6500m HOV Project
Stage 1: A-4500 HOV

Sphere Construction Plan

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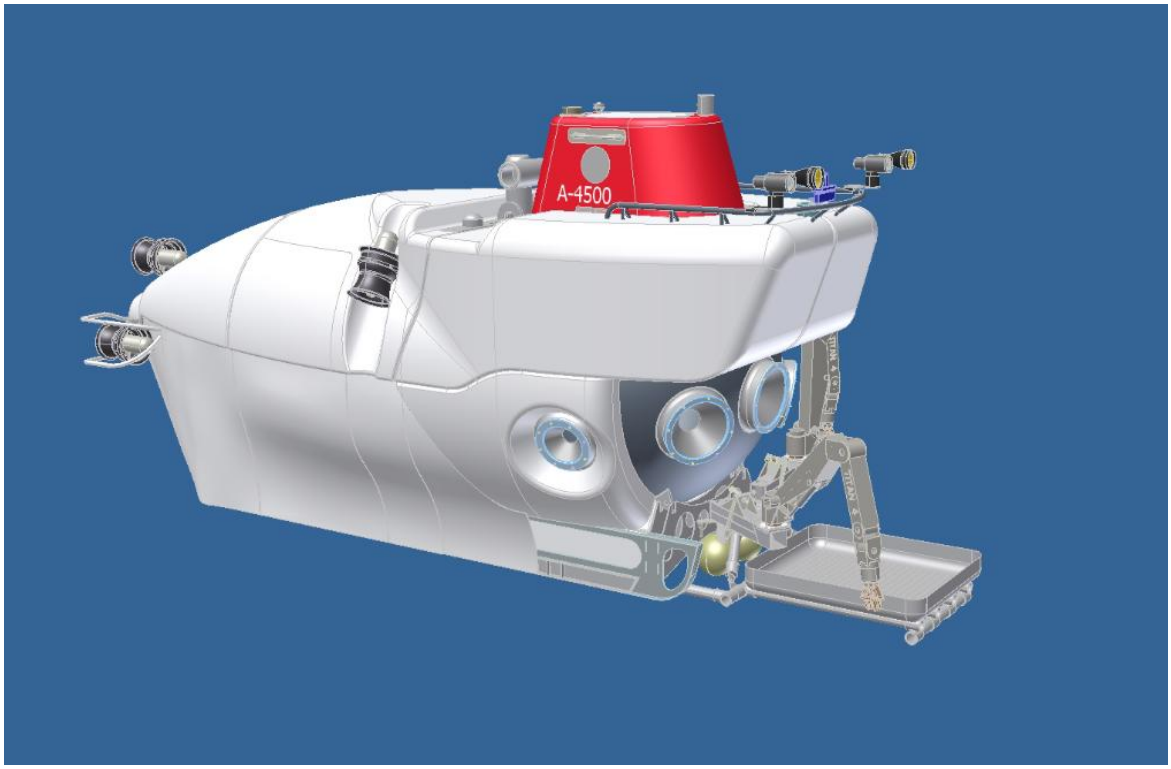

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WOODS HOLE, MA 02543

Document Control Sheet

Date	Originator	Description
09-05-09	S. Humphris	Initial draft
09-12-09	S. Humphris	Revised edits by D. Fox
10-30-09	S. Humphris	Revised draft

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1.0 Introduction

The successful, on-going construction of the personnel sphere represents a significant accomplishment and a major step forward for the 6500m HOV project. This was the first time that a project involving forging and welding of such thick titanium had ever been undertaken in the U.S., and hence the design and fabrication challenges of this "first of its kind" endeavor were extremely high risk.

The prime contractor for the personnel sphere construction is Southwest Research Institute (SwRI) in Texas. Design of the hull and material characterization of the titanium began in August 2005. With successful completion of the forging of the two hemispheres, stress relief of these hemispheres and the girth weld to produce the sphere, about 85% of the design and construction of the sphere has been completed. While the remaining tasks are lengthy, there is only one major technical risk (insert machining and welding) to be retired.

While the project has been technically successful, it has not been without its challenges in terms of cost and schedule.

2.0 Initial Schedule Considerations

Inherent in a developmental project of this type are delays in the schedule that cannot be scaled in the planning process and therefore, other than adding time to the schedule, cannot be mitigated in advance. Many of the engineering and construction processes necessary had not been developed, or needed to be significantly modified, to address the size and materials being used, specifically titanium alloy Ti 6Al-4V ELI. The required review by the classifying entity (American Bureau of Shipping) to ensure the safety of the human occupied sphere at 6500 meters has taken a significantly increased effort. The very high cost of raw materials – $1M for the titanium required for sphere forging alone – precluded manufacturing pre-production items that could be used for destructive testing to prove design or fabrication processes, and required stringent engineering efforts and sample items to be employed to validate the design and fabrication processes to avoid fatal errors during construction.

The construction risk plan focused on major technical risk mitigations: forging of the two hemispheres, stress relief after forging, electronic beam (EB) welding of the two hemispheres to create the final sphere, and the machining and EB welding of hatch, penetrator and window inserts. It was determined that the best mitigation to retire these risks and avoid destruction of materials as well as assure safety of the final product was to "measure thrice and cut once". Since schedule creep was not seen as a major risk when the project was first scoped, schedule mitigations were not considered critical, and additional "float" one might expect to see in a developmental project like this was not built into the initial schedule.

Another early consideration to the sphere schedule was cost. Again, as a developmental project, contracting with a fixed schedule and thus transferring the schedule risk for technical issues to the contractor would be cost and vendor prohibitive. It was acknowledged there were few organizations existing worldwide with the technical expertise and experience to execute this project. Imposing a fixed schedule would likely eliminate any contractor from accepting the task, increase cost, and could potentially lead to engineering and fabrication errors as schedule overtook fabrication errors.

3.0 Execution

From the beginning, delays were experienced that reflected the developmental nature of the project. Many of the analytical tools, like computer computations and modeling applied to the design, required far more time to execute than was initially allotted. Much of the material analysis relied on computations from a prior Navy project (the *SEA CLIFF* HOV that used a different Ti-alloy) that needed SwRI and ABS study and analysis. The complexity of the design and the lack of experience with a human occupied vehicle proposed to dive to 6500 meters required lengthy review by ABS. However, as these issues were experienced in late 2007, it was assumed that "float" built into the schedule for the forging, welding and machining would generate enough slack so that the expected delivery of February 2010 was still viable. As these delays occurred, the vendors selected for these processes (Ladish Forge, Bodycote Inc. and STADCO), while acknowledging they had yet to actually dedicate assets to the project, did not express concern about meeting schedule. As delays were experienced, the baseline schedule was modified and these delays were not tracked.

Figure 3.1 Two 36" hemisphere Ti alloy ingots and 1 insert ingot

As the sphere moved from design to construction, Ladish Forge, the contractor for the forging, became the major focus. The schedule was now dependent on their input. As they prepared for the forging, a critical process for which there was no mitigation for failure, their engineering and production team became more cautious. Technically, there were concerns about how the material (titanium alloy Ti 6Al-4V ELI which was not a common material used in this size forging)

would react to the stress of forging. The mitigation was for Ladish to execute additional analyses and reviews – this resulted in schedule slip. Scheduled plant shut downs and other work in the plant that were not accounted for in the SwRI baseline schedule, as well as extensive production planning efforts and delays in the tooling of the fabrication components, added to programmatic schedule stress.

In November of 2008, forging of two titanium hemispheres was successfully completed and the hemispheres were shipped to STADCO for machining and welding. This retired the first major technical risk in the construction of the 6500 meter personnel sphere. In December of 2008, as a result of these technical mitigations and programmatic delays, the schedule delivery date was re-baselined to June of 2010.

Figure 3.2 Forging of a hemisphere in June 2008

At the same time, the overall project had changed from sub-contracted vehicle construction to an in-house project incorporating the new personnel sphere into a significantly enhanced *Alvin*. As a result, the modifications required to the current vehicle would have a greater impact on the current operations, and the delivery of the sphere became part of the critical path for the entire project. Consequently, WHOI increased oversight of the sphere construction through weekly telecom reports on technical issues, monthly progress reports, and quarterly business reviews focused on cost and project management by SwRI.

The next major technical challenge was the joining of the two hemispheres to create a single sphere. STADCO was selected for this work because they were the only supplier responding to the SwRI RFP who could integrate the EB welding with the machining at one plant and as a single vendor. While a review of their history to meet schedule showed defects, their technical abilities and their cost far outweighed their scheduling deficiencies. At the time of execution of the contract (2007), it was determined technical and cost considerations outweighed possible schedule risk.

Work to date at STADCO has added to the delayed final delivery of the sphere to WHOI. Any "float" allotted in the initial schedule has been exhausted so that every day of delay at STADCO

is resulting in a delay in the delivery of the sphere to the next process. Technically, the machining and the welding of the sphere has been a challenging process. While EB welding has been used to join titanium in the past, the alloy of the 6500 meter sphere and its thickness has resulted in delays. Development of the girth weld procedures, design and fabrication of special tooling for machining, certifying of the welders for these procedures, generating and securing approval of test samples, and conducting material property tests are all technical challenges to completion of the machining and welding. To mitigate many of these challenges, additional analysis and review that was not planned has been required.

Figure 3.3 The sphere after a successful girth weld.

However, much of the delay has been programmatic in nature. Many of the critical items in the development of procedures and in generating designs for fixturing have not been done in parallel by the contractor. The focus of the contractor on this project has been diverted by other business that has higher return to the vendor. Finally, the oversight by SwRI was not focused on reduction of schedule risk, but on technical engineering challenges allowing programmatic issues to become second tier.

In August 2009, the next major technical milestone was retired. The girth weld has resulted in the successful joining of the two hemispheres and the results of the testing have shown the confidence placed in STADCO's technical abilities were well founded. However, it is apparent that oversight of both the primary contractor, SwRI, and their subcontractors must be heightened. The girth weld was completed approximately four months later than scheduled. As discussed below, this coupled with the Ladish delays caused us to re-baseline the schedule to completion.

4.0 The Path Forward

To accomplish the additional oversight and ensure delivery of the sphere in accordance with the proposed PDR schedule, WHOI has implemented a number of additional management tools to monitor progress on the sphere.

- To ensure SwRI is monitoring their subcontractor on a day-to-day basis, SwRI daily presence at the STADCO plant was implemented in June. This SwRI employee is to

monitor the daily progress of STADCO on the 6500 meter sphere, provide technical communications support, and report any anomalies in the activities at STADCO directly to the SwRI project manager. This presence will be continued until such time as WHOI is confident the major technical risks have been retired and that the follow on efforts at STADCO are not at risk.

- SwRI and STADCO have developed an integrated project schedule that has been approved by both senior management at SwRI and STADCO. It will not be changed without agreement of all parties, including WHOI. This schedule shows delivery of the sphere to WHOI on 03/23/2011, and final ABS classification approval occurring by 05/25/2011. (See Appendix A for the schedule and letters from SwRI and STADCO Vice Presidents confirming the schedule.)
- SwRI will continue weekly telecoms with WHOI on technical issues, but they will now include programmatic and schedule reviews.
- SwRI will now track and report to WHOI, every other week, on eight remaining major milestones leading to delivery and classification. These milestones are described in Appendix B and are:
    - First Insert Weld
    - STADCO Welding Activity – Other Inserts
    - Post Weld Stress Relief
    - Final Machining at STADCO
    - Hull Assembly, Component Testing and Hydro Preparation
    - Hydro Testing and Shipping
    - Hull Acceptance by WHOI
    - ABS Classing of Hull Assembly
- SwRI will continue to provide monthly reports to WHOI, but will enhance this reporting by adding cost and schedule to completion data.
- In addition to the quarterly business reviews, WHOI will periodically make unscheduled visits to primary contractors to review progress.
- Future contracts let by SwRI will require adherence to the integrated project schedule and include penalties and incentives for schedule performance. These contracting vehicles will be reviewed by WHOI before execution.

Implementation of these management tools and early mitigation of problems is already proving effective. We have experienced a minor schedule slip in Milestone 2 - Insert Weld Complete**.** The completion date has changed from 10/28/09 to 11/10/09 (9 working days). This was a result of a late start and increased duration for the assembly, integration, and functional verification of

the EB-welding sphere rotation system. Design and fabrication of the lathe, turning and insert welding fixture assemblies has also added to the delay. Immediately this delay was reported, mitigations were implemented that included:

- Direct engagement of STADCO's Vice President of Operations in the oversight and assessment of project performance and planning.
- Addition of dedicated staff to the project team (e.g., senior project management specialist and three mechanical engineers).
- Modification of the production plan to include rough machining of six insert holes (hatch, center 7-inch viewport, both 5-inch viewports and both penetration plates) instead of three, thereby reducing future risks associated with limited access of "high use" 5-axis gantry.
- Early "weld repair" of the girth weld, thereby retiring a future activity.
- Use of sub-contractors for preliminary set-up and integration testing of the new sphere rotation system.

Machining and EB welding of the remaining inserts are by no means "production line" activities. Although the processes associated with each insert weld activity are essentially identical, every subtask must be performed precisely and with intentionality.

That said, SwRI and STADCO are confident that efficiencies can and will be realized during the performance of Milestone 2 sub-tasks. These efficiencies will enable STADCO to recover schedule, completing Milestone 3 on or ahead of schedule.

While the construction schedule of the sphere has become a primary focus for WHOI management, the current schedule is considered realistic. Three of the four major technical risks involving fabrication of the sphere have been retired with progress on the fourth (first Insert Weld) being made daily. While past experience regarding schedule has not been adequate, we believe the heightened focus on schedule and the mitigations implemented recently will result in delivery as planned. This confidence is based not only on WHOI's increased oversight but also on the commitment of the senior management of SwRI and their current subcontractor, STADCO, to this schedule.

5.0 Cost

In the spring of 2005, WHOI began to prepare for the design and construction of the 6500 meter sphere to be used in the 6500m HOV project. As a partner in the development of the concept design used to generate the project, it was apparent that Southwest Research Institute was the single qualified source for completing the detailed design, and thus would be the single qualified source for designing the sphere.

Since the personnel sphere design had to be complete before the fabrication could begin, and because of the inherent risk associated with providing a completed design to another party for execution, it was decided to award both the design and fabrication efforts to SwRI. However, SwRI was to subcontract the fabrication effort on a competitive basis. Thus, the SwRI detail design would remain Contractor Furnished Information (CFI) and they would provide the completed, tested, and ABS classified personnel sphere to WHOI. Therefore, while SwRI would remain accountable for the successful delivery of the personnel sphere, WHOI would still enjoy the benefits of a competitive procurement.

In October of 2005, a contract was let to SwRI for the design and fabrication of the 6500 meter sphere. The contract vehicle consisted of two CLINS. CLIN I was for the design effort. CLIN II was for the construction of the sphere to be executed at WHOI's discretion after the completion of the detailed design. Due to the R&D nature of the effort, it was determined that the most cost-effective method was to share the risk of the development by using a cost plus fixed fee contract mechanism. The initial contract value was $1,578,861.

In late 2006, it became apparent the cost of the primary raw material for the construction of the sphere was escalating at a rate that could put the project in jeopardy. Between 2003 and 2006, the price of titanium alloy ingot quadrupled. To avoid the further derogation of the budget, WHOI executed the purchase of the bulk of the titanium needed for the forging of the sphere. In January of 2007, the contract was modified to allow for the purchase of two ingots of titanium increasing the contract value to $2,578,631.

At the same time, the design phase of the sphere was being completed. SwRI was asked to cost the construction (CLIN II) phase of the contract. As noted earlier, while the contract is cost plus fixed fee, SwRI's proposal for CLIN II was to be competitively bid and the costs of subcontracts were to be fixed by SwRI. Therefore, the cost plus agreement would apply only to the SwRI management of the construction and relevant engineering. After an extensive review of the CLIN II proposal, in April of 2007, a modification to the contract was instituted executing the CLIN II SwRI proposal. This increased the contract value to $7,001,152.

By the spring of 2008, it was apparent that the delivery schedule upon which CLIN II was based was not executable. As a cost plus contract, each delay in the final delivery of the sphere results in a corresponding increase in cost for additional management of the construction. In addition, previously unplanned reviews by NAVSEA and ABS (example: supplemental CREEP analysis), as well as corresponding design analysis, increased the cost of the design beyond the budgeted amount. Additional stress relief required by ABS at the sphere Preliminary Design Review was also not anticipated or budgeted in the CLIN II proposal. Finally, due to concerns about construction oversight, WHOI had implemented additional management attention and reporting that were not included in the original contract estimates. These unplanned actual and anticipated

costs associated with design, construction delays and oversight were put together and added to the contract in a modification executed in August of 2008 of $1,297,627 making the current value of the contract $8,298,779.

As the delivery of the sphere moved into the critical path of the project and construction delays were realized, additional SwRI oversight of the subcontractors was implemented (see discussion above.) This unplanned schedule mitigation has increased the cost of construction management. Extension of the delivery date to WHOI will also require continued SwRI management attention that was unanticipated in the previous modifications. Finally, the machining and welding contractor has claimed changes to the original scope of work that was presented to them for bidding of their fixed price contract with SwRI. While negotiations are underway concerning the scope of these claimed changes, it is anticipated a certain amount of the claim is valid and will result in additional cost to SwRI. As our agreement with SwRI is cost plus, these costs will flow to WHOI.

As a result of freezing the schedule and continued increased oversight by WHOI of SwRI and its subcontractors, the cost of the completed 6500 meter sphere will not exceed $9,500,000. It is anticipated that a contract modification to address these issues will be presented to WHOI in November 2009.

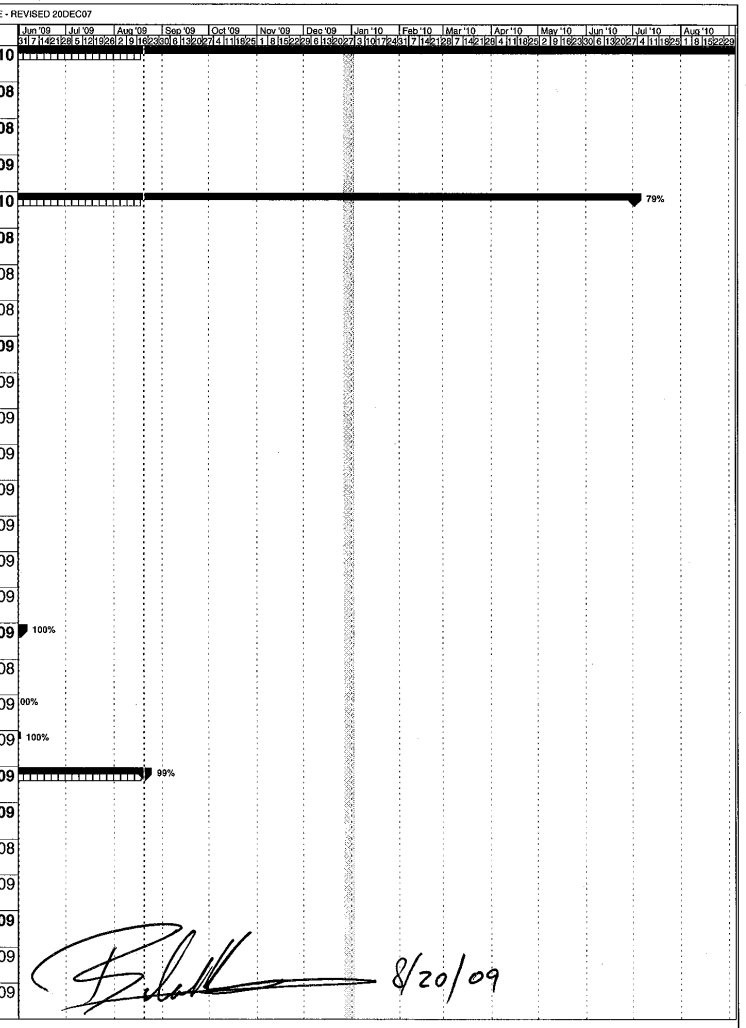
6.0 Conclusion

The personnel sphere is now on the critical path for the project. Our original intention was to begin the construction in October 2010 when the current HOV *Alvin* is scheduled to begin its regular overhaul. Delivery of the sphere in March 2011 would result in a long period of time without a human-occupied deep submergence vehicle for use by the U.S. community, which is not acceptable. Hence, our proposed plan for the construction of the A-4500 HOV is to begin the project on 1 April 2011, thereby keeping *Alvin* in service until that time (*Alvin's* NAVSEA certification runs out in May 2011). The *A-4500 HOV Construction Plan* timeline shows that assembly of the vehicle begins at the beginning of Month 4 (i.e. July 2011), and hence that is the deadline by which the personnel sphere would be needed so as not to delay the project. With aggressive monitoring of the project, WHOI will try to ensure that the March 2011 delivery date is maintained.

Appendix A. Timeline for Completion of the Sphere and Commitment Letters from SwRI and STADCO

RHOV PERSONNEL SPHERE MACHINING & WELDING SCHEDULE - REVISED 20DEC07

ID	Task Name	Duration	Start	Finish
1	**STADCO RHOV Hull Contract**	**803.5 days**	**Tue 7/31/07**	**Fri 9/17/10**
2	**RHOV Hull Machining-Welding - STADCO**	**119 days**	**Tue 7/31/07**	**Fri 1/11/08**
16	**Machining-Welding Tooling**	**240 days**	**Mon 8/20/07**	**Fri 7/18/08**
20	**Weld Procedures and Qualifications**	**407 days**	**Mon 8/20/07**	**Tue 3/10/09**
44	**EB Weldments**	**676.5 days**	**Mon 11/12/07**	**Fri 7/2/10**
46	**Hemispheres Delivery from Ladish**	**3 days**	**Mon 11/17/08**	**Thu 11/20/08**
46	Receive Hemis from Bodycote	0 days	Mon 11/17/08	Mon 11/17/08
47	STADCO Performs Hemisphere Dimensional Check	3 days	Tue 11/18/08	Thu 11/20/08
48	**Hemisphere Machining**	**86 days**	**Mon 1/12/09**	**Mon 5/11/09**
49	OD Machine Aft Hemi and Check OOS	12 days	Mon 1/12/09	Tue 1/27/09
50	Cut Access Hole in Aft Hemi and Check OOS	2 days	Wed 1/28/09	Thu 1/29/09
51	OD Machine Fwd Hemi and Check OOS	7 days	Fri 1/30/09	Mon 2/9/09
52	ID Machine Aft Hemi	44 days	Tue 2/10/09	Fri 4/10/09
53	ID Machine Fwd Hemi	14 days	Mon 4/13/09	Thu 4/30/09
54	Final Machine OD Aft and Fwd Hemis	6 days	Fri 5/1/09	Fri 5/8/09
55	Measure Hemi OD and ID Sphericity - Laser Tracking	1 day	Mon 5/11/09	Mon 5/11/09
56	**Component Machining**	**140 days**	**Mon 11/17/08**	**Mon 6/1/09**
57	Receive Component Forgings from Ladish	0.1 days	Mon 11/17/08	Tue 11/18/08
58	Prepare Program for Insert Machining	75 days	Tue 2/10/09	Mon 5/25/09
59	STADCO Machine 8 Inserts per SwRI Drawings	60 days	Tue 3/10/09	Mon 6/1/09
60	**EB Girth Weld**	**434 days**	**Mon 12/24/07**	**Thu 8/20/09**
61	**Girth Weld Fixture**	**335 days**	**Mon 12/24/07**	**Fri 4/3/09**
62	Fixture Design	220 days	Mon 12/24/07	Fri 10/24/08
63	Fixture Fabrication	130 days	Mon 10/6/08	Fri 4/3/09
64	**X-Ray Fixture**	**102 days**	**Mon 11/17/08**	**Tue 4/7/09**
65	Design	72 days	Mon 11/17/08	Tue 2/24/09
66	Fabrication	30 days	Wed 2/25/09	Tue 4/7/09



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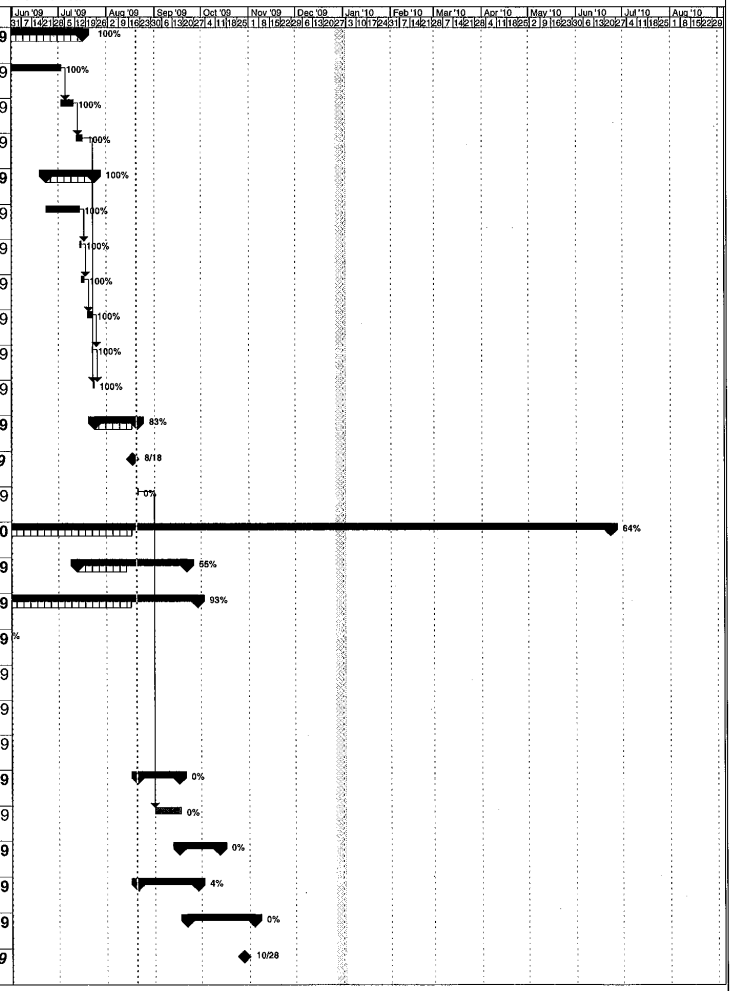
ID	Task Name	Duration	Start	Finish
67	**Girth Weld Preparations**	**41 days**	**Thu 5/21/09**	**Thu 7/16/09**
68	Conduct Girth EB Weld Start-Stop Tests	31 days	Thu 5/21/09	Thu 7/2/09
69	Perform Girth Start-Stop RT and UT Inspections	6 days	Fri 7/3/09	Fri 7/10/09
70	Perform Photomicrograph Evaluation (SwRI-Westmoreland)	4 days	Mon 7/13/09	Thu 7/16/09
71	**Girth Welding**	**23.5 days**	**Tue 6/23/09**	**Fri 7/24/09**
72	Blackline to create X-Ray Baseline	16 days	Tue 6/23/09	Tue 7/14/09
73	Assemble Hemispheres in Girth Weld Fixture	1 day	Wed 7/15/09	Wed 7/15/09
74	Girth Rotary Fixture Check-out	2 days	Thu 7/16/09	Fri 7/17/09
75	Prepare, Clean & Protect Girth Joint	3 days	Mon 7/20/09	Wed 7/22/09
76	Fit-up and GTAW Tack Hemis (ABS Witness)	0.5 days	Thu 7/23/09	Thu 7/23/09
77	Perform Girth Weld (ABS Witness)	1 day	Thu 7/23/09	Fri 7/24/09
78	**Post-Weld Inspection - Girth**	**19.5 days**	**Fri 7/24/09**	**Thu 8/20/09**
84	***Milestone 1- Girth EB-Weld Activity Complete***	***2 days***	***Tue 8/18/09***	***Wed 8/19/09***
85	Install Laser Reference Points on each Hemisphere	1 day	Thu 8/20/09	Fri 8/21/09
86	**EB Weld Insert Reinforcements (8 Total)**	**669.5 days**	**Mon 11/12/07**	**Wed 6/23/10**
87	**Insert Hole Machining Fixture (aka Lathe Fixture)**	**50 days**	**Mon 7/13/09**	**Mon 9/21/09**
92	**Insert Weld Fixture**	**490 days**	**Mon 11/12/07**	**Mon 9/28/09**
101	**Sphere Turning Fixture (Vert. to Horiz.)**	**23 days**	**Mon 4/13/09**	**Wed 5/13/09**
102	Determine Need	8 days	Mon 4/13/09	Wed 4/22/09
103	Fixture Design	5 days	Thu 4/23/09	Wed 4/29/09
104	Fixture Fabrication and Check-out	10 days	Thu 4/30/09	Wed 5/13/09
105	**Insert Holes Machining - 3 Holes (SwRI Approval)**	**18 days**	**Fri 8/21/09**	**Wed 9/16/09**
109	Perform OOS - Laser Tracking -In-Process (INFO ONLY)	12 days	Tue 9/1/09	Thu 9/17/09
110	**SwRI Material Property Testing**	**18 days**	**Thu 9/17/09**	**Mon 10/12/09**
114	**Insert Weld Preperations**	**26 days**	**Fri 8/21/09**	**Mon 9/28/09**
119	**EB Weld First 5-Inch Viewport Reinforcement**	**31.5 days**	**Tue 9/22/09**	**Wed 11/4/09**
133	***Milestone 2 - First Insert EB-Weld Activity Complete***	***0 days***	***Wed 10/28/09***	***Wed 10/28/09***



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ID	Task Name	Duration	Start	Finish
134	**EB Weld Second 5-Inch Viewport Reinforcement**	**20 days**	**Thu 10/29/09**	**Mon 11/30/09**
147	**EB Weld Center 7-Inch Viewport Reinforcement**	**17.8 days**	**Tue 12/1/09**	**Tue 1/5/10**
160	**Insert Hole Machining - 4 Holes (SwRI Approval)**	**14.2 days**	**Tue 1/5/10**	**Mon 1/25/10**
163	**EB Weld First Penetrator Reinforcement**	**20 days**	**Tue 1/26/10**	**Mon 2/22/10**
176	**EB Weld Second Penetrator Reinforcement**	**20 days**	**Tue 2/23/10**	**Mon 3/22/10**
189	**EB Weld Second 7-Inch Viewport Reinforcement**	**20 days**	**Tue 3/23/10**	**Mon 4/19/10**
202	**EB Weld Third 7-Inch Viewport Reinforcement**	**20 days**	**Tue 4/20/10**	**Mon 5/17/10**
215	**EB Weld Hatch Reinforcement**	**25.5 days**	**Tue 5/18/10**	**Wed 6/23/10**
230	**Hull Weld Repairs and Inspection**	**7 days**	**Wed 6/23/10**	**Fri 7/2/10**
231	Perform Remaining Minor-Weld Repairs	2 days	Wed 6/23/10	Fri 6/25/10
232	UT Inspect All Insert Welds & Review All X-Rays (ABS Witness)	3 days	Fri 6/25/10	Wed 6/30/10
233	PT Inspection of All Welds & Approve NCRs (ABS Witness)	2 days	Wed 6/30/10	Fri 7/2/10
234	**Hatch Assembly - Machining and GTAW**	**130 days**	**Tue 6/2/09**	**Fri 12/4/09**
240	**Hull - Lugs GTAW**	**74 days**	**Wed 11/11/09**	**Tue 3/9/10**
246	***Milestone 3 - All STADCO Welding Activity Complete***	***0 days***	***Fri 7/2/10***	***Fri 7/2/10***
247	**Post Weld Stress Relief**	**18 days**	**Fri 7/2/10**	**Thu 7/29/10**
253	***Milestone 4 - Post-Weld Stress Relief Complete***	***0 days***	***Wed 7/28/10***	***Wed 7/28/10***
254	**Final Machining at STADCO**	**35 days**	**Thu 7/29/10**	**Fri 9/17/10**
259	***Milestone 5 - STADCO Complete - SwRI Accept Hull***	***0 days***	***Fri 9/17/10***	***Fri 9/17/10***
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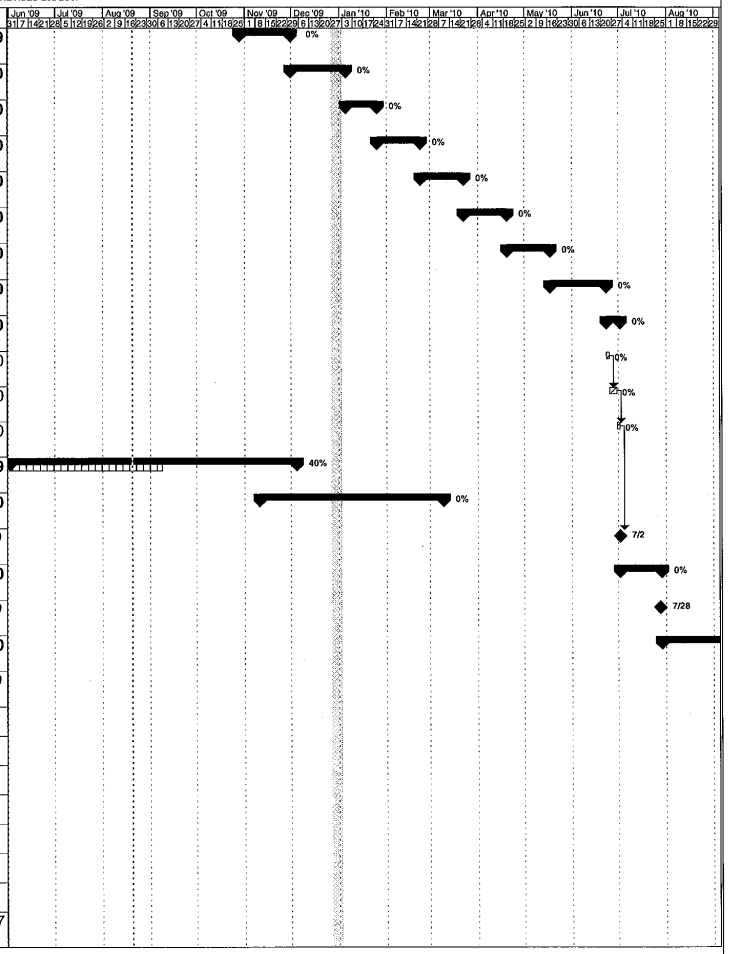
267	Perform Major Weld Repairs, X-Ray and OOS check	0 days	Tue 7/31/07	Tue 7/31/07



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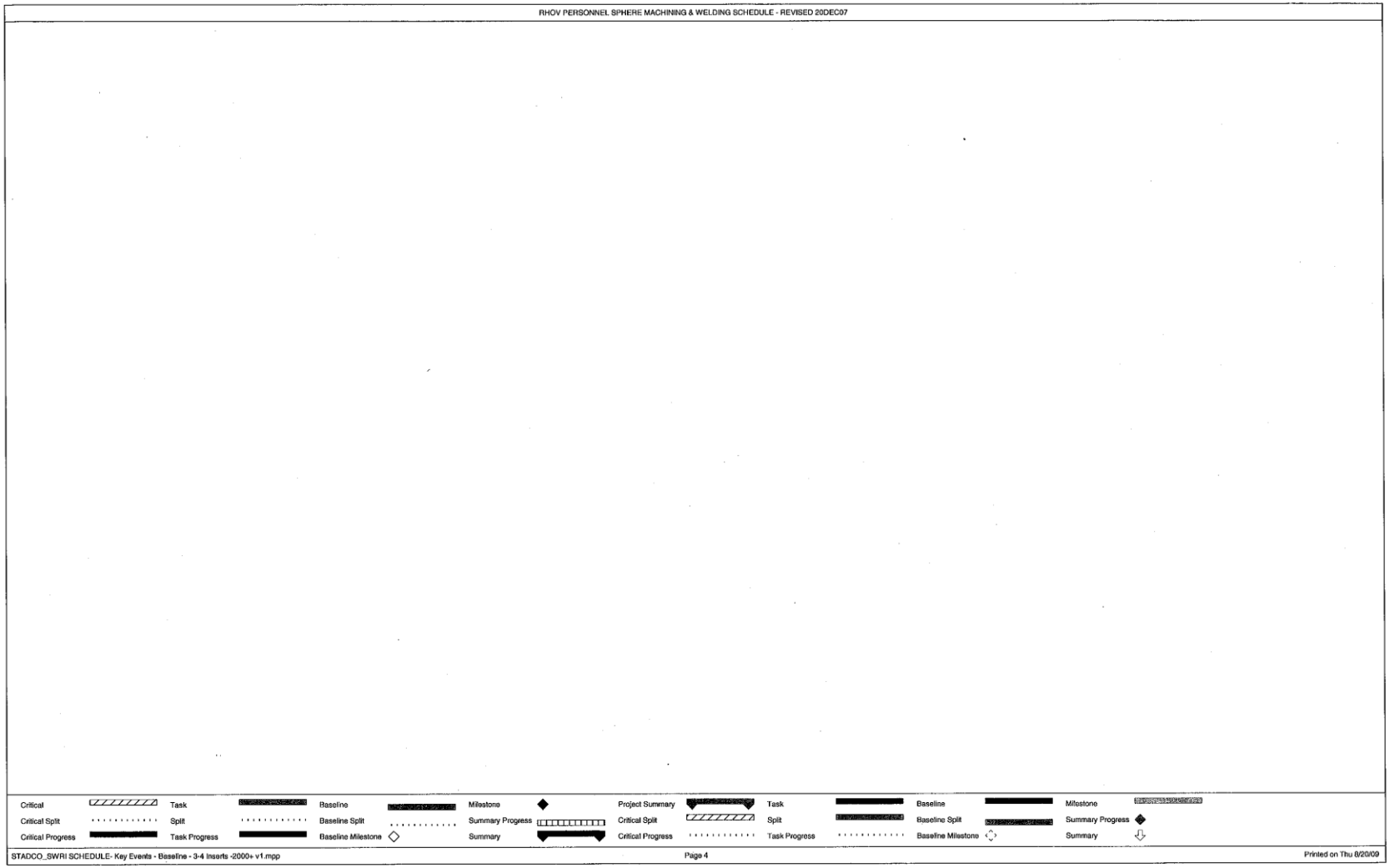
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Project Summary
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Critical Split
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Summary Progress
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Mechanical & Materials Engineering Division
August 24, 2009

Woods Hole Oceanographic Institution
86 Water Street
Woods Hole, Massachusetts 02543-1041

Attention: Mr. Dennis Fox, Procurement Director

Subject: Southwest Research Institute® Project 18.11975 "Replacement HOV Personnel Sphere Design and Fabrication Program" for Woods Hole Oceanographic Institution (WHOI)

Dear Mr. Fox:

I am pleased to write this letter to assure you of Southwest Research Institute's (SwRI) commitment to overall performance for the RHOV Hull Project. As promised during your July 22, 2009 visit to SwRI, the RHOV project team and my managers are concentrating their efforts on improving project schedule performance. This is being accomplished in concert with maintaining Technical Excellence and controlling Project Costs.

Development of the new 6500 msw hull, with its design and fabrication challenges, clearly qualifies as a "first of a kind" endeavor. As a result, it was understood prior to project award that hull design and fabrication were high risk activities. The technical successes realized have been the direct result of intense risk identification, abatement and mitigation efforts. SwRI remains committed to continuing these efforts now and through the delivery of the new 6500 msw personnel sphere.

The Fabrication Schedule for the RHOV Personnel Sphere was refined in your presence at STADCO on 19 and 20 August 2009. Consensus was achieved regarding Milestone dates and associated technical risk levels. The following Milestone dates and Risk Assessment values (1 = minimal; 5 = major) were developed.

- Milestone 1 – Girth Weld Complete – 08/19/2009 (Complete)
- Milestone 2 – First Insert Weld Complete – 10/28/2009 – Risk Assessment 4
- Milestone 3 – STADCO Welding Complete – 06/25/2010 – Risk Assessment 3
- Milestone 4 – Post-Weld Stress Relief – 07/22/2010 – Risk Assessment 1
- Milestone 5 – Hull Final Machining Complete – 09/02/2010 – Risk Assessment 1
- Milestone 6 – Hull Assembly, Component Testing and Hydro Test Prep – 02/02/2011 – Risk Assessment 1

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- Milestone 7 – Hull Assembly Hydrostatic Testing and Shipment – 03/07/2011 – Risk Assessment 1
- Milestone 8 – WHOI Hull Acceptance – 03/23/2011 – Risk Assessment 1
- Milestone 9 – ABS Classing of Hull Assembly – 05/25/2011 – Risk Assessment 1

Milestone schedule and risk assessment have been reviewed and discussed in detail by SwRI. As previously stated, this is a high risk project: it is advancing "the state-of-the-art" in the design, engineering, forging, forming, machining and EB-welding of large titanium alloy pressure vessels. Completion of Milestone 1 retired several major technical risks, but not all. Appropriately, our team will continue to 1) apply "best practice"; 2) assign our best personnel, and 3) exercise due diligence. If a major non-conformance result in spite of these efforts, it is likely that significant delays would ensue.

SwRI recognizes the new Milestone completion dates and their associated risks, and accepts the management challenge they impose. This commitment is shared by our team member STADCO (see attached letter). SwRI will continue to manage fabrication and testing efforts, anticipate and identify issues and "threats" and to respond appropriately.

Southwest Research Institute appreciates the opportunity provided by Woods Hole Oceanographic Institute for this very important and high profile program. SwRI remains committed to work closely with WHOI to assure success of the hull project and vehicle program.

Please call me (210) 522-2384 if you have any questions. Please direct any detailed project questions to BK Miller.

Sincerely,

Danny M. Deffenbaugh
Vice President
Mechanical & Materials Engineering Division

BKM/prb
Attachments

C:\Documents and Settings\pbrinkley\My Documents\Word\Active Projects\18.11975 - WHOI\Correspondence\Letter of Intent to WHOI dtd 8-24-09.doc

cc: H. Burnside
T. Fey
BK Miller
J. Henkener
D. Gohmert
C. Brown

Bret Matta
Vice President, Contracts & Programs

STADCO
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August 21, 2009

BK Miller
Program Manager
Marine Structures and Engineering
SwRI, Bldg71/Rm225

Subject: Program Level of Support

Reference: RHOV Project

As you are aware STADCO has an extensive and successful history of Electron Beam welding of Titanium components – including flight critical military aircraft assemblies, commercial engine components, and numerous other projects. We repeatably weld Titanium product up to 3" thick, and as you know STADCO has welded and successfully passed the RHOV girth-weld operation.

In addition to this critical EB weld milestone we recognize that we have additional critical EB welds to perform which have a high degree of development and complexity associated. To support the complex welding we are taking the appropriate and required steps to best provide a successful product and program schedule. Attached is the current project schedule that has been developed and agreed by the STADCO team. We believe that this is an achievable schedule although it is recognized by all that this is a best effort based upon the significant development activities associated with the project. We have initiated a full comprehensive high visibility action item matrix that includes all elements related to the project schedule which will be reviewed with the management team on a regular basis. This will be managed with the proactive look ahead to ensure that actions and details are conducted to support the best delivery possible.

STADCO is confident that we can meet the attached project schedule. We have a self directed team in place that is very familiar with the project and the program requirements. STADCO has recently upgraded our EB Chamber and X-ray equipment that has resulted in operational and through-put improvement. In addition we have acquired additional 5 axis machining equipment that will help mitigate risk to the program.

Upon your review should you have any questions or comments please contact the undersigned.

Best regards,

Bret Matta

Appendix B. Sphere Construction Progress Report

(As of 09/30/09)

Milestone 1 – Girth EB-Weld Activity – Complete 08/19/09

Milestone 2 – First Insert Weld: Risk Assessment 4/Date: Original 10/28/09 Current 11/10/09

RISK ASSESSEMENT – There are a number of processes that are developmental in nature during this milestone; thus technical risk is higher than with the following milestones. While EB welding was successful for the girth weld, the first vertical weld conical surface presents different challenges. A significant area of risk is maintaining sphere orientation throughout machining and welding. This will require particular attention to the rigging/handling of the 11,000 lbs sphere as it travels from one operation to the next. Finally, there is a programmatic risk associated with the X-ray of the weld as the methods used for the girth are not applicable with the conical surface.

MITIGATIONS – The schedule has been adjusted to allow for some delays in process due to engineering and rigging requirements. Building on the experience of the girth weld has mitigated many parameter development issues realized in the girth weld. The SwRI engineer remains on-site to monitor progress and assist with engineering efforts associated with the required fixtures. Bead-on-Plate testing is complete. Coupon welding is next, followed by UT/RT inspection and material properties testing (Westmorland). The order of cut-out machining and insert welding has been updated. Assembly and functional testing of the insert weld fixture is the "High Risk" key event (was 9/28/09; New ETC 10/15/09) on the path to Milestone 2 (two) completion.

SUB-TASK

1. Insert Hole Machining Fixture - Risk 1/Percent Complete 95%/Date: Original 09/22/09 Current 10/16/09
2. Weld Fixture Fabrication - Risk 4/Percent Complete 80%/Date: Original 09/28/09 Current 10/15/09
3. Insert Hole Machining (Original 3; Final 6) - Risk 2/Percent Complete 100%/Date: Original 09/16/09 Final 09/23/09

   NOTE: Late completion of the machining program, delayed access to Gantry Machine, cancellation of weekend shift and power failure resulted in 6-Working Day delay in completion of rough machining.

4. Machine of Holes and Insert Weld Preparation - Risk 3/Percent Complete 50%/Date: Original 09/28/09 Current 10/12/09
5. EB Weld Viewport Reinforcement - Risk 4/Percent Complete 0%/Date: Original 10/28/09 Current 11/10/09

Milestone 3 – All STADCO Welding Activity: Risk 3/Date 06/25/10

COMMENT – Subtask dates will remain unchanged until Milestone 2. Schedule impacts are fully understood.

RISK ASSESSMENT – While there is experience from the first insert weld and corresponding decrease technical risk, the weight and balance of the sphere will change with each removal of materials. Once material is removed, the balance and weight of the sphere must be analyzed, and fixtures and rigging must be adjusted to allow for the new center of gravity of the sphere. After the weld, the same process must be undertaken to account for the additional weight and changes in center of gravity due to the insert, and adjustments made to fixtures and rigging before the next cut can be started. The processes of cutting, welding and X-ray also must compete for assets at the correct time to ensure an appropriate flow of work with other jobs in the shop.

MITIGATIONS – As before, the schedule reflects some additional time allotted to processes that have higher programmatic risk than the process would dictate. This should mitigate schedule deterioration due to workflow issues. While not yet discussed, we will pursue "purchasing" time on machines to ensure other processes do not interfere with production flow.

SUB-TASK

1. EB Weld Second 5-Inch Viewport Reinforcement - Risk 3/ Percent Complete 0%/Date: 11/30/09
2. EB Weld Center 7-Inch Viewport Reinforcement - Risk 3/Percent Complete 0%/Date: 12/29/09
3. Insert Hole Machining - 4 Holes - Risk 2**/ Percent Complete 0%/Date: 1/19/10
4. EB Weld First Penetrator Reinforcement - Risk 3/Percent Complete 0%/Date: 02/16/09
5. EB Weld Second Penetrator Reinforcement- Risk 3/Percent Complete 0%/Date: 03/16/09
6. EB Weld Second 7-Inch Viewport Reinforcement - Risk 3/Percent Complete 0%/Date: 04/13/09
7. EB Weld Third 7-Inch Viewport Reinforcement - Risk 3/Percent Complete 0%/Date: 05/11/09

8. EB Weld Hatch Reinforcement - Risk 3/Percent Complete 0%/Date: 06/16/09
9. Hull Weld Repairs Inspection – Risk 1/Percent Complete 0%/Date: 06/25/09
10. Hatch Assembly - Machining and GTAW - Risk 1/Percent Complete 0%/Date: 12/04/09
11. Hull - Lugs GTAW - Risk 1/Percent Complete 0%/Date: 03/03/10

Milestone 4 – Post Weld Stress Relief: Risk 1/Date 07/22/10

RISK ASSESSMENT – Risk is associated with performance of stress release vendor adherence to schedule.

MITIGATION – The order for stress relief has yet to be released. Contract will recognize schedule using penalties/incentives for adherence to schedule. As before, the schedule reflects some additional time allotted to processes that are have higher programmatic risk than the process would dictate.

SUB-TASK

1. SwRI Sphericity Check - Risk 1/Percent Complete 0%/Date: 06/28/10
2. Wall Colmonoy Perform Vacuum Stress Relief – Risk 1/Percent Complete 0%/Date: 07/16/10
3. SwRI Post Stress Relief Sphericity Check – Risk 1/Percent Complete 0%/Date: 07/22/10

Milestone 5 – Final Machining at STADCO: Risk 1/Date 09/02/10

RISK ASSESSMENT – Technical risk associated with machining will be retired by this point. However, some programmatic risk will still be realized.

MITIGATION - As before, the schedule reflects some additional time allotted to processes that have higher programmatic risk than the process would dictate.

SUB-TASK

1. Final Machine Sphere & Fit Check Windows - Risk 1/Percent Complete 0%/Date: 08/12/10
2. Complete Final Inspection-Documentation - Risk 1/Percent Complete 0%/Date: 08/26/10

Milestone 6 - Hull Assembly, Component Testing and Hydro Prep: Risk Assessment 2/Date 02/02/11

RISK ASSESSMENT – Risk in this area are to schedule resulting from inputs from sources outside the control of SwRI. There are reports and analysis that must be completed by WHOI and ABS before some of the work in this area can begin.

MITIGATION – WHOI has been given finite deadlines for their input. SwRI is working with ABS to pre-load information to expedite analysis. Most of the operations in this milestone occur at SwRI. Their focus is on developmental projects and the sphere is not competing with "production" work. They will be able to assign assets as work schedules are more flexible.

SUB-TASK

1. Material Purchase – Risk 1/Percentage Complete 54%/Date: 12/10/09
2. Frame Lugs and Hardware Attachments – Risk 3/Percentage Complete 0%/Date: 01/25/10
3. Stud Welding – Risk 2/Percentage Complete 75%/Date: 09/22/10
4. Test Procedures Risk 2/Percentage Complete 50%/ Date: 08/23/10
5. Assembly and Structural Testing – Risk 1/Percentage Complete 0%/Date: 10/13/10
6. Pre Hydro Assembly & Preparation Risk 1/Percentage Complete 0%/ Date: 12/08/10

Milestone 7 – Hydro Testing and Shipping: Risk Assessment 1/Date 03/07/11

RISK ASSESSMENT - Risk is associated with performance of hydro test vendor adherence to schedule.

MITIGATION – The order for hydro testing has yet to be released. Contract will recognize schedule using penalties/incentives for adherence to schedule. As before, the schedule reflects some additional time allotted to processes that are have higher programmatic risk than the process would dictate.

SUB-TASK

1. Hull Hydro Test - Risk 1/Percentage Complete 0%/Date: 02/18/2011
2. Penetrator Test - Risk 1/Percentage Complete 0%/Date: 02/28/201
3. Ship to WHOI - Risk 1/Percentage Complete 0%/Date: 03/07/2011

Milestone 8 – Hull Acceptance: Risk Assessment 1/Date 03/03/11

RISK ASSESSMENT – Weather may affect cleaning and preparations

MITIGATION – None

SUB-TASK

1. Hull Receipt, Inspection and Turnover – Risk 1/Percentage Complete 0%/Date: 03/23/2011

Milestone 9 – ABS Classification; Risk Assessment 1/Date 05/25/11

RISK ASSESSMENT – There is a risk ABS will not allow WHOI to manipulate (work on) the sphere until it has completed the classification.

MITIGATION – SwRi is requesting clarification as to what, if any processes WHOI would not be able to perform before classification s complete.

SUB-TASK

1. ABS Classification Submission – Risk 1/Percentage Complete 0%/Date: 04/06/2011
2. ABS Classification – Risk 1/Percentage Complete 0%/Date: 05/19/2011