

National Aeronautics and
Space Administration

Space Technology Mission Directorate
Game Changing Development Program
2015 1st Quarter Review

ADEPT

Presented by:
Paul Wercinski

January 29, 2015

ADEPT Overview

Smart Book Required Chart

What would you say to a Senator that you meet in the elevator?

- In 3 sentences, what is your project and what does it do? ***The ADEPT project is a new, advanced heat shield design to protect payloads and landers delivered to planetary bodies with atmospheres. ADEPT is a mechanically deployable heatshield, like an umbrella, that can open up at planet arrival to diameters 2-5 times greater than current rigid heatshields. This large size overcomes the current limitations of NASA's heatshields to enable delivery of 10s of metric tons to Mars' surface – essential for human exploration.***
- Tweet of the description of your project ***"ADEPT is a mechanically deployable low-ballistic coefficient entry system (think: umbrella) which overcomes current limitations of rigid heatshield."***

Project Baseline

- Project Plan: FY15 Plan Approved
- Tech Port: Up to date
- Next Major Activity: Aeroloads 7x10 wind tunnel test scheduled for last week of April 2015.
- Infusion Status as of January 2015: Targeting SMD Discovery 2017 AO

Technology Infusion Plan:

- Near term: PC, Low Ballistic Coefficient EDL (1 m class), SMD, Potential secondary payload or TDO for Discovery 2017
- Long term: PC, Low Ballistic Coefficient EDL (10+ m class), HEOMD, Potential use on large payload delivery (10s of MT) to surface of Mars.

Key Personnel:

Project Manager: Paul Wercinski

Lead Center: Ames Research Center

Supporting Centers: LaRC, GSFC, AFRC, JPL

NASA NPR: 7120.8

Guided or Competed: Guided

Type of Technology: Push and Pull

Key Facts:

GCD Theme: AEDL

Execution Status: Year 1 of 2 (1m scale development)

Technology State Date: Oct 1, 2014

Technology End Date: Sep 30, 2016

Technology TRL Start: 3

Technology TRL End: 5-6

Technology Current TRL: 3

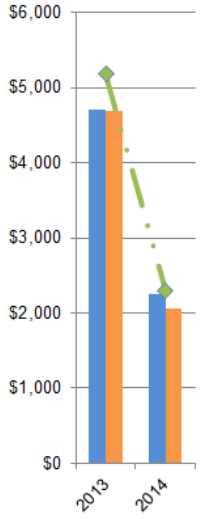
Technology Lifecycle Phase: Implementation (Phase B)

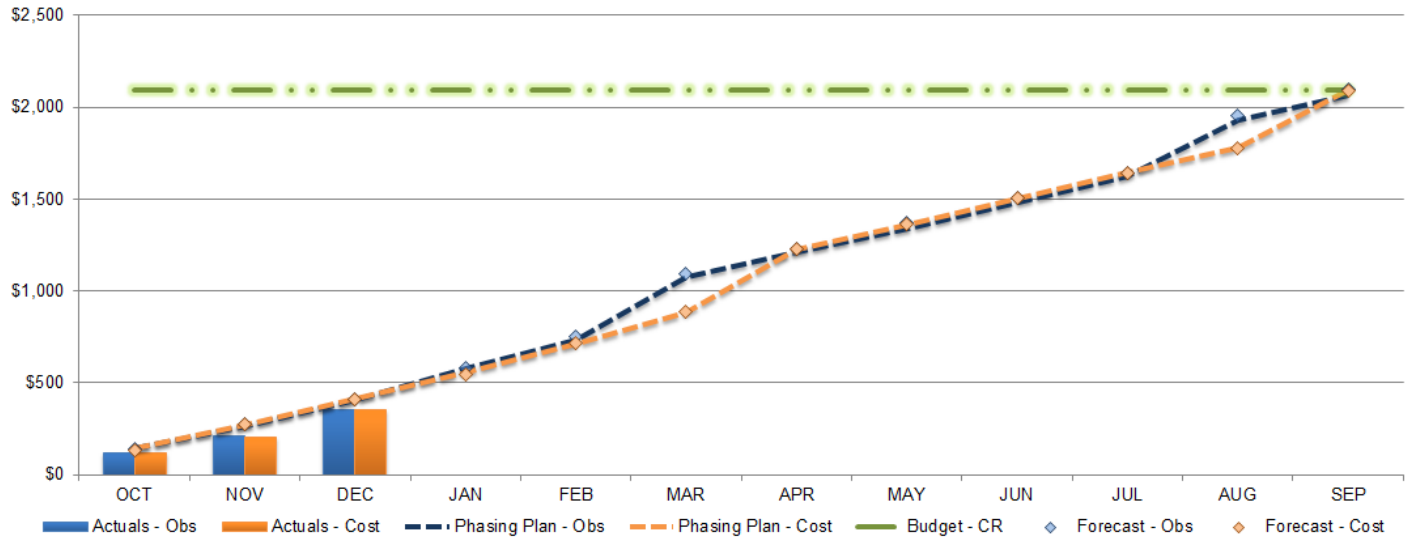
Project Manager Quarterly Assessment

Technology	Performance				Comments
	T	C	S	P	
Aeroloads Test					CDR passed Dec 2014. On schedule, within budget for late April test entry
SPRITE Test					Pathfinder test now schedule in Ames IHF facility for May 2014. Model 1 assembly near complete. Model 2 and 3 70% complete. Approximately 2 months ahead of schedule.
SR Flight Test Plan					Formulation and Planning activities started. Coordination with sounding rocket provider initiated.
Project					All activities are green with adequate margins.

Resources: Total Obligations and Cost

PY 2015 Financial Status





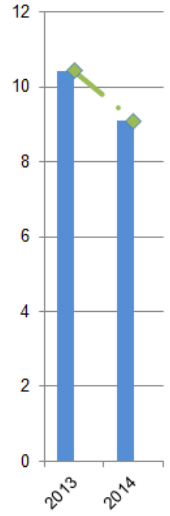
	Cum ($K)	2013	2014	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	Carry Out
	Budget	5,183.6	2,288.6	2,094.0	2,094.0	2,094.0	2,094.0	2,094.0	2,094.0	2,094.0	2,094.0	2,094.0	2,094.0	2,094.0	2,094.0	
Obs	Phasing Plan (RLS)			142.6	266.6	409.2	577.6	733.6	1,075.0	1,211.4	1,341.6	1,478.0	1,620.6	1,925.8	2,062.2	31.8
Obs	Actuals	4,708.4	2,256.9	117.5	211.6	356.8										
Obs	Forecast			137.9	274.8	411.7	582.6	751.5	1,093.4	1,230.3	1,369.2	1,506.1	1,643.0	1,956.9	2,093.8	0.2
Cost	Phasing Plan (RLS)			145.6	271.6	416.2	556.6	714.6	885.0	1,228.4	1,362.6	1,501.0	1,645.6	1,779.8	2,093.2	0.8
Cost	Actuals	4,693.2	2,060.0	117.5	204.6	356.8										
Cost	Forecast			134.9	272.8	409.7	546.6	717.5	886.4	1,228.3	1,365.2	1,504.1	1,641.0	1,777.9	2,091.8	2.2

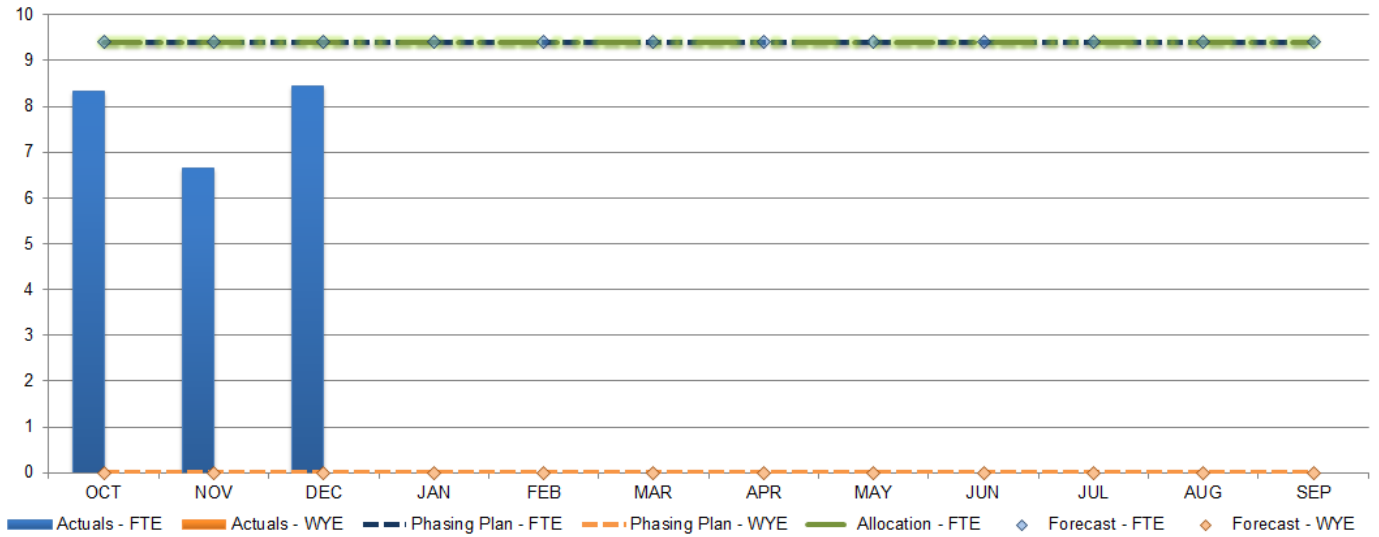
	YTD Status		Explanation required for YTD Variance in excess of 5% from Phasing Plan (shaded red)
'15 Obs	Phasing	$ 409	FTE level slightly below plan during 1st Quarter.
	Forecast*	$ -	
	Actuals	$ 357	
	Variance	$ (52)	
'15 Cost	Phasing	$ 416	FTE level slightly below plan during 1st Quarter.
	Forecast*	$ -	
	Actuals	$ 357	
	Variance	$ (59)	

* Forecast value is a snapshot of the Forecast from the previous reporting period

Resources: Total Project Workforce FTEs/WYEs

PY 2015 Workforce Status





	Incremental	2013	2014	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	2015 Avg
FTE	Allocation	10.4	9.1	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
FTE	Phasing Plan (RLS)			9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
FTE	Actuals	10.4	9.1	8.3	6.6	8.4										7.8
FTE	Forecast			9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4	9.4
WYE	Phasing Plan (RLS)			0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
WYE	Actuals	0.0	0.0	0.0	0.0	0.0										0.0
WYE	Forecast			-	-	-	-	-	-	-	-	-	-	-	-	-

	YTD Status		Explanation required for YTD Variance in excess of 5% from Phasing Plan (shaded red)
'15 FTE	Phasing	9.4	Actuals during 1st quarter do not to reflect plan as personnel are being assigned charge numbers and adjustments are made over the first few months of the fiscal year.
	Forecast*	-	
	Actuals	7.8	FTE level may be below plan when allocated FTEs worked on other assigned projects in any given month.
	Variance	(1.6)	
'15 WYE	Phasing	-	
	Forecast*	-	
	Actuals	-	
	Variance	-	

* Forecast value is a snapshot of the Forecast from the previous reporting period

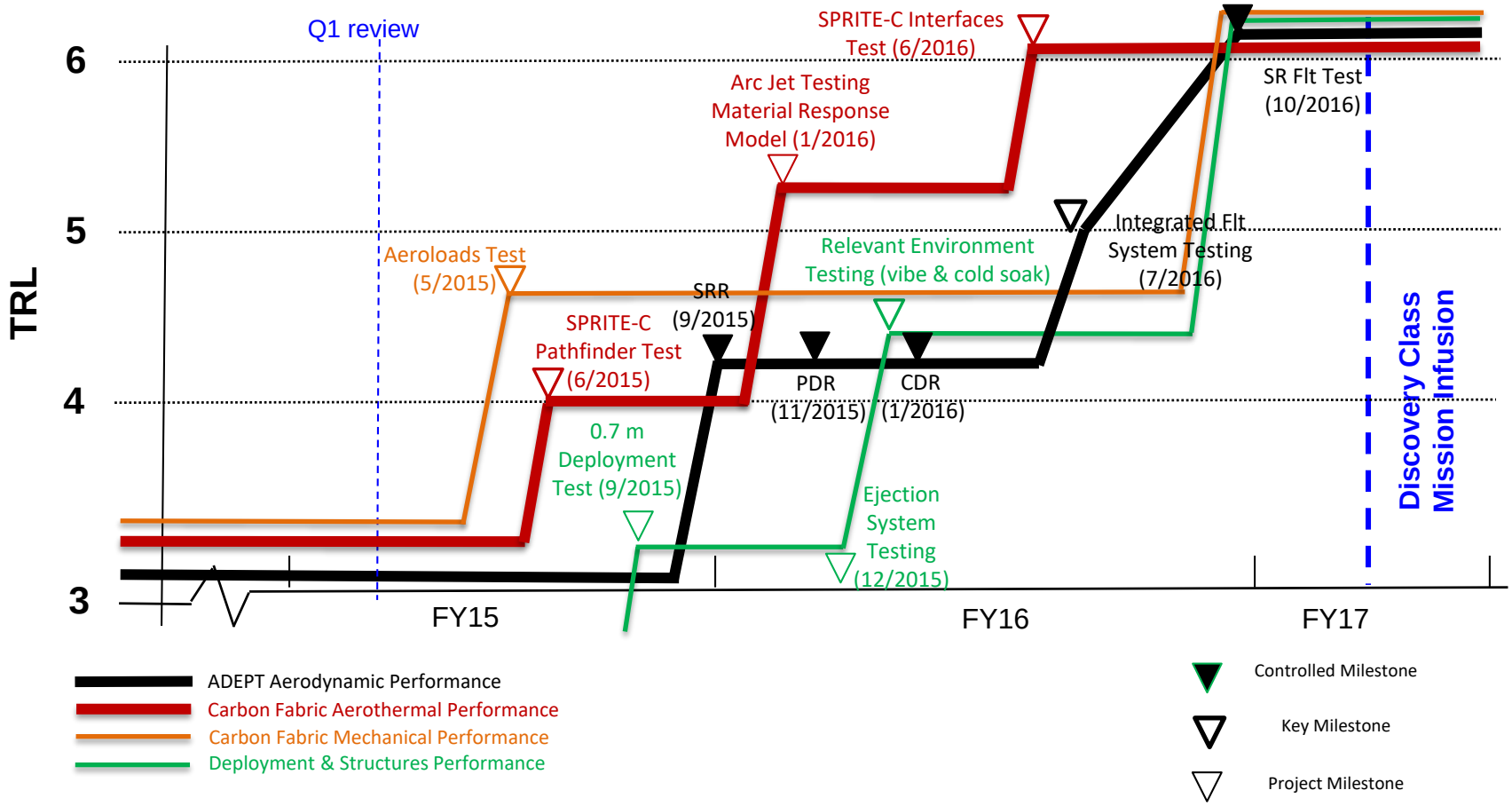
Resources: Project Execution Detail

Sum of Amount	Column Labels: ADEPT-Adaptable Deployable EDL
Row Labels	
Funding ($k)	
LABOR	
PO Allocation	1,619.000
Budget Distributed	320.700
Obligation	347.784
Cost	347.784
PhPlan:Cost	409.208
Non-LABOR	
PO Allocation	475.000
Budget Distributed	41.300
Obligation	9.044
Cost	8.993
PhPlan:Obs	0.000
PhPlan:Cost	7.000
FTE	
FTE	
PO Allocation	9.400
FTE Annual	1.956

Summary/Notes/Issues:

- **Lead Center – ARC**
- **Supporting Centers – LaRC, GSFC, AFRC**
- **No WYE for FY15**
- **Limited procurement funds for FTE overhead ($348K) and wind tunnel test ($96K) activities only**
- **$31K allocated for travel**

Component and System TRL Quarterly Assessment – ADEPT



Notes:

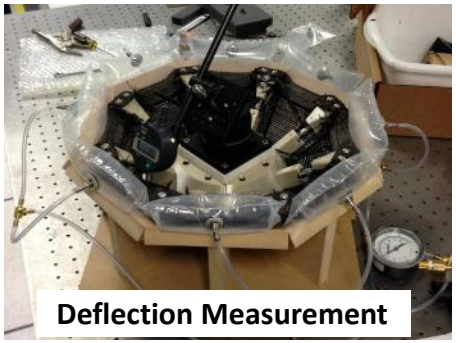
1) **TRL referenced to 1 m Mars Discovery DRM (delivery of several kg's to Mars surface for network science)**
2) **Risk items not in this plan: Payload integration/interfaces, integration with carrier S/C, thermostructural model validation**

ADEPT Accomplishments - SPRITE-C Arc Jet Test

- **Q1 Results – ADEPT SPRITE-C Arc Jet Test Preparation:**
  - Completed Assembly and Integration of 3 SPRITE-C Arc Jet Test Articles
  - Developed Selected Area Compression Molding Process to impart added robustness to stitched joints.
  - Developed Carbon Fabric deflection measurement apparatus to characterize fabric skirt tension distribution.







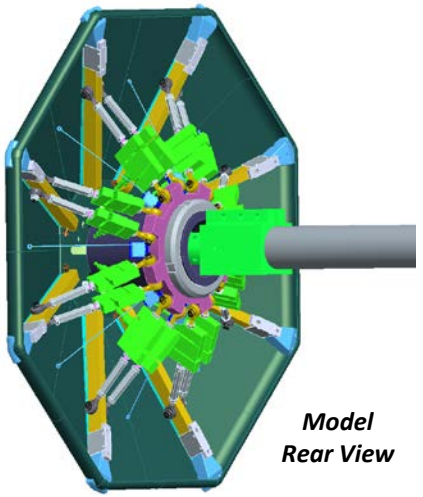
SPRITE-C Arc Jet Test Article Preparation

- **Challenges Faced**
  - Compression Molding Process imparted increased stiffness to flexible portion of fabric skirt due to high temperature phenolic resin cure (150 °C)
  - Seeking lower temperature cure processes or selected area heating approaches in order to minimize increases in fabric stiffness which could lead to undesired fabric deployment behavior.

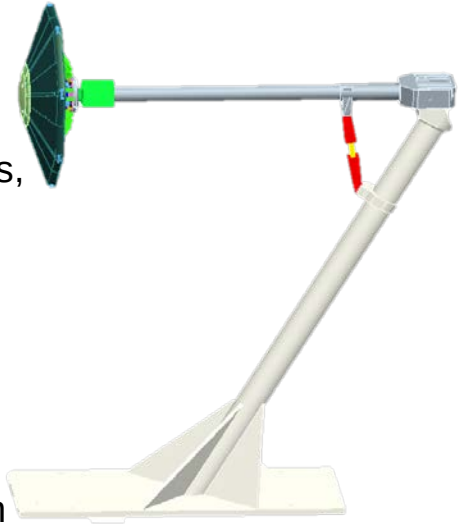
Aeroloads and FSI Wind Tunnel Test

US Army 7x10 Foot Wind Tunnel @ NASA Ames

- **Full-scale (0.7 m) "Nano-ADEPT" wind tunnel configuration will be tested in multiple tension states with flight-like carbon fabric skirt**
  - Fabric thickness and model diameter are identical to flight designs
  - Photogrammetry will be used to obtain high-resolution deflection maps
  - Test points include peak dynamic pressure for Mars, Earth, and Venus missions
- **Major 1st Quarter Results:**
  - Held successful CDR on 17 December 2014
    - Preliminary safety analysis approved by 7x10 tunnel management
    - Received positive feedback on technical approach and management
    - Green light to proceed with hardware fabrication granted by PM
  - Technical challenges:
    - Test article requirements derived from mission needs and desire to use low-cost, high-value test approaches
      - Specific examples: Fabric thickness driven by mission requirements, diameter driven by wind tunnel blockage constraints, shoulder and nose design driven by similarity with arc jet test article, stowed diameter driven by Flight Ops sounding rocket fairing diameter
    - Instrumentation had to be reduced to avoid unnecessary interaction with carbon fabric
  - Accomplishment relative to baseline:
    - Passed major milestone in one corner of "Venn Diagram" tech maturation strategy



Model Rear View



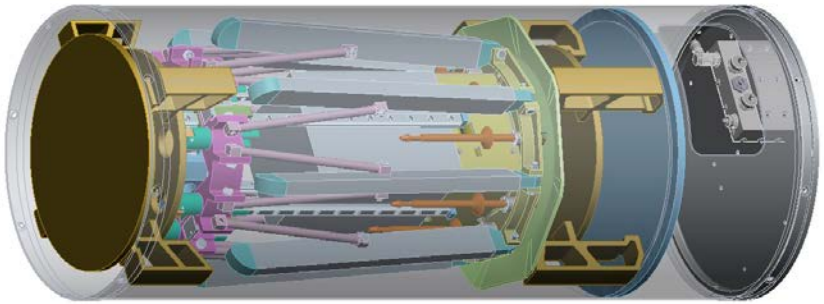
Profile View

Aeroloads and FSI Wind Tunnel Test
US Army 7x10 Foot Wind Tunnel, NASA Ames

- **Planned Technical Accomplishments in Q2 (Jan-Mar 2015)**
  - Drawing release, hardware procurement, hardware delivery
  - Test article assembly
- **Planned Technical Accomplishments in Q3 (Apr-Jun 2015)**
  - Test article instrumentation checkout
  - Test execution (27-April to 5-May, 7 days) **Come on out to watch!**
  - Debrief preliminary results to stakeholders
  - Preliminary results shared with EDL community (IPPW)
- **Planned Technical Accomplishments in Q4 (July-September 2015)**
  - Post-test fluid-structure interaction (FSI) analysis (CFD and FEA)
  - Final report released (July 2015)

ADEPT Accomplishments
- Sounding Rocket Flight Test Planning

- **Q1 Results – ADEPT Sounding Rocket Flight Test Planning:**
  - Generated draft set of interface requirements
  - Studied integration concepts between ADEPT and SpaceLoft XL sounding rocket
  - Identified key information needed for further development
  - Met with Flight Opportunities & UP Aerospace on 12/9/2014 to develop requirements and discuss sounding rocket mission concept of operations



ADEPT – SR Integration Concept

- **Sounding Rocket Flight Test is primarily FY'16 work**
  - Current work preparatory: mission concepts & requirements development
  - Leveraging current SR flight developments by Maraia and AVA projects

Key and Controlled Milestones

	FY15 Key and Controlled Milestones	Baseline Completion Date	Actual Completion Date	Estimated Completion Date	Variance Explanation
	FY15 Q1 (Oct 1 through Dec 31)				
	TIM with UP Aerospace Inc.	N/A	12/9/2015	12/9/2014	
	7x10 Wind Tunnel Test CDR	N/A	12/17/2015	12/17/2014	
	FY15 Q2 (Jan 1 through March 31)				
	STMD DPMC - ADEPT FY16 Plans	N/A		1/22/2015	
	Venus Lander Science Goals Kick-Off	2/1/2015			Expecting this milestone to be changed due to ADEPT de-emphasis on Venus Lander DRM
	7x10 Wind Tunnel Testing	N/A		5/2/2015	
	FY15 Q3 (Apr 1 through June 30)				
CM	**Airloads Wind Tunnel Test Report**	**5/15/2015**			
	SPRITE-C Pathfinder Arc Jet Testing	N/A		May 2015	Facility coming on-line after lengthy shutdown. Schedules still in state of flux
	Deployment System Demonstrator Design	6/1/2015			
	FY15 Q4 (Jul 1 through Sep 30)				
CM	**SPRITE-C Interface Test CDR**	**8/1/2015**			
	ADEPT Venus Revised Lander Design	9/1/2015			Expecting this milestone to be changed due to ADEPT de-emphasis on Venus Lander DRM
	ADEPT Thermal Test Planning Report	9/10/2015			

EPO: Activities and Conferences

Date	E/PO Activity	Representative(s)
18 Oct 2014	Ames 75th Anniversary Open House; ADEPT Exhibit (2m GTA on display, ADEPT-Venus GCDP Video on loop, Several ADEPT posters)	Brandon Smith, Alan Cassell, Paul Wercinski, Peter Gage, Parul Agrawal

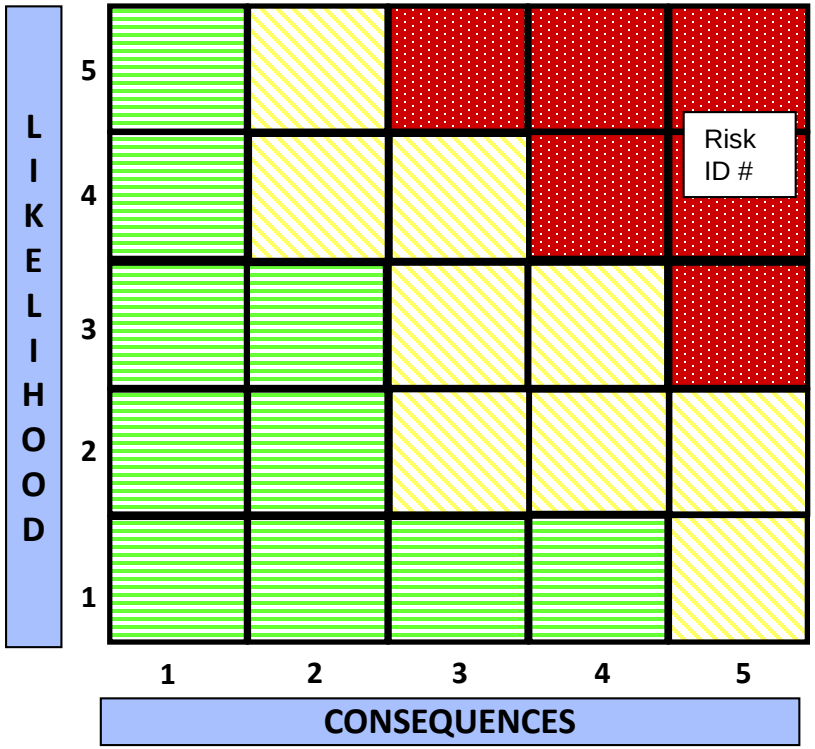


Peter Gage explains the ADEPT 2 m Ground Test Article to the public at the NASA Ames 75th Anniversary Open House

EPO: Activities and Conferences

Date	Conference	Papers	Rep(s)
7-14 March 2015	IEEE Aerospace Conference	Nano-ADEPT: An An Entry System for Secondary Payloads (Technology Overview Paper, Peer Reviewed)	Brandon Smith
15-19 June 2015	International Planetary Probe Workshop	Nano-ADEPT Aeroloads Wind Tunnel Test Overview and Preliminary Results	Brandon Smith

ADEPT Risk Summary



Risk ID Trend	Approach/ Affinity	Risk Title
1	R	Impact loads could render on-board data stored to non-volatile memory unreadable
2	R	Small radar cross section could make ADEPT difficult to track, complicating recovery
3	R	Unknown tip-off rates upon SR ejection and subsequent deployment could lead to undesirable attitude at atmospheric interface
4	R	Carbon fabric aeroshell trailing edge design may not package in allotted SR payload volume

Criticality

- High
- Med
- Low

L x C Trend

- ⇩ Decreasing (Improving)
- ⇧ Increasing (Worsening)
- ⇨ Unchanged
- □ New Since Last Period

Approach

- M - Mitigate
- W - Watch
- A - Accept
- R - Research

Affinity: T-Technical C-Cost Sc-Schedule Sa-Safety

Note: Project is not exercising formal risk management in FY15 due to limited resources but risk identification being used in engineering best practices

Summary and Near Term Challenges

Project Summary Performance

Project	Summary Performance				Rationale
	Technical	Cost	Schedule	Programmatic	
Quarter 1					All planned activities are green
Quarter 2					
Quarter 3					
Quarter 4					

Near Term Challenges

- **Sustaining team motivation to continue operating at high performance level for development activities that flow into next year with FY16 project scope uncertain.**

Back Up Charts

Quarterly Report Information Needed

<These charts feed quarterly reporting and Smart Book all charts are required>

Adaptable, Deployable, Entry and Placement Technology (ADEPT)

STATUS QUO

Robotic and human missions are limited by decades-old rigid, high ballistic coefficient aeroshells

- Geometry and packaging constraints within launch shroud or carrier spacecraft (secondary payload)
- Very high TPS certification and development costs and timeline
- Current EDL capability limits delivery of payloads to Mars surface at 1mT
- Probe missions to Venus experience 100s g's deceleration loads

NEW INSIGHTS

- Low ballistic coefficient aeroshell technology can reduce heat and g-loading during entry
- An innovative, mechanically deployable system:
  - Alternative approach to inflatable entry systems
  - Advances in 3-D carbon-cloth weaving provides a TPS that also sustains structural loads
  - Carbon cloth permits trade between ballistic coefficient and heating environment

PROBLEM / NEED BEING ADDRESSED

Large payload (> 1Mt) delivery at Mars and next generation science missions require deployable, low ballistic coefficient entry systems not achievable with conventional aeroshell technology.

PROGRAM DESCRIPTION:

- ADEPT develops a low ballistic coefficient aeroshell system that consists of a 3-D woven carbon cloth skin stretched over a mechanically deployable ribbed structure (similar to an umbrella)
- Design provides predictable structural loads via skin/ribs/struts behaving as a rigid system
- ADEPT entry conditions are well within the current arc jet capabilities – testable and certifiable
- Demonstration of aerodynamic stability and carbon fabric robust performance under entry loads
- Characterization of 3D woven carbon fabric for thermal & structural behavior
  - Carbon fabric testing under relevant heating conditions while under sustained bi-directional tension loads
- Design, integrate and test a 1m diameter class test article with flight-like carbon fabric design and structure attachment. Perform systems level testing in both ground and sounding rocket flight environments.

QUANTITATIVE IMPACT

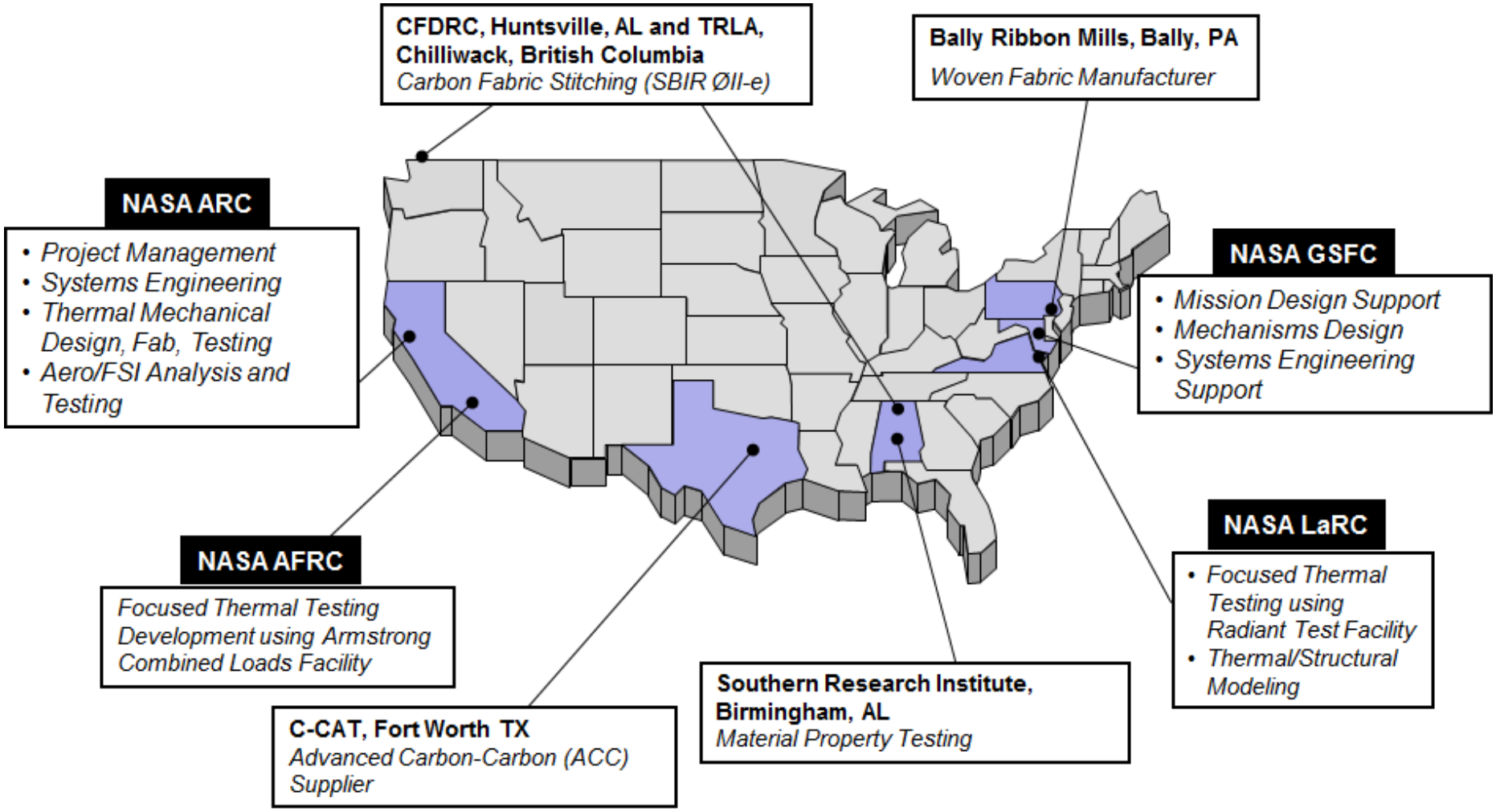
- ADEPT enables missions with breakthrough science capability and fills the 'gap' in future EDL needs
  - Enables 10x reduction in peak entry heating and deceleration loads
  - Venus in-situ atmosphere science now feasible for secondary payload missions
  - Mars robotic lander missions (>1mT) avoid supersonic chutes and can reach pole-pole landing sites without MOLA limits
  - Long term Mars Human Exploration to deliver 10s mT payloads are enabled with deployable low ballistic coefficient architecture

PROGRAM GOAL

- **Design, test, and demonstrate test article to TRL 6**
- **Fully mitigate all development challenges and risks to enable ADEPT as candidate technology for future Discovery class missions**

Breakthrough capability to deliver entry system payloads to the most challenging mission destinations

ADEPT Organization and Key Members



ADEPT Resources

Key Milestones:

Milestone	Baseline Date	Current Date	Comment
Wind Tunnel Test CDR	N/A	12/17/14	Completed
Venus Lander Science Goal Kick-Off	2/1/15	TBD	Expecting milestone change
* Wind Tunnel Test Report	5/15/15	5/15/15	On schedule
* SPRITE-C Interface Test CDR	8/1/15	TBD	Expecting delay due to Pathfinder test slip by 4 months

* Controlled Milestone

Quarterly Technical Accomplishments:

- Completed Assembly and Integration of 3 SPRITE-C Arc Jet Test Articles
- Held successful CDR on 17 December 2014. Green light to begin hardware procurement and fabrication.
- Met with Flight Opportunities & UP Aerospace on 12/9/2014 to develop requirements and discuss sounding rocket mission concept of operations

Concerns: Limited procurement budget and lack of multi-year program commitment make mission infusion stakeholder engagement challenging.

Cost	Schedule	Technical	Programmatic

Resources:

- FY2014: $2,317K
- FY2015: $2,094K ($1,654K ARC, $154K GSFC, $187K LaRC, $99K AFRC)
- FTE: 9.4 (6.9 ARC, 1.0 GSFC, 1.0 LaRC, 0.5 AFRC)
- WYE: 0

Budget ($K)	Q1	Q2	Q3	Q4	Total
Approved (received)	362				362
Obligated	357				357
Costed	357				357

Annual Budget Profile ($M)

