DIRECT’s Plan for Consolidating Plan/Policy/Budget Options

During the August 5, 2009 hearing the Committee Chairman emphasized the need to consolidate the number of viable options they present to policy and budget makers. This is indeed a daunting assignment given the importance of the upcoming review, the extensive number of permutations in budget, policy and plans identified by the Beyond LEO Sub-Committee and the limited time in which to accomplish this task. In order to aid the Commission in achieving their assignment, the DIRECT team has attempted to formulate an approach that will consolidate the myriad of options and scoring rational while still retaining the critical essence of the issues and findings of this Commission.

We have found that by intersecting policy with implementation plan options, shown in figure 1, we can eliminate a significant amount of information duplication thereby improving the clarity of the policy and budget decisions. Along the top of the chart are the various policy questions that the space exploration community needs answers to in order to narrow down the range of viable implementation plans within a given budget level. These near term policy questions are associated vertically with the current policy as defined by the 2005 NASA Authorization act. On the horizontal axis are the viable implementation plan families detailed by the Beyond LEO Sub-Committee report out on August 5, 2009. The intersection points of all policy decision with all technically viable implementation plans results in a unique location to place a rating of whether a specific implementation plan can achieve a particular policy objective or not under the current budget guidance. Increasing, relaxing and/or eliminating current policy requirements and/or increasing/decreasing the current budget guidance would change these pass/fail scores creating a third dimension to this decision matrix.

The DIRECT team would certainly advocate an increase in the NASA budget guidance. It should be noted though that a budget increase, while required by the Program of Record (PoR) to solve serious policy and budget misalignments, would advance and improve more efficient plans that work within the current guidelines as well. Therefore since a budget increase will significantly improve the policy achievement dates of all plans, budget cannot logically be used as a discriminator between the various plans. The primary discriminator therefore remains the ability of particular plan to efficiently meet the approved policy objectives at the appropriated budget level.

We sincerely hope that the United States will not only continue to have a Human Spaceflight program but will remain committed to going Beyond Earth Orbit (BEO) after the completion of the upcoming policy and budget review. If these two assumptions are correct then we also believe this effectively rules out the exclusive use of existing launch systems. Existing launch systems, while sufficient and essential for achieving many critical national objectives, place serious constraints on spacecraft diameter, volume and mass needed for human BEO space exploration. There is ample evidence to prove that high spacecraft densities and/or architectures that require significant in space assembly of spacecraft elements increases overall cost faster than increased launch frequency can reduce it. As a result, some form of high volume, heavy lift will be required as part of the mix for a worthwhile and cost effective human BEO space exploration based on proven technologies and systems.
We continue to believe that the best way to utilize the capabilities and innovation of Commercial and International launch service providers is via the incorporation of orbital propellant depots into the human BEO exploration architecture. Unlike spacecraft, the cost of propellant is not affected by packing density or multiple in space assembly operations yet represents almost 70% of the mass required in Earth orbit by human BEO exploration missions. The combination of the high demand level and commodity nature of this in space resource makes it much easier to close new and innovative technology/business cases than the significantly lower demand, more complex and higher risk market for crew and spacecraft delivery.

It should also be noted that a number of unmanned exploration capabilities have been and will continue to be impacted negatively in terms of value (i.e. significant new knowledge gained/cost) without corresponding improvements in our launch system capabilities. The serious cost overruns of James Webb Space Telescope (JWST) and the Mars Science Laboratory (MSL), now running many times their respective launch costs, are due in large part to attempting to exceed the impressive achievements of past unmanned missions while limited to the same launch capabilities. So while the cost of a high volume heavy lift launch systems cannot be justified independent of a vibrant Human Spaceflight program, unmanned exploration will not only reduce its overall cost by lowering spacecraft packing densities but will significantly increase its future reach by leveraging this new capability. In a like manner Human Spaceflight as a method of space exploration and development has a similar synergistic relationship with unmanned exploration as demonstrated by the Hubble Space Telescope repair missions. The key to enabling this synergistic relationship though is making sure that the funding required for a visionary human BEO exploration program doesn’t reduce the funding needed for a vibrant unmanned exploration effort. Rather both methods working together can achieve more by sharing resources and unique capabilities than either could alone if they were somehow able to consume all the resources of the other.

Another policy question is whether the United States should continue its partnership in the International Space Station (ISS) past 2015. Some plans can continue this support indefinitely within the current budget guidance while others will require an increase. For example if constrained to the current budget guidance the PoR cannot continue United States support of the ISS beyond 2015. This is in marked contrast to the 2005 NASA Authorization that directs NASA to utilize the ISS as a national laboratory for the development of technologies to mitigate the effects of long duration exposure of humans and equipment to the hostile Space environment. The ability to safely live in Space for long durations is an obvious building block required for human BEO exploration thus making the ISS central to the current United States Space Exploration Policy (USSEP).

Ideas for further enhancement of the ISS investment were discussed in greater detail in a paper we submitted to the Beyond LEO Sub-Committee on July 20th 2009. In summary, the idea is to develop with our international partners a follow on habitation module (ISS 2.0) to be tested at the current ISS (ISS 1.0). This habitation module would serve as the proto-type for all subsequent Hostile Surface and Deep Space spacecraft. With this in mind the expense associated with maintaining the ISS 1.0 need not be arbitrarily extended to 2020. The ISS 1.0 mission could be concluded once ISS 2.0 system is operational. In this way ISS 1.0 mission would serve as the bridge for the development of ISS 2.0 thereby directly enabling long duration human habitation in LEO, Deep Space, and on Hostile surfaces. Under the DIRECT plan, an extension of the ISS 1.0 mission therefore leverages our extensive investments in technology and International partnerships both of which are synergistic and central to achieving the human BEO exploration policy objectives.
The next policy question, similar in nature to the ISS 1.0 continuation decision, concerns whether or not we build upon the existing and operational Space Transportation System (STS) industrial base and workforce. This critical near term policy decision is closely related to the existing policies of reducing the American based Human Spaceflight gap and the safe completion of the remaining Space Shuttle missions. All Shuttle Derived Heavy Lift Vehicle (SDHLV) plans have a strong synergist relationship with the current STS industrial base and workforce. For example, if the policy decision to close the gap by delaying the Space Shuttle retirement is combined with policy makers reasserting their original guidance to NASA of developing a true SDHLV replacement, like the Jupiter, the implementation cost associated with both policies will be significantly reduced.

Further, because the Space Shuttle is among the most complex systems ever put in Space an equally competent and experienced workforce needs to remain at their posts until the very last flight. The current plan to rapidly fly out the remaining Space Shuttle manifest followed by an abrupt layoff of the workforce is completely at odds with the existing safety policy. In fact continuing along this path will significantly increase the probability of yet another accident more than a limited extension of the Space Shuttle mission would entail. As a result SDHLV plans have a number of unique and synergistic policy advantages over the PoR and Advanced EELV/COTS plans because neither of them utilizes the STS industrial base or workforce.

In addition, a SDHLV solution doesn’t necessarily require a zero gap or an arbitrary extension to 2015 of the Space Shuttle in order to execute a smooth and safe fly out of the committed manifest. A more cost efficient approach, that still retains critical skills through the transition, would be to base the Space Shuttle’s retirement date on achieving key operational test milestones of the replacement systems. In this scenario the retirement of the Space Shuttle could commence once an independent review panel determines that the operational date for the Jupiter/Orion systems are less than two years away. The United States has endured two year flight gaps twice in its history. While these two year gaps were difficult periods they did not result in any long term damage to the United States Human Spaceflight skill base. Further, once key operational tests for the replacement systems are successfully accomplished the proper focus of the workforce talent and resources needs to logically shift towards bringing the new systems safely on line as soon as possible anyway. A two year gap in American based access to the ISS has been bridged successfully before thanks to the support of our International partners. This new limited duration gap will be even easier to endure though because of the exciting new capabilities that awaits human BEO exploration for the United States and the International partners that supported us during that transition.

There are two primary variations within the SDHLV plan family. The first variation is the Inline configuration as represented by the Jupiter Launch System (JLS) in the DIRECT plan. The second variation, closely aligned with the Space Shuttle configuration, is the Sidemount approach as represented by the Shuttle –C (S-C) or Not Shuttle C (NSC) plans. It should be mentioned that NASA launch system design engineers have consistently determined that an Inline SDHLV is far safer for the crew, higher performing, more flexible, less expensive to develop/operate and offers a wider range of payload diameter, volume and spacecraft configuration options than (S-C). The only area in which the (S-C) has shown any advantage at all over Inline is in its closer operational synergy with the existing Space Shuttle. Unless a highly unlikely shift in policy is made to retain the Space Shuttle indefinitely, this sole (S-C) advantage over Inline is not even relevant.
It should also be stated that Space Shuttle Sidemount configuration has always been a compromise in best rocket design practices. There is absolutely no logical reason why our nation should continue to compromise our space program many decades into the future. Further the misalignment between budget and policy, an issue that this Commission is tasked with assessing and providing a range of solutions to, can trace its roots directly back to how the PoR has significantly strayed from the SDHLV policy requirement. As such, it is equal important that this Commission not leave ambiguous the high level specifics of the best SDHLV configuration option they found during the review should policy makers recommit to a SDHLV approach.

The last fundamental policy decision required is whether the selected plan needs to maintain a steady and sufficient developmental budget margin at all times in order to enable a gradual progression towards the long term objective of human Mars exploration and development. Any plan, like the PoR, that eventually leads to fixed costs sufficient to consume the entire Human Spaceflight budget in launch and mission operations alone will ultimately stagnate at some mission capability, atrophy, and then fail. In addition, the development budget needs to be composed of a diverse portfolio of projects across a range of Technology Readiness Levels (TRL). These development projects should be primarily targeted at lowering the cost of subsequent missions through efficiency improvements in existing systems and by bring about fundamental shifts in existing paradigms as the implementation plan progresses forward. This is absolutely essential if we are to maintain steady progress against the increasing head wind brought on by ever more ambitious objectives as we attempt to move from the Cradle of Spacecraft Earth to the Colonization of Mars.

The DIRECT team sincerely hopes that the ideas presented above will be useful in helping the Commission form a succinct yet comprehensive list of options and discussion points for policy and budget makers in the upcoming watershed review. What happens in the next thirty days may well determine what happens in the next thirty years.

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**Figure 1: Consolidated Plan, Policy and Budget Options Matrix**

### Consolidated Plan, Policy and Budget Options Matrix

<table>
<thead>
<tr>
<th>Policy Decisions</th>
<th>Jupiter SDHLV</th>
<th>COTS/EELV Advanced</th>
<th>Ares PoR</th>
<th>COTS/EELV Existing/Exclusive</th>
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**Fundamental Objective of VSE**
- Use ISS to Develop Long Duration In Space Capabilities
- Leverage STS Industrial Base and Minimize the Gap
- Enable Lunar Surface Mission by 2020
- Provide Budget Margin for an Eventual Manned Mission to Mars


1. Existing COTS/EELV volume/diameter/single unit lift mass not sufficient for Beyond LEO
2. The same additional budget that is needed to make the Ares plan feasible would also significantly improve all other viable Beyond LEO options as well
3. True SDHLV not only directly leverages the existing STS industrial base but also helps insure a safe flyout of remaining STS missions by providing continuity to the critical skill base
4. All prior NASA Studies concerning (Jupiter) Inlune vs (Shuttle –C), Sidemount SDHLV have conclusively indicated that Inlune is safer, higher performing, less expensive to develop and operate, and has greater payload volume/flexibility. There is no advantage to the cross operational capability of the Sidemount since the Space Shuttle is to be retired and the External Tank design is not on the critical path to ILC, Orion is.
5. The incorporation of in Space propellant deposits into the human BEO exploration architecture would enable a more cost optimal mix of high volume heavy lift and Commercial Launch Service providers to be utilized though