

Guidelines for Hosted Payloads Integration Product Overview

May 8, 2014

Jack Kawamoto
Acquisition Risk and Reliability Engineering Department
Mission Assurance Subdivision

Prepared for:

Space and Missile Systems Center
Air Force Space Command
483 N. Aviation Blvd.
El Segundo, CA 90245-2808

Contract No. FA8802-14-C-0001

Authorized by: Space Systems Group

Developed in conjunction with Government and Industry contributions as part of the U.S. Space Program Mission Assurance Improvement Workshop.

Distribution Statement A: Approved for public release; distribution unlimited.

Report Documentation Page				Form Approved OMB No. 0704-0188	
Public reporting burden for the collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing the collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden, to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington VA 22202-4302. Respondents should be aware that notwithstanding any other provision of law, no person shall be subject to a penalty for failing to comply with a collection of information if it does not display a currently valid OMB control number.					
1. REPORT DATE 08 MAY 2014		2. REPORT TYPE Final		3. DATES COVERED -	
4. TITLE AND SUBTITLE Guidelines for Hosted Payloads Integration Product Overview				5a. CONTRACT NUMBER FA8802-14-C-0001	
				5b. GRANT NUMBER	
				5c. PROGRAM ELEMENT NUMBER	
6. AUTHOR(S) Jack Kawamoto				5d. PROJECT NUMBER	
				5e. TASK NUMBER	
				5f. WORK UNIT NUMBER	
7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES) The Aerospace Corporation 2310 E. El Segundo Blvd El Segundo, CA 90245-4609				8. PERFORMING ORGANIZATION REPORT NUMBER TOR-2014-02158	
9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES) Space and Missile Systems Center Air Force Space Command 483 N. Aviation Blvd. El Segundo, CA 90245-2808				10. SPONSOR/MONITOR'S ACRONYM(S) SMC	
				11. SPONSOR/MONITOR'S REPORT NUMBER(S)	
12. DISTRIBUTION/AVAILABILITY STATEMENT Approved for public release, distribution unlimited					
13. SUPPLEMENTARY NOTES The original document contains color images.					
14. ABSTRACT					
15. SUBJECT TERMS					
16. SECURITY CLASSIFICATION OF:			17. LIMITATION OF ABSTRACT UU	18. NUMBER OF PAGES 36	19a. NAME OF RESPONSIBLE PERSON
a. REPORT unclassified	b. ABSTRACT unclassified	c. THIS PAGE unclassified			

Acknowledgments

This presentation provides a summary overview of TOR-2014-02199, “Guidelines for Hosted Payloads Integration”, which was produced as part of the 2014 Mission Assurance Improvement Workshop.

This document was created by multiple authors throughout the government and the aerospace industry. For their content contributions, we thank the following contributing authors for making this collaborative effort possible:

Jack Kawamoto	The Aerospace Corporation
Michael Moore	The Aerospace Corporation
Jeff Conyers	Ball Aerospace & Technologies Corporation
Rick Krause	Ball Aerospace & Technologies Corporation
Andrew Adams	The Boeing Company
Deborah Valley	MIT/Lincoln Labs
Steve Kuritz	Northrop Grumman Aerospace Systems
Megan Paulette	Orbital Sciences Corporation
Tracy Fiedler	Raytheon Space and Airborne Systems
Ken Dodson	SSL

A special thank you for co-leading this team and efforts to ensure completeness and quality of this document goes to Ken Dodson (Co-Lead), SSL and Steve Kuritz (Co-Lead), Northrop Grumman Aerospace Systems.

Acknowledgments (Cont)

The authors deeply appreciate the contributions of the subject matter experts who reviewed the document:

John Brader	The Aerospace Corporation
Frank Knight	The Aerospace Corporation
Bill Frazier	Ball Aerospace & Technologies Corporation
Steven Pereira	John Hopkins Applied Physics Laboratory (APL)
Louis D'Angelo	Lockheed Martin Corporation
Jeff Mendenhall	MIT/Lincoln Labs
Brent Armand	Orbital Sciences Corporation
Angela Phillips	Raytheon Space and Airborne Systems
Jonathan Sheffield	SSL
Gerrit VanOmmering	SSL



Guidelines for Hosted Payloads Integration

Product Overview

Steve Kuritz, Northrop Grumman Aerospace Systems

Ken Dodson, SSL

Jack Kawamoto, The Aerospace Corporation

May 8, 2014

This presentation provides a summary overview of TOR-2014-02199, "Guidelines for Hosted Payloads Integration", which was produced as part of the 2014 Mission Assurance Improvement Workshop.

U.S. SPACE PROGRAM MISSION ASSURANCE IMPROVEMENT WORKSHOP
ORBITAL SCIENCES CORPORATION | DULLES, VA | MAY 7 - 8, 2014

Agenda

- Motivation for the Project
- Examples that Motivated the Project
- Product Overview
- Topic Details
- Product Implementation Recommendations
- Topic Follow-on Recommendations
- Team Membership and Recognition



Motivation for Guidelines for Hosted Payloads Integration

- Independently developed payloads can enter service more economically as a “Hosted Payload” than as a dedicated mission.
- An operator can defray its own costs by providing hosted payload opportunities to an independently developed payload.
- Because of these advantages and others, Hosted Payloads are an attractive approach for government missions.
- Early hosted payload projects have met with success, but have also experienced problems during integration, test, and on orbit due to unforeseen schedule, technical, and operational compatibility issues.
- This product is motivated by a desire to reduce the number of problems and the disconnects that can cause those problems.

Examples and Concerns

- Concerns and experiences of the project framers included
 - *Coupling between primary and redundant command channels*
 - *Premature connection of battery to power bus in “dead bus recovery”*
 - *Power in-rush current and relay isolation from “smart shorts”*
 - *Radiated interference and conducted susceptibility issues*
- Our own group had several experiences including
 - *Ripple on downlink signal in orbit due to non-representative ground test*
 - *Physical interference of components after delivery for integration*
 - *System test environments exceeding hosted payload design*
 - *Contamination of optics due to venting flow and chamber issues*
 - *Mismatch between payload qualified environments and those of the host*

Team Considered Wide Variety of Impacts

- Programmatic information exchange disconnects
- Interface issues
- Performance compromises
- Resource deficiencies or excesses
- Schedule mismatches
- Many others

**Successful accommodation goes far beyond
“Do No Harm”**



Intended Audience for the Document

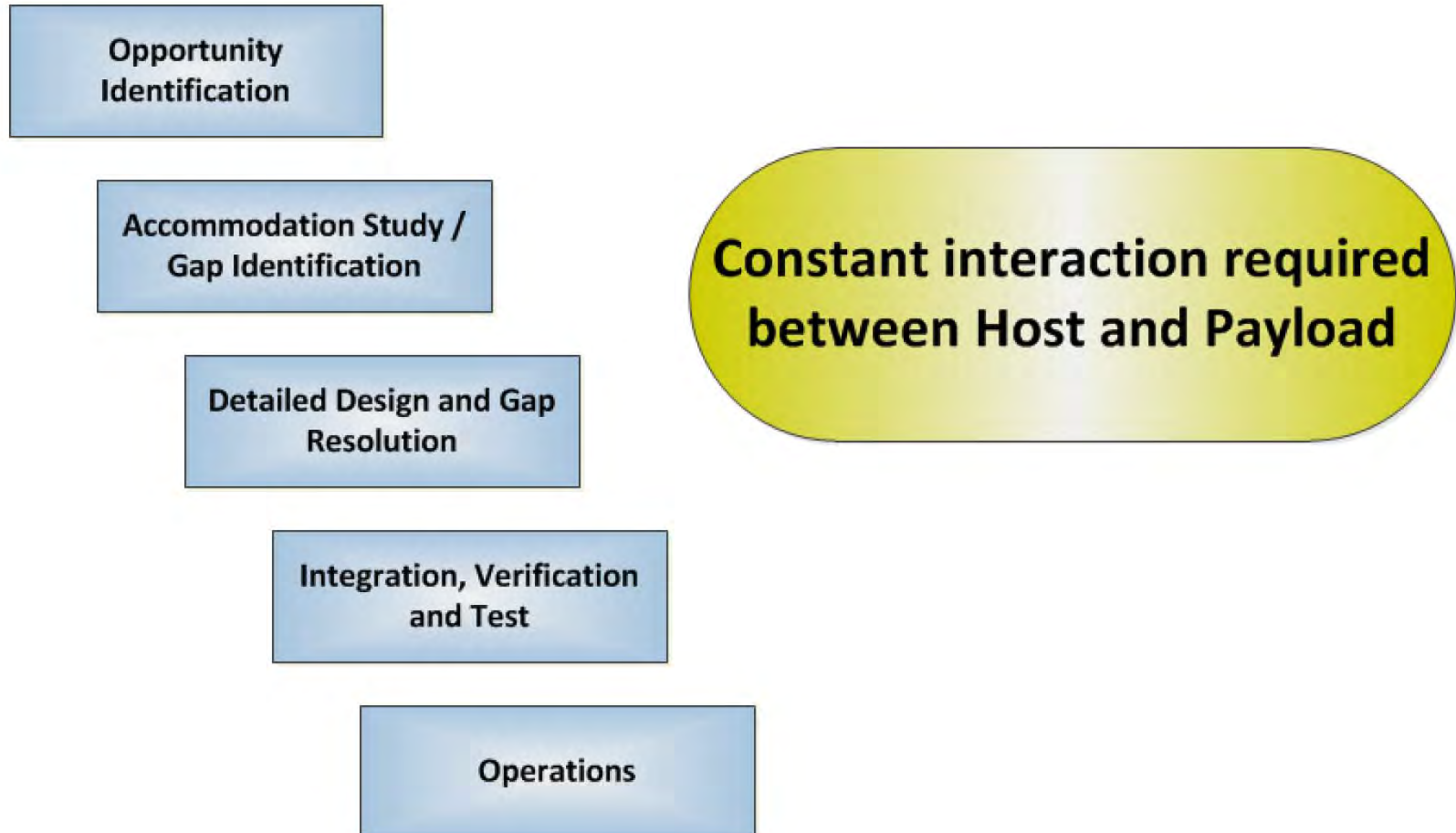
- It is intended to aid those involved in a hosted payload project
 - *Requirements generators*
 - *Program managers and planners*
 - *Designers and analysts*
 - *Systems engineers*
 - *Test planners and engineers*
 - *Mission assurance and other relevant specialty engineering disciplines*



Charter

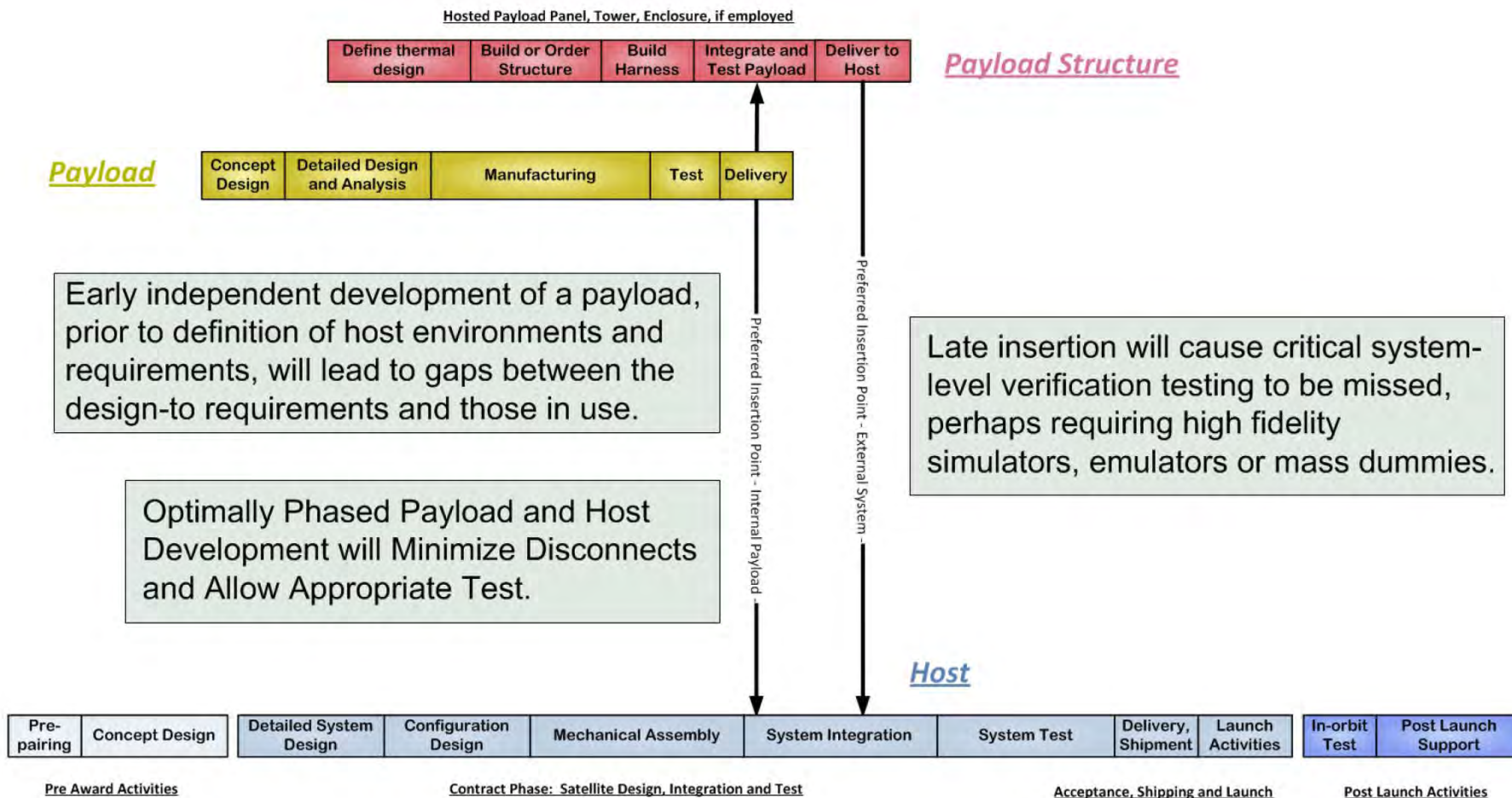
- Provide an overall approach to the process of hosting payloads
 - *Evaluation criteria to ensure the payload and host are compatible*
 - *Help identify and resolve environmental and interface incompatibilities*
 - *Provide analyses to ensure compatible interface and functionality*
 - *Recommend testing of mechanical, electrical and thermal interfaces*
 - *Assess fault tolerance/impact to the host and payload components*
 - *Provide guidelines for deliverable information and documentation*
 - *Provide references for further information*
- Done using text, tables and checklists, emphasizing the latter
 - *Easy to compile, use and update*

Accommodation Phases



Host – Payload Integration

In-phase development presents best opportunity



Gaps Between Payload & Host Must be Resolved

Analysis of Gaps

Always relevant and essential

Host
Environments

Host Interface
Descriptions



Payload Qualified
Environments

Payload Analyzed
Properties

Payload Interface
Descriptions

Requirement and interface disconnects for any cause will necessitate modification and verification on the Host or Payload side of the interface.

Document Topics Include

- Gap Identification and Resolution
- Control of Budgeted and Expendable Items
- Survival in Space and Ground Environments
- Mission Operations
- Critical Analyses
- Deliverable Products
- On-orbit Fault Management
- Verification by Test
- Detailed checklists
 - *An aid in gap identification, provided as an appendix*



Intended Product Use

- A reference and resource to promote a comprehensive accommodation approach that also evaluates risk
- Evokes questions like
 - *Have all relevant environments been taken into account?*
 - *Is hardware designed /qualified to the correct environments?*
 - *Are all appropriate analyses required /performed for my project?*
 - *Does my RFI, RFP or ICD have sufficient content?*
 - *Are all appropriate deliverables planned and available at key decision points?*
 - *Are these tests required /performed or are analyses required to reduce risk?*
 - *Are the interfaces and properties in the checklists relevant and accounted for?*

Summary Findings from Lessons Learned

Finding	Recommendation
Payloads are often developed to requirements that are different from those of the Host	Hosts should publish and distribute their environments and interfaces
There is no universally accepted cross-industry interface standard	Industry should move toward a common interface standard
Insufficient interaction or too many layers between Host and Payload engineering teams often disrupts information flow	Teams should collaborate to define roles, analyze gaps and exchange information directly
Insufficient participation by Payload representatives in system-level test / test planning leads to problems	Payload should participate in planning and execution of relevant system level tests
Late Payload delivery can lead to insufficient testing of the integrated system	Test Like You Fly with actual Payload or realistic simulator

Recommended Follow-on Activities

Activity	Status
Present to Industry	Abstract submitted to RAMS 2015
Define realistic cross-industry environmental ranges	2015 MAIW topic submitted
Develop cross-industry interfaces	Suggested for future MAIW
Collect & evaluate lessons going forward to improve document	Aerospace Corp. can be a focus; Industry cooperation needed
Revisit and update as necessary	2 to 3-years more experience

Workshop Accomplishments

- Silver Updates Reviewed and Agreed Upon
 - *Silver-to-gold transition in process*
- Lessons and Conclusions Discussed
 - *Recommendations provided on previous slides*
- Identify, resolve and report on any significant conflicts
 - *There are no significant conflicts*
- Additional pending recommendations
 - *Suggest more appropriate title for the TOR:*
 - *Guidelines for Hosted Payload Integration*



Team Introductions

Core Team		Subject Matter Experts	
The Aerospace Corporation	Jack Kawamoto Michael Moore	The Aerospace Corporation	John Brader Frank Knight
Ball Aerospace & Technologies Corp	Jeff Conyers Rick Krause	Ball Aerospace & Technologies Corp	Bill Frazier
The Boeing Company	Andrew Adams	John Hopkins APL	Steven Pereira
MIT/Lincoln Labs	Deborah Valley	Lockheed Martin	Louis D'Angelo
Northrop Grumman Aerospace Systems	Steve Kuritz	MIT/Lincoln Labs	Jeff Mendenhall
Orbital Sciences	Megan Paulette	Orbital Sciences	Brent Armand
Raytheon Space and Airborne Systems	Tracy Fiedler	Raytheon Space and Airborne Systems	Angela Phillips
SSL	Ken Dodson	SSL	Jonathan Sheffield Gerrit VanOmmering



Guidelines for Hosted Payloads Integration Product Overview

Approved Electronically by:

Jacqueline M. Wyrwitzke, PRINC
DIRECTOR
MISSION ASSURANCE SUBDIVISION
SYSTEMS ENGINEERING DIVISION
ENGINEERING & TECHNOLOGY
GROUP

Russell E. Averill, GENERAL MANAGER
SPACE BASED SURVEILLANCE
DIVISION
SPACE PROGRAM OPERATIONS

David J. Gorney, EXECUTIVE VP
SPACE SYSTEMS GROUP

Jackie M. Webb-Larkin, SECURITY
SPECIALIST III
GOVERNMENT SECURITY
SECURITY OPERATIONS
OPERATIONS & SUPPORT GROUP

© The Aerospace Corporation, 2014.

All trademarks, service marks, and trade names are the property of their respective owners.

SK0670

Guidelines for Hosted Payloads Integration Product Overview

Technical Peer Review Performed by:

Norman Y. Lao, DIRECTOR DEPT
ACQ RISK & RELIABILITY ENGINEERING DEPT
MISSION ASSURANCE SUBDIVISION
ENGINEERING & TECHNOLOGY GROUP

Jacqueline M. Wyrwitzke, PRINC DIRECTOR
MISSION ASSURANCE SUBDIVISION
SYSTEMS ENGINEERING DIVISION
ENGINEERING & TECHNOLOGY GROUP

© The Aerospace Corporation, 2014.

All trademarks, service marks, and trade names are the property of their respective owners.

SK0670

External Distribution

REPORT TITLE

Guidelines for Hosted Payloads Integration Product Overview

REPORT NO.	PUBLICATION DATE	SECURITY CLASSIFICATION
TOR-2014-02158	May 8, 2014	UNCLASSIFIED

Charles Abernethy
charles.abernethy@aerojet.com
Aerojet

David Adcock
adcock.david@orbital.com
Orbital

Aaron Apruzzese
aaron.apruzzese@atk.com
ATK

Carlo Abesamis
abesamis@jpl.nasa.gov
NASA

Robert Adkisson
robert.w.adkisson@boeing.com
Boeing

Chic Arey
areyc@nro.mil
NRO

Andrew Adams
andrew.c.adams@boeing.com
Boeing

Scott Anderson
scott.anderson@seaker.com
Seaker

Brent Armand
Armand.Brent@orbital.com
Orbital

Larry Arnett
arnett.larry@ssd.loral.com
Loral

Glenn Barney
glenn.barney@comdex-use.com
Comdev-USA

Robert Bodemuller
rbodemuller@ball.com
Ball

Ken Baier
ken.b.baier@lmco.com
Lockheed Martin

David Beckwith
beckwith@nro.mil
NRO

Silvia Bouchard
silver.bouchard@ngc.com
Northrop Grumman

Dean Baker
bakerdea@nro.mil
NRO

Theresa Beech
tbeech@metispace.com
Metispace

Wayne Brown
wayne.brown@ulalaunch.com
ULA Launch

Mark Baldwin
Mark.L.Baldwin@raytheon.com
Raytheon

Barry Birdsong
barry.birdsong@mda.mil
MDA

Christopher Brust
Christopher.Brust@dcma.mil
DCMA

Lisa Barboza
Lisa.Barboza@gd-ais.com
General Dynamics

Ruth Bishop
ruth.bishop@ngc.com
Northrop Grumman

Alexis Burkevics
Alexis.Burkevics@rocket.com
Rocket

Thomas Burns
thomas.burns@noaa.gov
NOAA

Will Caven
caven.will@ssd.loral.com
Loral

Jerald Cogen
Jerald.Cogen@FreqElec.com
FREQELEC

Edward Bush
Edward.Bush@ngs.com
Northrop Grumman

Shawn Cheadle
shawn.cheadle@lmco.com
Lockheed Martin

Bernie Collins
bernie.f.collins@dni.gov
DNI

Tim Cahill
tim.cahil@lmco.com
Lockheed Martin

Janica Cheney
janica.cheney@atk.com
ATK

Jeff Conyers
jconyers@ball.com
Ball

Kevin Campbell
kevin.campbell@exelisinc.com
Exelis Inc

Brian Class
class.brian@orbital.com
Orbital

Kevin Crackel
kevin.crackel@aerojet.com
Aerojet

Larry Capots
larry.capots@lmco.com
Lockheed Martin

Brad Clevenger
brad_clevenger@emcore.com
EMCORE

James Creiman
James.Creiman@ngc.com
Northrup Grumman

Stephen Cross
stephen.d.cross@ulalaunch.com
ULA Launch

Jaclyn Decker
decker.jaclun@orbital.com
Orbital

Susanne Dubois
susanne.dubois@ngc.com
Northrop Grumman

Shawn Cullen
shawn.cullen@jdsu.com
JDSU

Larry DeFillipo
defillipo.aryy@orbital.com
Orbital

David Eckhardt
david.g.eckhardt@baesystems.com
BAE Systems

Louis D'Angelo
louis.a.d'angelo@lmco.com
Lockheed Martin

Ken Dodson
ken.dodson@sslmda.com
SSL MDA

Robert Ellsworth
robert.h.ellsworth@boeing.com
Boeing

David Davis
David.Davis.3@us.af.mil
SMC

Tom Donehue
tom.donehue@atk.com
ATK

Matt Fahl
mfahl@harris.com
Harris Corporation

Douglas Dawson
douglas.e.dawson@jpl.nasa.gov
NASA

Mary D'Ordine
mdordine@ball.com
Ball

James Farrell
james.t.farrell@boeing.com
Boeing

Tracy Fiedler
tracy.m.fiedler@raytheon.com
Raytheon

Mike Floyd
Mike.Floyd@gdc4s.com
General Dynamics

Matteo Genna
matteo.genna@sslmda.com
SSL

Brad Fields
fields.brad@orbital.com
Orbital

David Ford
david.ford@flextronics.com
Flextronics

Helen Gjerde
helen.gjerde@lmco.com
Lockheed Martin

Sherri Fike
sfike@ball.com
Ball

Robert Frankievich
robert.h.frankievich@lmco.com
Lockheed Martin

Ricardo Gonzalez
ricardo.gonzalez@baesystems.com
BAE Systems

Richard Fink
richard.fink@nro.mil
NRO

Bill Frazier
wfrazier@ball.com
Ball

Dale Gordon
dale.gordon@rocket.com
Rocket

Bruce Flanick
bruce.flanick@ngc.com
Northrop Grumman

Jace Gardner
jgardner@ball.com
Ball

Chuck Gray
Chuckg@fescorp.com
Fescorp

Luigi Greco
luigi.greco@exelisinc.com
Exelis Inc

Bob Harr
bob.harr@seaker.com
Seaker

Paul Hopkins
paul.c.hopkins@lmco.com
Lockheed Martin

Gregory Hafner
Hafner.Gregory@orbital.com
Orbital

Frederick Hawthorne
frederick.d.hawthorne@lmco.com
Lockheed Martin

Kevin Horgan
kevin.horgan@nasa.gov
NASA

Joe Haman
jhaman@ball.com
Ball

Ben Hoang
Hoang.Ben@orbital.com
Orbital

Eugene Jaramillo
eugenejaramillo@raytheon.com
Raytheon

Lilian Hanna
lilian.hanna@boeing.com
Boeing

Rosemary Hobart
rosemary@hobartmachined.com
Hobart Machined

Dan Jarmel
dan.jarmel@ngc.com
Northrop Grumman

Harold Harder
harold.m.harder@boeing.com
Boeing

Richard Hodges
richard.e.hodges@jpl.nasa.gov
NASA

Robert Jennings
rjennings@raytheon.com
Raytheon

Mike Jensen
mike.jensen@ulalaunch.com
ULA Launch

Mike Kahler
mkahler@ball.com
Ball

Byron Knight
knightby@nro.mil
NRO

Amanda Johnson
johnson.amanda@orbital.com
Orbital

Yehwan Kim
ykim@moog.com
Moog

Hans Koenigsmann
hans.koenigsmann@spacex.com
SpaceX

Edward Jopson
edward.jopson@ngc.com
Northrop Grumman

Jeff Kincaid
Jeffrey.Kincaid@pwr.utc.com
Power

James Koory
james.koory@rocket.com
Rocket

Jim Judd
judd.jim@orbital.com
orbital

Mark King
markking@micropac.com
Micropac

Brian Kosinski
Kosinski.Brian@ssd.loral.com
SSL

Geoffrey Kaczynski
gkazynik@neaelectronics.com
NEA Electronics

Andrew King
andrew.m.king@boeing.com
Boeing

John Kowalchik
john.j.kowalchik@lmco.com
Lockheed Martin

Rick Krause
rkrause@ball.com
Ball

Chris Larocca
clarocca@emcore.com
EMCORE

Don LeRoy
dleroy@bardenbearings.com
Barden Bearings

Steve Krein
steve.krein@atk.com
ATK

Robert Lasky
lasky.robert@orbital.com
Orbital

Scot Lichty
scot.r.lichty@lmco.com
Lockheed Martin

Steve Kuritz
steve.kuritz@ngc.com
Northrop Grumman

Eric Lau
lau.eric@ssd.loral.com
SSL

Sultan Ali Lilani
sultan.lilani@integra-tech.com
Integra - Tech

Louise Ladow
louise.ladow@seaker.com
Seaker

Marvin LeBlanc
Marvin.LeBlanc@noaa.gov
NOAA

Josh Lindley
joshua.lindley@mda.mil
MDA

C J Land
cland@harris.com
Harris

Scott Lee
Scott.lee@ngc.com
Northrop Grumman

Henry Livingston
henry.c.livingson@baesystems.com
BAE Systems

Art Lofton
Art.Lofton@ngc.com
Northrop Grumman

Joan Lum
joan.l.lum@boeing.com
Boeing

John Mc Bride
Mcbride.John@orbital.com
Orbital

James Loman
james.loman@sslmda.com
SSL

Brian Mack
mack.brian@orbital.com
Orbital

Ian McDonald
ian.a.mcdonald@baesystems.com
BAE Systems

Jim Loman
loman.james@ssd.loral.com
SSL

Julio Malaga
malaga.julio@orbital.com
Orbital

Kurt Meister
kurt.meister@honeywell.com
Honeywell

Lester Lopez
llopez04@harris.com
Harris

Kevin Mallon
Kevin.P.Mallon@1-3com.com
1-3 Com

Jeff Mendenhall
mendenhall@ll.mit.edu
MIT

Frank Lucca
frank.l.lucca@1-3com.com
1-3 Com

Miroslav Maramica
miroslav@area51esq.com
Area 51

Jo Merritt
jmerritt@avtec.com
AVTEC

Charles Mills
charles.a.mills@lmco.com
Lockheed Martin

Deanna Musil
deanna.musil@sslmda.com
SSL

Mike Numberger
nurnberger@nrl.navy.mil
Navy

Edmond Mitchell
edmond.mitchell@jhuapl.edu
APL

Thomas Musselman
thomas.e.musselman@boeing.com
Boeing

Michael O'Brien
michael.obrien@exelisinc.com
Exelis Inc

Dennis Mlynarski
dennis.mlynarski@lmco.com
Lockheed Martin

John Nelson
john.d.nelson@lmco.com
Lockheed Martin

Michael Ogneovski
michael.ognenovski@exelisinc.com
Exelis Inc

George Mock
gbm3@nyelubricants.com
NYE Lubricants

Dave Novotney
dbnovotney@eba-d.com
EBA

Debra Olejniczak
Debra.Olejniczak@ngc.com
Northrop Grumman

Nancy Murray
Nancy.murray@saftbatteries.com
Safety Batteries

Ron Nowlin
ron.nowlin@eaglepicher.com
EaglePicher

Larry Ostendorf
Lostendorf@psemc.com
psemc

Anthony Owens
anthony_owens@raytheon.com
Raytheon

Mark Pazder
mpazder@moog.com
Moog

Kay Rand
kay.rand@ngc.com
Northrop Grumman

Joseph Packard
Joseph.packard@exelisinc.com
Exelis Inc

Steven Pereira
Steven.Pereira@jhuapl.edu
APL

David Rea
david.a.rea@baesystems.com
BAE Systems

Peter Pallin
peter.pallin@sslmda.com
SSL

Richard Pfisterer
Richard.Pfisterer@jhuapl.edu
APL

Forrest Reed
forrest.reed@eaglepicher.com
EaglePicher

Richard Patrican
Richard.A.Patrican@raytheon.com
Raytheon

Angela Phillips
amphillips@raytheon.com
Raytheon

Thomas Reinsel
thomas_j_reinsel@raytheon.com
Raytheon

Paulette Megan
paulette.megan@orbital.com
Orbital

Dave Pinkley
dpinkley@ball.com
Ball

Bob Ricco
bob.ricco@ngc.com
Northrop Grumman

Mike Rice
mrice@rtlogic.com
RT Logic

John Rotondo
john.l.rotondo@boeing.com
Boeing

Michael Sampson
michael.j.sampson@nasa.gov
NASA

Sally Richardson
richardson.sally@orbital.com
Orbital

William Rozea
william.rozea@rocket.com
Rocket

Victor Sank
victor.j.sank@nasa.gov
NASA

Troy Rodriquez
troy_rodriquez@sierramicrowave.com
Sierra Microwave

Dennis Rubien
dennis.rubien@ngc.com
Northrop Grumman

Don Sawyer
don.sawyer@avnet.com
AVNET

Ralph Roe
ralph.r.roe@nasa.gov
NASA

Larry Rubin
Rubin.larry@ssd.loral.com
SSL

Fred Schipp
frederick.schipp@navy.mil
MDA - Navy

Mike Roller
mike.roller@utas.utc.com
UTAS

Lane Saechao
lane.saechao@rocket.com
Rocket

Jim Schultz
james.w.schultz@boeing.com
Boeing

Gerald Schumann
gerald.d.schumann@nasa.gov
NASA

Andrew Shroyer
ashroyer@ball.com
Ball

Jerry Sobetski
jerome.f.sobetski@lmco.com
Lockheed Martin

Annie Sennet
Annie.Sennet@saftbarries.com
Safety Batteries

Fredic Silverman
fsilverman@hstc.com
HSTC

LaKeisha Souter
lakeisha.souter@ngc.com
Northrop Grumman

Michael Settember
michael.a.settember@jpl.nasa.gov
NASA

Rob Singh
rob.singh@sslmda.com
SSL

Jerry Spindler
Jerry.Spindler@exelisinc.com
Execlis Inc

Tom Sharpe
tsharp@smtdcorp.com
SMT Corp

Kevin Sink
kevin.sink@ttinc.com
TTINC

Peter Stoltz
pstoltz@txcorp.com
TX Corp

Jonathan Sheffield
jonathan.sheffield@sslmda.com
SSL

Melanie Sloane
melanie.sloane@lmco.com
Lockheed Martin

Thomas Stout
thomas.stout@ngc.com
Northrop Grumman

George Styk
george.styk@exelisinc.com
Exelis Inc

Ghislain Turgeon
ghislain.turgeon@sslmda.com
SSL

Michael Verzuh
mverzuh@ball.com
Ball

David Swanson
swanson.david@orbital.com
Orbital

Deborah Valley
deborah.valley@ll.mit.edu
MIT

John Vilja
jussi.vilja@pwr.utc.com
Power UTC

Mauricio Tapia
tapia.mauricio@orbital.com
Orbital

Fred Van Milligen
fvanmilligen@jdsu.com
JDSU

Vincent Stefan
vincent.stefan@orbital.com
Orbital

Jeffrey Tate
jeffery_tate@raytheon.com
Raytheon

Marvin VanderWeg
marvin.vanderwag@spacex.com
SpaceX

James Wade
james.w.wade@raytheon.com
Raytheon

Bill Toth
william.toth@ngc.com
Northrop Grumman

Gerrit VanOmmering
gerrit.vanommering@sslmda.com
SSL

John Walker
JohnF.Walker@sslmda.com
SSL

Brian Weir
weir_brian@bah.com
Booz Allen Hamilton

Charlie Whitmeyer
whitmeyer.charlie@orbital.com
Orbital

George Young
gyoung@raytheon.com
Raytheon

Arthur Weiss
arthur.weiss@pwr.utc.com
Power UTC

Michael Woo
michael.woo@raytheon.com
Raytheon

Craig Wesser
craig.wesser@ngc.com
Northrop Grumman

Larry Wray
wray.larry@ssd.loral.com
SSL

Dan White
dan.white@comdev-usa.com
Comdex-USA

Mark Wroth
mark.wroth@ngc.com
Northrop Grumman

Thomas Whitmeyer
tom.whitmeyer@nasa.gov
NASA

Jian Xu
jian.xu@aeroflex.com
Aeroflex

APPROVED BY
(AF OFFICE)

J. Rodriguez

DATE June 30, 2014