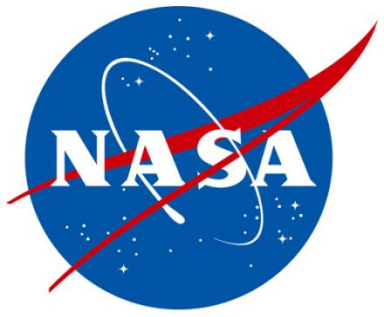

Preliminary Report
Regarding
NASA's Space Launch System and
Multi-Purpose Crew Vehicle

Pursuant to
Section 309 of the NASA Authorization Act of 2010 (P.L. 111-267)

January 2011

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Executive Summary

NASA prepared this preliminary report regarding NASA's plans for developing a Space Launch System (SLS) and Multi-Purpose Crew Vehicle (MPCV) in response to direction in Section 309 of the NASA Authorization Act of 2010 (P.L. 111-267):

> ***SEC. 309: REPORT REQUIREMENT***
>
> *Within 90 days after the date of enactment of this Act, or upon completion of reference designs for the Space Launch System and Multi-purpose Crew Vehicle authorized by this Act, whichever occurs first, the Administrator shall provide a detailed report to the appropriate committees of Congress that provides an overall description of the reference vehicle design, the assumptions, description, data, and analysis of the systems trades and resolution process, justification of trade decisions, the design factors which implement the essential system and vehicle capability requirements established by this Act, the explanation and justification of any deviations from those requirements, the plan for utilization of existing contracts, civil service and contract workforce, supporting infrastructure utilization and modifications, and procurement strategy to expedite development activities through modification of existing contract vehicles, and the schedule of design and development milestones and related schedules leading to the accomplishment of operational goals established by this Act. The Administrator shall provide an update of this report as part of the President's annual Budget Request in subsection (a) not later than one year after the date of enactment of this Act.*

With the President's signing of the NASA Authorization Act of 2010 on October 11, 2010, NASA has a clear direction and is making plans for moving the Agency forward. NASA appreciates the significant effort that has gone into advancing this bipartisan legislation, particularly efforts by the leadership and Members of this Committee. There are still details that the final FY 2011 appropriations outcome and the President's FY 2012 budget request will provide, but broad guidelines have now been enacted into law. This is a time of opportunity for NASA to shape a promising future for the Nation's space program. Today it is no longer a question of IF we will explore, but how.

Since the enactment of the Authorization Act, NASA has been working expeditiously to meet the requirements of the Act, and this preliminary report details our best information for the MPCV and SLS as of early January 2010. NASA commits to providing a follow-on report to Congress as early as the Spring 2011 timeframe to update our approach based on the plans described herein and, if necessary, modifications based on the outcome of FY 2011 appropriations and the President's FY 2012 budget request.

On December 6, 2010, NASA formally established planning teams at Marshall Space Flight Center (MSFC) and Johnson Space Center for the eventual SLS and MPCV programs, respectively, to carry out the work described in this report.

Guidance from the Administrator has established three principles for development of any future systems for exploration. These systems must be affordable, sustainable, and realistic. To date, trade studies performed by the Agency have yet to identify heavy-lift and capsule architectures that would both meet all SLS requirements and these goals. For example, a 2016 first flight of the SLS does not appear to be possible within projected FY 2011 and out year funding levels. Based on the guidance in the Authorization Act to take advantage of existing designs and

hardware, the Agency has selected Reference Vehicle Designs for both of these vehicles as bases from which to work and which we believe most closely align to the requirements and goals of the Authorization Act. However, to be clear, neither Reference Vehicle Design currently fits the projected budget profiles nor the schedule goals outlined in the Authorization Act. Additionally, it remains to be determined what level of appropriations NASA will receive in FY 2011 or beyond – a factor that will impact schedule as well.

NASA has developed a process to make progress on the Reference Vehicle Design for the SLS while the Agency determines whether the design is sufficiently affordable, sustainable, and realistic, and also while the Agency studies other options to solicit innovative ideas and ensure the best value for the American taxpayers. Given that affordability for heavy-lift is a primary objective, second to crew and public safety, NASA has initiated several industry study contracts regarding heavy-lift and propulsion. The study contracts will help inform decisions on the final detailed design concept and acquisition details for the SLS. In parallel, NASA will conduct studies on concepts that were competitive in our internal trade studies to validate, support, or challenge our current thinking in an effort to ensure an affordable design that meets Authorization Act requirements.

By Spring of 2011, NASA expects to have completed several key analytical steps:

- Analysis of the current Ares and Shuttle contracts for their applicability to the future development program;
- Analysis of the cost and benefits of the Reference Vehicle Design and other vehicle designs
- Analysis of potential initial procurement approaches (in the case when procurements are required, NASA will follow applicable procurement regulations, including the March 4, 2009, Presidential Memorandum on Government Contracting).

With regard to NASA's MPCV requirement, NASA has performed initial assessments of the current Orion Project's applicability to the new MPCV requirements in the Authorization Act, and has adopted the beyond-low Earth orbit (LEO) Orion design as the Reference Vehicle Design for MPCV. These initial assessments included factors such as the current Orion design and phased development approach for operational beyond-LEO capabilities, the current Project organization and processes, existing facilities and infrastructure, and the current prime contract. For the near term, NASA will continue work on the Orion until the MPCV Program is formally authorized to proceed, and once authorized to proceed, NASA plans to initiate the Program with design robustness and affordability while making use of current Orion investments and workforce as practicable.

NASA recognizes it has a responsibility to be clear with the Congress and the American taxpayers about our true estimated costs and schedules for developing the SLS and MPCV, and we intend to do so, to the best of our ability in this preliminary report, as well as in the follow-on report. To this end, NASA commits to obtaining independent (outside of the Agency) assessments of cost and schedule for SLS and MPCV design options as part of its decision process this Spring or Summer, and further to make these assessments public.

Currently, our SLS studies have shown that while cost is not a major discriminator among the design options studied, none of the design options studied thus far appeared to be affordable in our present fiscal conditions, based upon existing cost models, historical data, and traditional acquisition approaches. Operational costs will have to be scrutinized and reductions from current

projections will be needed in order to ensure affordable operations and so that funds are available for other necessary Exploration developments such as long-duration habitats and landers. A feature of the Shuttle/Ares-derived reference vehicle is that it enables leveraging of current systems, current knowledge base, existing hardware and potentially current contracts, thereby providing schedule and early-year cost advantages. However, a 2016 first flight does not appear to be possible within projected FY 2011 and out year funding levels, although NASA is continuing to explore more innovative procurement and development approaches to determine whether it can come closer to this goal. In this context, we are still reviewing overall affordability for the longer-term, and alternative design analysis continues to be part of our strategy. Other technical options will be considered based on industry input, innovative methodologies for affordability will be explored, and partnership opportunities will be pursued with other government agencies with the goal of identifying a significant affordability benefit.

It is clear that successful development of SLS and MPCV will be dependent on sufficiently stable funding over the long term, coupled with a successful effort on the part of NASA and the eventual industry team to reduce costs and to establish stable, tightly-managed requirements.

All development options require NASA's greatest asset, our skilled workforce, consisting of both civil servants and contractors who embody 50 years of learning and expertise. Although NASA must find greater efficiencies in its next-generation human spaceflight efforts, NASA will strive to utilize our workforce in a manner that will ensure that the Nation maintains this unique asset during the development of the SLS and the MPCV, focusing on safely executing the NASA mission and achieving our affordability and sustainability goals.

In summary, we are committed to developing an affordable, sustainable, and realistic next-generation human spaceflight system that is in the best interests of the Nation, and we therefore look forward to working with Congress as we finalize our strategy for achieving human spaceflight to many destinations in our solar system.

I. Where We Are Today: Our Assumptions

NASA recognizes the constrained budgetary environment, and therefore is grateful for the strong ongoing support of Congress for NASA and our human spaceflight programs. We pledge to be wise stewards of taxpayer dollars in our journey to develop the next-generation vehicles that will allow us to explore near-Earth asteroids, the Moon, Lagrange points, and, ultimately, Mars. With the enactment of the NASA Authorization Act of 2010 and guidance provided by the new National Space Policy, it is no longer a question of IF we will explore, but how.

In developing this preliminary report, NASA has begun with a series of assumptions that were based on policy direction, requirements, and goals in the Authorization Act, as signed by the President on October 11, 2010. Additionally, guidance from the NASA Administrator has established three principles for development of any future systems for exploration – namely that these systems must be **affordable**, **sustainable**, and **realistic**. By definition, affordability implies we will remain under the mandated funding curve at all points in the life cycle (out years) of resultant systems and it is essential that any design selected be affordable over the long-term. This means that not only should the operation of the vehicles fit within a realistic budget profile, but also that enough room must be left in the profile to develop other key elements of the exploration architecture and ultimately conduct meaningful missions. Along with safety, this over-arching consideration of affordability must be a central part of any planning that takes place on these transportation systems going forward. Further, the cost and operational capability of the

systems must be sustainable over multiple Administrations and multiple Congresses. Any designs selected also must meet the test of being realistic – not relying on assumptions of increased funding or other "miracles" for attainment.

NASA is currently in the process of running budget exercises to determine the implications of various potential budget scenarios, and thus creating development schedules to fit those associated budget profiles. In doing so, we have utilized traditional cost models and expunged any systems that did not fit within the funding and schedule goals provided by the Authorization Act. However, until NASA has final FY 2011 appropriations and the FY 2012 President's budget request to work from, we cannot at this time finalize our assessments for the SLS, the MPCV and their associated support elements, and thus this report can only provide details that we know as of early January 2011. Therefore, it is clear that final funding levels will drive many other key decisions NASA still needs to make, including schedule projections and acquisition plans.

In parallel to these budget exercises, NASA continues to perform technical assessments to determine the best path forward for both the SLS and the MPCV. As of late December, NASA had selected Reference Vehicle Designs for both of these vehicles as bases from which to work and which we believe most closely align to the requirements and goals of the Authorization Act. However, to be clear, neither Reference Vehicle Design currently fits the projected budget profiles nor the schedule goals outlined in the Authorization Act. Additionally, it remains to be determined whether NASA will receive appropriations consistent with the full authorized level in FY 2011 or beyond – all factors that will impact schedule as well.

For the SLS, the Agency has decided to use a Reference Vehicle Design that is derived from Ares and Shuttle hardware, given the Congressional direction and that our initial studies have shown that development cost is not a major discriminator in the near-term when it comes to varying heavy-lift configurations. The current concept vehicles would utilize a liquid oxygen/liquid hydrogen (LOX/LH2) core with five RS-25 Space Shuttle Main Engine (SSME)-derived engines, five-segment solid rocket boosters, and a J-2X based Upper Stage for the SLS. This would allow for use of existing Shuttle and Ares hardware assets in the near term, with the opportunity for upgrades and/or competition downstream for eventual upgrades in designs needed for affordable production.

For the MPCV, the Agency has decided to utilize the Orion as the Reference Vehicle Design. The Orion development effort already has benefited from significant investments and progress to date, and the Orion requirements closely match MPCV requirements as defined in the Authorization Act. Like with the SLS, NASA's acquisition strategy for the MPCV and plans for utilizing current Agency infrastructure and facilities for both vehicles must still be formalized in the coming months as final FY 2011 appropriations are received, the President's FY 2012 budget request is released, and as both programs are formally initiated.

As stated earlier, another unknown for the Agency is schedule. While the Authorization Act sets a goal of 2016, a first flight this early does not realistically appear to be possible based on our current cost estimates for the Reference Vehicles and given the levels proposed in the Authorization Act. NASA is in the process of developing an integrated schedule for the SLS and MPCV Vehicles. This schedule requires additional time for development due to the on-going SLS trade studies, understanding of the appropriated budget profile, integration of the respective budget profiles, and development of the acquisition strategies. The integrated schedule will also address the relative development maturity of the SLS and MPCV reference vehicles. The SLS and MPCV planning teams are working to align the respective budgets and schedules. A draft version of the integrated schedule will be included in the update to this report.

Additionally, the acquisition strategy for both vehicles will not be solidified until all pertinent information is obtained to finalize a strategy, assure an affordable solution, and then gain final Agency approval. NASA will follow its Agency acquisition process to make decisions in a timely way and ensure that programs remain consistent with NASA's Strategic Plan and Agency commitments.

As part of that process, NASA will hold an Acquisition Planning Meeting that will review the early acquisition plans of the SLS and MPCV programs, followed by an Acquisition Strategy Meeting that will provide formal Agency approval of their plans for formulation and implementation plans for both programs. And finally, prior to the release of any procurement solicitation, NASA will hold a Procurement Strategy Meeting to approve the specific details for each individual procurement action. NASA hopes to finalize its acquisition decisions as early as Spring of 2011– details that will be included in a follow-on report to Congress.

II. Space Launch System

2.1 Intro

The NASA Authorization Act of 2010 directs NASA to develop an SLS as a follow-on to the Space Shuttle that can access cis-lunar space and the regions of space beyond LEO in order to enable the United States to participate in global efforts to access and develop this increasingly strategic region. The Act also provides a series of minimum capabilities that the SLS vehicle must achieve:

- The vehicle must be able to initially lift 70-100 tons to LEO, and must be evolvable to 130 tons or more;
- The vehicle must be able to lift a MPCV; and
- The vehicle must be capable of serving as a backup system for supplying and supporting cargo and crew delivery requirements for the International Space Station (ISS) in the event such requirements are not met by available commercial or partner-supplied vehicles.

The Act also directs NASA to begin development of the SLS vehicle "as soon as practicable after the date of the enactment of" the NASA Authorization Act of 2010 and with the goal of achieving operational capability for the core elements not later than December 31, 2016.

The Act authorizes a total of $6.9 billion for SLS development over a three-year period, with $1.6 billion authorized in FY 2011. However, the final SLS funding guidelines are pending the enactment of FY 2011 appropriations.[1] The amount appropriated for SLS development efforts in FY 2011 – and the phasing of the funding in the five-year plan reflected in President's FY 2012 budget request – are important factors that will allow NASA to finalize plans for the SLS.

[1] The FY 2011 Senate Appropriations Report would fund the SLS at $1.9B in FY 2011, and with a proposed cost cap of $11.5B through FY 2017. Within 60 days of enactment of the appropriations bill, NASA is directed to submit a report that includes, among other things, an evaluation of this proposed cost cap.

In compliance with the Act, NASA plans to make use of current investments and workforce as appropriate. The Nation's new SLS will leverage these critical capabilities and experience and will be designed with innovation, robustness and affordability. It also will employ modern manufacturing and processing techniques, improved insight and oversight practices, and streamlined infrastructure requirements, while also reducing other fixed costs to help drive down development and operational costs, as also required by Congress. We therefore request that the Agency continue to be given the flexibility it needs to develop the optimal solutions for SLS and the associated schedule that best benefits the Agency's mission and is affordable in the long-term.

2.2 Heavy-Lift Background

Over the course of the last decade, NASA has analyzed more than 2,000 separate launch vehicle concepts and architectures, with varying figures of merit, and in concert with industry and multiple potential partners such as the Department of Defense (DOD). These studies have established a broad collection of reference launch vehicle configurations that the Agency continues to refine consistent with the evolving figures of merit noted earlier – where affordability has been established by the Administrator as dominant.

In 2009, NASA initiated a comprehensive internal study to examine the trade space for heavy-lift vehicles for the next-generation of human spaceflight systems. This study, jointly commissioned by NASA's ESMD and the Space Operations Mission Directorate (SOMD), quantitatively addressed launch vehicle configurations, both new concepts and those previously studied by NASA, with the specific goal of comparing concepts using common ground-rules, assumptions, and figures of merit (such as cost, number of launches for various deep space missions, etc.) to evaluate each launch vehicle option consistently. Numerous launch vehicle concepts were studied including variations of liquid oxygen/liquid hydrogen (LOX/LH2) heavy lift vehicle architectures with solid rocket boosters (side-mount and inline Shuttle derived options), and LOX/Hydrocarbon heavy lift launch vehicle architectures. The LOX/Hydrocarbon vehicle concepts were less mature than the LOX/LH2 concepts at the time of the study.[2] Initial findings of this study showed that neither development schedules nor life cycle costs for the various launch vehicle concepts were discriminators and that annual recurring costs for any concept would need to be reduced through aggressive cost reduction measures.

In May 2010, NASA initiated a joint NASA-DOD study to determine the feasibility of a common large hydrocarbon engine that could be used by multiple stakeholders including NASA, DOD, and industry. The team defined engine requirements, studied the impact of fuel depots on the launch vehicle architecture, and assessed the impacts on the National industrial base if large hydrocarbon or rocket propellant (RP) engines were selected over large segmented solids. Five families of RP vehicles of varying configurations were studied to meet the NASA missions; the Air Force used its current Atlas V fleet as their reference vehicle for the study. The Air Force was looking at a modest upgrade with minimal change to the existing structure of Atlas V. After six weeks of thorough analysis, the team concluded that there is significant synergy should NASA pursue a kerosene (RP-1) / liquid oxygen launch system. The team has identified three common engines for use on NASA's heavy lift launch vehicle and DOD's launch vehicle needs. The three common engines identified were:

[2] Additional studies were later performed to mature these concepts to the same level as the LOX/LH2 heavy-lift concepts.

- A RP Oxygen-Rich Staged Combustion core stage engine with a thrust level of 1.0 to 1.25 million pounds (Mlbf), with an Air Force need date of 2018;\.
- A J-2X class LH2 engine with a thrust level of approximately 294 pounds (Klbf), with an Air Force need date of 2025; and
- A RL-10 Replacement Engine; expander cycle with a thrust level of approximately 30 Klbf), with an Air Force need date of 2020.

The decision for choosing the next SLS is not clear-cut. With the numerous trade studies that have already been performed, the Agency has determined that there is not a "one size fits all" vehicle selection.

Another key NASA study was performed by MSFC in September 2010. This Figures of Merit (FOM) analysis looked at various launch vehicle architectures that have been studied over the years. In doing so, five heavy lift launch vehicle families were reviewed:

- A 27.5-foot diameter core LOX/LH2 vehicle with five RS-25D/E core stage engines and two five-segment polybutadiene acrylonitrile (PBAN) solid rocket boosters;
- A 33-foot core LOX/LH2 vehicle with six RS-68 core stage engines, an Upper Stage with two J-2X engines and two five-segment PBAN solid rocket boosters;
- A 33-foot diameter core LOX/RP vehicle with five 2.0 Mlbf thrust RP core stage engines (Gas Generator or GG) and an Upper Stage with one J-2X Upper Stage engine;
- A 33-foot diameter core LOX/RP vehicle with five 1.25Mlbf thrust RP core stage engines (Oxygen Rich Stage Combustion or ORSC) and an Upper Stage with one J-2X engine; and
- A hybrid Heavy Lift Launch Vehicle – a clean-sheet combination of a LH2 core stage with RP strap-on boosters.

In conducting its analysis and while maintaining a threshold safety requirement, the MSFC team performed an analytical hierarchy process and used weighted FOMs as follows:

- Affordability[3]: 55 percent
- Schedule: 25 percent
- Performance: 10 percent
- Programmatic: 10 percent

The findings of the MSFC study showed that the 27.5-foot LOX/LH2/SSME HLV and 2Mlbf GG RP vehicles were highest rated across all of the FOMs. The 2.0 Mlbf RP engine vehicle scored better than the 1.25 Mlbf RP common engine because of its higher reliability (more engines would be required for 1.25 Mlbf). However, the LOX/LH2 RS-68 vehicle and the combined vehicles (LH core and RP strap-on boosters) did not fare well due to high potential costs and underrated performance.

In these studies, NASA used traditional cost modeling techniques, which reflect current development and operational practices. With these traditional cost models, development of these systems did not fit within the funding and schedule specified in the Authorization Act of 2010. In light of the studies performed to-date, NASA recognizes that in order for the exploration missions to have a sustainable manifest or cadence, future launch systems and infrastructures (and their corresponding missions) must be affordable to develop and to operate. The costs for design,

[3] It should be noted that NASA reviewed affordability of development and operation.

development, test and evaluation (DDT&E) for new propulsion systems must be driven to be within the projected NASA budgets through improved practices and streamlined supporting infrastructure as well as exploring partnerships with other Government agencies and commercial partners. Similarly, the recurring costs of producing and operating these systems in future space exploration missions must be dramatically reduced to enable future NASA missions. NASA is committed to finding the necessary efficiencies to drive costs down and develop this system as soon as possible.

2.3 Overall description of Reference Vehicle Design

Informed by the analyses described above, and consistent with the requirements of the Authorization Act, the current NASA Reference Vehicle Design assumes a 27.5-foot diameter LOX/LH2 core stage with five SSME-derived engines, also known as RS-25D/E engines, a J-2X-based Upper Stage, and two Ares-derived five-segment PBAN solid rocket boosters to provide an ultimate lift capability of approximately 130 metric tons to LEO. This design would allow NASA to use existing Shuttle main engine and booster component assets in the near term, with the opportunity for upgrades and/or competition downstream for eventual upgrades in designs needed for production of engines after flying out the current inventory of main engines and booster components. It also would allow flexibility in phasing costs for these design upgrades. This reference configuration would take advantage of the skills of the current workforce and allow for competition as design upgrades or configuration changes occur. Knowledge gained in the development effort could provide an informed basis for the follow-on production and operations of the launch system leading to informed, affordable production contracts.

The overarching goal of the SLS is to enable human exploration at the highest possible safety standards and the lowest life-cycle costs for beyond-LEO missions. Based on current information and analysis, the Reference Vehicle Design represents the lowest near-term costs, soonest available, and the least overall risk path to the development of the next, domestic heavy lift launch vehicle. Selecting this SLS architecture would mean that a new liquid engine in the near term would not need to be developed, thus shortening the time to first flight as well as likely minimizing the overall DDT&E cost of the SLS. However, the Reference Vehicle Design may not be affordable within expected budget levels. These issues are being considered in NASA's ongoing trades and analyses, as outlined below.

2.4 System Trades and Analyses

NASA is devising affordability strategies in this context to enable meeting the given budget constraints while also meeting the requirements of the Authorization Act. In FY 2011, the SLS formulation phase will pursue multiple parallel activities to help drive down the development and operations costs for the SLS. NASA plans to transition relevant work from the Space Shuttle Program and Ares Project to the new SLS Program, while also continuing to define the requirements for the new SLS system.

NASA is performing its analyses using a government Requirements Analysis Cycle (RAC), in which ESMD, with support from the SLS Center Planning Team at MSFC, will develop a set of SLS requirements by early Spring 2011. These requirements will be informed by NASA analysis

of the direction in the Authorization Act, needed SLS safety, performance, existing national capabilities, and Administration priorities. NASA has assembled four multi-Center formulation teams: 1) a team focused on the LOX/LH2 Reference Vehicle Design; 2) a team focused on a LOX/RP-derived architecture; 3) a team focused on a modular, common-core launch vehicle architecture; and 4) a team focused on affordability. The LOX/LH2 team will evaluate the Reference Vehicle Design (point of departure) while the other two vehicle assessment teams are analyzing alternative architectures as required to support NASA's acquisition process and to determine if one of the alternatives would provide costs that are dramatically reduced compared with the Reference Vehicle Design.

All four NASA study teams will be challenged to reach completion of a preliminary analysis of high-level system requirements by March 2011, which will include initial development planning, design concept, and preliminary Level II requirements. In the end, the RAC will accomplish multiple objectives:

- Infuse affordability of both development and operations without compromising safety as the predominate figure of merit into the DDT&E process;
- Allow NASA to exercise an enhanced and leaner SE&I approach;
- Allow NASA to become a smart buyer for the eventual procurement; and
- Make forward progress toward launch vehicle development.

In parallel with the RAC teams, on November 8, 2010, NASA announced the results of the heavy lift and propulsion study contracts that were awarded as part of a Broad Agency Announcement (BAA) issued in May 2010. As part of this competitive solicitation, utilizing approximately $7.5 million in FY 2010 dollars, NASA selected 13 companies to conduct six-month studies examining the trade space of potential heavy-lift launch and space transfer vehicle concepts. The BAA is focused on achieving affordability, operability, reliability and commonality at the system and subsystem levels with multiple users, including other Government, commercial, science and international partners. These trade studies will provide a "fresh look" at innovative launch vehicle concepts, propulsion technologies and processes that can be infused into the development of the new human exploration missions – information that will be used to help inform the overall selection and development of the final SLS vehicle detailed design.

The Kennedy Space Center (KSC) Ground Processing Team will be an active participant on the SLS design teams due to the substantial impacts to their system design and operations as well as MPCV and Mission Operations. NASA plans to institute a "Red Team" to review the results of the requirements review in a board format. The "Red Team" evaluations will be based on key drivers including affordability, partnerships, innovation, and lean systems engineering and integration approach, and leverage of prior investments. The RAC study team results will be used to develop and refine the vehicle design concepts and to determine whether the NASA Reference Vehicle Design meets the SLS mission requirements as well as the Administrator's goals that the design be affordable, sustainable, and realistic. To this end, NASA commits to obtaining independent (outside of the Agency) assessments of cost and schedule for SLS and MPCV design options as part of its decision process this Spring or Summer, and further to make these assessments public.

2.5 Plan for utilization of existing contracts, civil service and contractor workforce

In keeping with in the NASA Authorization Act of 2010, which states that the Administrator shall "…to the extent practicable extend or modify existing vehicle development and associated contracts necessary to develop the SLS," NASA has chosen a Reference Vehicle Design that makes maximum use of heritage hardware designs and existing assets.[4] In addition, the Ares I (First Stage, Upper Stage, J-2X) contracts and workforce (both civil servant and industry partners) will continue along their current development plan within the existing FY 2011 Continuing Resolution funding constraints so that technologies and processes developed for that Project can be readily transferred to the SLS Program.

It is clear that NASA possesses valuable assets from the Shuttle Program and Ares Project that could be directly applied to the development of the SLS. To the extent practicable, NASA intends to leverage and build off of previous investments from all human spaceflight programs. For example, from the Shuttle Program, critical assets that could contribute to the success of the SLS development are ground handling hardware and materials from the External Tank as well as 15 remaining SSMEs (RS-25D). The Ares Project's five-segment boosters, J-2X Upper Stage engine, and the Ares I Upper Stage manufacturing concepts and instrument unit assembly also could be applicable for the SLS. Using existing hardware assets, such as the Shuttle main engines and solid rocket components, can help in phasing development of improvements for affordability as these assets are flown out in early tests.

Assuming current trade and analysis activities go as planned, and FY 2011 appropriations are in place, NASA plans to make final acquisition decisions for the SLS as early as Spring 2011. Such a decision will take into account Agency analysis on whether the existing Ares and Shuttle contracts could be used for SLS work. Data from the RAC and the BAA study contracts also will be used to help make an informed decision about SLS technical alternatives that will inform procurement and workforce matters.

As noted earlier, NASA's workforce is our most valuable asset. Therefore, our consideration of future workforce implications will include how NASA must address the potential loss of the skill-base and knowledge base of both the NASA workforce and the industry partners. It must also take into account the advantages of a leaner team in achieving an affordable system.

2.6 Plan for supporting infrastructure utilization and modifications

ESMD will work closely with SOMD to assure that the ground infrastructure plan and associated modifications are developed in support of the SLS requirements. Overall supporting infrastructure must be minimized in these future programs to be affordable. NASA intends to use only what is needed of existing capabilities, facilities and infrastructure with minimum modification to conserve limited resources. New ground infrastructure and other supporting elements will be minimized unless they prove to be more affordable.

[4] Consistent with the provisions of the FY 2010 Consolidated Appropriations Act (P.L, 111-117), and other law, NASA is continuing to implement the programs and projects for the architecture of the Constellation Program while we await our final FY 2011 appropriations direction.

NASA has many unique facilities and infrastructure that can contribute to the successful development of the SLS. Such facilities include the Michoud Assembly Facility, propulsion test stands at the Stennis Space Center, as well as the vehicle processing, integration and launch complexes at KSC. The use of these facilities will be considered in the analysis for life cycle costs and right-sized infrastructure. During the RAC studies, NASA will investigate potential facilities and evaluate the required modifications to existing infrastructure that could be used to support the SLS. This evaluation will be closely linked to all efforts within the 21 Century Launch Complex activity managed by SOMD. RAC analysis will include a plan of the specific facilities and infrastructure to be utilized during the development of the SLS. This plan will be described in the updated SLS/MPCV report.

2.7 Procurement strategy to expedite development activities through modification of existing contract vehicles

NASA is still in the process of developing the full acquisition strategy for the SLS. Given that the current Reference Vehicle Design utilizes heritage systems from Shuttle and Ares, NASA is evaluating existing Ares and Shuttle contracts -- and potential money saving improvements and modifications to them -- to determine whether those contracts could be used for development work on the SLS and whether doing so would be the most affordable and efficient option for developing the SLS.

In the meantime, in order to maintain existing capabilities during this planning effort, as discussed in Section 2.4, NASA continues work on the elements of the Ares I Project that are most likely to feed forward into the SLS.

Reducing recurring and operations costs will be one of the greatest challenges for the SLS team. For all SLS acquisitions and development activities, NASA will employ innovative acquisition approaches such as Design-to-Cost and Life Cycle Costs that utilize industry best practices; consider incentives for contractor reductions in fixed costs; and address cultural changes within the Agency to focus more on affordability rather than just performance factors. More specifically, NASA plans to focus on a number of affordability initiatives such as: 1) identifying affordability as the over-riding driver while not reducing safety priorities, 2) exploring innovative acquisition approaches and incentivizing industry partners to focus on building a system that is economical to operate, 3) coordinating with the 21st Century Launch Complex planning effort to achieve an efficient operational concept that reduces excessive infrastructure fixed costs, and 4) exploring opportunities and approaches for implementing an efficient, right-sized Government insight workforce and industrial base. NASA is looking to the recently awarded study contracts to engage industry in identifying potential cost-saving approaches.

2.8 Schedule and design of development milestones and related schedules

As noted earlier, the NASA Authorization Act of 2010 directs NASA to begin development of the SLS vehicle "as soon as practicable after the date of the enactment" and with the goal of achieving operational capability for the core elements not later than December 31, 2016. While NASA will work as expeditiously as possible to meet the 2016 goal, NASA does not believe this goal is achievable based on a combination of the current funding profile estimate, traditional

approaches to acquisition, and currently considered vehicle architectures. However, we are exploring more innovative procurement and development strategies to determine whether we can come closer to the December 31, 2016 goal. It is clear that innovative, lower cost ways of doing business and expedited processes at all levels must be implemented for SLS to achieve the first flight milestone anywhere near this goal. NASA will be pursuing such innovations as we formulate plans for SLS development.

NASA is hopeful that the RAC teams and the BAA study contracts teams will develop ideas to accelerate that development timeline such that it comes as close to the goal identified in the Authorization Act as possible, given budget realities and the need for the program to be affordable over the long-term. We will not commit to a date that has a low probability of being achieved. Additionally, NASA believes that utilizing heritage systems could help expedite the development process, even though launch vehicle integration challenges would still exist as a schedule threat. It is important to note, however, that it is very likely this first flight would not be "operational" under traditional NASA definitions.

2.9 SLS summary

In summary, the current SLS Reference Vehicle Design would utilize to the maximum extent practicable assets from the Space Shuttle Program and Ares Project. The Reference Vehicle Design is an in-line, large-diameter liquid oxygen/liquid hydrogen (LOX/LH2) core stage with multiple liquid propulsion core stage SSME-derived engines, and two five segment solid rocket boosters. The Upper Stage consists of a J-2X cryogenic Upper Stage with approximately 294 klbf thrust capability. The vehicle will be able to meet the following requirements specified in the NASA Authorization Act of 2010: 1) initially lift approximately 100 tons to LEO, and be evolvable to 130 tons or more; 2) be able to lift an MPCV; and 3) be capable of serving as a backup system for supplying and supporting cargo and crew delivery requirements for the ISS – if such requirements are not met by available commercial or partner-supplied vehicles.

The Reference Vehicle Design does not appear to be affordable within expected budget levels (based upon traditional cost models and acquisition approaches), thus NASA will also investigate alternative concepts, cost estimating and acquisition approaches over the coming months. The SLS acquisition strategy will not be solidified until all pertinent information is obtained to finalize a strategy and gain Agency approval. NASA will follow its Agency acquisition process by requiring the earliest possible informed decisions to ensure that programs remain consistent with NASA's Strategic Plan and Agency commitments and are affordable and sustainable in the long-term.

This preliminary report has highlighted the approach and content for the SLS, known as of early January 2011. In order to fully comply with direction in Section 309 of the NASA Authorization Act 2010, NASA will submit a more defined, detailed and comprehensive report to Congress as early as the Spring 2011 timeframe that will include a more mature assessment of our design, acquisition approach, and an operational readiness goal.

III. Multi-Purpose Crew Vehicle

3.1 Intro

The NASA Authorization Act of 2010 directs NASA to develop an MPCV that continues the advanced development of the human safety features, designs, and systems in the Orion Project. The Act also provides a series of minimum capability requirements that the MPCV must achieve:

- The vehicle must be able to serve as the primary crew vehicle for missions beyond LEO;
- The vehicle must be able to conduct regular in-space operations, such as rendezvous, docking and extra-vehicular activities, in conjunction with payloads delivered by the SLS or other vehicles in preparation for missions beyond LEO;
- The vehicle must provide an alternative means of crew and cargo transportation to and from the ISS, in the event other vehicles, whether commercial or partner-supplied, are unable to perform that function; and
- The vehicle must have the capability for efficient and timely evolution.

The Act also sets a goal of full operational capability not later than December 31, 2016.

In terms of funding, the Act authorizes a total of $3.92 billion for MPCV development over a three-year period, beginning with $1.12B authorized in FY 2011. However, the final MPCV funding guidelines are pending the enactment of FY 2011 appropriations.[5] In the meantime, NASA is proceeding based on the FY 2011 Continuing Resolution funding and budgetary projections derived from the Authorization Act guidance. The final amount appropriated for MPCV development efforts in FY 2011 – and the phasing of funding reflected in the five-year plan in the President's FY 2012 budget request – are important factors that will drive NASA's final planning efforts for the MPCV.

It is important to note that the MPCV Project will be operating in a cost-constrained environment. The three-year authorized funding level represents a significant reduction[6] relative to previously planned Orion budgets. Therefore, controlling and reducing costs will require implementing numerous affordability measures such as streamlining NASA's insight/oversight of contractor activities, implementing a streamlined test and verification strategy consistent with other aerospace practices, phasing work to meet spending rate targets, adopting incremental development methods to achieve capabilities consistent with the Agency strategy, realizing efficiencies in the implementation of internal NASA governance and program management processes and practices, and optimizing agency facilities and infrastructure costs among others. However, NASA is confident that the MPCV can be designed with robustness and affordability, given the flexibility to develop optimal technical solutions for the MPCV and an associated schedule that best benefits the Agency's long-term exploration needs.

[5] The FY 2011 Senate Appropriations Report would fund an Orion Crew Exploration Vehicle at $1.1B in FY 2011, with language stipulating ISS access by FY 2014 and with a proposed cost cap of $5.5B through FY 2017 of $5.5B, which is less than existing estimates of Orion costs-to-go to achieve crewed flights. Within 60 days of enactment of the appropriations bill, NASA is directed to submit a report that includes, among other things, an evaluation of this proposed cost cap.

[6] NASA recently estimated that Orion would need a total of $11.5-$12.0 billion through 2015 in order to achieve the first crewed flight in 2015, minus the $4.9 billion already expended through November 2010.

NASA's initial assessments show high applicability of the Orion spacecraft development to the MPCV requirements specified in the NASA Authorization Act of 2010, and this report describes how NASA has chosen the Orion as its Reference Vehicle Design. Plans for acquisition strategy and use of infrastructure and facilities must be formalized through NASA's required processes in the coming months as final appropriations – and the phasing of funding reflected in the five-year plan in the President's FY 2012 budget request – are received, and the MPVC Program is formally initiated. Therefore, NASA will provide an updated report to Congress as early as Spring 2011.

3.2 Background

NASA's plans for a crewed exploration vehicle and associated supporting functions such as space suits and mission operations have been evolving over a seven year period. Earliest plans involved a phased acquisition strategy with multiple competing vendors, with such a vehicle later becoming an integral part of the Constellation Program in the form of Orion, with mission requirements for both ISS crew and cargo transportation and lunar exploration.

During the congressional consideration regarding NASA's future direction that has taken place over the last year, progress on Orion and support functions has continued, albeit at a slightly slower pace than originally planned, with many of the lessons learned and other accomplishments from this time period being directly applicable to future MPCV work. For example:

- In August 2009, Orion successfully completed the technical portion of its Project-level preliminary design review (PDR). This validated the designs as meeting requirements for both ISS crew and cargo transportation and beyond LEO exploration. This was followed by completion of the Phase I safety review, which validated that the PDR-level designs will meet NASA's human rating requirements. (Cost and schedule elements of the PDR were not completed in this review.) Orion's PDR level of design maturity will contribute to the success of the MPCV program.

- On May 6, 2010, the Pad-Abort I test for Orion's launch abort system (LAS) took place at the White Sands Missile Range in New Mexico. This test flight demonstrated a development version of the LAS by simulating an abort during an emergency occurring before the launch vehicle has left the pad. It also demonstrated an early version of the parachute and forward bay cover deployment design. All flight test objectives were fully met. Data gathered from the flight proved that the overall design concept and LAS architecture are feasible and will also improve computer design and analysis models and tools and reduce risks and uncertainty. The test also wrung out critical procedures, facilities and processes that will be directly applicable to the MPCV mission. All of this effort will directly contribute to final design of the launch abort system for the MPCV, which will ensure crews can be transported to safety during an SLS contingency requiring an abort. The test also marked a significant advancement in the state of the solid rocket technology base by demonstrating in flight the coordinated operation of three new solid rocket motors, two of which represented major technological advancements.

- Fabrication of the Ground Test Article was completed in December 2010, at the Michoud Assembly Facility in Louisiana. This unique test article will be used for early systems integration tests, assembly evaluations, and development structural testing including

water drop tests at the new Langley water basin facility. Data resulting from these evaluations and tests will directly contribute to the final designs of the structure, layout, and fabrication and assembly techniques for the MPCV. In fabricating the Ground Test Article, the Orion team has developed, tested, and refined self-reacting friction stir welding techniques that are ground-breaking in their size and quality.

Given budget challenges in FY 2010, NASA is now developing plans for a phased development approach for the Orion that could carry over into the MPCV Program. This approach would defer work on some systems such as life support and extra-vehicular activity suits, while focusing on core components and systems that will be applicable to the MPCV such as vehicular structure, thermal protection systems and parachutes. This will enable incremental test flights and subsequent upgrades to full operational capability as quickly as the budget profile allows.

In summary, the Orion work performed to date and the associated accomplishments establish an effective foundation for the development of NASA's next human exploration vehicle as the MPCV. In light of this experience and lessons-learned, NASA recognizes that affordability is key to achieving a sustainable MPCV Program. The costs for MPCV DDT&E must be within the projected NASA budgets and affordable and sustainable once in operations. The recurring costs of producing and operating the MPCV must be significantly less than those of previous human spaceflight programs. To this end, NASA commits to obtaining independent (outside of the Agency) assessments of cost and schedule for SLS and MPCV design options as part of its decision process this Spring or Summer, and further to make these assessments public.

3.3 Overall description of Reference Vehicle Design

NASA has performed initial assessments of the current Orion Project's applicability to the new MPCV requirements in the Authorization Act, and has adopted the beyond-LEO Orion design as the Reference Vehicle Design for MPCV. This assessment has included the current Orion designs and phased development approach leading to operational beyond-LEO capabilities, the current Project organization and processes, existing facilities and infrastructure, and the current prime contract.

The current Orion design supported by the FY 2010 appropriated budget consists of a Crew Module (CM), Service Module (SM), and the LAS. The CM would provide safe habitat for the astronauts from launch through landing and recovery, including launch/ascent/entry suits, and would be the only part of the spacecraft that would return to Earth following a mission. The SM would provide consumables, propulsion, and power generation for the spacecraft. Mounted at the top of the Orion and launch vehicle stack, the LAS would use a solid rocket motor to automatically separate the CM from the launch vehicle and position it for a safe landing should there be an emergency on the launch pad or during the climb to Earth orbit. Preliminary designs exist for both an ISS transportation version of the Orion and a lunar exploration mission version. The ISS mission design is capable of crew and cargo transport to LEO, whereas the lunar mission design is optimized to provide the capability for longer missions beyond LEO and a higher velocity re-entry. The NASA Reference Vehicle Design for MPCV is the beyond-LEO version of Orion, but the ISS designs demonstrate the capability of Orion to act as a backup to ISS as directed in the Act.

NASA's current designs for the beyond-LEO (formerly lunar) version of the Orion include the following basic capabilities and specifications – all of which are traceable to MPCV requirements in the Authorization Act:

- **Crew size:** 2 to 4
- **Crewed mission duration:** 21.1 days
- **Velocity change capability:** 5233 ft/s
- **Main engine thrust:** 7,500 pounds
- **Pressurized volume:** 690.6 cubic feet
- **Net habitable volume:** 316 cubic feet
- **Skipped Entry Capability:** Can traverse up to 4,800 nautical miles (nmi) from atmospheric entry interface to landing point from lunar return trajectories;
- **Landing:** Water landing off California coast with a 5.4 nmi landing accuracy
- **EVA Capability:** Via depressurization of the crew compartment

Based on the aforementioned minimum capability requirements listed in Section 3.1 of this report, NASA has concluded that the beyond-LEO version of the current Orion spacecraft meets the minimum capabilities required by the Authorization Act, in that it will:

- Provide crew launch, return, and operation in deep space;
- Be fully capable of performing missions in cis-lunar space; and
- Be evolvable to serve as the primary crew vehicle for missions beyond cis-lunar space.

The Authorization Act also calls for the MPCV to be capable of providing, as a back-up to commercial crew and international partner services, crew and cargo transportation to and from the ISS. The beyond-LEO Orion also meets this requirement of contingency transportation to and from the ISS. Although the beyond-LEO Orion design does not include volume in the SM for large unpressurized cargo items for ISS, this is enabled in the Orion PDR design through mission kitting that would remove consumables tanks not needed for back-up ISS transportation missions and replace the volume with cargo capability. Other mission-specific design variations can be designed for the beyond-LEO Orion to enable support for the variety of other missions described in the Act, such as performing EVA, rendezvous and docking, and operating in conjunction with payloads delivered by the SLS or other vehicles in preparation for missions beyond LEO.

Given the applicability of the current Orion work, NASA's Reference Vehicle Design for MPCV is the beyond-LEO version of the current Orion. It must be emphasized for clarity that the MPCV design will be optimized for beyond-LEO exploration capability. Any contingency utilization as a backup-LEO crew vehicle will represent a highly inefficient vehicle usage.

It is not yet clear whether the Reference Vehicle Design fully meets the NASA Administrator's three principles for development of any future systems for exploration -–– namely that these systems must be **affordable**, **sustainable**, and **realistic**. Further work is required in assessing potential contract changes, oversight simplifications and other cost-saving measures to understand the degree to which this development meets these principles. NASA recognizes that new affordability strategies must be implemented in the design and Project management process to meet a constrained budget environment. Given these affordability challenges, NASA must validate this approach through our required acquisition process outlined in Section 1 of this report. If the current Reference Vehicle Design is found not to be affordable, sustainable, and realistic, then NASA will explore other options, including changes to the Reference Vehicle Design.

There are some uncertainties for the Reference Vehicle Design with respect to integration with a launch vehicle. The degree to which the final design for the SLS might affect the current Orion's designs for ascent environments, abort conditions, staging scenarios, and physical connections is unknown. However, preliminary assessments indicate that environments and conditions driven by the Ares I vehicle, which drove the current Orion designs, will envelope any likely design-driving parameters of the SLS. This will, of course, be studied, verified, and tested as the designs for SLS mature. But at this point, NASA is confident that the robust design of the current Orion is such that integration with the SLS will not be a significant challenge.

In conclusion, NASA has evaluated the degree to which the existing Orion Project, including designs, facilities, infrastructure, organization, contract, and processes could be transitioned and continued under the MPCV Program. The current designs are a good match with the requirements specified in the NASA Authorization Act of 2010, although affordability and sustainability have not yet been proven and will weigh heavily in the final MPCV Program formulation. NASA hopes to provide final decisions in an updated report to Congress as soon as Spring 2011.

3.4 Plan for utilization of existing contracts, civil service and contract workforce

In keeping with the 2010 Authorization Act, which states that the Administrator shall "to the extent practicable extend or modify existing vehicle development and associated contracts necessary" to develop the MPCV, as well as the requirements of the FY 2011 Continuing Resolution, existing Constellation contracts pertaining to the Orion Project and supporting functions, including the Constellation Space Suit Systems (CSSS) contract, will continue to be executed, and other Government efforts will be on-going, while the final MPCV implementation plan is being developed[7]. This approach provides the fewest near-term job impacts while providing maximum leverage to the Agency to achieve the earliest MPCV approach that is affordable.

Plans for utilization of existing contracts, civil service, and contract workforce will be updated as necessary when final FY 2011 appropriations are provided– and the phasing of funding reflected in the five-year plan in the President's FY 2012 budget request is known – and presented in the updated report to Congress. Initial planning is focusing on using the existing Orion Project contract, organization and workforce to the maximum extent possible. NASA plans to make final decisions pertaining to utilization of the existing contract for the MPCV by as early as Spring 2011.

[7] Consistent with the provisions of the FY 2010 Consolidated Appropriations Act (P.L, 111-117), and other law, NASA is continuing to implement the programs and projects for the architecture of the Constellation Program while we await our final FY 2011 appropriations direction.

3.5 Plan for supporting infrastructure utilization and modifications

Many Orion support facilities are complete or nearing completion, and appear to be applicable to the MPCV Program. Despite the recent budget challenges, the Orion Project has continued progress on the highest priority facilities that would have applicability to MPCV. These include:

- The Operations and Checkout Facility at KSC. Intended for Orion vehicle assembly and integration, it would be able to serve the same function for MPCV.
- The current Canister Rotation Facility at KSC. Intended for Orion LAS assembly, integration and checkout operations.
- Systems Environmental Test facility at Plumb Brook Station. The completed facility will provide state-of-the art capability to simulate the space and launch environment, including vibration, aero-acoustic loads, and thermal/vacuum. This facility would likely meet qualification testing requirements for the MPCV.
- Launch Abort Test complex at the U.S. Army's White Sands Missile Range. This facility will support the processing and launch of sub-orbital test flights to validate a LAS's performance during ascent. This will likely be required for MPCV.
- Water drop test facility at Langley Research Center. To be used for simulating Orion's water landings to test structure design and computer models. Will also be applicable to MPCV, assuming its landing strategy is Orion-derived.

However, it is important to note that no final decisions have been made yet with regard to infrastructure needs for the MPCV, and as such plans for completed and new infrastructure will be presented in the updated report to Congress. NASA hopes to make final decisions on MPCV supporting infrastructure utilization and phasing together with other programmatic decisions as soon as Spring 2011.

3.6 Procurement strategy to expedite development activities through modification of existing contract vehicles

Given that the current Reference Vehicle Design builds on the Orion CEV, NASA will carefully examine whether it can utilize the current Orion contract awarded to Lockheed Martin in September 2006 to develop the MPCV. In doing so, NASA will have to determine whether the Lockheed Martin contract could be used for development work on the MPCV through mapping of requirements, between Orion and the MPCV, and whether doing so would be the most affordable and efficient option for developing the MPCV, including whether modifications to the contract would enhance affordability. Final decisions will be informed based upon technical analysis, budget projections based on the latest information for FY2011 and the out years, and acquisition options. Additionally, NASA is evaluating the applicability of other support contracts such as the Constellation Space Suit Contract and the optimum long-term acquisition strategy for these functions.

Reducing recurring and operations costs will be one of the greatest challenges for the MPCV team. For all MPCV acquisitions and development activities, NASA will employ innovative acquisition approaches such as Design-to-Cost and Life Cycle Costs that utilize industry best practices; consider incentives for contractor reductions in fixed costs; and address cultural changes within the Agency to focus more on affordability rather than just performance factors. More specifically, NASA plans to focus on a number of affordability initiatives such as: 1)

identifying affordability as the over-riding driver while not reducing safety priorities, 2) exploring innovative acquisition approaches and incentivizes industry partners to focus on building a system that is economical to operate, 3) coordinating with the 21st Century Launch Complex planning effort to achieve an efficient operational concept that reduces excessive infrastructure fixed costs, and 4) exploring opportunities and approaches for implementing an efficient, right-sized Government insight workforce and industrial base.

3.7 Schedule and design of development milestones and related schedules

As noted earlier, the NASA Authorization Act of 2010 directs NASA to begin development of the MPCV with the goal of achieving full operational capability not later than December 31, 2016. While NASA will work expeditiously to meet the 2016 goal, NASA notes that, as with the SLS, a 2016 crewed first flight does not appear to be possible within projected FY 2011 and out year funding levels. It is clear that successful development of the MPCV will be dependent on sufficiently stable funding over the long term and a successful effort on the part of NASA and the eventual industry team to reduce costs and to establish stable, tightly-managed requirements. We will investigate the best phasing for the development of the SLS and MPCV. This phasing will be driven by the annual budget estimates and will be phased such that both vehicles (SLS and MPCV) will be ready at the earliest practical date. An updated plan based on the study teams' results will be provided in the update of this report. NASA is also investigating whether to perform an MPCV test flight prior to the program critical design review. A test flight could potentially retire significant technical uncertainties and help to insure that the later combined SLS and MPCV test flight is fully successful. The advantages and disadvantages along with cost considerations will be carefully reviewed, and the update will reflect the outcome of these trades.

Later in FY 2011, NASA plans to finalize its acquisition strategy for the MPCV and based on the Agency's decision, NASA will transition relevant work from the Orion Project to the new MPCV Program, while also continuing to define the requirements for the MPCV system. Available funding will drive work that can be accomplished in terms of technical content and schedule milestones.[8] Planned FY 2011 work will focus on continuing design of core vehicle systems and performing planned testing of the Ground Test Article, which are tasks applicable to MPCV.

An MPCV master program schedule, including all major milestones from inception to achieving operational capability, will be developed in coming months and will be provided in the updated report to Congress. NASA will endeavor to achieve the earliest possible operational readiness date within the available budget and in a way that leads to affordable operations over the long term.

3.8 MPCV summary

In summary, NASA is continuing to work on the Orion, and is planning to initiate the MPCV Program with design robustness and affordability while making use of current investments and workforce as appropriate. It is clear that innovative, lower cost ways of doing business must be implemented if MPCV is to be affordable and sustainable and be available in a timely manner.

[8] It is important to note that the MPCV budget must also cover costs for supporting elements such as mission operations and EVA suit development, and integration with the SLS, in addition to the MPCV development itself.

As such, MPCV management will seek to develop and implement innovative, improved practices, creative development approaches, right-sized infrastructure, and reductions in other fixed costs to reduce development and operational costs in order to enable earliest possible flight dates in an affordable manner. Current NASA estimates do not meet the goals laid out in the Authorization Act.

In the meantime, NASA will continue to execute existing Constellation contracts as required in the Continuing Resolution while we finalize the MPCV acquisition strategy. Such an approach will provide the fewest near-term job impacts while also providing maximum leverage to the Agency to achieve an MPCV approach that is as early as possible and affordable.

This preliminary report has highlighted the approach and content for the MPCV, known as of mid December 2010. In order to fully comply with direction in Section 309 of the NASA Authorization Act 2010 (P.L. 111-267), NASA will submit a more defined, detailed and comprehensive report to Congress as early as Spring 2011 that will include a more mature assessment of our design, acquisition approach, and operational readiness goal.

IV. Summary

NASA takes seriously its responsibility to keep the Congress informed of our SLS and MPCV development planning efforts, and we believe this preliminary report provides substantial detail about the facts known to date, while also foreshadowing the process of how decisions will be made by Agency management early next year. We are committed to providing the Congress updated information as part of the President's FY 2012 budget request and plan to provide Congress with an updated version of this report as early as Spring 2011.

In conclusion, NASA would like to emphasize that we are committed to meeting the goals and requirements of the NASA Authorization Act of 2010 to the best of our ability and in a way that is affordable and offers the best value to the Nation, and we look forward to continuing to work with the Congress on this new path of space exploration.