UAS Integration in the NAS Project
Test Site Kick-off Meeting

Task 1 – UTM Integration
Parimal Kopardekar (PK)
Kevin Witzberger

Task 2 – LVC-DE Connectivity
Davis Hackenberg
Jim Murphy

September 29, 2015
Overview

- Roll Call
  - UAS-NAS Project
  - UTM project
  - FAA
  - Alaska
  - Nevada
  - New York
  - North Dakota
  - Texas
  - Virginia
  - Other

- Congratulations to all on the Award!!!

- Opening Remarks
- IDIQ Overview
- Task 1 UTM Integration
  - UTM Overview
  - Task 1 Discussion
- Task 2 LVC-DE Prototype Connections
  - LVC Overview
  - Task 2 Discussion
- Test Site presentations and questions
IDIQ Overview

• Please submit all formal requests through, and copy the COR and CO on all relevant emails

• Administering Contracting Officer
  Rosalia Toberman
  rosalia.toberman-1@nasa.gov
  661-276-3931

• Contracting Officer Representative
  Davis Hackenberg
  Davis.L.Hackenberg@nasa.gov
  661-510-4832

• Task 1 Technical POC
  Kevin Witzberger  Joey Rios
  Kevin.E.Witzberger@nasa.gov  joseph.l.rios@nasa.gov
  650-604-2035  650-604-0231

• Task 2 Technical POC
  Jim Murphy
  James.R.Murphy@nasa.gov
  734-676-1164
IDIQ Overview

• **Airworthiness (due one month after contract award)**

As NASA and the FAA shall not be in operational control of the UAS operating at the Test Sites a clear declaration and understanding by each Test Site vendor needs to be clarified with the precise manner and processes in which each Test Site exercises their authority as a public entity in regards to airworthiness, safety, training, and operations of UAS operated within their Test Site. The contractor shall be responsible for operational oversight. That includes aircraft and crew certification and range safety.

The Test Site shall establish airworthiness, flight safety, mission readiness, and configuration control review processes and procedures to identify any hazards, to manage the risks associated with flight programs, to ensure safe flight operations, to manage and thoroughly document aircraft configurations, and to ensure that flight objectives satisfy programmatic requirements.(NPR 7900-003)

The Test Site shall be responsible to delineate specifically under whose public use authority that each Test Site’s UASs shall be operated under, as part of their technical approach. The Test Sites are expected to operate under their own public use authority, and not that of NASA’s. This information is needed to determine the operator’s understanding of the SOW requirements to ensure the quality of deliverables as well as the processes and authority for complying with federal regulations for the performance of government flight activities.

The Test Site shall submit their documents that address current or planned airworthiness processes and other associated documentation that addresses operational control plans and incident response for NASA Review. [30 days after contract award]
IDIQ Overview

• IT Security Plan (due one month after contract award)
• Intent of initial deliverable: Ensure all test sites have:
  – A base level of IT security process followed are their facilities
  – An understanding of NASA’s IT security requirements
  – Common understand for the use of data between the test site and NASA
• Initial deliverable does not cover the anticipated connection to be developed between each Test Site and NASA. This will be determined based on the proposed system architecture and specific data interface requirements
  – A direct connection between a Test Site facility and NASA will require an Authority to Operate (ATO)
    • Negotiated between the Test Site and NASA
    • This initial IT Security Plan is a subset of the required documentation
  – ATO deliverable 3/31/2016
# IDIQ Deliverable Dates

<table>
<thead>
<tr>
<th>Test Site</th>
<th>Deliverable</th>
<th>Deliverable Instructions</th>
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### POC’s

**Test Site Distribution List as of 09.13.15**

#### University of Alaska Fairbanks

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Email</th>
<th>Phone</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ro Bailey*</td>
<td>Director: Pan-Pacific UAS Test Range Complex and Associate Director: Alaska Center for Unmanned Aircraft Systems integration - ROT&amp;E</td>
<td><a href="mailto:rbailey11@alaska.edu">rbailey11@alaska.edu</a></td>
<td>(mobile) 907-322-2255</td>
<td></td>
</tr>
<tr>
<td>Catherine Cahill</td>
<td>Management of Alaska Center Unmanned Aircraft Systems Integration (ACUASI)</td>
<td><a href="mailto:cfcahill@alaska.edu">cfcahill@alaska.edu</a></td>
<td></td>
<td>Request came from Rosemary Madnick on September 22nd via a memorandum requesting replacement of Marty Rogers.</td>
</tr>
<tr>
<td>Rosemary Madnick</td>
<td>Grants and Contracts Administration</td>
<td><a href="mailto:rmadnick@alaska.edu">rmadnick@alaska.edu</a></td>
<td>(mobile) 907-474-6446</td>
<td></td>
</tr>
</tbody>
</table>

#### State of Nevada

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Email</th>
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<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Thomas Wilczek*</td>
<td>Defense and Aerospace Industry Representative; Governor's Office of Economic Development</td>
<td><a href="mailto:tawilczek@diversifynevada.com">tawilczek@diversifynevada.com</a></td>
<td>757-687-9900</td>
<td></td>
</tr>
<tr>
<td>Michelle Schierholt</td>
<td>Executive Assistant; Nevada Governors Office</td>
<td><a href="mailto:mschierholt@diversifynevada.com">mschierholt@diversifynevada.com</a></td>
<td>757-687-9900</td>
<td></td>
</tr>
</tbody>
</table>

#### New York - Oneida County (Griffiss UAS Test Site)

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Email</th>
<th>Phone</th>
<th>Notes</th>
</tr>
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<tbody>
<tr>
<td>Chad Lawrence</td>
<td>Deputy Commissioner of Aviation</td>
<td><a href="mailto:clawrence@ocgov.net">clawrence@ocgov.net</a></td>
<td>702-525-1562</td>
<td></td>
</tr>
<tr>
<td>Dr. Raymond Young</td>
<td>Technical Director</td>
<td><a href="mailto:ryoung@nuair.org">ryoung@nuair.org</a></td>
<td>702-525-1562</td>
<td></td>
</tr>
</tbody>
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#### Northern Plains UAS Test Site North Dakota

<table>
<thead>
<tr>
<th>Name</th>
<th>Title</th>
<th>Email</th>
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<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>Robert J Becklund*</td>
<td>Executive Director; Northern Plains Unmanned Aircraft Systems Test Site</td>
<td><a href="mailto:rbecklund@nd.gov">rbecklund@nd.gov</a></td>
<td>701-777-6330</td>
<td></td>
</tr>
<tr>
<td>Paul Lucy</td>
<td>Director: Economic Development &amp; Finance at North Dakota</td>
<td><a href="mailto:plucy@nd.gov">plucy@nd.gov</a></td>
<td>701-328-5388</td>
<td></td>
</tr>
<tr>
<td>Brian Opp</td>
<td>Manager, Aerospace Development: North Dakota Department of Commerce</td>
<td><a href="mailto:blopp@nd.gov">blopp@nd.gov</a></td>
<td>701-325-5342</td>
<td></td>
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#### Texas A&M University - Corpus Christi

<table>
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<tr>
<th>Name</th>
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<th>Phone</th>
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<tbody>
<tr>
<td>Luis Cifuentes, Ph.D.*</td>
<td>Vice President for Research, Commercialization and Outreach; Acting Executive Director of the Lone Star UAS Center of Excellence and Innovation</td>
<td><a href="mailto:luis.cifuentes@tamucc.edu">luis.cifuentes@tamucc.edu</a></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dr. Mayra Hough</td>
<td>Contracts</td>
<td><a href="mailto:mayra.hough@tamucc.edu">mayra.hough@tamucc.edu</a></td>
<td>361-825-3882</td>
<td></td>
</tr>
<tr>
<td>Dr. Melanie Neely Willis</td>
<td>Technical</td>
<td><a href="mailto:mneelywillis@camber.com">mneelywillis@camber.com</a></td>
<td>361-825-4120</td>
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<tr>
<td>Ms. Lori Blades</td>
<td>Pricing</td>
<td><a href="mailto:lori.blades@tamucc.edu">lori.blades@tamucc.edu</a></td>
<td>301-825-2856</td>
<td></td>
</tr>
<tr>
<td>Dr. Chris Walach</td>
<td>Director of Technical Operations, NIAS-Nevada</td>
<td><a href="mailto:chris.walach@nias-neas.com">chris.walach@nias-neas.com</a></td>
<td></td>
<td>Requested to be added 09.22 via email to Davis</td>
</tr>
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#### Virginia Tech

<table>
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<tr>
<th>Name</th>
<th>Title</th>
<th>Email</th>
<th>Phone</th>
<th>Notes</th>
</tr>
</thead>
<tbody>
<tr>
<td>John Rudd*</td>
<td>Assistant Vice President for Sponsored Programs Administration</td>
<td><a href="mailto:ruddj@vt.edu">ruddj@vt.edu</a></td>
<td>540-231-5281</td>
<td></td>
</tr>
<tr>
<td>John Greene</td>
<td>Technical</td>
<td><a href="mailto:greenej@vt.edu">greenej@vt.edu</a></td>
<td>540-231-8566</td>
<td></td>
</tr>
<tr>
<td>Emilee Hillman</td>
<td>Commercial Contracting Program Coordinator</td>
<td><a href="mailto:eande06@vt.edu">eande06@vt.edu</a></td>
<td>540-231-2593</td>
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</table>
Safe and Autonomous System Operations (SASO) Organizational Structure

PM: Dr. Parimal Kopardekar
DPM: Sharon Graves
APM: Craig Hange

Resources: Julie Huynh
Scheduling: Joseph Cronauer
Risk Management: Seth Kurasaki
NRA Manager: Naz Galeon

SASO Technical Advisory Committee:
Dr. Danette Allen, Tom Davis, Davis Hackenberg, Dr. Sanjay Garg, Dr. John Ryan, and Don Simon

Emerging Opportunities (Candidates for TC in out years)
- Autonomous aircraft operations
- Autonomous Traffic Flow Management
- Autonomous Localization, sensing, and conformance
- Autonomous Airport
- Autonomous AOC
- Additional items from ARC, AFRC, GRC, & LaRC to be considered as part of current planning

Foundational, Cross-Cutting or Exploratory R&D
- V&V and Certification Methods for Autonomous Operations (Dr. Guillaume Brat and Dr. Paul Miner)
- Analysis Studies (Stakeholder survey, benefits, affordable air mobility) (Jeremy Smith)
- Human-autonomy Teaming (TBD)
- Communication, Navigation, and Surveillance (TBD)
**Near-term Goal** – Enable initial low-altitude airspace and UAS operations with demonstrated safety as early as possible, within 5 years

**Long-term Goal** – Accommodate increased UAS operations with highest safety, efficiency, and capacity as much autonomously as possible (10-15 years)
UTM – One Design Option – Towards Autonomy

<table>
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<th>Multiple customers With diverse mission needs/profiles</th>
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<tbody>
<tr>
<td>UAS 1</td>
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<td>UAS 2</td>
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<td>UAS 3</td>
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<td>UAS n</td>
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<tr>
<td>Range of UAVs from disposable to autonomous</td>
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**Low altitude CNS options such as:**
- Low altitude radar
- Surveillance coverage (satellite/ADS-B, cell)
- Navigation
- Communication

**Autonomicity:**
- Self-Configuration
- Self-Optimization
- Self-Protection
- Self-Healing
- Operational data recording

**Authentication**
- Airspace design and geofence definition
- Weather integration
- Constraint management
- Sequencing and spacing
- Trajectory changes
- Separation management
- Transit points/coordination with NAS
- Geofencing design and adjustments
- Contingency management

**Constraints based on community needs about noise, sensitive areas, privacy issues, etc.**

**3-D Maps:**
Terrain, human-made structures

**Real-time Wx and wind**

**Wx and wind Prediction**

**Airspace Constraints**

**Other low-altitude operations**

**Transition between UTM and ATM airspace**

**Multiple customers With diverse mission needs/profiles**

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10 of 29
Schedule

- UTM research and development driven by various “Builds”
- Each Build adds more services and capabilities

**Build 1**
- Demo: **Aug 2015**
- Geo-fencing and airspace design
- Open/close airspace for wx
- Basic procedural separation
- Simple scheduling
- Initial constraint database

**Build 2**
- Demo: **Oct 2016**
- Dynamic airspace adjustments
- Demand/Capacity imbalance
- Initial contingency management

**Build 3**
- Demo: **Jan 2018**
- Trajectory conformance monitoring
- Web portal for UTM access
- Heterogeneous operations

**Build 4**
- Demo: **Mar 2019**
- Large scale contingency management
UAS Traffic Management Build 1 Flight Demonstration: Overview

NASA Ames Research Center
09/29/2015
Partnerships
UTM Vehicles
Equipment

- **Ground Equipment**
  - Air Traffic Surveillance
    - (ADS-B, ASDE-X, air traffic radar)
  - Radar Station
    - SRHawk 2D low altitude radar
  - 1 ADS-B Ground Relay Station
  - Sound Microphone Sensors
  - Weather Station
    - 100 ft Weather Tower
    - Radiosonde System
    - Microwave Profiler

- **Vehicles:**
  - Multi-rotors:
    - 5 QuadCopters
    - 1 Hexacopter
    - 2 Octocopters
  - Fixed Wing : 2
  - Range in size, weight, endurance, and capabilities
  - 1 ADS equipped aircraft
  - 1 vehicle equipped to be tracked over cellular network
  - UTM Connection via LAN

- **UTM Manager displays**
Test Objectives

• **Objective 1:** Demonstrate UTM Capabilities
  – Show connection of a variety of vehicles to the UTM system

• **Objective 2:** Collect Data on UAS Navigation Performance Error
  – Collect data on a vehicle's ability to track a flight plan and maintain a geo-fenced boundary

• **Objective 3:** Collect Data on Aircraft Tracking Performance
  – Collect data on the ability and performance of an independent surveillance source to track the UAS

• **Objective 4:** Collect Weather Observations for Forecasting Models
  – Collect localized weather information and compare them to forecasting models and support the development of vehicle performance models

• **Objective 5:** Collect Data on Noise Signature of UAS Vehicles
  – Collect data on the decibel levels and frequencies at which UAS operating at different altitudes will produce in an operational environment.
Flight Plan

Altitudes:
• Launches will occur at local airfield elevation (approx. 166 ft. MSL)
• Maximum flight altitudes up to 400 ft. AGL

Range:
• Flights to remain within MOA airspace constraints & site layout operational area (see next slide).
• Flights will be staged over terrain which consists of the airfield runways & unpopulated farm land.

Duration:
• Eight (8) to thirty (30) minutes on average, not to exceed safe battery limits.

Modes:
• Single aircraft launch & recovery
• Dual aircraft launch & recovery
Connection to the UTM System

- Communication between GCS & UTM system is over ad-hoc WiFi network (5.0GHz router)
  - Telemetry information is read-only from GCS
  - GCS can submit a flight plan to the UTM system & UTM system can respond with an approval or rejection message to the GCS.

Flight Plan
Take-Off Clearance
Telemetry
Close Flight Plan

UAS GCS
Approval/Rejection
UTM System

TP-Link Archer C9 WiFi Router
UTM Manager Display
Only two aircraft will operate simultaneously and will operate in separate flight areas.
From the UTM effort’s perspective, there are several ways we see value being generated for our project.

These high-level goals are more qualitative and not hard requirements indicating the technical success of this Task 1.
Task 1 Qualitative Goals

Exercise the UTM prototype

- Use several new clients
- Test system under geographic diversity
Task 1 Qualitative Goals

Introduce Test Sites to UTM concept and use

- Leverage capabilities of test sites
- Obtain feedback (formal and informal) on UTM concept from experts in the field
Task 1 Qualitative Goals

Shakeout prototype technical issues

• Data exchange formats
• Manager implementation
• Connectivity
Task 1 Qualitative Goals

Pave way for potential future collaborations

• Make it easier to work with test sites in various capacities
• No guarantees
Test architecture options for UTM

- How do multiple UTM Systems interact?
- How well can a monolithic version of UTM handle geographic diversity?
Demo Notes

- Test sites will conduct roughly independent shakedown tests (with and without flights) through the end of Feb 2016
- In April 2016, we will attempt a coordinated demonstration wherein each site is executing flights under UTM simultaneously
- We will test at least two UTM architectures during the coordinated demo: monolithic UTM, and separate UTMs
## Task 1 Deliverables

<table>
<thead>
<tr>
<th>Task 1 (All Test Sites) POP through 05/31/2016</th>
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<tbody>
<tr>
<td>Joint Kick-off Meeting</td>
<td>Each Test Site will plan for a joint kick-off meeting</td>
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<tr>
<td>Task 1 Test Plan</td>
<td>Each Test Site shall submit a test plan to accomplish the goals of the task. The test Plan shall include content described in the SOW</td>
</tr>
<tr>
<td>Shakedown tests</td>
<td>Each test site shall conduct a UTM shakedown activity with multiple aircraft as a precursor to Initial Safe National UAS integration Campaign/Initiative</td>
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<tr>
<td>Task 1 Safe Integration Month Demo</td>
<td>Each test site shall conduct a UTM demo with multiple aircraft in conjunction with Initial Safe National UAS integration Campaign/Initiative</td>
</tr>
<tr>
<td>Task 1 Final Report</td>
<td>Each Test Site shall submit a report on the simultaneous UTM demonstration per content described in Task 1</td>
</tr>
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UAS Integration in the NAS Organizational Structure

Host Center
- AFRC Director of Programs: Dennis Hines
- Deputy Director: Joel Sitz

Project Office
- Project Manager: Laurie Grindle - AFRC
- Deputy Project Manager, Integration: Davis Hackenberg - AFRC
- Chief Systems Engineer: Debra Randall - AFRC
- Deputy Chief Systems Engineer: Peggy Hayes - AFRC
- Staff Systems Engineer: Dan Roth - AFRC

Project Support
- Lead Resource Analyst: Cindy Brandvig - AFRC
- Lead Procurement Officer: R. Toberman - AFRC
- Lead Scheduler: John Percy - AFRC
- Mgmt Support Specialist: Jamie Turner - AFRC
- Administrative Support: Giovanna Bowen - AFRC

Subprojects/Technical Challenges (TC)
- TC-SAA: SAA Performance Standards
  - Separation Assurance/Sense and Avoid Interoperability (SSI)
  - Co-PEs: Confesor Santiago - ARC, Keith Arthur - LaRC
- TC-C2: C2 Performance Standards
  - Communications PE: Jim Griner - GRC
- TC-HSI: Human Systems Integration (HSI)
  - HSI PE: Jay Shively - ARC
- TC-ITE: Integrated Test and Evaluation (IT&E)
  - IT&E Co-PEs: Sam Kim - AFRC, Jim Murphy - ARC
- Certification PE: Kelly Hayhurst - LaRC

ExCom, RTCA Steering Committee, UAS Aviation Rulemaking Committee
External Interfaces
- FAA, DoD, RTCA SC-228, Industry, etc.

AFRC ARD
ARC ARD
GRC ARD
LaRC ARD

PE: Project Engineer, DPMf: Deputy Project Manager for
UAS-NAS Project OV-1 in support of P1 MOPS
Possible NASA Project OV-1 in Support of Phase 2 MOPS TOR

LEGEND
- Detect and Avoid (DAA) Technologies
- Air Traffic Control (ATC) Services
- Control and Non-Payload Communications (CNPC) Network
- Phase 2 MOPS Command and Control (C2) Links
- Legacy C2 Links

ACRONYMS
- ADS–B: Automatic Dependent Surveillance—Broadcast
- BVLOS: Beyond Visual Line of Site
- LOS: Line of Site
- sUAS: Small Unmanned Aircraft System
- TCAS–II: Traffic Alert and Collision Avoidance System

COMMUNICATIONS
- SatCom BVLOS Communications
- DAA Sensors
- Legacy LOS Link

SENSE AND AVOID
- Airborne Sense and Avoid
- Non-cooperative Aircraft (live or virtual)
- Class D Airspace Integration
- Ground Based Sense & Avoid

LEGEND
- P1-MOPS BVLOS Link
- P2-MOPS BVLOS Link
- Legacy BVLOS Link

ACRONYMS
- ADS–B: Automatic Dependent Surveillance—Broadcast
- BVLOS: Beyond Visual Line of Site
- LOS: Line of Site
- sUAS: Small Unmanned Aircraft System
- TCAS–II: Traffic Alert and Collision Avoidance System
LVC Client Assets

- **Live**
  - Ikhana (NASA’s MQ-9)
  - T-34C (Manned Intruder)
  - S-3B Viking (Surrogate UAS)

- **Virtual**
  - Ikhana Sim
  - B747 Flight Simulator
  - Ground Control Station
  - Multi-Aircraft Control System (MACS) ATC Emulator

- **Constructive**
  - MACS Pseudo Pilot
Task 2 Overview

- Connect to the LVC-DE!
LVC Gateway Bridge Connection

Options:

1. Connect to LVC Gateway
   - Direct connection to local LVC Gateway
   - Direct Connection to remote LVC Gateway

2. Leverage existing Test Site Middleware
   - Connect Middleware to LVC Gateway
   - Develop Bridge between middleware and LVC HLA

Tasks:

- **Identify candidate test**
  - Required equipment
  - Support systems
- **Determine system architecture**
  - Start Connection Agreement paperwork
- **Setup LVC Gateway at local facility (if required)**
  - Sign LVC Gateway SUA and receive software
  - Procure/identify LVC Gateway hardware
  - Install gateway
- **Identify Interface**
  - Work with LVC Team to integrate ICD changes into existing LVC system
  - Establish connection
  - Test
### Task 2 Deliverables

<table>
<thead>
<tr>
<th>Task 2 (All Test Sites) - POP through 09/30/2016</th>
<th>Description</th>
<th>Date</th>
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<tbody>
<tr>
<td>Joint Kick-off Meeting</td>
<td>Each Test Site will plan for a joint kick-off meeting</td>
<td>10/31/15</td>
</tr>
<tr>
<td>Proof of Hardware purchases</td>
<td>Documentation of equipment to be installed for LVC-DE connection</td>
<td>12/31/15</td>
</tr>
<tr>
<td>Software Usage Agreement</td>
<td>Final signed software usage agreement necessary for connection to LVC</td>
<td>3/31/16</td>
</tr>
<tr>
<td>Authority to Operate (ATO)</td>
<td>Final signed ATO necessary for connection to LVC</td>
<td>3/31/16</td>
</tr>
<tr>
<td>Initial Safe National UAS Integration Testing</td>
<td>Initial Testing of LVC system connectivity during the timeframe of an independent NASA initiative.</td>
<td>4/30/16</td>
</tr>
<tr>
<td>Final LVC-DE Connection</td>
<td>Final Demonstration of all LVC-DE, likely a multiple week period. Live flight data will be passed to NASA from the vehicle system through the LVC</td>
<td>07/31-08/31/2016</td>
</tr>
<tr>
<td>LVC-DE ICD Gap Assessment</td>
<td>Description of deficiencies or necessary changes to NASA ICD to allow for more efficient connections, and to document final configuration ICD</td>
<td>9/30/16</td>
</tr>
</tbody>
</table>
Proposed SMART NAS Project Structure

**PROJECT**

- **Systems Engineering Office (shared)**
  - Lead: Ron Johnson (shared)
  - Scheduler
  - Risk manager

- **PM:** Dr. S. Grabbe
- **DPM:** R. Aquilina
- **APM:** J. Koelling
- **APM for Technology (temporary):** R. Mah

**PP&C (shared)**
- Host Center Analyst: Janine Yip (shared)
- Center Analysts: Paula Chambers, LaRC (shared)
- NRA manager: N. Galeon (shared)

**SMART-NAS Test Bed**
- Co-SPM: Kee Palopo
  - SPM: Tim Lewis
- Co-SPM: Mike Guminsky

**Function Allocation**
- SPM: Dr. Deepak Kulkarni

**Networked ATM**
- SPM: Paul Lee

**New York Trajectory Based Operations (TBO)**
- SPM: Dr. Deepak Kulkarni

**Systems Assurance Technologies**
- SPM: Debbie Martinez

**Real-time Safety Modeling**
- SPM: Dr. Kai Goebel