"DIRECT" Shuttle Derivative
Universal Launch Solution

www.directlauncher.com

A Cost Effective, Higher Performance, Alternative to the Ares-I and Ares-V

By: Ross B Tierney
Based on works by: NASA's Marshall Space Flight Center

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EXECUTIVE SUMMARY

The DIRECT Shuttle Derivative Universal Launch Solution (DIRECT) is an alternative approach to launching missions planned under NASA's new mandate: The Vision for Space Exploration (VSE).

DIRECT would replace the separate Ares-I Crew Launch Vehicle (CLV) and Ares-V Cargo Launch Vehicle (CaLV), with one single Universal Launcher, capable of performing both roles. This alternative architecture completely removes the costs and risks associated with developing and operating a second launcher system. Additionally, removing the second launcher system from the critical path accelerates the schedule for returning to the moon.

Instead of one small (22mT) launcher and one very large (131mT) launcher, DIRECT leverages the existing Space Shuttle's facilities and launch hardware to create a single Launcher in the performance "mid-range", capable of lifting over 70mT in basic configuration or over 98mT with an Upper Stage.

This approach has the following key benefits over the current Ares Launch Vehicle family:

1) DIRECT reduces the total non-recurring cost of Launch Vehicle development by $19.0 Billion, and reduces project operating cost by more than $35 Billion over the next 20 years, compared to the current Ares-I and Ares-V concepts.

2) The cost of operating and maintaining a complete second launcher system is removed, promising annual recurring cost savings of between $1 and $3 Billion every year.

3) DIRECT eliminates critical flaws in the current Ares systems.

4) DIRECT's first launch vehicle creates access for Lunar missions. Because there is no need to wait for a second launcher to be developed, the Lunar missions can be greatly expedited.

5) The near-term $3 Billion cost of developing the 5-segment SRB's is removed. DIRECT reuses the existing man-rated 4-segment SRB's from Space Shuttle.

6) DIRECT halves the cost of Infrastructure modifications necessary at all the manufacturing and processing sites involved, offering a near-term saving of at least $2 Billion.

7) DIRECT triples the Crew Launch Vehicle performance to LEO, allowing a far wider range of missions to be performed, and for large amounts of cargo to be launched with every crew.

8) Lunar Mission Initial Mass in Low Earth Orbit (IMLEO) increases by 6%, while also reducing the costs by more than $1 Billion every year.

9) The projected cost savings with the DIRECT concept could relieve NASA from reducing funds from other programs, such as the much-publicized missions of NASA's Science Directorate.

10) Because the DIRECT concept expedites the time-line for the new Launch Vehicle and the first return-to-the-moon mission, it more effectively ensures retention of existing NASA and Contractor Workforce at MSFC, JSC, KSC and other supporting NASA centers. It reduces the personnel turnover and "brain-drain". And because so many elements are re-used from Shuttle as- they-are, it also eliminates many of the costs for re-training. All this contributes to Reducing employee anxiety during this transition.

The following document demonstrates how DIRECT can accomplish all these goals.

DESCRIPTION OF DIRECT

DIRECT is based on considerably more Space Shuttle hardware than the currently proposed Ares vehicle family. DIRECT re-uses the existing man-rated 4-segment SRB's from the Space Shuttle, virtually unchanged. This results in significant cost saving and schedule risk reduction by eliminating the all-new 5-segment Solid Rocket Boosters (SRB), which require $3 Billion extra to develop.

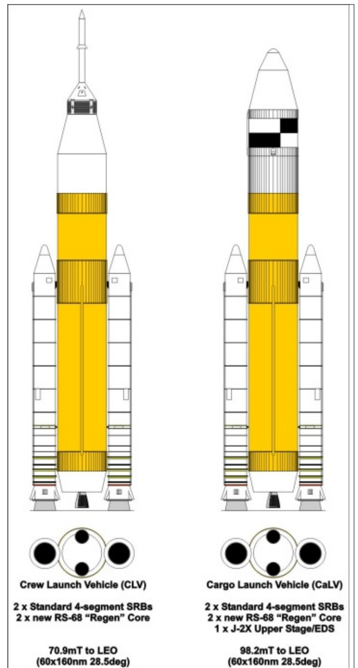


Fig 1: DIRECT

DIRECT's configuration, of a 27ft 7in (8.41m) central core with 4-segment SRB's, is so similar to the current Space Shuttle hardware that the processing facilities at Kennedy Space Center could be ready to start processing almost immediately. This is in sharp contrast to the costly changes being planned to support the radically different Ares designs.

The Main Propulsion System engine for DIRECT's Core Stage is provided by a pair of RS-68 LOX/LH2 engines from the Delta-IV. These are more powerful, yet far less costly powerplants than the three venerable Space Shuttle Main Engine's (SSME) this configuration would originally have required. While the existing RS-68 engines are utilized initially for DIRECT, the Lunar program will benefit from a relatively routine upgrade program to the engine - to install the system with a Regenerative Nozzle so that the maximum performance can be earned from the powerplant. The "Regen" nozzle version of RS-68 provides an increase in efficiency to 435 seconds vacuum engine Isp, while increasing thrust across the range by approximately 5%. This increases performance for DIRECT by more than 8mT on every flight.

This arrangement increases performance of the most basic DIRECT Launch Vehicle to over 70mT per flight. With an Earth Departure Stage, similar to Ares-V's, that performance climbs to over 98mT. This payload capacity is higher than necessary for a bare Crew launch, but it opens up the possibility for a payload module massing over 48mT to be launched at the same time as every Crew. In addition to the Exploration missions, this superior capability would allow NASA to consider also:

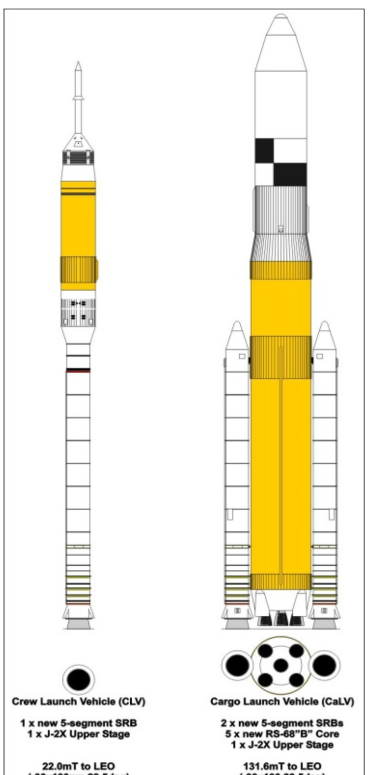


Fig 2: Ares-I and Ares-V

* Flying all the remaining ISS elements which Shuttle can't.
* Bring major repair elements to ISS after Shuttle is retired.
* Launch Station Experiment payloads with Crew.
* Launch a new 70mT ISS module to extend its life beyond 2016.
* Perform future Hubble Servicing Missions.
* Launch a 70mT "Hubble-II" with an 8m diameter mirror.
* DoD may also find uses for an 8m diameter LEO telescope.
* Launch Jupiter Icy Moons Orbiter (JIMO) on a single flight.

Ares-I will simply never offer any of these mission options.

Ares-V is not planned to even begin it's 7 year development cycle until after Shuttle has already been retired. The Heavy Lifter will not become operational until, at the earliest, 2018 - two years too late to be of any assistance to the ISS National Laboratory. And that assumes Ares-V is not cancelled by changing political winds at any time over the next 12 years.

COMMONALITY BETWEEN LAUNCHERS

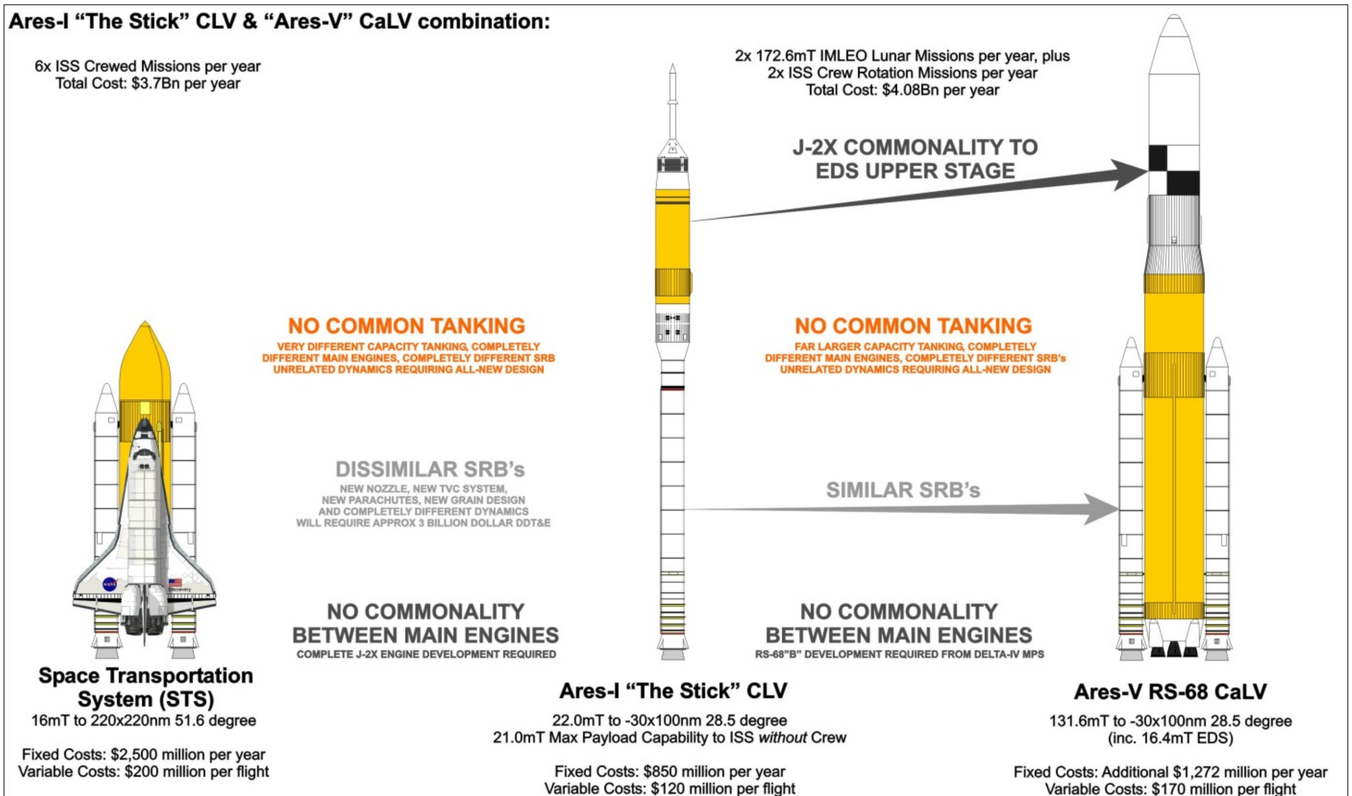


Fig 3: Commonality between Shuttle, Ares-I and Ares-V proposed vehicles

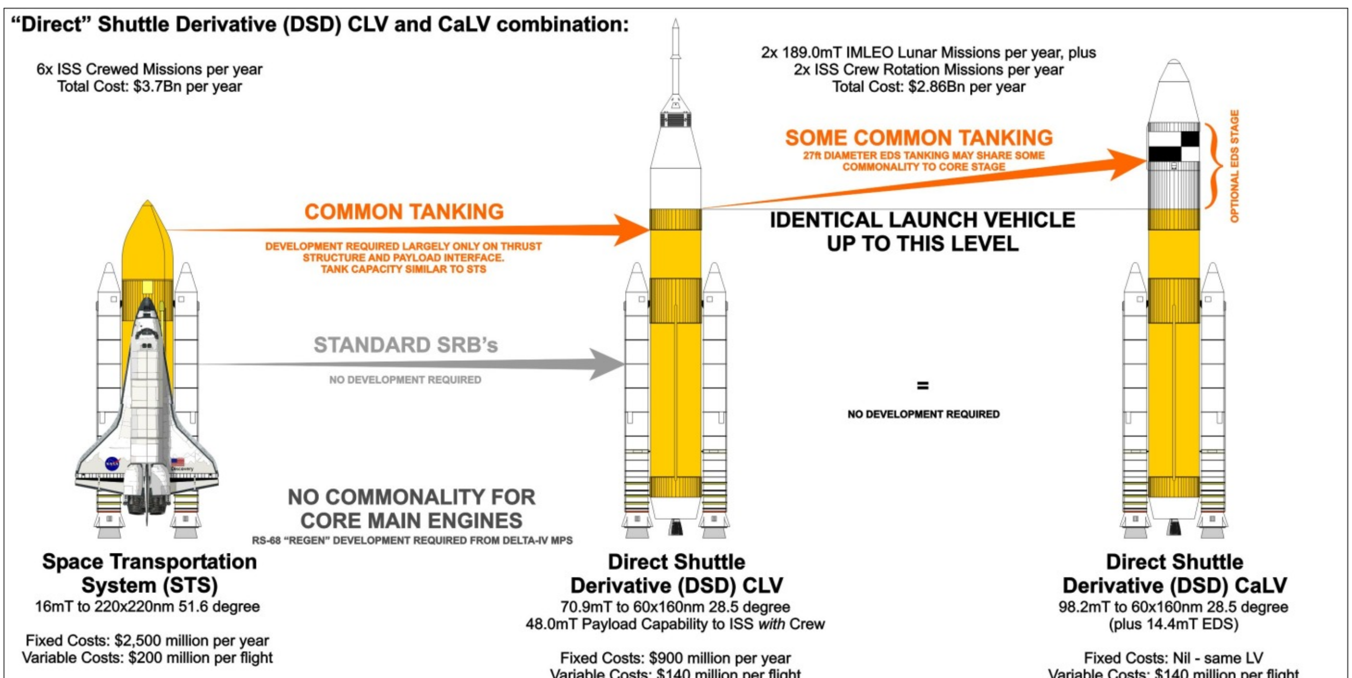


Fig 4: Commonality between Shuttle and DIRECT CLV & CaLV proposals

Summary:

There is virtually no commonality between Shuttle, Ares-I and Ares-V - despite appearances.

DIRECT shares a number of elements with Shuttle, including major tanking structures and SRB's. The basic Launcher is identical for both CLV and CaLV operations.

COMPARISON BETWEEN ARES AND DIRECT

Figure 5 (right) details the key differences between Ares and DIRECT. Of particular note are the following points:

* Total Lunar Mission Design, Development, Testing & Evaluation (DDT&E) program cost is reduced by $19.0 Billion - or 43%.

* DIRECT Crew LV development costs reduced by $3.8 Billion.

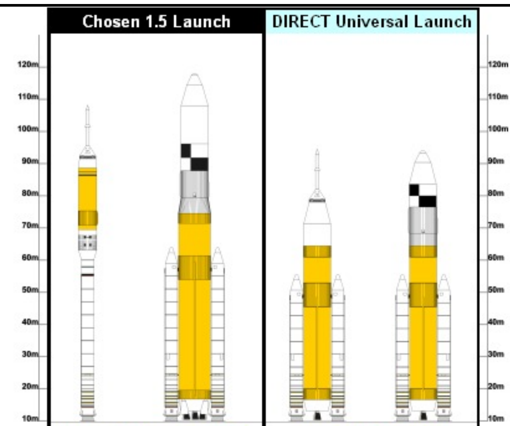
* Near-term $3.0 Billion cost for developing 5-segment SRB's is removed. This expense is removed from the Critical Path for Lunar Missions, and becomes a Growth Option for the future (see Appendix 9 for specific details).

* Separate Cargo LV development cost is removed completely. Saves $14.0 Billion: Equivalent to saving 32% of overall DDT&E Budget.

* At least $2.0 Billion saving in infrastructure costs at MAF and KSC. $800 million in near-term savings by directly re-using existing STS facilities immediately.

* Average Lunar Mission LV Operational Costs reduced by 31%.

* IMLEO is 11.0 metric Tons (mT) higher than current Ares maximum for every CLV & CaLV Lunar mission. This extra performance increases to 52.8mT if the Crew LV also flies an EDS.



	Crew: 5 Segment RSRB w/ 1 J-2X Upper Cargo: 5 Segment RSRB In-Line w/ 5 RS-68 Core and 1 J-2X EDS	Crew: 4 Segment RSRB In-Line w/ 2 RS-68 Regen Cargo: Same, w/ 1 J-2X EDS	
Crew LV Payload (28.5deg) (Ares -30x100, DIRECT 60x160)	22.0 mT	70.9 mT (98.2 mT w/ upperstage)	322% 446%
Cargo LV Payload (28.5deg) (Ares -30x100, DIRECT 60x160)	131.6 mT (106 mT w/out upperstage)	98.2 mT (70.9 mT w/out upperstage)	75% 67%
Total Crew & Cargo LV IMLEO payload	172.6 mT	183.6 mT (225.4 mT w/ EDS on CLV)	106% 131%
Crew LV DDT&E	$19.90 Bn	$16.90 Bn	85%
Cargo LV DDT&E	$14.00 Bn	-	-
EDS DDT&E	$6.10 Bn	$6.10 Bn	100%
Crew & Cargo LV DDT&E (family op, inc. EDS)	$40.00 Bn	$23.00 Bn	58%
Crew LV Facility DDT&E	$2.40 Bn	$1.60 Bn	67%
Cargo LV Facility DDT&E (inc. EDS)	$1.40 Bn	$0.20 Bn	14%
Crew & Cargo LV Facility DDT&E (family op)	$3.80 Bn	$1.80 Bn	47%
TOTAL DDT&E (family op)	$43.80 Bn	$24.80 Bn	57%
Lunar Mission Average Cost/Flight @ 2 per year	$1.92 Bn	$1.33 Bn	69%
500+mT IMLEO Mars Mission Total Cost (inc. 100% Ops)	$4.22 Bn (1 CLV, 4 CaLV; 517mT)	$3.13 Bn (6 Direct, 5 EDS; 562mT)	74% 109%
LOM - Cargo (mean)	1 in 124	1 in 184	148%
LOC (mean)	1 in 1,918	1 in 1,355	71%

Fig 5: Comparison Between Ares and DIRECT

* Lunar Loss of Mission (LOM) risk improves by 48%.

* Loss of Crew (LOC) risk 1 in 1,355 missions. While 19% lower than Ares-I, assuming a literal context, would equate to just one crew loss every 226 years, compared to 320 years for Ares-I at the expected flight rate of 6 crewed launches per year. DIRECT's LOC risk is far superior to Ares-V's 1 in 815 LOC risk factor.

* Every Crew LV mission to the ISS can be accompanied by an additional 48.9mT (76.2mT w/ EDS) payload module.

* 500+mT Mars IMLEO launches would reduce costs by $1.1 Billion (26%) using DIRECT instead of Ares-I and Ares-V.

COST COMPARISON

	Ares 2-Launcher Solution		DIRECT Universal Launcher Solution	
Mission:	CLV	CaLV	CLV	CaLV
Design, Development, Test & Evaluation (DDT&E):				
Launch Vehicle:	$ 19,900m	$ 14,000m	$ 16,900m	-
Earth Departure Stage:	-	$ 6,100m	-	$ 6,100m
TOTAL:	**$ 40,000m**		**$ 23,000m**	
			Saves: $ 17,000m non-recurring	
Infrastructure:				
KSC: (VAB, MLP, Pad, SRB):	$ 1,500m	$ 1,000m	$ 1,000m	-
MAF: (Tooling, Pegasus):	$ 900m	$ 400m	$ 600m	$ 200m
TOTAL:	**$ 3,800m**		**$ 1,800m**	
			Saves: $ 2,000m non-recurring	
Operations (All Facilities: MSFC, JSC, KSC etc):				
Fixed per year:	$ 900m	$ 900m	$ 1,000m	$ 900m
Variable per flight:	$ 120m	$ 250m	$ 130m	$ 220m
TOTAL Cost for 2 x ISS CLV Missions, and 2 x Full Lunar missions (CLV & CaLV) per year:	**$ 4,080m**		**$ 2,860m**	
			Saves: $ 1,220m recurring annually	

Fig 6: Cost Comparison Between Ares and DIRECT

NOTE: Ares figures are based on the ESAS Report 20-year budget assessment, updated to reflect changing Ares designs.

Summary:

DIRECT saves at least $19.0 Billion in development costs, compared to Ares-I & Ares-V.

Recurring costs for DIRECT are reduced by more than $1 Billion every year, for a total cost saving of approximately $35.1 Billion thru 2025, compared to the Ares solution.

20-YEAR PROGRAM BUDGET COMPARISON

Below are budget comparisons between the Ares and DIRECT over the next 20 years, thru 2025.

Included are the common costs for the Orion CEV, the new Lunar Surface Access Module (LSAM) and the Earth Departure Stage (EDS), along with the detailed allocations for the various Launchers:

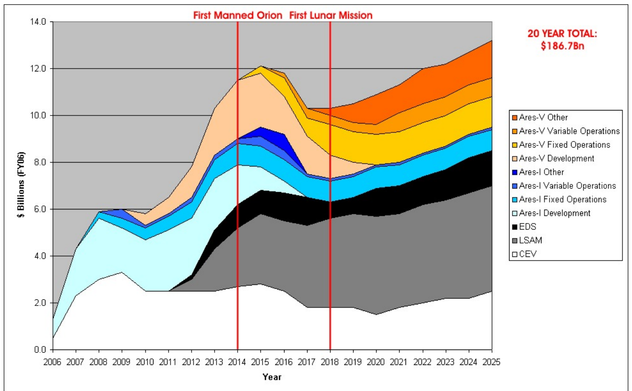


Fig 7: Ares-I and Ares-V - 20-year Budget Summary

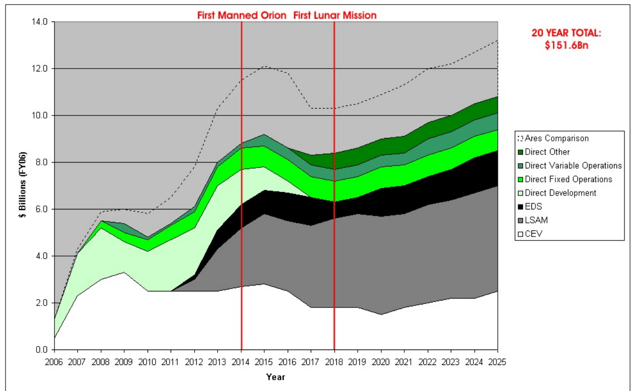


Fig 8: DIRECT 20-year Budget Summary

As can be seen in Figures 7 and 8 (above), the removal of the second launcher saves a large amount of expenditure every year throughout the next 20 years, growing to around $2 Billion per year.

Further, without the need to develop the 5-segment SRB's, the development costs of DIRECT itself are considerably lower than that of the Ares-I alone.

Assuming precisely the same mission schedule as Ares, annual savings with DIRECT climb to $1 Billion in 2011, break $2 Billion in 2013, climb to a peak saving of $3.2 Billion in 2016 and settle back to between $1.9 to 2.5 Billion in savings every single year after that. Thru 2025, more than $35 Billion is saved by developing DIRECT instead of both Ares vehicles. That is equivalent to two complete annual NASA budget appropriations...and would allow many other areas of the VSE to be more fully funded and expanded instead.

As Figure 9 (right), demonstrates, DIRECT has an additional major advantage over Ares: By reallocating the budget savings from the Ares vehicles, the first flight of the Orion CEV could be expedited by one full year, and the first return-to-the-moon mission could be expedited two full years ahead of present Ares-based schedules by bringing forward the budget allocations of both the new Lunar Surface Access Module (LSAM) and the new Earth Departure Stage (EDS).

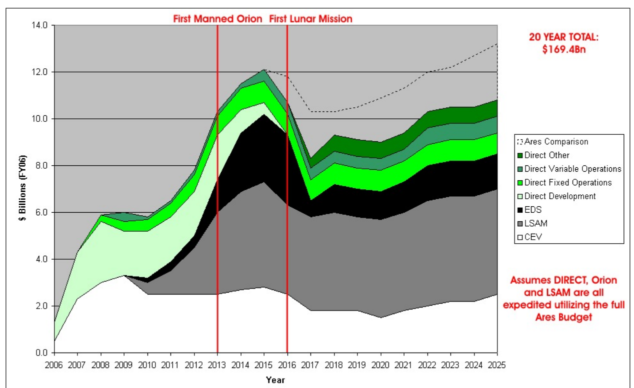


Fig 9: Expedited DIRECT 20-year Budget Summary

Summary:

DIRECT removes $19 Billion of costs incurred in developing a second Launch Vehicle.

DIRECT removes $16 Billion of costs over 20 years for operating a second Launch Vehicle.

DIRECT removes the near-term $3 Billion development costs incurred by the 5-segment SRB's.

DIRECT can achieve the "Lunar Sooner" targets without strangling NASA's budget.

INFRASTRUCTURE - MICHOUD ASSEMBLY FACILITY (MAF)

Fig 10: External Tank Manufacturing at MAF

One single production line obviously costs half as much as two equivalent ones. The separate Ares CLV and CaLV design share little to no commonality, thus share little to no cost savings in the manufacturing of their individual components..

MAF, today, produces the 27ft 7in (8.41m) diameter Space Shuttle External Tank structures which share much commonality with DIRECT, such as:

- Al-Li LOX & LH2 Tanking Walls
- Al-Li LOX & LH2 Tanking Domes
- Inter-Stage structure
- Inter-Stage LOX Line routing
- Inter-Stage internal SRB Support Structure
- LOX Line routing
- GH2 Vent Umbilical Connection

The “Pegasus” transport barge is equipped to handle ET-sized elements immediately. While it can easily carry Ares-I’s Upper Stages, it would require extensive alteration to support the Ares-V’s 33ft (10.06m) diameter stages, which are also far longer - it might even require complete replacement.

In addition, the existing Space Shuttle’s External Tank, the DIRECT’s Core and EDS/Upper Stage all share the same basic 27ft 7in (8.41m) diameter form factor. This is likely to result in a variety of benefits from being able to share many manufacturing facilities in place today.

None of this commonality exists between Ares-I or Ares-V which both require all-new infrastructure assets throughout both Ares programs.

Fig 11: External Tank is delivered to KSC by the “Pegasus” Barge

Summary:

DIRECT does not require the costly changes at MAF in order to accomplish a successful new Lunar Program.

MAF is ready immediately to support the manufacturing of DIRECT elements, with minimal re-tooling required.

INFRASTRUCTURE - KENNEDY SPACE CENTER (KSC) - I

Solid Rocket Boosters (SRB):

NASA’s facilities at KSC currently process man-rated 4-segment SRB’s for the Space Shuttle program.

Because DIRECT re-uses the Shuttle boosters exactly as they are, little to no changes should be required to support DIRECT immediately.

Fig 12: SRB recovery at SRB Slip after flight

Fig 13: Hangar AF post-flight inspection

Conversely, both Ares Launchers require extensive and very costly modifications to support the longer 5-segment configuration boosters.

Modifications required by each of the Ares vehicles encompass all the major processing areas within KSC; from the SRB Recovery ships “Freedom Star” and “Liberty Star”, to the recovery slip on the river at Hangar AF, to the Work Platforms inside the VAB - even the Mobile Launcher Platforms. All of this existing infrastructure must be modified or completely replaced to suit the different SRB configurations which the Ares-I and Ares-V require.

DIRECT removes all of these unnecessary costs, by retaining the current configuration of SRB’s, as flown by the Space Shuttle Program today.

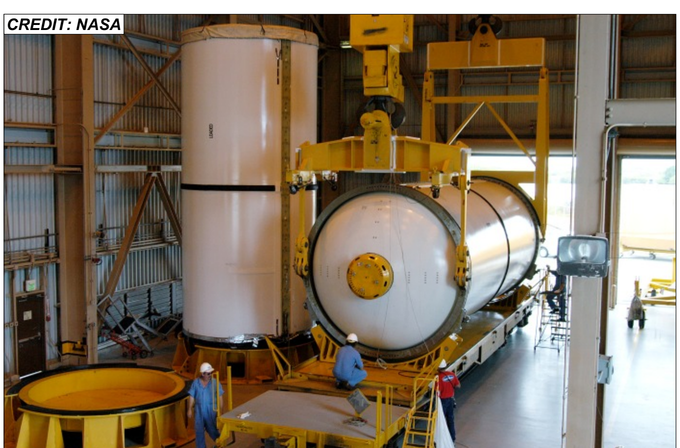


Fig 14: Rotation Processing and Surge Facility

Fig 15: Build-up for flight

INFRASTRUCTURE - KENNEDY SPACE CENTER (KSC) - II

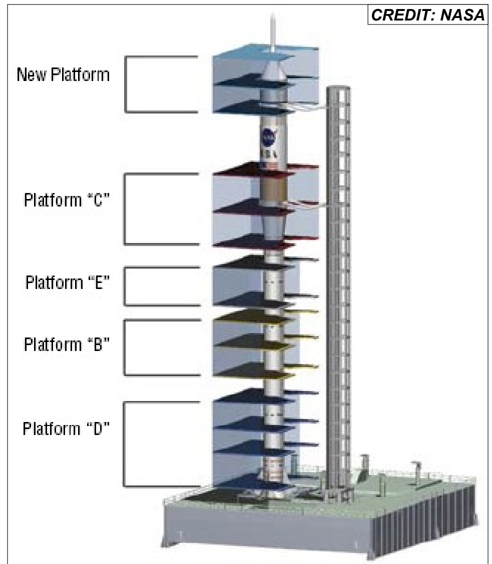


Fig 16: Ares-I Highbay Work Platforms

Vehicle Assembly Building (VAB):

VAB Highbays 1 & 3 are currently configured to assemble and checkout the Space Shuttle. All facilities there today are designed to process a 27ft 7in (8.41m) diameter central Core (the External Tank) with two 4-segment SRB's attached either side.

Ares-I:
As Figure 16 (right) indicates, Ares-I will require extensive alterations to the Highbay Work Platforms "E" and "C" to support the new launcher's design, and an all-new work platform (probably designated "A") needs to be designed, built and installed high in the VAB to support the Ares-I's great height.

Ares-V:
The current Space Shuttle Work Platforms will not fit around the new Ares-V's 33ft (10.06m) wide tank structure, and the new 5-segment SRB's will be 27ft 7in (8.41m) taller and will stand 5ft 5in (1.65m) wider apart than at present. Again, this difference requires that a brand-new upper Work Platform ("A2") must be fabricated to suit the payload shroud at the top of that vehicle's considerable height.

Because the placement of the Ares-I's SRB will be different than the Ares-V's on the Mobile Launcher Platforms (MLP), the two vehicles must have uniquely dedicated Highbays for processing. There will be no way to share facilities between the two launchers. This will require that, at minimum, three of the VAB's Highbays must be overhauled, if not all four in order to support Lunar missions.

All of these requirements add considerable extra cost to the Ares program development budget and schedule which are not necessary with DIRECT.

DIRECT:
DIRECT retains the exact configuration as Space Shuttle today: 27ft 7in (8.41m) diameter Core, with two 4-segment SRB's, and only requires two Highbays to support all configurations of missions.

DIRECT also does not require any modifications to the existing Work Platforms "B", "D" or "E", shown in Figure 17 (right).

DIRECT, being the same vehicle for CLV and CaLV configurations, can be processed in any High-Bay. CLV missions and CaLV missions can share VAB facilities at any time.

DIRECT requires only that Work Platform "C" be modified, and only in Highbays 1 & 3. No new "A" work platform is required at all, because DIRECT is not as tall as either of the Ares Launchers.

Fig 17: Current Highbay Work Platforms can be used by DIRECT

INFRASTRUCTURE - KENNEDY SPACE CENTER (KSC) - III

Launch Pads and Mobile Launcher Platforms (MLP):

Ares planners are aiming for a "Clean Pad" concept. On the surface, this would seem to offer development cost and maintenance reduction benefits. However, even a basic assessment of what is truly required, shows very clearly that in practice, this is a mistaken assumption.

The real-world implementation for the new launchers is proving to be problematic. Ares-I requires two brand new MLP's, custom-designed for the new launcher.

Fig 18: Ares-V on rebuilt MLP, with 500ft LUT

Ares-V requires that the three current Space Shuttle Mobile Launcher Platforms (MLP) must be completely re-designed and re-built to support its massively taller height and weight.

Further, the Ares-V's SRB's are mounted 5ft 5in (1.65m) wider apart than on the Space Shuttle today. The current SRB exhaust chambers through the MLP are simply not compatible with this new 'footprint'. Each SRB exhaust chamber must thus be relocated 2ft 11.25in (82.5cm) wider apart than at present - in addition to opening up a 33ft (10.06m) wide chamber for the Core engines to fire through.

The SRB exhaust chamber modifications alone require extensive and enormously costly changes to the primary structures inside each of the MLP's. Just as major a conversion is required now to support Ares-V as that which was done between 1975 and 1980 to convert the MLP's from Apollo to Shuttle - a process which proved very costly, and time-consuming.

Fig 19: Comparison between Ares and DIRECT Infrastructure Requirements

INFRASTRUCTURE - KENNEDY SPACE CENTER (KSC) - IV

Launcher/Umbilical Towers:

Finally, both Ares-I and Ares-V also require brand-new, 500ft (150m) tall, Launcher/Umbilical Towers (LUT) on all five of the MLP's in order to support their extreme heights during rollout and processing at the Pads. Massing an additional 800mT, the extra weight of the LUT's combined with the extra mass of the 5-segment boosters (massing another 300mT for Ares-V), mean that the current Crawler Transporters are not capable of moving this new configuration from the VAB to the Pads.

Crawler Transporters:

Brand-new 6-truck Crawler Transporters are being planned for Ares-V, in order to transport all of this massive extra weight - at substantial expense.

DIRECT does not require any of this additional launch support hardware at KSC.

DIRECT's modifications are fundamentally limited to a new exhaust chamber being created on the standard Space Shuttle MLP's between the existing SRB exhaust chambers's, along with a far simpler Umbilical Tower, and relatively straight-forward modifications to the existing Fixed Service Structures located at the Pads today. See Appendix 5, 6 and 7 for more detailed information on the new configuration.

DIRECT's changes are far less costly, far easier to execute and could be ready within just two years of contracting.

Summary:

Specifically relating to KSC's facilities, DIRECT has three key advantages over Ares-I & Ares-V:

1) Neither Ares Launcher can utilize the current Space Shuttle infrastructure without extensive and costly alterations, or completely new facilities. By comparison, DIRECT only requires moderate alterations to the existing facilities to become fully operational.

2) Ares will require two divergent sets of facilities to be designed and built to support two Incompatible Launcher systems, whereas DIRECT requires only one single support program.

3) Ares requires five large, complex Service Structures to be maintained every year (on the five MLP's). DIRECT requires only two (located at the Pads, and based on the existing Fixed Service Structures).

These advantages greatly impact both expenditure and schedule.

The savings on these facilities reduce DIRECT's near-term costs for modifications to less than half that of Ares-I alone. The DIRECT solution means this one-time cost allows both CLV and CaLV missions to be performed on the same Launcher, with no costs incurred for any second program.

Further, because DIRECT only requires these far less extensive changes, there are substantially shorter schedules for implementing them. This helps reduce the Lunar schedule drastically.

This combination of fewer modifications, half as many launcher programs and faster schedule makes the DIRECT alternative far superior to Ares.

FLAWS WITH THE ARES LAUNCH VEHICLE FAMILY

Ares-I:

The "Stick" concept was originally sold as ***"Safe, Simple & Soon"***. The current version of the concept however, fails to fulfill that promise. The original design, of 4-segment SRB with Space Shuttle Main Engine Upper Stage, would probably have lived up to expectations - if the SSME could have been air-started. It can not. NASA is left with a compromise which attempts to fulfill the same requirements, but which fails to.

George Santayana, an American philosopher of note, once said, ***"Those who do not learn from the mistakes of the past are condemned to repeat them"***. The last time NASA was forced to "compromise" their launch vehicles the result was the desperately flawed Space Shuttle we are all familiar with today, and which is about to be retired because of its design weaknesses. Does NASA really want to repeat the mistakes of the past by building a system which they are fully aware is badly compromised already in the early design phase?

"Safe":

The "Stick" Crew LV's biggest selling point was its high safety figures. However, the difficulties the design is suffering from today are continually whittling those away, with each 'fix' causing ever-larger penalties to the performance.

The new 5-segment SRB's and J-2X engines are both completely unproven. Together their performance is so desperately low that other parts of the vehicle are having to be designed down to a dangerously minimal weight, in order just to get the system to fly at all. Performance of just **22mT to -30x100nm 28.5deg** is at best, ***mediocre***, at worst, ***anæmic***. This poor performance is causing a detrimental domino effect throughout every phase of the development of the new vehicle.

Ares-I is currently suffering from serious design concerns including:

1) A normal rocket is naturally stabilized throughout its flight by having the **Center of Gravity (CofG)** ahead of the **Center of Pressure (CofP)**. Like a thrown dart, the rocket will naturally fly nose-first. But the Ares-I's **CofG** is behind the **CofP** - which causes the rocket to want to flip around in mid-air. Only with very precisely applied Thrust Vector Control, can the rocket be kept on track without applying very high stress loads to the structure.

2) The first stage has a very slow Trust Vectoring system, simply because it is a Solid Rocket Booster. This is causing concern during the first minute after launch, before speed builds and aerodynamics affect the ascent. It is the job of the SRB's Thrust Vectoring system to keep the very tall and ungainly rocket stable and pointing in the right direction as it lifts from the Pad. It is a problem often equated to balancing a pencil, on end, using your finger. The nozzle at the bottom of the SRB is proving to be a very slow 'finger' performing the balancing act. If the rocket becomes unbalanced, perhaps due to crosswinds, the nozzle may be too slow, and be forced to apply very high bending moment forces on the structure in order to try to re-stabilize.

3) The two issues above can cause forces which, quite literally, try to bend the vehicle in half. The SRB is a very strong structure. The pressurized Upper Stage tanking is also a very strong structure. But the Interstage between them is a hollow cylinder, 18ft (5.5m) wide, and 40ft (12m) long, with walls only 1.25" (3cm) thick - and complicated further by a conical structure changing diameter from 13ft (3.9m) to 18ft (5.5m). The Interstage will be the "weak point" if the vehicle suffers instability issues during flight. It is the structure which would fail first if the rocket goes off-course and takes too much time to be forced back on course. The Ares-I

test vehicles' Interstages are being specifically over-built to combat this problem in a bid to dissuade disparaging comment from the space community, who is already well aware of this concern. But the final flight versions of Ares-I must be built down to the lowest possible weight limits in order to keep performance high enough - which means this will be the weakest structural point in the final design.

4) The SRB first stage is currently 18,000lb overweight because the seals around all of the segments need additional, unplanned, strengthening. This is because the in-line design, with the stage and payload located above the booster instead of beside it, are experiencing different loads during flight from the SRB's intended design - so require additional strengthening at these joints to compensate.

5) The roll-control system was not predicted to be as considerable an issue as it is proving to be. It requires an extra system which was unplanned originally, which impacts the weight of the vehicle, and increases the number of systems which can cause an expensive **Loss of Mission** or, worst of all, a **Loss of Crew** contingency.

6) The original "Stick" launcher utilized the Upper Stage to reach an initial elliptical orbit of **60x160nm**, then that Upper Stage to then perform the Circularization burn to achieve the stable **160x160nm** orbit.

   The current evolution of the Crew launcher is simply incapable of placing a fully fueled Lunar Orion CEV into it's 'safe' orbit. The 'kludge' which has been chosen to address this shortfall in performance is to utilize the Orion CEV itself to complete the launch process:

   The Orion is now required to perform a 1000ft/s high-Delta-V burn to reach an initial orbit of just **-30x100nm** - that means the low-point is 30 nautical miles ***under*** the Earth's surface.

   Then the Orion is expected to perform a second burn, 45 minutes later, to increase that orbit to **160x100nm**.

   Finally, a third burn must be performed by the Orion 90 minutes after launch, to finally reach the intended 'circularized' **160x160nm** orbit suitable for safe rendezvous operations.

   This requires two previously unplanned uses of the same engine which is essential for safely returning a crew to Earth at the end of every Lunar mission. These additional firings of that engine add significant extra risks to the overall system. It should not be forgotten that this is a system which will be bringing people to another world for the first time in 30 years and will already be pushing the boundaries of the possible flight envelope. The low performance of the Ares-I is causing serious degradation to the overall safety of the Orion CEV spacecraft. Together, this reduces the original "Stick" concepts **Loss of Crew (LOC)** figures below the stated **1 in 1918**.

7) The Ares-I's fundamental design requires that the Upper Stage engine be ignited at altitude, only after the SRB First Stage has burned-out. There is no guarantee that any engine will start correctly, or safely, let alone at altitude. If there is a problem, the mission would become an abort, requiring the use of the escape system.

   DIRECT however, ignites the Core engines while still on the ground. As the Space Shuttle program has experienced, when an engine does not ignite correctly, the system can be safely shut-down before committing to the launch. This ability not only saves the vehicle for another attempt once the problems are resolved, but also does not force the Crew to endure a very uncomfortable and potentially very dangerous abort scenario with the Launch Abort System.

NASA has yet to publish new, independent, 'apples-to-apples' comparison safety figures between the original CLV and the current evolution. The figures will obviously be lower today. **Loss of Crew (LOC)** safety figures of between **1 in 1500** to **1600** are rumored for the current risk factor as this paper was compiled - so the gap to DIRECT's **1 in 1355 LOC** risk is now very narrow indeed.

If the CEV must perform three extra burns just to get into space at the start of the mission, then it suffers a serious weight penalty by requiring much larger fuel tanks for all the extra propellant. Going to the moon, this extra mass must be dragged all the way to the moon and back again. It is the worst possible form of waste because every kilogram (or pound) of mass you send to the moon requires between ten and twenty times as much mass to be launched in order to get it there.

This would not be such a serious problem if the launcher were able to accommodate the extra weight - but this is happening **BECAUSE** the launcher is underpowered already. This then becomes a vicious circle which must be avoided at all costs. Ultimately it detracts from the useful payload mass which can be sent to the moon - and that is the single most important factor in all such missions.

NASA is currently pursuing some fairly desperate ideas to attempt to get around this basic flaw, ideas such as refueling in space prior to leaving for the moon, a procedure which would add a lot of potential risk itself. But ultimately all of these problems boil down to one fact: They all lose performance for Lunar missions by wasting weight elsewhere.

The only real solution to this problem is to launch more mass. And that simply means requiring more powerful boosters. Ares-I is at its absolute design and weight limits already, and many inside the program publicly consider it to be beyond the realistic limits already. NASA cannot do much more to improve the performance beyond the current limits - the engines are already being designed to be as powerful as they're likely to get, and the structure is already being designed as light as possible.

On an unmanned booster, it might be possible to strap extra solid rocket boosters to the launcher to increase performance - but NASA's own ESAS Report specifically criticizes this approach because it severely cripples the Crew safety of the launcher - and the Ares-I's last remaining, although dwindling, benefit is in it's marginally higher safety numbers.

DIRECT, on the other hand, utilizes the existing 4-segment SRB's, which have a flawless history since they were redesigned following the *Challenger* accident in 1986. They have a perfect history of 182 successful manned ascents, plus numerous additional ground tests - a record no other booster worldwide can match. DIRECT also re-uses most elements from the External Tank from Shuttle, which combined with crew flying on top instead of on the side, is a very safe approach. Further, DIRECT utilizes the existing RS-68 engines from the Delta-IV program, with an upgraded variant to follow in time for the Lunar missions. By reusing so much existing hardware, with little to no changes, the facilities are already in place to handle them, the workforce is largely ready to start without re-training, and there are fewer costs involved in this transition. All of these facts build into a very strong argument for DIRECT's overall safety being of the highest possible class.

"Simple":

Because of the long list of necessary mass reduction requirements, and the underperforming launcher is forcing other systems to compensate, the "simplicity" of the concept evaporates completely because the technical requirements increase exponentially in order to make up for the poor implementation of the launcher.

NASA is today desperately seeking ways to improve this launcher's performance without compromising its safety further. Fixes to a number of technical difficulties which have been highlighted are not impossible, but are going to cause further problems throughout the overall system. Fundamentally, NASA is making the same "*Shuttle Mistake"* again - attempting to fix a seriously compromised design, instead of utilizing one which would work well from the get-go. DIRECT's surplus performance for Crew lift could easily absorb all such technical requirements without penalty, and still have plenty of performance left over.

Compared to Ares-I's remarkably low performance, DIRECT can lift more than three times the mass - and that to a much higher altitude and safer orbit every flight. By reusing so many existing and proven components throughout the launcher and support facilities, DIRECT reduces complexity far more than Ares-I by simply being a more 'direct' evolution of what we fly today.

"Soon":

Dr. Griffin is on public record that there is no way to accelerate the Ares and Orion programs to the original plan of 2012. The first manned flight of the new program has already been pushed back to the end of 2014 - which is the deadline specified in the original 2004 "Vision for Space Exploration" announcement.

The delays have been due to unplanned costs for developing the new 5-segment SRB's and J-2X engine for Ares-I, combined with the high costs of flying the Space Shuttle until 2010, and the science community's concerns over budget cuts.

Ten years from announcement to flight is simply not "*soon*" - especially not for a system which, in the same breath, claims to be so "*simple*".

Ares-V:

Ares-V development can not begin until after Shuttle has been retired - there simply is not sufficient funding to allow NASA to build it until the money Shuttle and ISS currently utilizes is made available. This puts an immediate 4-year long delay into the Ares-V's development program. It will not become operational for 7 years after it begins serious development, making a total of 11 years from now before there can be any Lunar missions at all.

While some of the parts developed for Ares-I are common, such as the SRB's and the J-2X engine for the upper stage, there is no further commonality at all between either existing Space Shuttle or Ares-I flight hardware, manufacturing processes or launch infrastructure. Everything must be extensively re-built or created afresh in order to support a second Launch Vehicle in the family.

The planned 5-segment SRB's have no safe flight record yet. Ares-V is totally reliant on their successful development and use on the Ares-I. If they should prove to have unforseen flaws on the Ares-I, the Ares-V program will be placed in immediate jeopardy.

With the Ares-I, America will regain its ability to access space again. This may be enough for many in the political world. There are already a significant number of people wishing to strip NASA's budget for other programs. Being that the Ares-V will not follow for a number of years after the Ares-I becomes operational, it is possible that the second vehicle may be "castrated" politically. This is especially critical if there is any accident involving the Ares-I prior to the Ares-V becoming operational.

DIRECT removes all of these issues and concerns, by making the first vehicle development program, not the second, the one which opens-up access to the moon, Mars and Beyond.

By reusing all of the existing facilities and launch hardware to the maximum possible extent, and by requiring very little new, unproven technology, DIRECT reduces the risks and the schedule compared with the Ares solution. At the same time, DIRECT saves $19 Billion in development funds, and approximately $1-3 Billion in operational expenses every year - all of which would allow NASA to do far more Exploration with its available budget.

CONCLUSION AND RECOMMENDATIONS

The current interpretation of the Ares-I has very serious technical concerns. As now configured, Ares-I has arguably become less safe and less capable and more expensive than other alternatives which were rejected in the ESAS Report.

Further, having two separate launchers promises to cost twice as much as a single launcher able to accomplish all missions. NASA already knows its available funding with the current program will leave it short of resources for the next 20 years. Without a large injection of additional funding, NASA may ultimately be left with two shiny new launch systems, but have no funds available to do anything really useful with them.

DIRECT's different approach completely removes both of these major concerns for NASA.

DIRECT requires no $3 Billion, 3-years long SRB development program. Much of the Core stage and manufacturing facilities exist today, and no immediate engine development (and only upgrades later) required. Very few changes are necessary to the nationwide facilities which already manufacture and support a very similar system today.

DIRECT could be operational three full years ahead of Ares-I, in 2011, for the same cost as Ares-I; alternatively, for $3 Billion lower cost, DIRECT can match Ares-I's current schedule of 2014.

Knowing this, NASA must give serious consideration again to viable alternatives, such as presented in this report.

A single Universal Launcher would save half the development and recurring operations costs, improve the raw performance considerably, drastically reduce the programmatic risks, and speed-up development by years. Combine that with an almost non-existent safety gap between Ares and DIRECT, and it becomes clear DIRECT allows NASA to simply do a lot more with its resources.

For just the recurring fixed cost of Ares-V alone (on top of Ares-I's costs), DIRECT could launch eight additional flights - placing 567mT in orbit, before the very first Ares-V flight is even paid for.

The current NASA Administration might believe that the Ares-I is *"too far along to change direction now"*, but NASA's own history demonstrates that this is faulty thinking. During Project Apollo, a cost effective alternative, with big performance advantages, known as Lunar Orbit Rendezvous, persuaded Werner von Braun to change the launcher designs radically at a far later point in the Saturn's development program than NASA is at today with Ares. Would Apollo have succeeded in its target of landing a man on the moon by the end of 1969 without that change?

Concerns about public relations issues cannot be allowed to outweigh technical logic. If the public wonders why NASA changed direction, saving money is a very strong argument. And since most of the work done to date for Ares can also benefit DIRECT, there is very little wasted effort in changing direction now. It must be technical reasoning which determines NASA's choices, not PR.

The DIRECT Universal Launcher offers the most versatile and least costly architecture for the new US Space Program over the next two decades. DIRECT offers a viable path to reduce cost, increase performance, preserve safety, and reduce program timeline.

Therefore, NASA should immediately replace the two separate Ares-I and Ares-V launchers with the single DIRECT Universal Launcher architecture to best achieve the far-reaching targets of the Vision for Space Exploration.

APPENDIX 1: FLIGHT PROFILE

Here is the flight profile of a standard mission performed by DIRECT, without the Upper/EDS:

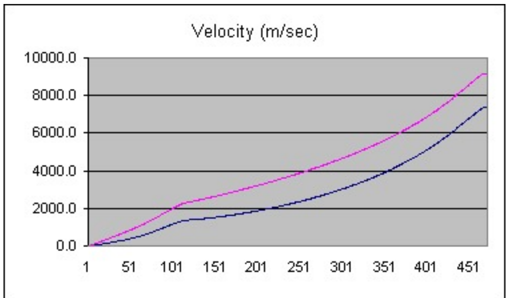


Fig 20: Velocity

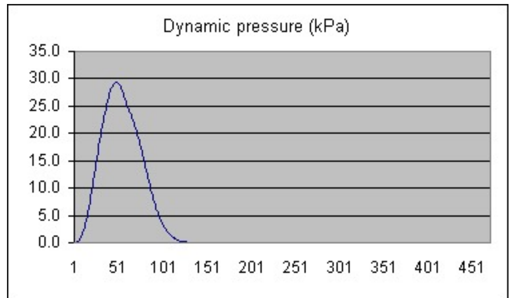


Fig 21: Dynamic Pressure

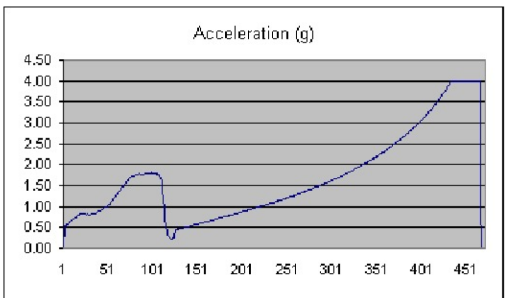


Fig 22: Acceleration

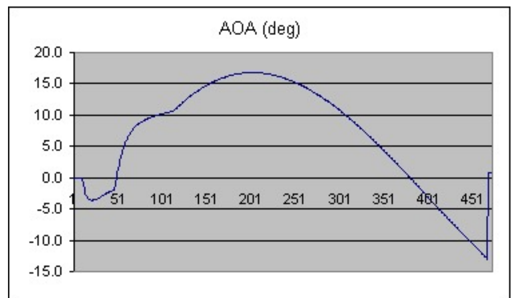


Fig 23: Angle of Attack

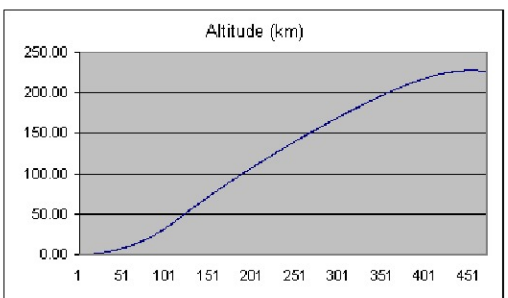


Fig 24: Altitude

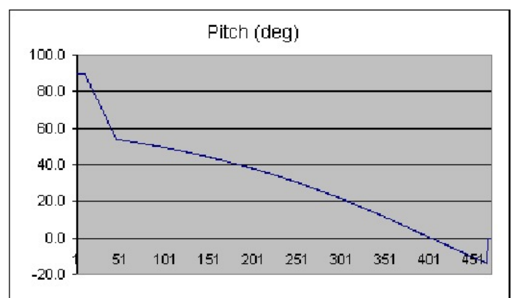


Fig 25: Pitch

Payload Performance: 70,916Kg to 60x160nm, 28.5 degrees LEO

NOTE: All ESAS Ground Rules and Assumptions (GRA’s) are assumed throughout.
Figures assume a 5% margin of error on payload performance, and these performance figures have been confirmed in POST to be “conservative”.

This payload capability would allow for a 22mT Orion CEV to launch, with 48.9mT of additional cargo mounted inside the SLA.

APPENDIX 2: EXAMPLE LUNAR MISSION PLAN

Here is an example Lunar Mission Plan, utilizing the DIRECT launchers as CLV and CaLV:

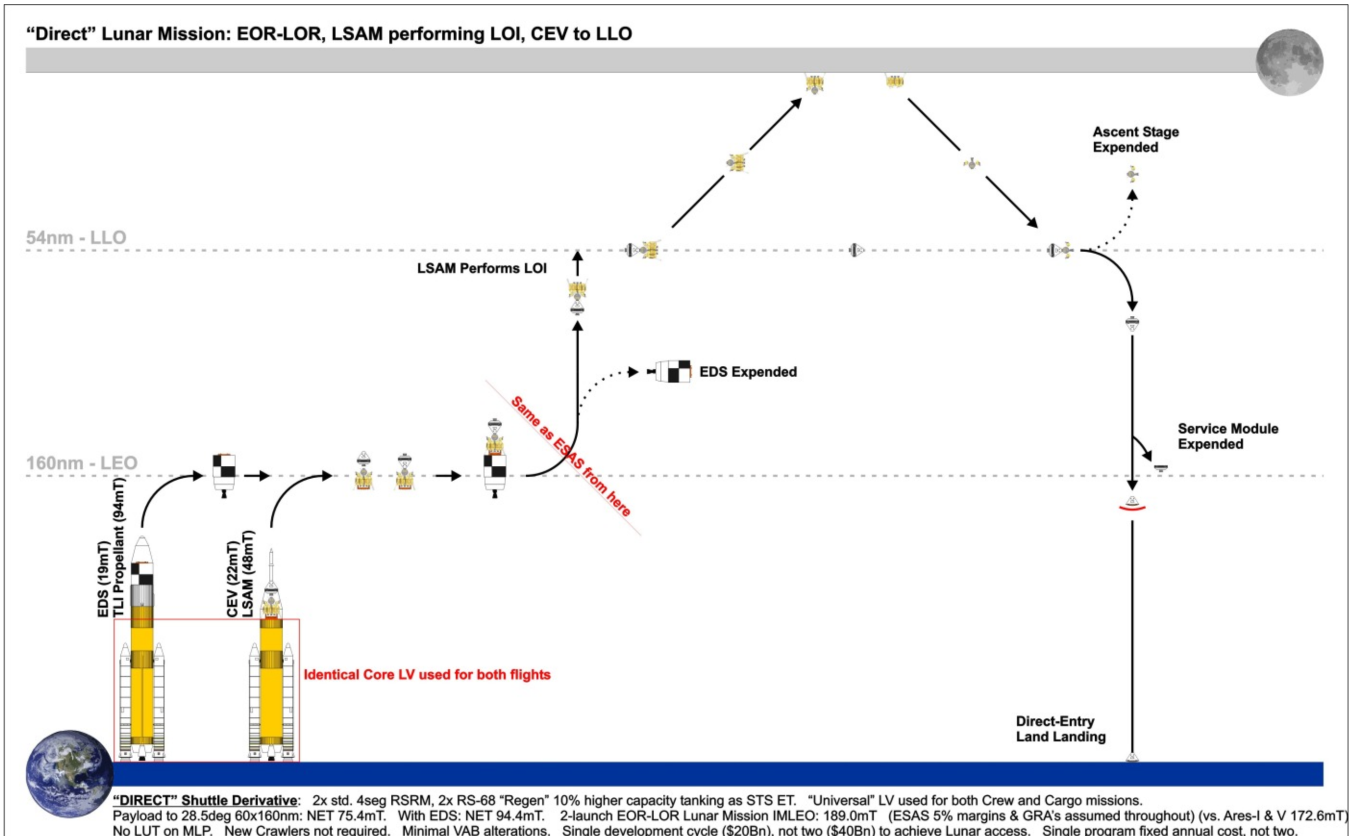


Fig 26: Example DIRECT Lunar Mission Plan

This plan is merely a simple extrapolation of the ESAS chosen solution, tailored to fit the DIRECT's launch capabilities.

It is certainly not the most optimized approach, but simply demonstrates that the Universal DIRECT Launcher can perform the exact same Lunar missions, with higher payload performance, as the family of Ares Launchers.

The ESAS "2-launch EOR-LOR" proposal identified that in practice, this arrangement may actually benefit from the Lunar Orbit Injection (LOI) burn being performed by the Orion CEV instead of the LSAM. This would potentially benefit the mass fraction of the IMLEO being able to be deployed to the Lunar surface.

A Trade Study would need to be performed to configure the mission model for the optimum capability utilizing this launcher system, and the ongoing Trade Studies being performed for Ares-I and Ares-V today are already laying the groundwork for this approach also. In truth, none of the work done to date by teams working on the Ares-I will go to waste - all the work is equally relevant to DIRECT.

APPENDIX 3: EXAMPLE LUNAR MISSION MODELS

If following standard EOR-LOR methods, DIRECT requires one extra docking maneuver to be performed in Low Earth Orbit at the start of the mission.   Here are two example Lunar Mission Models, demonstrating just a few of the many available approaches to this problem:

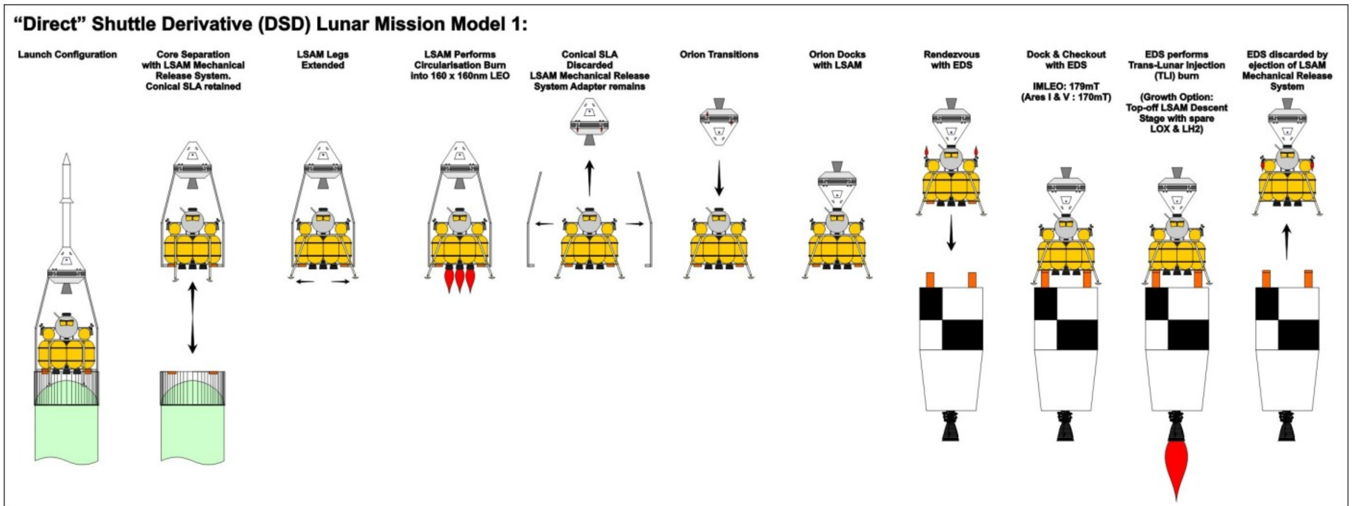


Fig 27: Example DIRECT Lunar Mission Model

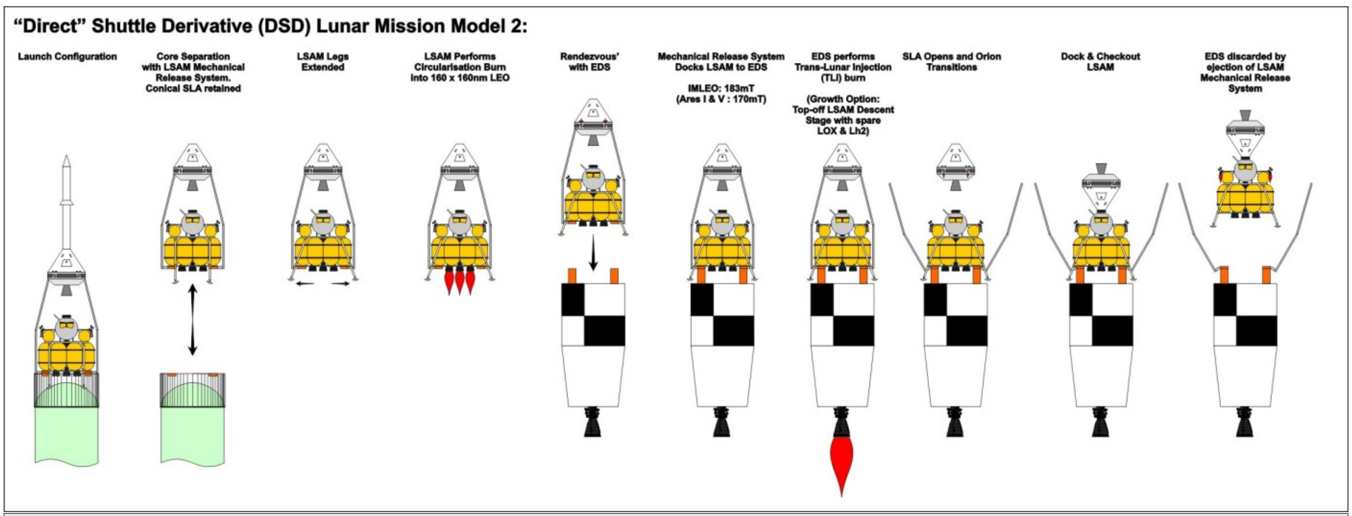


Fig 28: Example DIRECT Lunar Mission Model

DIRECT allows for another alternative: LOR-only:

The LSAM is sent to Lunar orbit without the crew.   The Orion CEV is then sent to the moon using an EDS of its own, where it rendezvous in Lunar Orbit.

This approach can offer better performance in terms of payload mass to the surface of the moon.

Summary:

Trade Studies will be required to decide which of the various alternative mission models offer the best balance between safety, reliability, performance and costs.

DIRECT simply opens up additional performance options for NASA to take advantage of.

APPENDIX 4: PAYLOAD CONFIGURATION OPTIONS

Below are a series of images depicting potential payload configurations for DIRECT.

Fig 29: Example DIRECT Payloads

From Left to Right are:

* "DAC-2" CEV with 48.9mT Mass Simulator
* "DAC-2" CEV with ATV Cargo Module
* "DAC-2" CEV with Lunar Surface Access Module
* Lockheed-Martin style CEV Lunar Surface Access Module
* Empty Payload Shroud to contain More than 70 tons of useful payload

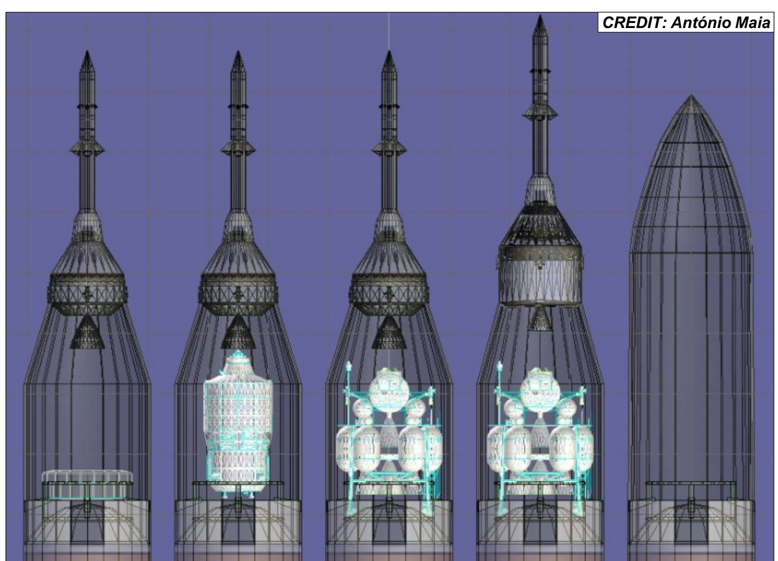


Fig 30: Example DIRECT Payloads - Side View Meshes

APPENDIX 5: MLP ALTERATIONS - I

DIRECT requires relatively minor modifications to the current Space Shuttle Mobile Launcher Platforms (MLP) to support the new configuration.

While the finite details of the rerouted plumbing for the water suppression systems, propellant feed lines and electrical connections can not be detailed in this paper, the primary structural changes can be described.

As can be seen in Figure 31 (right), the SRB chambers do not require alteration at all with DIRECT.

Also, the internal structure of the current MLP only requires a few walls to be removed, to open a new exhaust chamber in between the SRB's.

Additional strengthening may be necessary to brace the inner SRB mount points. This author would suggest two structural beams across the Core Stage Exhaust Chamber, with blast shielding over them - somewhat akin to a flame deflector. This structure should obviously be designed with protection sufficient to ensure the thrust from the RS-68's is not be able to damage this beams.

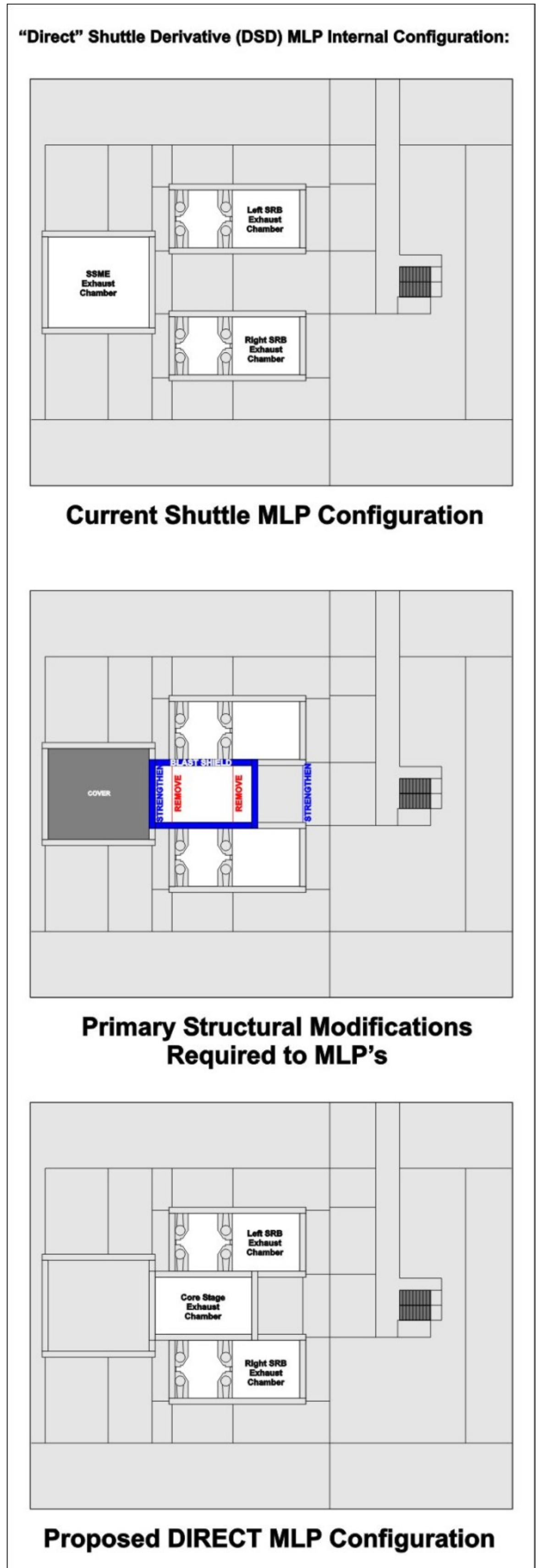


Fig 31: Structural MLP Alterations

APPENDIX 5: MLP ALTERATIONS - II

Two new Tail Service Masts are required on the deck of the MLP to fuel the Core Stage of DIRECT.

For the Upper/Earth Departure Stage and also for specific Payloads such as the Orion CEV and Lunar Surface Access Module (LSAM), a relatively simple Umbilical Tower (UT) can be used - a 70m tall tower designed in the same fashion as the light-weight one used today by Lockeed-Martin at LC-41 for the Atlas-V.

This small UT would allow all umbilical connections to the vehicle to be made and checked-out in the VAB prior to rollout, yet reduces the weight of the rollout stack sufficiently so as not to require any new Crawler Transporters.

Maintenance access at the Pad is provided by Service Arms permanently located on the Fixed Service Structures (see Appendix 6).

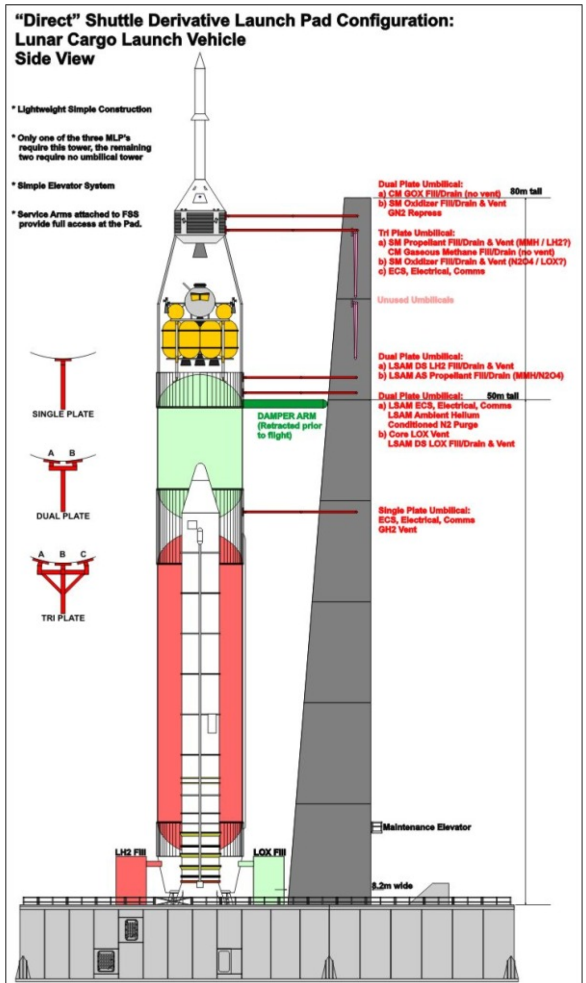


Fig 32: Lunar Crew LV - MLP Configuration

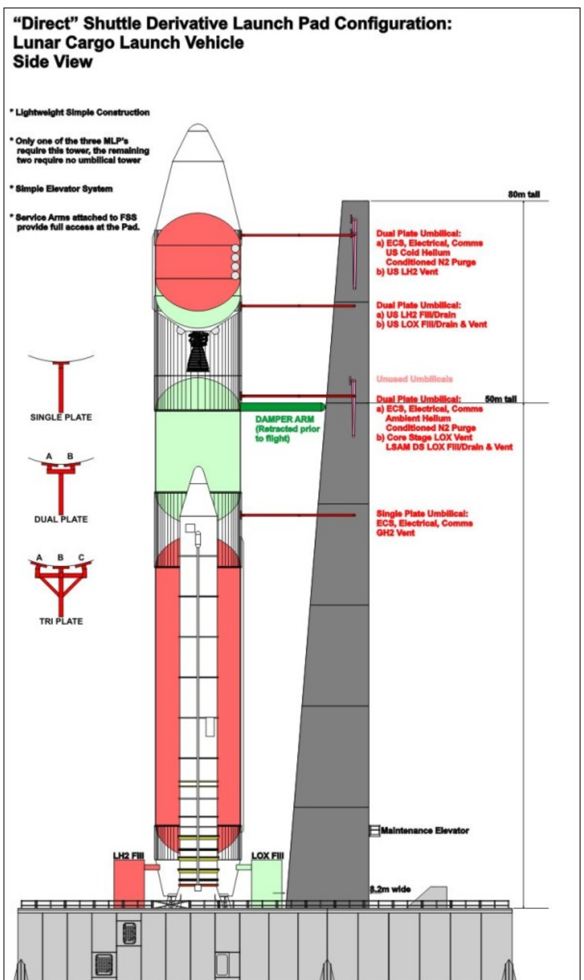


Fig 33: Lunar Cargo LV - MLP Configuration

The Umbilical Tower in this design has deliberately been located over the middle pair of Mount Mechanism points. While these have not been utilized on the Space Shuttle program, they still exist and could be used to provide additional support if ever required.

A "Damper Arm" is included in this design for taller configurations to receive additional bracing. This is unlikely to be necessary in practice, because DIRECT should be as self-supporting as the Space Shuttle is today, but is included here to demonstrate the option is available if needed.

As can be seen, the retracted Umbilical Connections for other configurations are kept protected during launch operations. The connections themselves should be kept in cheap, disposable (possibly climate-controlled via ECS system) boxes when not in use. Such boxes might possibly suffer some damage during a launch, but they are cheap and easy to replace, so this is virtually an irrelevance.

APPENDIX 6 : LC-39 PAD ALTERATIONS - I

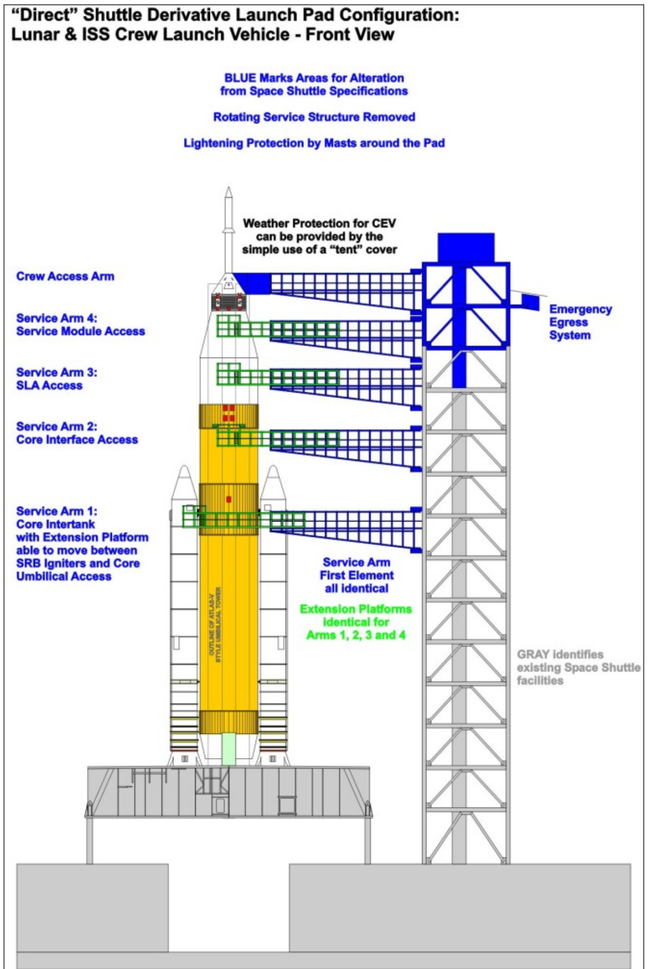


Fig 34: Lunar Crew LV - Pad Configuration

DIRECT re-uses the Fixed Service Structure (FSS) located at the Pads today. These 247ft (75m) structures operate close to their maximum operating weight. The foundations underneath can not support much more weight without a major rebuild.

The new design requires two extra floors to be installed, each massing around 40mT. Some careful design needs to be included right from the start.

There are many ways to remove weight there today. For example, the Rotating Service Structure (RSS) can be removed. This structure masses hundreds of metric Tons - not least of which is the massive hinge arrangement mounted on the South Eastern corner of the Fixed Service Structure.

Additionally there is a wide range of equipment on the FSS, supporting the Space Shuttle Orbiter. On the top of the structure is the machine room of the old Hammerhead Crane (the boom was removed in the early 90's), the very tall lightening mast, and a very heavy upper deck designed to support the Crane's workloads.

All of these items can be removed for DIRECT. Combined, the RSS Hinge, the RSS itself, the Shuttle equipment, Crane Machine Room, Lightening Mast and replacing the top deck of the tower, will remove more than 150mT of weight from the current FSS - more than enough to compensate for the 80mT for the two extra levels on top.

<u>Lightening Mitigation:</u>

Experience at other Pads has shown that a series of three or four tall dedicated lightening masts around the Pad, and connected by conductive wires, offers a more effective protection for launchers at Kennedy Space Center. Being the most effective approach, and considering it reduces the weight of the FSS, this approach to lightening mitigation should be utilized for the new program.

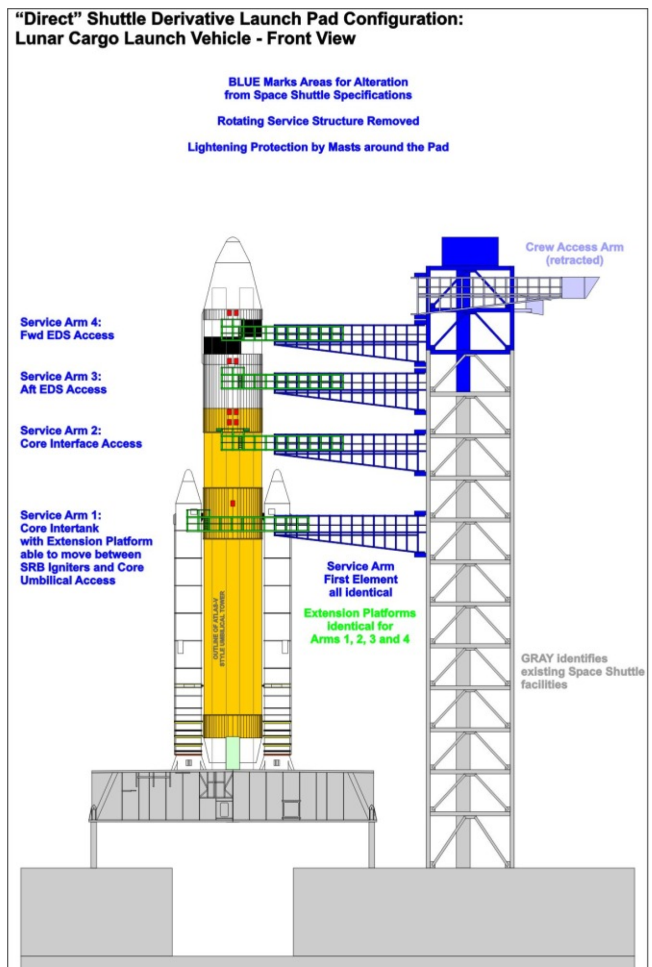


Fig 35: Lunar Cargo LV - Pad Configuration

APPENDIX 6 : LC-39 PAD ALTERATIONS - II

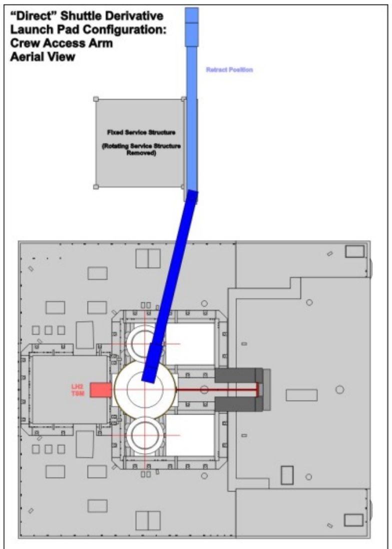


Fig 37: Crew Access Arm

The Pad facilities are based on the existing Space Shuttle hardware in place today.

All five Service Arms, including the Crew Access Arm, are based on the precisely the same First Element section, with extra reinforced structure underneath.

The Work Platforms on the first four Service Arms are all completely identical, using the same mechanical parts throughout.

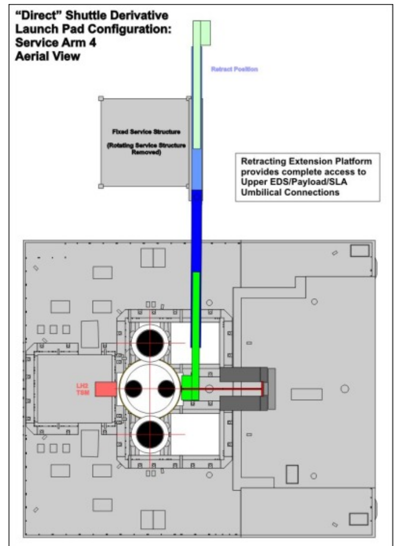


Fig 38: Service Arm 4

This commonality throughout the design is specifically to keeping maintenance costs down to the minimum. Most of the parts are interchangeable, which allows the maintenance stocks to be kept to the minimum.

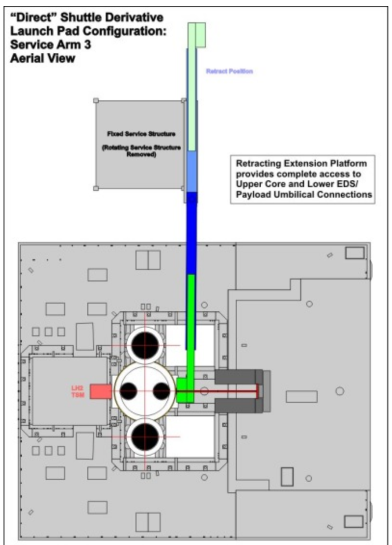


Fig 39: Service Arm 3

The Crew Access Arm is designed to attach to the Orion CEV, providing Environmentally Controlled conditions for Crew Ingress.

If the Orion requires weather protection at the Pad, the roof of the White Room could be utilized to drape a protective cover around the entire spacecraft. A lightweight “tent” would allow easy protection from the elements. If required, an inflatable “skirt” could seal around the spacecraft to create a climate controlled environment inside.

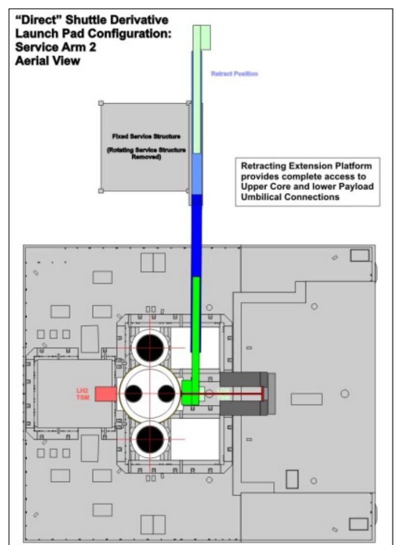


Fig 40: Service Arm 2

All Service Arms provide maintenance access to the Umbilical Connections and Access Hatchways at that level on the vehicle.

In addition to the routine duties, Service Arm 2 provides access to the optional Damper Arm disconnects.

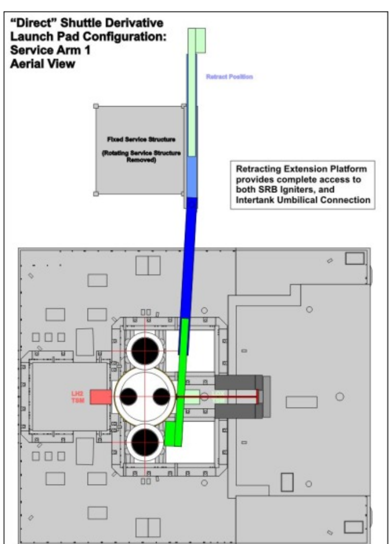


Fig 41: Service Arm 1

Service Arm 1 provides a movable platform which can also approach each of the SRB’s - specifically required for installing the SRB Igniters at the Pad. Figure 41 (left) shows the maximum Extension Platform extension, for accessing the most distant SRB.

APPENDIX 7 : VAB ALTERATIONS

Operations within the VAB will largely remain the same as today:

"Direct" Shuttle Derivative (DSD) VAB Configuration:

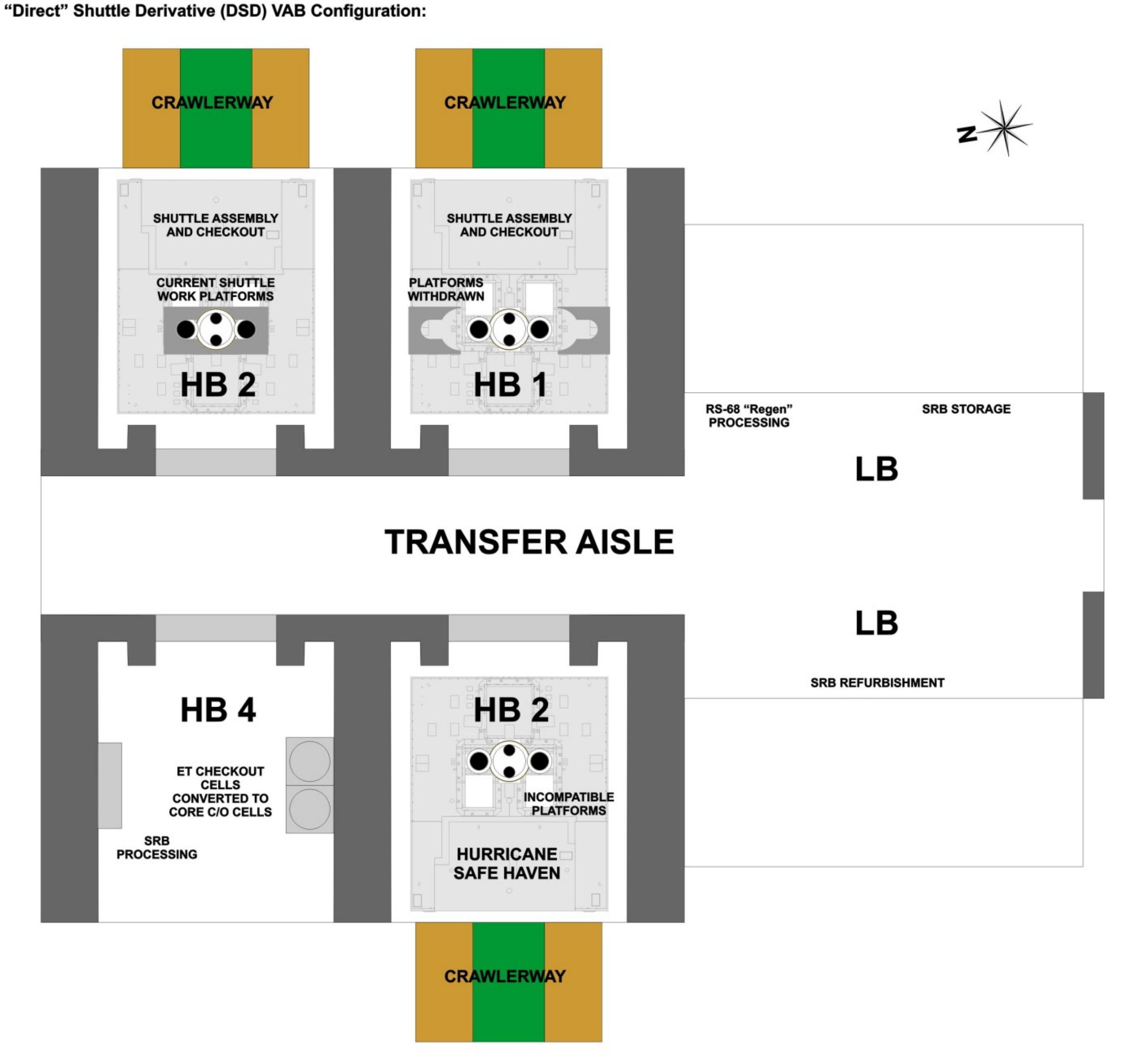


Fig 42: VAB Configuration for supporting DIRECT

NOTE: The Highbay Work Platforms are indicated in Highbays 1 & 3.

APPENDIX 8 : DEVELOPMENT PHASES

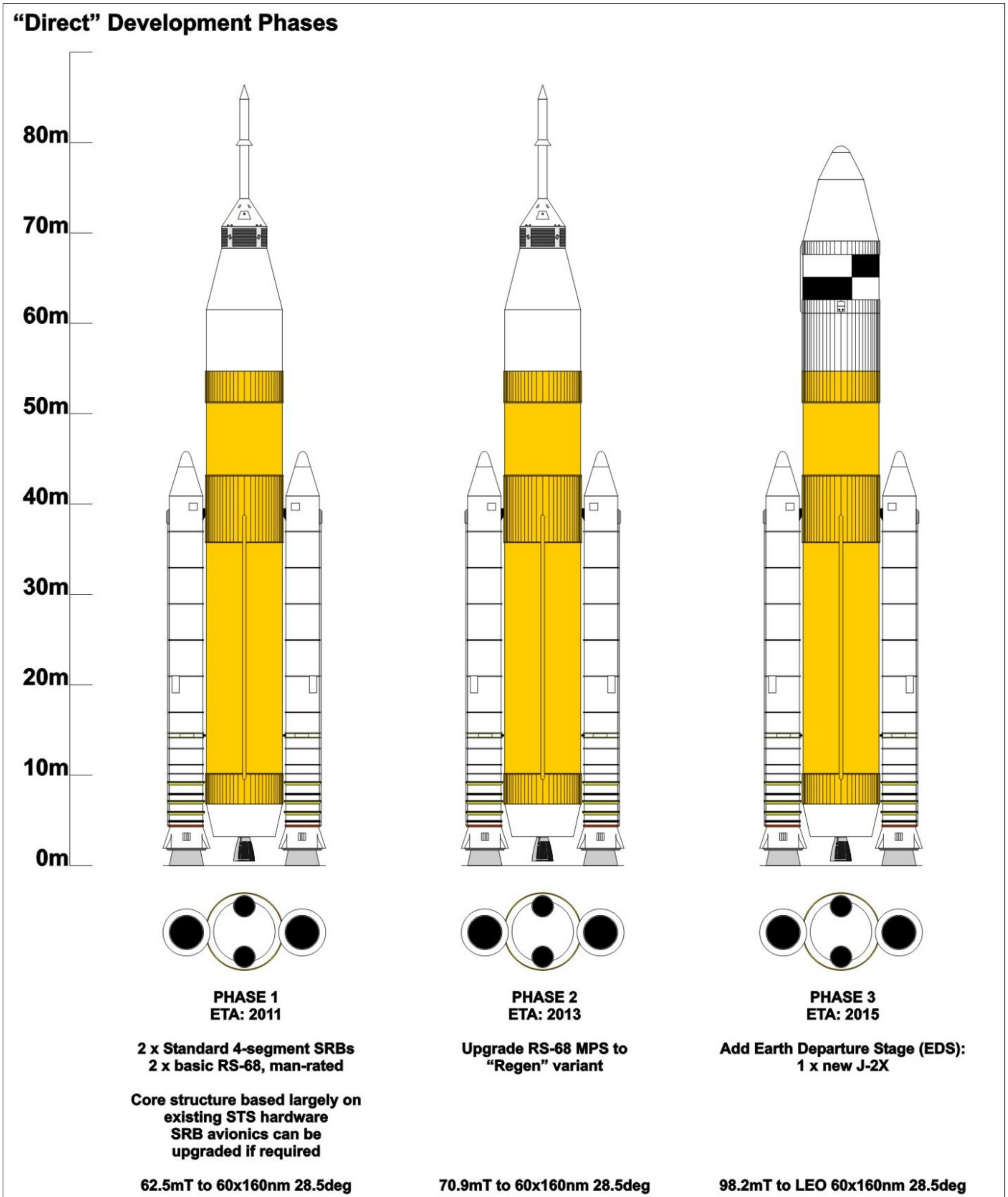


Fig 43:Development Phases for creating DIRECT Lunar Mission architecture

APPENDIX 9 : FUTURE GROWTH OPTIONS

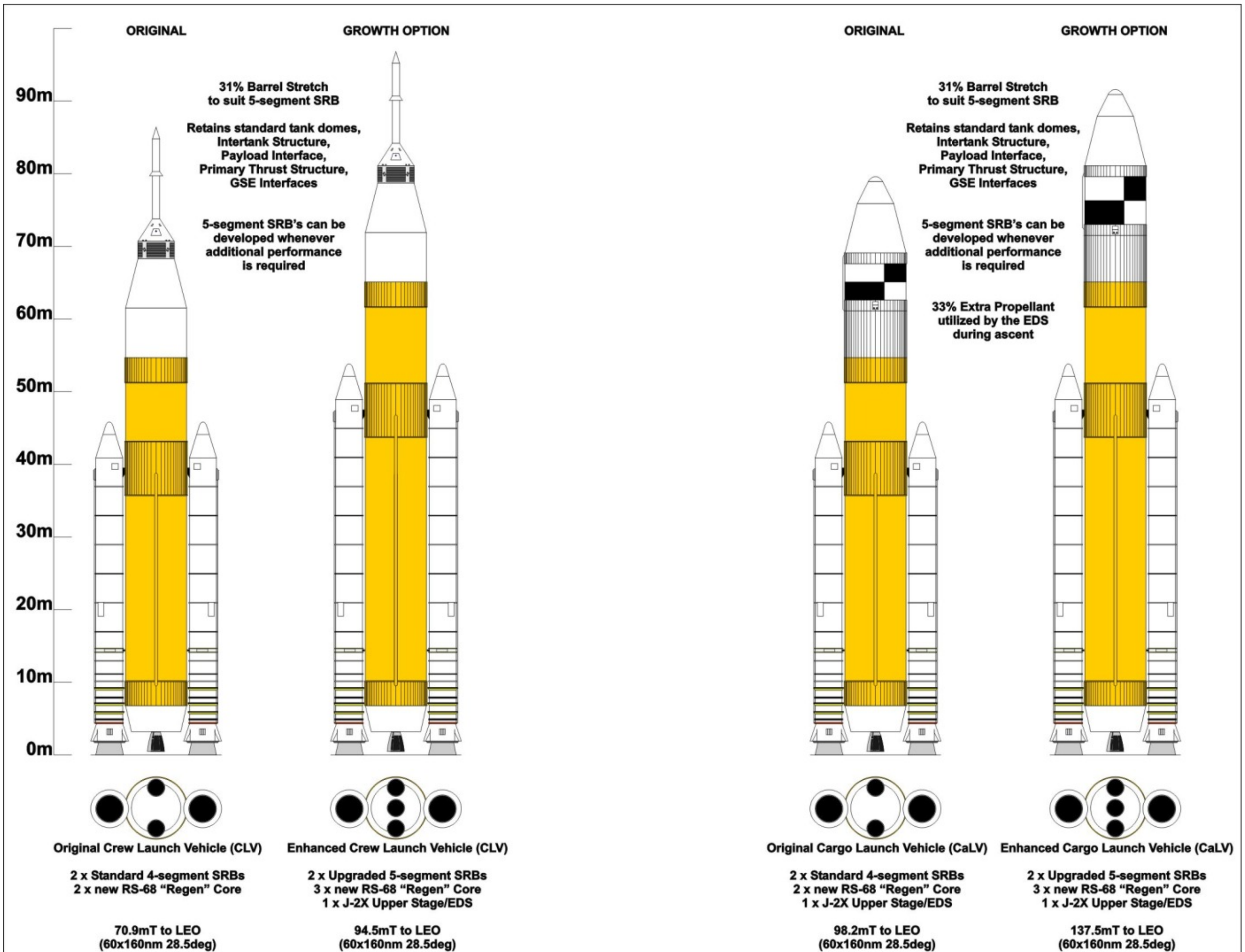


Fig 44: Future Growth Options for increasing DIRECT's performance further

The most logical upgrade growth option for DIRECT is to upgrade the boosters to 5-segment variants. This does not require any investment at the start of the program and is only necessary if the basic DIRECT is not powerful enough to fulfill requirements of future missions. This option is not a critical element of the Vision for Space Exploration.

A simple Barrel-Stretch of 31% will suit the upgraded boosters when combined with one additional Core engine. This combination increases performance of the basic CLV by more than 20mT to LEO.

With a 32% increase in capacity for the EDS also, the maximum Cargo LV performance increases to 137.5mT per flight – which is 6mT higher than the massive Ares-V's capacity, yet that launcher flies to a much lower orbital insertion of just 30x100nm which requires the payload to burn propellant to reach the correct orbit.

This potential upgrade for DIRECT brings the Lunar IMLEO for a CLV & CaLV to a vast 251.1mT – which is 45% more than the Ares-I and Ares-V combined. 292mT if CLV flies an EDS.

Utilizing far less funding than used to develop the Ares-V, this upgrade to DIRECT offers even higher lift capacity. However, unlike the Ares solution, only one single recurring operations cost is required, not two.

APPENDIX 10 : DIRECT CREATES MORE OPPORTUNITIES

DIRECT saves $19 Billion for developing one Launcher instead of two. With between $1 and $3 Billion of additional recurring savings every year of operations, NASA saves approximately 10% of it's entire Congressional Budget appropriations over the next 20 years, totaling more than $35 Billion.

Dr. Griffin has stated recently that, with the current Ares vehicles, NASA will not have any spare money to do anything when the US returns to the moon late in the next decade. What could NASA do with that $35 Billion saved by switching to DIRECT?

* Shuttle's 2010 retirement has meant many missions have been cancelled. DIRECT could fly them all, starting as soon as 2011. This includes launching all the remaining elements of the International Space Station which are no longer planned to fly - items such as the Science Power Platform. The outpost could still become fully operational.

* After Shuttle has retired, there is no way to deliver heavy replacement items to ISS, such as the problematic Gyro's. DIRECT can bring such elements up with any routine crew rotation flight.

* A new, large, ISS module could be designed, to be launched around 2016, with the intention of extending the station's lifespan for another decade.

* Additional Lunar missions could be added to the flight manifest. With four Lunar missions every year instead of two it would double the science return and halve schedule for the Lunar base.

* The Jupiter Icy Moons Orbiter (JIMO) spacecraft could easily be funded again, not to mention that it could be launched on a single DIRECT LV instead of requiring a fleet of EELV's.

* New 70mT LEO satellites can be designed for autonomous exploration of the universe. A new "Hubble-II" with an 8m diameter mirror would prove a worthy successor to even the new James Webb Space Telescope (JWST). DoD could presumably find a use for an 8m diameter telescope system.

* Launch a large Fuel Depot / Transfer Station in either (both) Low Earth Orbit or Lagrange Point 1 between the Earth and the moon to expand NASA's capabilities to access the whole solar system.

* A complete GPS2 Satellite Constellation could be launched on a single DIRECT launcher.

* DIRECT is estimated to be able to launch over 12mT (26,500lb) to Geosynchronous Orbit (22,000nm) in a single flight. This would be sufficient to launch 4 or 5 replacements for the ageing Tracking and Data Relay Satellites (TDRS) on a single launch.

Summary:

Ares-I can not perform any of these missions. Not without spending the additional $20 Billion to make the Ares-V first.

70mT launch capability, early in the next decade, would open up new possibilities which we can not yet predict. It has been more than 30 years since the US had such a capability, and a variety of currently impossible programs could be made possible.

Having this ability, allows NASA to look into completely new, and more varied programs, without the massive additional costs incurred by developing two separate vehicles in order to perform the same missions.

APPENDIX 11 : BRIEF HISTORY OF THE DIRECT CONCEPT

The DIRECT concept is not this author's idea. **NASA's Marshall Space Flight Center is the original inventor**, although the idea has actually been proposed continuously throughout the Space Shuttle's existence due to it's obviously logical evolutionary path based on existing Shuttle hardware.

After the *Challenger* accident in 1986, NASA investigated alternative approaches to launching cargo on an unmanned version of Shuttle. The famous "Shuttle-C" was the result of that investigation, but an in-line variant was also considered, with the Payload on top, and Main Engines mounted under the External Tank. Neither concept came to fruition because there was no development funding available.

Fig 45: National Launch System

In 1991, the idea was resurrected under the guise of the "National Launch System" (NLS) - see Figure 44 (left). Proposed by NASA and the USAF to launch large US "national interest" payloads, it featured four inexpensive engines on the Core and was designed to launch about 45 tons to orbit in that configuration. The DoD payload requirements evaporated, and NASA did not have the cash available to build the launcher on its own, just for assembling Space Station Freedom.

Finally the idea surfaced again in the Exploration Systems Architecture Study (ESAS) Report of 2005. With three standard Space Shuttle Main Engines under the core, this concept (LV 24/25 shown in Figure 45 - below) formed the backbone of the "2-launch EOR-LOR" solution which, throughout the report, was continually found to be less costly, more reliable and quicker to create than the chosen solution.

But an accidental oversight by the ESAS team prematurely 'short-changed' the concept:

ESAS simply did not evaluate this vehicle with an EDS like the one ultimately chosen for the final CaLV. The CaLV utilizes the EDS as a "push stage" to complete the launch to orbit, then to circularize the orbit and finally to perform the Trans-Lunar Injection (TLI) Burn to go to the moon.

If the EDS is configured to do exactly the same on LV-24/25, then the payload capacity for a combined CLV and CaLV mission clearly outperforms the Ares configuration CLV (LV 16) and CaLV (LV 27.3 - which has very similar performance to the final Ares-V configuration).

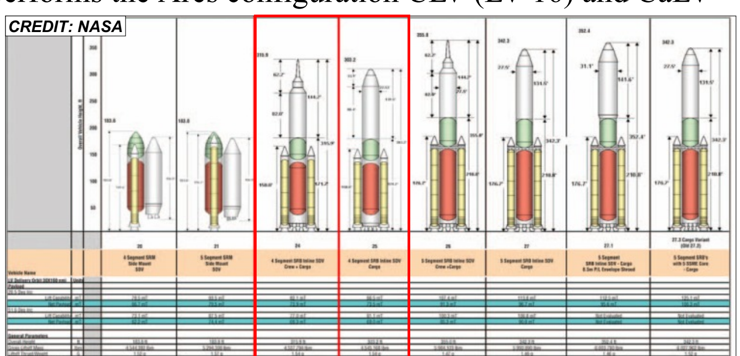


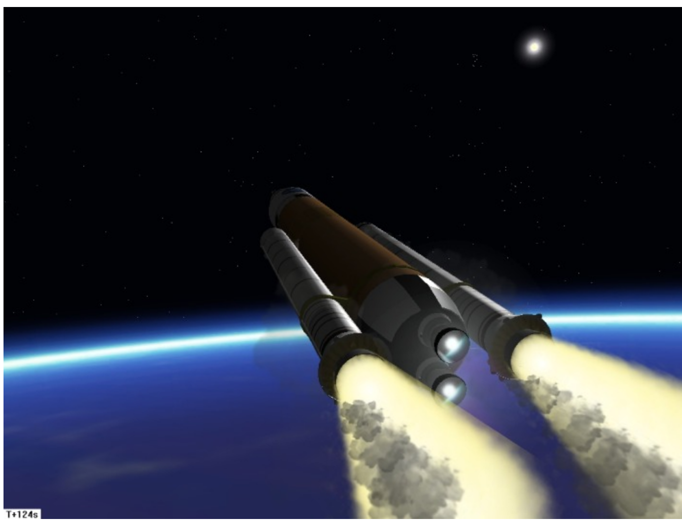
Fig 46: Table from ESAS Report showing SSME variant of DIRECT

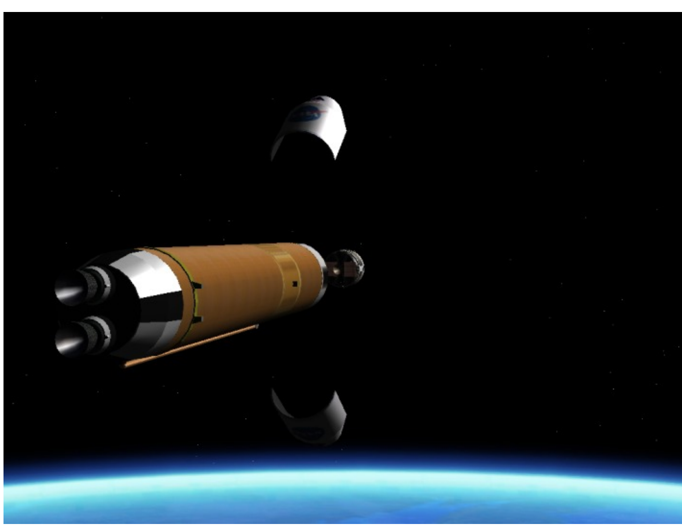
"DIRECT" grew from the realization that operating two distinct LV programs is never going to be as efficient as one - and that a very simple evolution of the current Shuttle hardware would offer a very powerful solution for both CLV and CaLV missions.

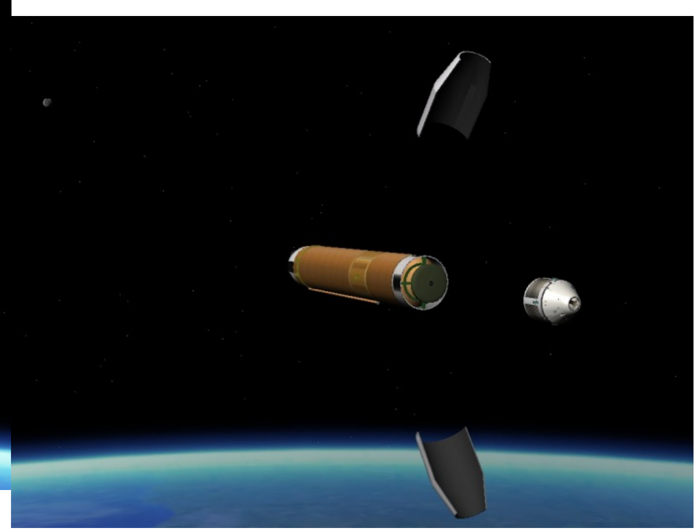
The only further change to the basic concept was the simple decision by NASA to switch from the $90m SSME engines, to the $20 million RS-68 for the Ares-V. The $25 million RS-68 "Regenerative Nozzle" variant of this engine allows for only two of these powerful engines to exceed the three SSME's performance in this Launcher's configuration.

Much fine-tuning, further analysis, and design for the launch facilities, resulted in this paper.

APPENDIX 12 : PICTORIAL LAUNCH SEQUENCE







A 5m 25s video sequence of this Crew Launch Vehicle configuration launch is available on:
www.directlauncher.com

CREDIT: António Maia

ACKNOWLEDGMENTS

Many highly qualified persons at NASA HQ and Field Centers and NASA's major contractors, were among the contributors and critiques of the technical and financial merits of this approach. Ultimately, after intense discussions and the resulting revisions, the general consensus is that this approach, the “DIRECT” approach, is the one that will best serve the VSE and the national interests.

In order to not complicate their lives as they continue to focus on the tasks before them of trying to implement the VSE as currently envisioned, I am providing them with the confidentiality they deserve. They are all free, of course, to discuss this paper, and their role in its formation, if desired, with their co-workers and managers as they see fit.

You know who you are, and I thank-you for all of your efforts.

I would like to specifically acknowledge the assistance of those who contributed to the 3D visualizations used throughout this report:

“DIRECT” 3D model by António Maia [simcosmos@clix.pt]
“LSAM” & “CEV” 3D model by Franz Berner
“ATV” 3D model by Brad Hodges

Orbiter implementation by António Maia [simcosmos@clix.pt]

Orbiter Simulator available at www.orbiter.com