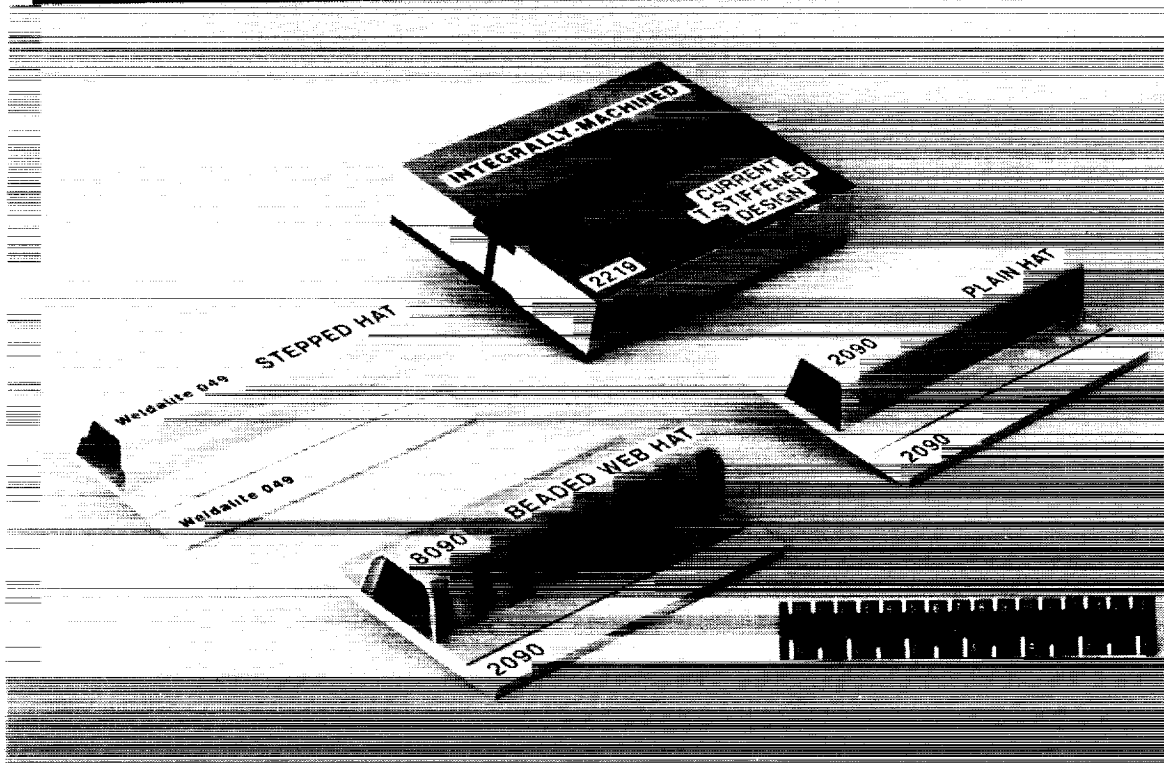


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**BUILT-UP Al-Li STRUCTURES FOR CRYOGENIC TANK
AND DRY BAY APPLICATIONS**

W. Barry Lisagor
NASA Langley Research Center

SPF TECHNOLOGY FOR Al-Li BUILT-UP STRUCTURES



ADVANCED LAUNCH SYSTEM

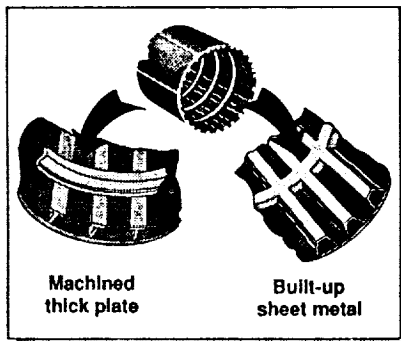
Structures, Materials & Manufacturing

Built-up structures for ALDP #3104

Responsible Org: NASA/LaRC

Execution: LaRC/Rockwell/GD

Funding (\$M):



	4.9	0.4	0.1	1.5	2.0		8.9
FY	Prior	90	91	92	93	ΔTC	Total
Built-up panel concepts defined		(1) complete					
SPF and RSW parameters established			(2)				
Test stiffener and column buckling panels						(3)	
Materials characterization and properties						(4)	
Fab and test subscale barrel section						(6)	

Objectives:

- Demonstrate the cost benefits of built-up cryotank & dry bay structures
- Conventional Al alloys
- Low density Al-Li alloys
- Evaluate alternative low-cost stiffener and joining concepts

Payoffs:

- Lower weight/lower system costs
- Significant reduction in tank costs
 - Reduced scrap rate/lower material costs
 - Reduction in major machining costs
- Avoid thick plate issues

TASK #3104 BUILT-UP STRUCTURE FOR CRYOTANKS

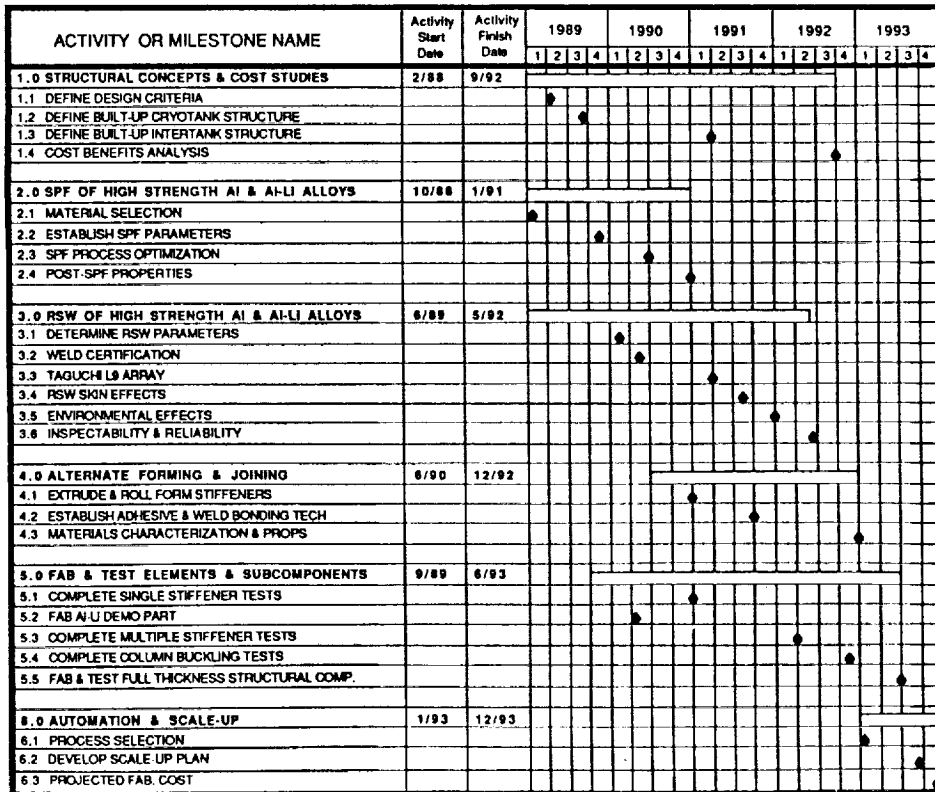
Program Participants

Organization

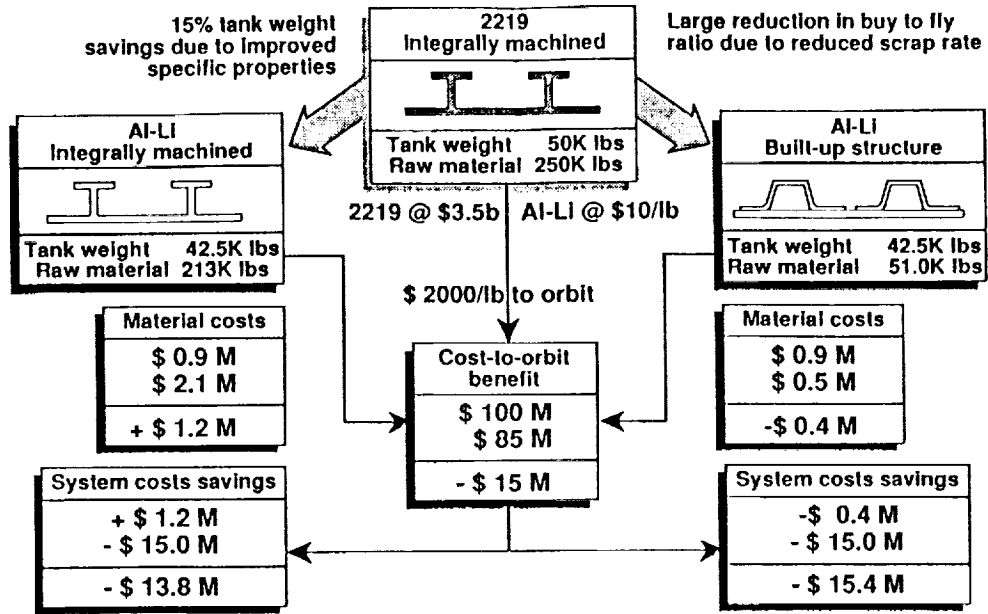
Key activity

- NASA -LaRC
 - Martin Marietta
 - Reynolds
- Rockwell
- General Dynamics
- SPF/RSW
 - Alternate forming & joining methods
 - SPF of chemistry modified Weldalite™
 - Weldalite stiffener extrusions
- SPF of Al & Al-Li alloys
- RSW of Al & Al-Li alloys

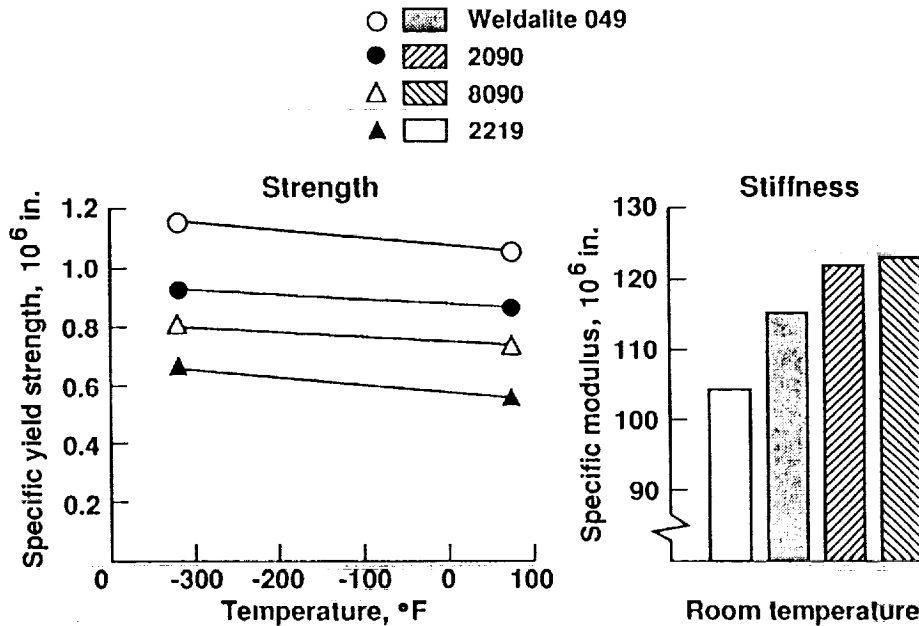
ADP TASK #3104 BUILT-UP ALUMINUM CRYOTANKS



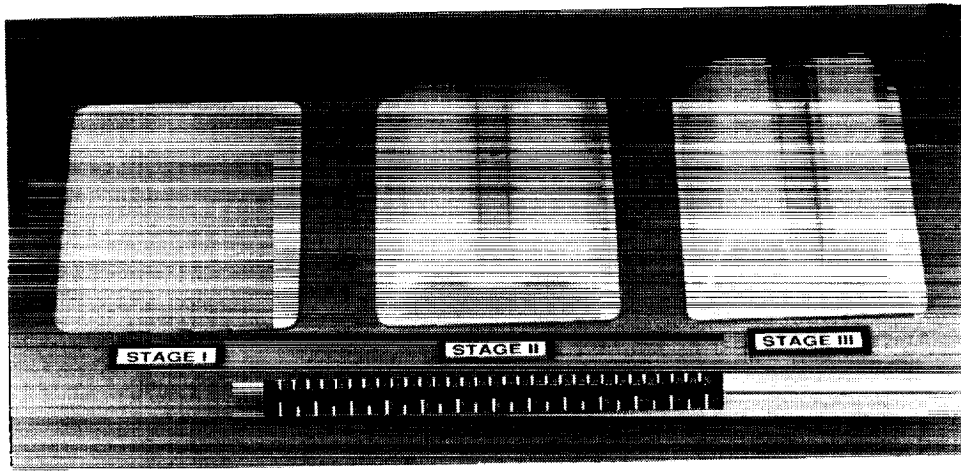
BENEFITS OF USING AL-LI ALLOYS FOR CRYOGENIC TANKS



SPECIFIC PROPERTIES VERSUS TEMPERATURE FOR SELECTED AL ALLOYS IN T8 TEMPER



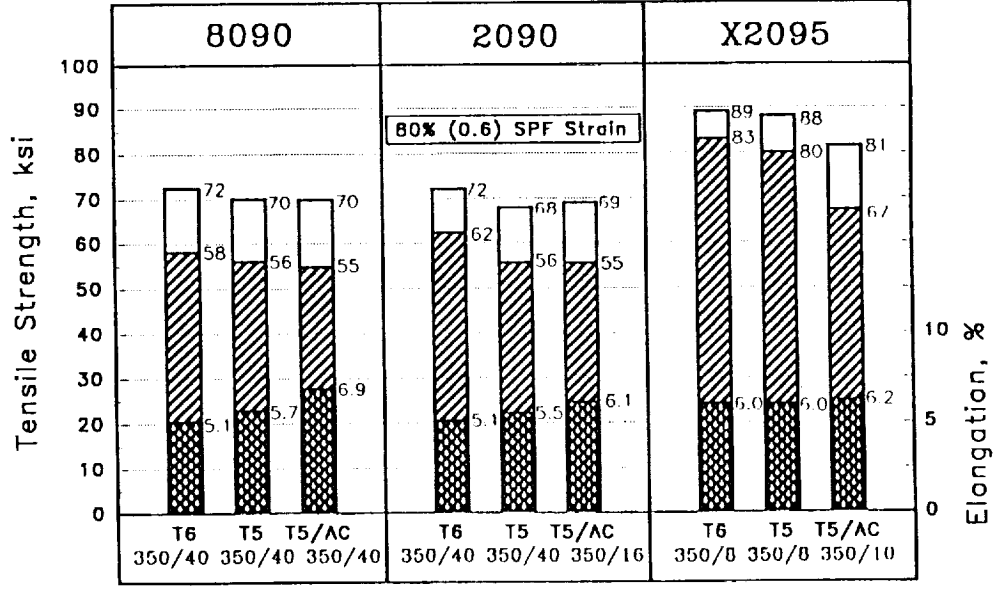
EXPERIMENTAL VERIFICATION OF SUPERPLASTIC FORMING PROFILE



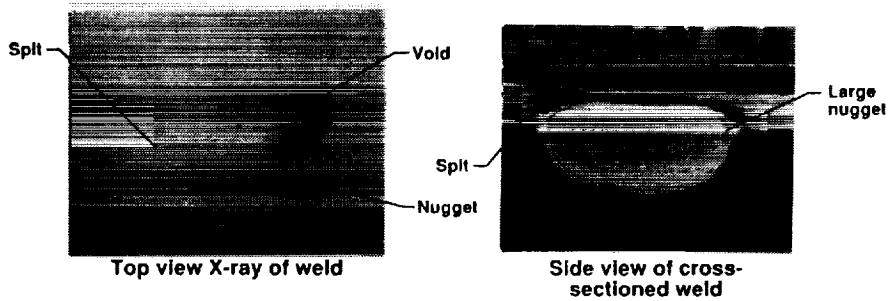
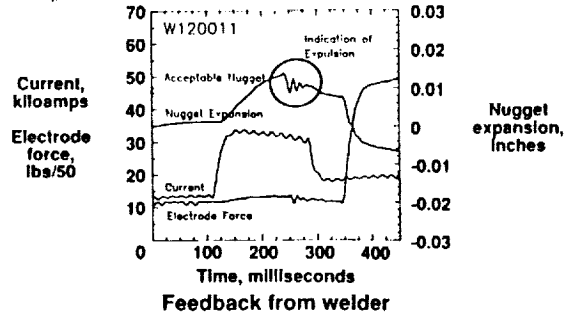
OPTIMUM POST-SPF PROPERTIES OF AL-LI ALLOYS

Legend :
 [White Box] Ultimate Strength
 [Diagonal Lines] Yield Strength
 [Checkered Box] Elongation

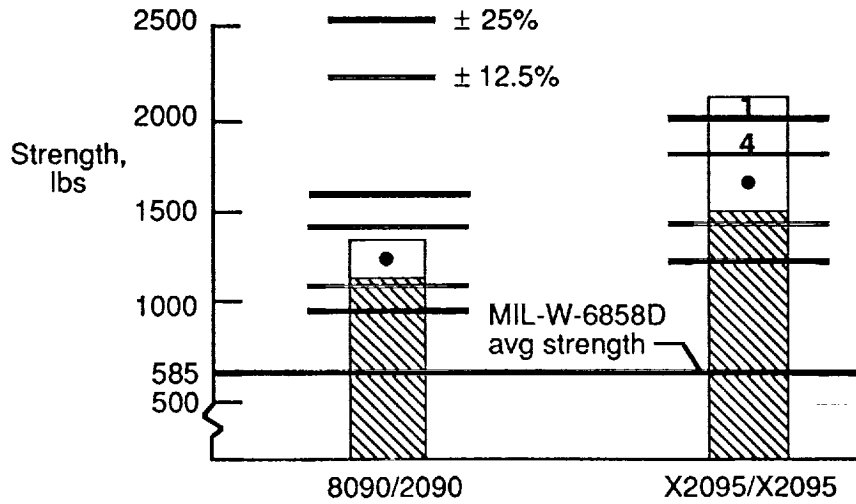
Considerations :
 (i) Maximum Strength (Under-aged)
 (ii) Adequate Ductility ($\geq 5\%$)
 (iii) Practical Aging Time (≤ 40 hrs)



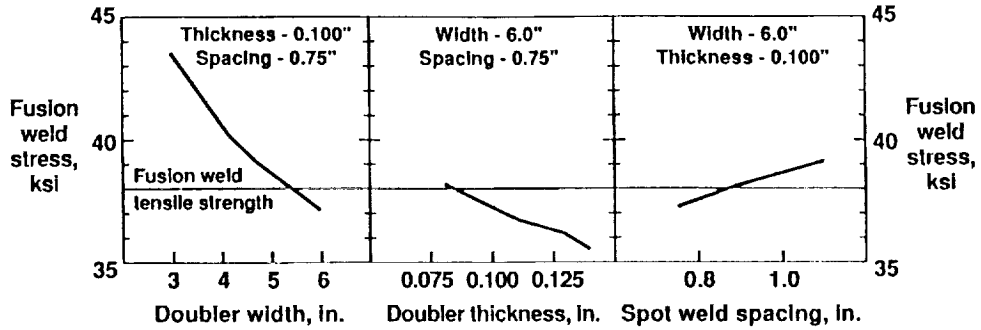
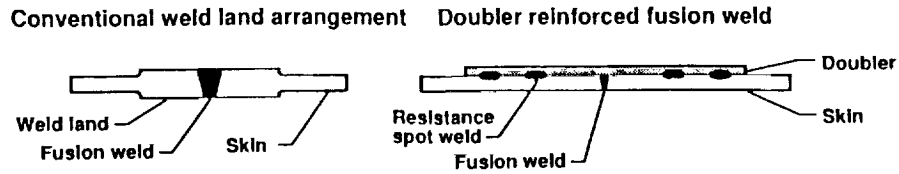
CHARACTERIZATION OF RESISTANCE SPOT WELDS 8090 T-6 to 2090 T-8E50 Spitting, High strength (1603 lbs overlap shear)



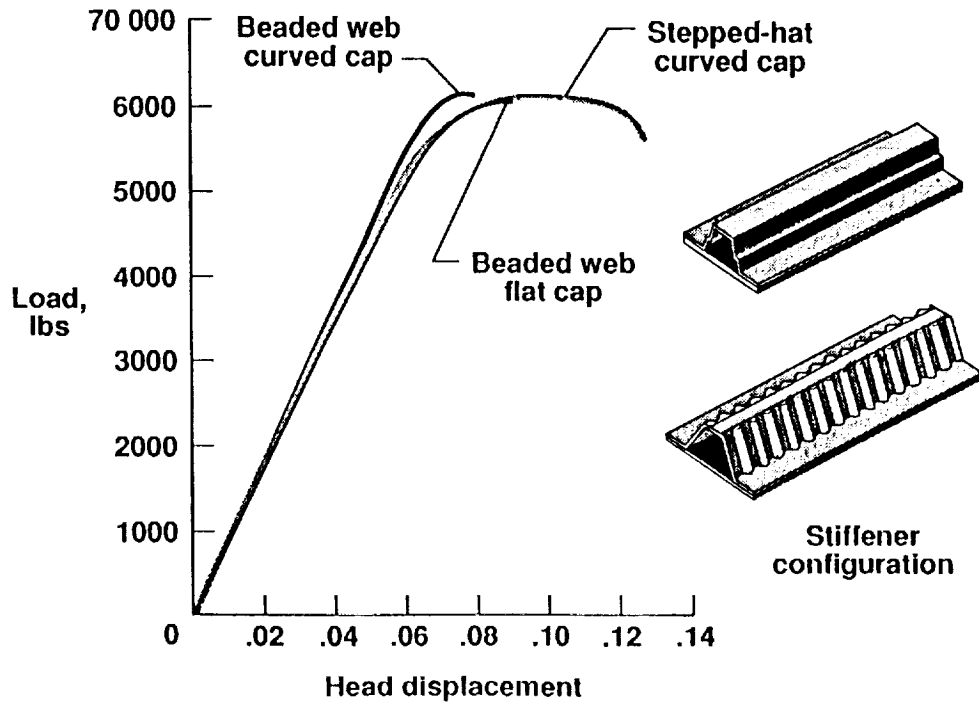
RESISTANCE SPOT WELDS OVERLAP SHEAR STRENGTHS



BUILT-UP STRUCTURE APPROACH TO REINFORCE FUSION WELDS



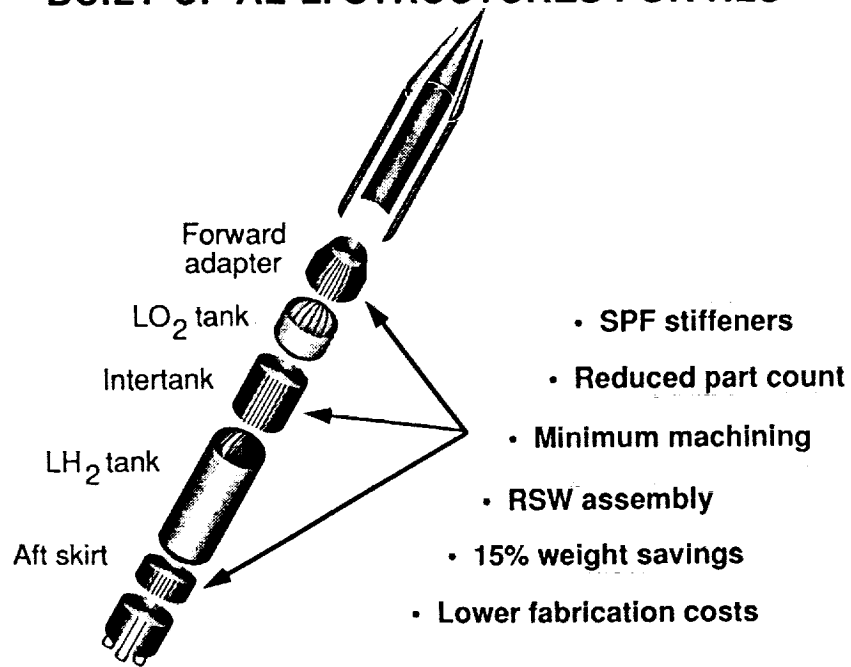
2090-T6(SPF)/2090-T8 Al-Li COMPRESSION PANELS Tested at NASA LaRC



SUPERPLASTICALLY FORMED Al-Li MULTIPLE STIFFENED PANEL



BUILT-UP AL-Li STRUCTURES FOR NLS



PERFORMANCE BENEFITS USING AL-LI (G.D.)

- Direct substitution of Al-Li for conventional Al alloys can add 6000 lbs of payload to the baseline 11/2 stage vehicle. Redesigning the structure to take full advantage of the higher properties of Al-Li alloys could add >12000 lbs in payload savings.
- Weight savings of ~10% achievable by making the propellant tank of the 11/2 stage vehicle from Al-Li.
- Weight savings of ~5% achievable by making the adapter and thrust structure of the 11/2 stage vehicle from Al-Li.
- High raw material costs of Al-Li are the primary driver in selecting the appropriate fabrication approach.
- **Dependent on the material substitution approach and fabrication method the increased cost of using Al-Li could range from \$0.5M to \$4.0M per vehicle.**
- In the baseline 11/2 stage vehicle the cost performance for Al-Li ranges from \$150/lb to \$750/lb of payload increase compared with the current projected payload performance of \$1500/lb using other alternatives.

ALDP BUILT-UP STRUCTURE FOR CRYOGENIC TANKS #3104

STATUS

- SPF OF AL-LI ALLOYS
 - Post-forming mechanical properties determined
 - 3' x 5' multiple stiffener panel formed
- RSW OF AL-LI ALLOYS
 - RSW schedules optimized using taguchi design of experiments
 - RSW strength of Al-Li alloys exceeds standard military specs
- STRUCTURAL TESTING
 - Crippling panels tested and shown to meet design req'ts
 - Stiffener design selected for column buckling panel
- COST/TRADE STUDIES
 - Cost analysis comparing roll forming, brake forming, extrusion and SPF fabrication methods near completion
- Current program focus assessing the benefits of Al-Li built-up dry-bay structures (intertank, fwd adapter, aft skirt)

8.3.2 Orbital Lessons Learned - A Guide to Future Vehicle Development by H. Stan Greenberg, Rockwell International