocket Booster rendering the SRB to be fly back reusable. The SRB (currently used as a part of space shuttle) is designed to be integrated and serve as an auxiliary booster with the core stage described above.

This enhancement enables the simplification of the SRB design and addition of additional capabilities based on the parallel invention application "Continuous Space SAFETY" referred to above making it safer.

In one embodiment (primary) the reusable SRB has 4 segments enhanced after derivation from the STS system (shown in Figure 12). In another embodiment (shown in Figure 13), the reusable SRB has 5 segments. These solid boosters may be modified to have 3, 5.5, 6 segments or similar sizes as alternate embodiments.

Currently the SRBs flash down in the ocean. As per this invention, the SRBs are flown back along with other modular spacecraft elements such as the core stage and the wing. Currently SRBs reach Apogee (maximum height booster reach after separation) of about 238,000 feet or 72,542 meters on its own momentum after separation from core stage at about 156, 000 feet or 47,549 meters. In the primary embodiment of the SRB invention, they are carried up beyond this apogee height up to the first stage return height through the thrust of the core stage main engines. In this embodiment, the 16 solid separation motors are not needed.

In another embodiment, the SRBs separate as usual and milliseconds after SRB separation, 32 solid-fueled separation motors, eight in the forward section and eight in the aft skirt of each SRB (4 each associated with the Core Stage and with the wing), are fired to help carry the SRBs away from the rest of the first stage. In this instance, only the core stage is flown back with the aid of the wing.

In another embodiment, the SRBs have additional strap on motors that help propel them to the return height of the first stage. In yet another embodiment, the SRBs are redesigned so that they are able to maintain thrust up to a height of 80 km and momentum up to the return height of first stage (100km).

Fly Back Liquid Rocket Boosters (Claim 7)

As per this claim, enhanced Liquid Rocket Boosters (modular element according to claim 1) are designed to work with other modular elements (such as the core) and be flown back.

In one embodiment, this invention enables the enhancement of the Delta IV core stage to be integrated and serve as an auxiliary booster with the core stage described above, rendering the Delta IV core stages to be reusable and capable of being flown back.

In other embodiment enhancement of the Atlas V core stage to be integrated and serve as an auxiliary with the core stage described above, rendering Atlas V core to be reusable and capable of being flown back, is within the purview of this invention.

Note that the embodiments of this invention can be reused with either Delta IV or Atlas V where the current Delta IV or Atlas V cores serve as auxiliaries to the core specified in this invention. Enhancing Delta or Atlas class vehicles to make combined platform/architecture re-usable, responsive and capable of carrying large payloads is also within the claims of this invention.

As yet another embodiment, Falcon 9 (which is under development) enhancement to be integrated and serve as an auxiliary with the core stage described above, rendering Falcon 9 to be reusable and capable of being flown back, is within the purview of this invention as well.

In a similar manner, this invention enables the enhancements of other liquid rockets to be integrated and serve as auxiliary boosters for the core stage described above, rendering these other rockets to be reusable and capable of being flown back.

Reusable fly back Wing (Claim 8)

A reusable wing (modular element according to claim 1) is invented according to this claim. The elements claimed in claims 5 (core), 6 (Solid Rocket Booster), 7 (Liquid Rocket Booster) can be attached to this reusable wing element making the combination to be flown back for reuse. The wing embodiment is designed with different sizes to suite the different launch system configurations.

Since the first stage along with the wings do not reach escape velocity (speed remains below Mach 10) and are meant to fly back from a height of about 100 km, the detailed tile based Thermal Protection System (TPS) used in the space shuttle is not needed.

The wing is light in weight and Delta shaped and one example of the wing is shown in Figure 14. The wing has dual vertical stabilizers (tails).

In a primary embodiment the wing is made of Al-LI alloy with Titanium for the leading edges.

In one embodiment, the wing is built largely of stainless steel, sandwiched honeycomb panels, and titanium for the leading edges.

In another embodiment, wing is built out of composites with leading edges having metallic thermal protection. In yet another embodiment the leading edges have durable TPS.
In addition cold jets can be turned on inside the wing surface to provide active cooling as needed.

In another embodiment, canards are used in addition to the primary wing to maintain aerodynamic stability of the returning first stage.

In an embodiment of the wing control surfaces, the control surfaces have titanium or metal TPS.

Design modifications to the wing (not mentioned here) are a part of the invention. Other suitable, appropriate material composition of the wing is well within the purview of this invention. Mounting components to help mount the core stage and the boosters are a part of this invention as well.

Fly Back Clustered First Stage (Claim 9)

The reusable and responsive element in 8 and the element combinations (claim 5, 8), (claims 5, 6, 8), (claims 5, 7, 8) are embodiments of the combined first stage of the ARES space exploration platform (architecture). In accordance with Claim 1, this is represents a fly back clustered first stage system.

This clustered first stage invention is shown in Figures 24, 41 and 42.

Augmentation of the capabilities of the first stage through small solid or liquid strap on boosters is within the scope of this invention.

The clustered first stage takes the upper stages up to a height between 50 and 62 miles (edge of space or more precisely up to Kármán line which is "100 km altitude boundary for aeronautics"). The clustered first stage then flies back to the launch site after giving the launching the upper stages into space.

Reuse Recovery Support Modules/Devices (Claim 10)

According to this claim, the redundant attachments of multiple recovery devices such as parachutes inflatable airbags, landing gears, retro-rockets and others are modular elements according claim 1. The spacecraft elements in claims 2 through 9 are designed to land in either liquid surface (water) or solid surface (land) with the aid of these attachments. Some examples (not exhaustive) include (a) Multiple redundant parachutes attached to element in claim 8 deployed to slow the flight (b) inflatable rafts attached to element in claim 8 deployed after landing of space craft element in water.

Several illustrative embodiments of this invention are outlined below:

In one embodiment the crew capsule is equipped with retro-rockets that help slow down the descent into planetary/moon surface and help provide a soft approach for landing to the crew. In another embodiment the capsule has drogue and main parachutes that help slow down descent into deep gravity wells of earth, mars and other planets. In yet another embodiment, the capsule is outfitted with underside inflatable air bags to cushion the final landing on hard surface. In another instance, the capsule has underside inflatable rafts and topside airbags to keep the capsule afloat in the eventuality of a water landing.

In one embodiment the wing invention described above in claim 8 is equipped with parafoils and parachutes that slow down the clustered first stage in claim 9 before landing. In another embodiment the wing invention describe about in claim 8 has landing gears that allow the safe landing of clustered first stage in claim 9. In yet another embodiment, the wing is outfitted with deployable inflatable rafts and airbags to help in water landing of clustered first stage in claim 9 and keep it afloat after landing.

Other supportive devices/embodiments (modular elements) that help in the safe and efficient landing and reuse of spacecraft systems are also well within the scope of this invention.

Versatile Rocket Stage (Claim 11)

According to this claim a versatile thrust stage containing multiple Common Extensible Cryogenic Engines (CECE) or RL series (RL10A-4-2 or RL10B-2) engines or other engines belonging to this class constitute a modular spacecraft element as per claim 1. This stage provides a high degree of flexibility with throttling range from 100% (all engines at 100%) to 4-5% (one engine at 20-25%). This stage comes in different instances/embodiments with different number of engines, for example engines in cluster of 3, 4, 5, 6, 7 or other similar groups.

Since this stage has a very high degree of flexibility, it has a variety of embodiments and can be used in a highly versatile way. In Figure 15, an embodiment having 5 engines is shown. In the figure, several bulkheads for oxidant (example liquid oxygen - LOX) and fuel (example liquid hydrogen LH2) are shown. In another embodiment, the fuel and oxidant can be in a common bulkhead.

As one embodiment of this stage (invention), it acts as a second stage and can be used for launching capsules and other human and cargo carrying modules (sub-systems) into space regions that constitute low earth orbit (LEO). Examples of this usage are shown in Figures 18 and 19.

As another embodiment this modular element (stage), serves as a third stage and is usable for launching capsules and other human and cargo carrying modules (sub-systems) into near earth orbit (NEO) space regions (spaces). These spaces (regions of space) include langrangian points (regions), near earth asteroids and comets, lunar orbits, geo-stationary orbits and other near earth orbits. One example of this usage is shown in Figure 23.

As yet another embodiment this versatile stage (modular element) acts as a space tug transferring capsules and other human and cargo carrying modules between different orbits.

Yet another embodiment of this versatile stage is useable for raising the orbit of space station and other in-orbit systems and for avoiding space debris.

A key embodiment of this invention is a design meant for lunar landing of crew and cargo modular elements (modules) such as capsules.

In another embodiment the Versatile stage uses engines using pintle injector (and/or moveable pintle) technologies. Moveable pintle injector attributes include deep throttle capability. In another embodiment multiple pintle injectors are used which provide yet another way to achieve deep throttle capability whereby some injectors are turned on or off upon commands.

Other similar versatile uses of this stage are within the scope of this invention.

Flexible Service Module and Service Module Crew Capsule Sub-System (Claim 12)

According to this invention/claim, the service module is designed to be powerful and has a minimum diameter of about 6.1 m (20 feet). The service module is a modular spacecraft element according to claim 1. It is designed to be flexible to be integrated with different classes of capsules (both crew and cargo). The integrated service module and modular capsule is a sub-system according to claim 1.

In one embodiment it is designed for integration with Apollo class crew module described above. In another embodiment it can be integrated with Orion class crew module. In the preferred embodiment the service module integrates with VECTOR (Orion block 2) class crew module. The integrated service module crew module sub-system is shown in Figure 16.

In a preferred embodiment, the service module is based on the design specified in the Continuous Space SAFETY invention. In an alternative embodiment, the service module engine is a hypergolic engine.

Enhanced Upper Stage (Claim 13)

As per this claim, the upper stage (a modular element as per claim 1) is designed/invented to have double hulls and a minimum diameter of about 6.1 m (20 feet). The upper stage launches the spacecraft elements (sub-systems) that include crew modules (capsules) and cargo modules into space orbit.

In an alternative embodiment the upper stage has a minimum diameter of 5 or 5.5 meter.

In a primary embodiment, the upper stage is designed as a double hull module based on the Continuous Space SAFETY invention referred above. The cryogenic fluids, LOX and LH2 are kept in the inner hull that is designed as s common bulkhead.

In the preferred embodiment, the upper stage has a single J2X engine. In another embodiment, the upper stage has multiple RL series (RL10A-4-2 or RL10B-2) engines. The upper stage in the preferred embodiment is shown in Figure 17.

HUMAN SPACE FLIGHT SYSTMES

Human Reusable Responsive Space Launch System – HRLS (Claim 14)

The first stage as per claim 5 and 9 combined with an upper stage constitutes the reusable (responsive) space launch system (RLS). This system (and components thereof in claims 5 through 14) used for launching the capsule element claimed in 2, 3 and 4, provides a versatile human exploration capability. The various embodiments are classified as systems forming a part of the Architecture for Reusable Responsive Exploration System (ARES) according to claim 1.

Different recommended embodiments (systems) of this invention (named ARES, αAres, αPegasus, αEagle, or αPhoenix) described below constitute sub-claims.

Experimental Launch System (Claim 14-a)

In this embodiment, Experimental Launch System consists of a core stage with one RS-68 evolved expendable LV engine, versatile rocket stage in the role of an upper stage and several small strap-on boosters. This embodiment is shown in Figure 18.

Other embodiments containing other configurations used for experimental purposes are within the scope of this invention.

The experimental launch system is also classified as an expendable small/light lift embodiment launch system capable of launching 10 -15 tons to orbit and is useable only for cargo launches.

Medium Human Reusable Launch System – Medium HRLS (Claim 14-b)

Medium Lift embodiment consists of (a) Wing (b) 2 engine core stage (c) Versatile Stage acting as a second stage, (c) Apollo class crew exploration vehicle/capsule (CEV) and service module according to the claims of the invention, and (d) Aero Jet class solid strap on boosters or boosters with a similar capability. Medium Lift embodiment (for Apollo class vehicles without the air-lock) is shown in Figure 19.

This embodiment is usable for Apollo class vehicles without the airlock is shown in Figure 19. It is capable of launching 15 – 20 tons to orbit.

Medium Heavy Human Reusable Launch System – MH HRLS (Claim 14-c)

Medium Heavy Lift embodiment consists of (a) Wing (b) one engine core stage (c) Auxiliary first stage 4 segment solid rocket boosters, (d) enhanced upper stage, (e) ORION class crew exploration vehicle - capsule (CEV) and service module according to the claims of the invention. This embodiment is shown in Figure 20 is capable of launching 20-30 tons to low earth orbit.

Another embodiment consists of replacing the two auxiliary first stage 4 segment solid rocket boosters with two core stages serving as auxiliaries. In another embodiment, the enhanced upper stage with J2X engine is replaced by the versatile stage serving as an upper stage.

Heavy Human Reusable Launch System – Heavy HRLS (Claim 14-d)

The preferred Heavy Lift embodiment consists of (a) Wing, (b) Space Shuttle inspired 3 engine core stage, (c) Auxiliary first stage 4 segment solid rocket boosters, (d) enhanced upper stage, (e) VECTOR class (ORION Block 2 class) crew exploration vehicle/capsule (CEV) and service module according to the claims of this invention. This embodiment is shown in Figure 22.

In another embodiment, the 3 engines core stage is replaced by a 2 engines stage (shown in Figure 21). In another embodiment, the enhanced upper stage with J2X engine is replaced by the versatile stage serving as an upper stage. In yet another embodiment, the first stage 4 segment solid rocket boosters are replaced with 5 segment solid rocket boosters serving as auxiliaries.

The heavy human reusable launch system embodiments are capable of lifting 30 to 60 tons to orbit. This system's embodiments are usable for launching capsules and other human carrying modules (sub-systems) into low earth orbit (LEO) and geo stationary orbit (GSO).

Ultra Heavy Human Reusable Launch System – Ultra HRLS (Claim 14-e)

One embodiment of the Ultra Heavy Launch system consists of (a) Wing, (b) 2 engines core stage, (c) Auxiliary 2 engine core stages, (d) enhanced upper stage (e) versatile stage serving as the third stage and (f) VECTOR (ORION Block 2 class) crew exploration vehicle/capsule (CEV) and service module according to the claims of this invention. As per this claim, the system is augmented with strap-on boosters as needed. This system without the boosters is shown in Figure 23.

In another embodiment, the 2 engines core and auxiliary stages are replaced with 3 engines stages. In yet another embodiment, the core stage is replaced by a 4 engines core stage and the auxiliary core stages are replaced with 5 segment solid rocket boosters.

The ultra heavy human reusable launch system embodiments are capable of launching 60 to 120 tons to orbit. This system's embodiments are usable for launching capsules and other human carrying modules (sub-systems) into near earth orbit (NEO) space regions (spaces). These spaces (regions of space) include langrangian points (regions), near earth asteroids and comets, lunar orbits, geo-stationary orbits and other near earth orbits.

Summary

This invention is the first conception of a highly reusable, responsive, efficient human space flight architecture that is adaptable to different ranges of space exploration from low earth orbit (LEO) to near earth orbit (NEO) including moon exploration. Enhancement of this architecture into planetary exploration architecture will be addressed in the following invention. This invention enables other systems and other programs to be enhanced to transform them into reusable systems.

In other embodiments of this system the first stage solid rocket booster auxiliaries are replaceable by the following: (a) enhanced Delta IV core stage as auxiliaries, (b) enhanced Atlas V core stage as auxiliaries, (c) enhanced Falcon 9 core stage as auxiliaries (d) enhanced Vega solid rocket boosters as auxiliaries (e) enhanced JAXA H-IIA (H2A) as auxiliaries, (f) enhanced Soyuz rockets as auxiliaries (g) enhanced Long March rockets as auxiliaries (h) and so on. This invention is applicable to in-development systems such as Ariane-6, GSLV Mark 3 and others as well for transforming them into reusable efficient systems.

Other embodiments containing other similar configurations are within the scope of this invention. In this manner the intellectual property of this invention covers and is able to transform and enhance other systems whether they are mentioned here specifically or not (including new ones that belong to the same classes as those mentioned herein) to make them reusable, responsive and efficient.

CARGO MODULES

Earth Departure Stage (Claim 15)

As per this claim Earth Departure Stage (a modular element as per claim 1), is designed as double hull module with a common inner fuel-oxidizer bulkhead capable of launching large objects into space. In this embodiment, the Earth Departure Stage is designed for use both with a single engine and with multiple engines depending on the sizes of the objects to be launched into space.

In an alternative embodiment, the inner fuel and oxidizer bulkheads are kept separate. A one engine EDS is shown in Figure 25. A three engines EDS configuration is shown in Figure 26. Integrated sub-system with EDS and cargo is shown in Figure 27.

The EDS comes in different sizes: (a) different diameters 30 feet (9m), 33 feet (10 m), 40 feet (12.2 m) and so on and (b) different lengths. The EDS serves a variety of purposes. It can be used to transfer Lunar Surface Access Module (LSAM) and the crew/cargo capsule into lunar orbit through TLI. It can be used to transport large observatories to their designated orbits and so on.

Precious Cargo Capsule and Extension (Claim 16)

In the precious cargo embodiment of this invention (modular element as per claim 1), the human rated modules/capsules adapted with increased mass carrying capacity and designed to serve as cargo capsules is claimed. As an adjunct embodiment (another modular element as per claim 1), the cargo capsule has an extension that can be mated as required for supporting higher loads (cargo carrying capacity). The assembly is a sub-system according to claim 1. The cargo capsule and the extension are shown in Figure 28. The cargo and extension integrated sub-system is shown in Figure 29.

In a primary embodiment both the crew and cargo capsules have common bases. In the cargo version, the top is wide and designed to have larger capacity. In the crew version, the top is more aerodynamic ensuring higher crew safety during capsule landing phases.

In an alternative embodiment, the crew and cargo capsules are designed separately with the major part of the body hull designed as one piece in each case.

The cargo capsule and extension can be used both for transferring cargo up into space and for carrying precious cargo from orbit onto planetary/moon surface. These capsules that provide pressurized valuable cargo carrying capacity are named as αVECTOR-C or αORION-C or VECTOR-C for the cargo capsule and VECTOR-CX/ORION-CX for the extension.

Cargo Payload Bay (Claim 17)

This claim involves the invention of enhanced payload bay for holding and transporting cargo and is integrate-able with upper rocket stages (as per claim 11 and 12). This invention is a modular element as per claim 1.

In the primary embodiment, the payload bay module has docking adapter that allows the payload bay to dock with the crew capsule. It can also dock with the International Space Station (ISS). The payload bay named αPAYLOAD has capability to hold the Shuttle Remote Manipulator System (SRMS) to maneuver a payload from the αPAYLOAD bay to its deployment position and then release it. The payload bay can also be used to grapple a free-flying payload, maneuver it to the payload bay and berth it. The αPAYLOAD bay serves a variety of purposes. It can be used for transferring space station modules to support ISS enhancement and repair. It can be used for repair of precious in-orbit scientific instruments such as telescopes. It can be used for development of new in-orbit stations, fuel depots and so on.

The payload bay comes in different sizes: (a) different lengths 40 feet, 60 feet, 80 feet and so on (b) different diameters 5 m, 5.5 m, 6m, 7m and so on.

αPAYLOAD provides up-mass capability greater than current Shuttle. One embodiment of the payload bay is shown in Figure 30. In the figure, the integrated payload bay upper stage sub-system is shown.

CARGO SPACE FLIGHT SYSTMES

EDS Cargo System (Claim 18)

The Earth Departure Stage (EDS) Cargo System invention/claim (classified as a system according to claim 1) consists of (a) Three core stages (each with 3 cargo RS/68 based engines), (b) 5 segment solid rocket boosters, (c) Earth Departure Stage (EDS) module with cargo and launch shroud for the cargo (as per claim 15). In the preferred embodiment, EDS has multiple engines and in an alternative, it has one engine. This invention known as ARES-III or ARES-3 is classified as a Super Ultra Heavy Lift System.

The primary uses of this invention is for Transfer Lunar Injection – TLI of in-orbit integrated Lunar Surface Access Module (LSAM) cargo and crew exploration vehicle/capsule (CEV) having sizes from Apollo to VECTOR class. Alternate uses of this invention include launch of large telescopes and scientific instruments. In Figure 31, the EDS (with 3 engines) Cargo system is shown. In an alternative embodiment, the three engines core stages (total of 9 engines) can be replace by 4 engines large diameter core stages providing a clustered core stage with as many as 12 engines capable of launching extremely large objects.

In an alternative (Ultra Heavy Lift) embodiment of this invention, one 4(or 5) engines large core stage is used with two 5 segments solid rocket boosters (SRB) and one engine EDS shown in Figure 32. This can be used for launching large cargoes to low earth orbit (LEO) and geo stationary orbit (GSO) such as extra large earth science satellites.

This super ultra heavy launch system in its various embodiments is capable of lifting 100 – 250 tons.

Precious Cargo System (Claim 19)

The preferred Precious Cargo System embodiment (classified as a system according to claim 1) consists of (a) Wing, (b) 3 engine core stage containing engines meant for cargo use such as RS-68 based ones, (c) Auxiliary first stage 4 segment solid rocket boosters, (d) enhanced upper stage, (e) cargo capsule

VECTOR-C (as per claim 16) and service module according to the claims of this invention. This embodiment is shown in Figure 33.

In another embodiment of this invention, 5 segment solid rocket boosters are used instead of 4 segment ones. In the extended cargo embodiment, the cargo extension VECTOR-CX is used with the cargo capsule in addition to the 5 segment boosters.

In another extended cargo embodiment invention, the Return (Precious) Cargo and Extension Assembly Launch Vehicle has 4 engines core stage with cargo (RS-68 based) engines. With this, in one case 4 segment boosters are used, and in another instance 5 segment boosters are used (shown in Figure 34).

This system is useful both for launching precious (pressurized) cargo into low earth orbit (LEO) and geo stationary orbit (GSO) and for bringing back cargo safely onto earth surface.

Cargo Payload System (Claim 20)

The preferred Cargo Payload System embodiment (classified as a system according to claim 1) consists of (a) Wing, (b) 3 engine core stage containing engines meant for cargo use such as RS-68 based ones, (c) Auxiliary first stage 5 segment solid rocket boosters, (d) enhanced upper stage, and (e) payload bay αPAYLOAD (as per claim 17) according to this claim/invention. This embodiment is shown in Figure 35.

In an alternative embodiment, the three engines core stage is replaced by a four engines large diameter core stage. This embodiment is shown in Figure 36. In yet another embodiment, the first stage consists of a 4 engines core stage and 2 4 segments solid rocket boosters (SRB). In the all-liquid core embodiment, three core stages (containing either 3 engines or 4 engines, or combinations) are used (along with additional small boosters) to achieve the same carrying capacity as the preferred embodiment.

This system in its various embodiments provides a versatile cargo modules carrying capacity that is greater than the current shuttle program. While the current shuttle can only be used for assembly and servicing of space station in low earth orbit (LEO), this system along with other systems (succinctly the architecture) can be used for assembly and servicing of current and future stations in both low earth orbit (LEO) and geo stationary orbit (GSO).

Cargo Systems Summary

This invention is the first conception of a highly reusable, responsive, efficient combined human space flight and cargo architecture that is adaptable to different ranges of space exploration from low earth orbit (LEO) to near earth orbit (NEO) including moon exploration. Enhancement of this architecture into planetary exploration architecture will be addressed in the following invention. This invention enables other systems and other programs to be enhanced to transform them into reusable systems.

From a cargo launch and exploration perspective, the invention of the cargo systems mentioned here in provide a comprehensive and flexible set of capabilities that include a diverse set of solutions such as precious cargo launch and return, in-orbit space craft modules, and very large cargoes such as large science observatories, lunar and planetary surface access modules to name a few.

In other embodiments of this system the first stage solid rocket booster auxiliaries are replaceable by the following: (a) enhanced Delta IV core stage as auxiliaries, (b) enhanced Atlas V core stage as auxiliaries, (c) enhanced Falcon 9 core stage as auxiliaries (d) enhanced Vega solid rocket boosters as auxiliaries (e) enhanced JAXA H-IIA (H2A) as auxiliaries, (f) enhanced Soyuz rockets as auxiliaries (g) enhanced Long March rockets as auxiliaries (h) and so on. This invention is applicable to in-development systems such as Ariane-6, GSLV Mark 3 and others as well for transforming them into reusable efficient systems.

Other embodiments containing other similar configurations are within the scope of this invention. In this manner the intellectual property of this invention covers and is able to transform and enhance other systems whether they are mentioned here specifically or not (including new ones that belong to the same classes as those mentioned herein) to make them reusable, responsive and efficient.

AUXILIARY MODULES

Shield-Shroud (Claim 21)

As per this claim, heat resistant shields/shrouds (modular elements according to claim 1) are designed-invented for protecting the core stage and booster from hot gasses exhaust from the upper stage rockets and high temperatures during return flight.

In one embodiment the shrouds are conical in shape. In another embodiment the shields have aerodynamic shape.

In one embodiment, the shroud is designed for the core stage, shown in Figure 37. In another embodiment the shield is designed for the solid rocket booster (SRB), shown in Figure 38.

Air Breathing Aircraft Engines (Claim 22)

According to this claim, the attachment of air breathing aircraft engines (modular element as per claim 1) to the wing element claimed in 8 will aid in fly back of spacecraft systems. The attachment of air breathing aircraft engines in other means to the elements claimed in 5, 6, and 7 will aid in fly back of space craft elements as well. (This is an alternative to having fly back engines at the bottom of core stage).

To provide fuel to the aircraft engines, aircraft fuel tanks are integrated with the spacecraft modular wings in one embodiment. In another embodiment the aircraft engines have integrated fuel tanks.

These aircraft engines help in the flight back to ground after the spacecraft combine first stage descends to lower levels of atmosphere.

Fly Back Rocket Engines (Claim 23)

As per this invention, the design and attachment of liquid strap on boosters to the elements claimed in 5, 6, 7 that aid in fly back of space craft elements constitute another modular element according to claim 1. (This is yet another alternative to having fly back engines at the bottom of core stage or aircraft engines as per above claim).

In one embodiment of the invention, the fly back rocket engines are liquid oxygen (LOX) and methane engines. In another embodiment they are LOX and liquid hydrogen (LH2) engines. In yet another embodiment, the fly back strap-on engines are designed to use liquid oxygen and RP1 or aircraft fuel. Other different embodiments supporting other types oxidizers and fuel that perform the function of fly back rocket engines to first stage of integrated launch systems are within the scope of this invention.

The fly back strap on engine is shown in Figure 39.

In one embodiment of this invention, the strap-on engines serve as boosters to the first stage from the beginning and serve as fly back engines on return flight. In another embodiment, the strap-on engines are only used for fly back after the spacecraft systems reach upper atmosphere.

ARCHITECTURE SUMMARY

Reusability and Responsiveness (Claim 24)

One of the salient claims of this architecture is the design for reusability and responsiveness of modular elements, sub-systems and complete systems. In the principal embodiment, the integrated first stage and upper stage systems are launched vertically and the first stage sub-system consisting of the core, auxiliaries and wing after launching of upper stages at the edge of atmosphere, are flown back and land. In this embodiment, the capsules are recovered from landing sites (land or water) and are reused. These recovered systems are made reusable in a highly responsive manner through support systems. As an adjunct to this invention, the upper stage rocket is reused as a part of in-orbit fuel depots.

The first stage is shown in landing approach in Figure 24. The support systems and conversion of upper stage into in-orbit fuel depots are patented separately.

Conversion from a vertical launch into a horizontal launch is a natural extension of this invention. Integrating the crew capsule and upper stage engine into a re-usable space plane to result in a two stage to orbit and landing (TSTOL) architecture is a natural extension of this invention. A combined horizontal takeoff and landing with a two stage to orbit and landing (HTHL TSTOL) architecture is natural extension of this invention.

Flexible Architecture Operation Profiles (Claim 25)

The elements modules, sub-systems and systems claimed herein (in this document) in isolation or combination (that comprise a platform-architecture according to claim 1) are usable in a flexible manner for a variety of space exploration operational profiles as per this claim for low earth orbit (LEO), geo stationary orbit (GSO), near earth orbit (NEO) exploration and so on.

This use can constitute light lift (10-15 tons), medium lift (15-20 tons), medium heavy lift (20-30 tons), heavy lift (30-60 tons), ultra heavy lift (60 to 120 tons), and super ultra heavy lift (greater than 120 tons). For the purposes of the rest of the discussion, medium lift is expanded to span 15-25 tons while heavy lift is expanded to span 25-60 tons.

Some embodiments of the flexible exploration profiles are presented below. Other similar exploration embodiments are within the scope of this invention.

Low earth orbit exploration embodiment

Light, Medium Heavy and Heavy human and cargo launch systems (that are part of this architecture invention) describe above are used to carry out exploration of low earth orbit regions of space. In one embodiment large earth science satellites are launched. Other embodiments are used for launching human and cargo missions to low earth orbit.

In another embodiment, Super Ultra Heavy and EDS systems are used for launching large solar collectors for efficient solar power generation.

Geo Stationary orbit exploration embodiment

Medium Heavy, Heavy, Ultra Heavy human and cargo launch systems described above are used to carry out exploration of geo stationary orbit (GSO) regions of space. In one embodiment, large geo stationary satellites, science observatories are launched. In other embodiment, human exploration is used for human habitats in such orbits.

Near Earth Orbit exploration embodiment

Ultra Heavy, Super Ultra Heavy and EDS human and cargo launch systems described above are used to carry out exploration of near earth orbit (NEO) regions of space. In one embodiment, lagrangian point science observatories are launched. In other embodiment, human exploration is used for servicing of science instruments in such orbits. Yet other embodiments support human and robotic (cargo) exploration of near earth objects such as asteroids and comets.

Lunar Exploration embodiment

To achieve lunar exploration, Medium/Heavy and Super Ultra Heavy/EDS launch systems are used in tandem as per this architecture. The medium or heavy launch systems are used for human or precious cargo capsule launch and the Super Ultra Heavy/EDS system is used for launching the EDS cargo sub-system. The human or precious cargo capsules and the EDS cargo sub-system rendezvous in low earth orbit (EOR) and the EDS stage provides the transfer lunar injection (TLI) boost to the space integrated human and cargo (lunar surface) sub-systems for achieving lunar exploration.

In another embodiment, two Ultra heavy launch systems are used (one for crew and other for cargo) for launches to lunar orbit rendezvous (LOR) where human and cargo sub-systems link up before lunar surface exploration.

Precious cargo launches and return embodiment

Precious cargo launches and return is achieved by launching precious cargo capsules and cargo extensions using heavy or ultra heavy lift systems. Cargo is returned my means of precious cargo capsules and cargo extensions.

Space station construction, support and service embodiment

Space station construction, support and service are performed by a combination of different systems in this architecture. Human capsules are launched using heavy the lift system. Station modules are launched with the help of payload cargo bay using heavy/ultra heavy lift systems in one embodiment. Human capsules and payload cargo bay hook up in space and perform station construction, support and service. This ensures separate crew and cargo launch that helps achieve dual purposes:

(a) Crew safety
(b) Heavy cargo launch capability

As needed, extremely heavy and/or large station modules are launched using super ultra heavy / EDS lift systems.

This architecture not only provides comprehensive construction, support and service of the existing international space station (ISS) but also can help build new space stations with a more expansive set of capabilities.

Fly back embodiment

Space systems fly back is achievable using different means passive, powered and crewed, tele-operated in this architecture.

<u>Tele-operated fly back</u>

The system design/architecture of wing, and clustered core and auxiliaries is naturally fly back enabled and the first stage can glide back passively without any engines. In one embodiment, fly back engines located integral to the core stage (in Figure 7) help the system fly back in a powered mode. In another embodiment, fly back strap on engines are used in conjunction with the launch system as shown in Figure 40. In this embodiment the returning system powered by strap-on fly back engines is shown in Figure 41. These passive and powered fly back embodiments are flown back through tele-operation.

<u>Crewed fly back</u>

In the crewed fly back embodiment, Apollo class crew capsule is installed on the core stage with launch abort motors. In the preferred embodiment these are enhanced launch abort motors installed underneath the capsule as per the Continuous Space SAFETY invention. The returning first stage (Apollo class) crew capsule on the top is shown in Figure 42.

Summary

The architecture and platform described in this invention is very comprehensive and flexible. It can be used for creation of a wide variety of exploration systems. It can be used for a constellation (large group) of exploration activities. It should be understood that the invention is not limited to the particular construction and arrangement of parts herein illustrated and described, but embraces such modified forms thereof as come within the scope of the claims. Those skilled in the art can make enhancements, improvements, and modifications to the invention, and these enhancements, improvements, and modifications will nonetheless fall within the spirit and scope of the claims of this invention.

Other References

Space shuttle 1976: status report for the Committee on Science and Technology, U.S. House of Representatives, Ninety-fourth Congress, first session

"Space Shuttle 1978", Status Report for the Committee on Science and Technology, U.S. House of Representatives, Ninety-Fifth Congress, Jan. 1978

Apollo Program: http://nssdc.gsfc.nasa.gov/planetary/lunar/apollo.html

Shuttle Reference Manual: http://spaceflight.nasa.gov/shuttle/reference/shutref/

Buran Reference: http://www.buran.ru/htm/molniya.htm

Energia Launchers: http://www.energia.ru/english/energia/launchers/vehicle_energia.html

Assessment of Candidate Expendable Launch Vehicles for Large Payloads: http://ntrs.nasa.gov/archive/nasa/casi.ntrs.nasa.gov/19850015556_1985015556.pdf

Alternatives for Future US Space-Launch Capabilities: http://www.cbo.gov/ftpdocs/76xx/doc7635/10-09-SpaceLaunch.pdf

Shuttle II: http://web.archive.org/web/19970428141138/http://vab02.larc.nasa.gov/Activities/ShuttleII/STSII.html