Assessing the Impact of Operational Constraints on the Near-Term UAS Traffic Management Supported Market

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AIAA Aviation, Washington DC
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Agenda

- **Motivation**
  - Commercial Unmanned Aircraft Systems (UAS)
  - NASA UAS Traffic Management (UTM)

- **UAS Application Review**
  - Identification of 135 UAS applications
  - Proposal of five comprehensive UAS mission categories

- **Market Analysis Methodology**
  - Power line sector example

- **Market Analysis Forecast for 2020 Commercial UAS Sectors**
  - Sensitivities to UTM operational constraints

- **Conclusions**
DOD UAS Investment

DOD UAS spending (Billions $)

$3.9 Billion

$26 Billion

[CRS, 2012]
Global Commercial UAS Industry

[BI Intelligence, 2014]
US Commercial sUAS Industry

[FAA Aerospace Forecast Report, 2016]
The NASA Unmanned Aircraft System Traffic Management (UTM) program is committed to safely enabling low-altitude airspace and UAS operations.
Can a market analysis of the commercial UAS industry through 2020 provide insight into the economic impact of UAS traffic management operational constraints?
Commercial UAS Applications

Proposed commercial applications for UAS have ballooned over the past two years
135 unique UAS applications were identified

Performance and cost data were collected for nearly 400 UAS

Five commercial UAS mission categories were identified to capture the diversity of ConOps in the 135 applications
UAS Mission Categories

1. Aerial Photography, Sensing & Surveillance
2. Communications
3. Transportation, Delivery & Interaction
4. Atmospheric & Earth Sciences
5. Audiovisual Presence
The research considered only TCLs 1 and 2

16 representational commercial UAS sectors were defined to host the market analysis

Each sector had the following traits:

- Represented one or more application enabled by TCL 1 or 2
- Substantial UAS market penetration possible by 2020
- Anticipated to represent a significant market opportunity
Three sectors concerned UAS applications for farming

1. Cropland Precision Agriculture
2. Pasture/Range Management
3. Aerial Application
UAS Application Down-Selection

Five sectors involved the inspection of large infrastructure complexes

1. Cropland Precision Agriculture
2. Pasture/Range Management
3. Aerial Application
4. Wind Turbine Inspection
5. Solar Farm Inspection
6. Dam Inspection
7. Heavy Industry Inspection
8. Communications Tower Inspection
Five sectors concern the inspection of highly dispersed critical infrastructure

1. Cropland Precision Agriculture
2. Pasture/Range Management
3. Aerial Application
4. Wind Turbine Inspection
5. Solar Farm Inspection
6. Dam Inspection
7. Heavy Industry Inspection
8. Communications Tower Inspection
9. Pipeline Inspection
10. Power Line
11. Railroad
12. Bridge Inspection
13. Trestle Inspection
Three sectors concern the use of UAS for specialized purposes with changing needs:

1. Cropland Precision Agriculture
2. Pasture/Range Management
3. Aerial Application
4. Wind Turbine Inspection
5. Solar Farm Inspection
6. Dam Inspection
7. Heavy Industry Inspection
8. Communications Tower Inspection
9. Pipeline Inspection
10. Power Line
11. Railroad
12. Bridge Inspection
13. Trestle Inspection
14. Search and Rescue
15. Maritime Security & Surveillance
16. Construction
Market Analysis Methodology

SME Interviews

Primary Source Data Collection

Multi-Source Estimation

Sector ConOps definition

Sector size estimation

Business case definition

Representative UAS selection

Determine market value along chosen metrics
First step: identify and characterize the various UAS application ConOps in the sector

1. **Power Line Patrol** – power line overflight
2. **Pylon Inspection** – pylon hovering
3. **Climber Assist** – rope lifting
4. **Construction** – wire stringing
First step: identify and characterize the various UAS application ConOps in the sector

1. **Power Line Patrol** – power line overflight

2. **Pylon Inspection** – pylon hovering

3. **Climber Assist** – rope lifting

4. **Construction** – wire stringing

Only power line and pylon inspection will be supported by TCLs 1 and 2
Second step: characterize the sector size and market penetration potential

<table>
<thead>
<tr>
<th>Sector Size Statistic</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>2010 High Voltage Transmission Lines (miles)</td>
<td>288,418</td>
</tr>
<tr>
<td>% of Transmission Lines in Rural Areas</td>
<td>75%</td>
</tr>
<tr>
<td>Annual Inspection Rate of Transmission Lines</td>
<td>100%</td>
</tr>
<tr>
<td>Average Span between Transmission Line Pylon (ft)</td>
<td>750</td>
</tr>
<tr>
<td>Annual Detailed Inspection of Pylons</td>
<td>50%</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Market Penetration</th>
<th>Base</th>
<th>Medium</th>
<th>High</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAS Transmission Line Inspection</td>
<td>20%</td>
<td>35%</td>
<td>50%</td>
</tr>
<tr>
<td>UAS Transmission Line Pylon Inspection</td>
<td>10%</td>
<td>25%</td>
<td>50%</td>
</tr>
</tbody>
</table>
Third step: establish the business case for the proposed sector:

- For power lines, current industry costs were determined through the published financials.
- UAS service costs were estimated from SME information, available published rates, or a cost based approach.

### Visual Patrol Business Case Data

<table>
<thead>
<tr>
<th></th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAS Fee per Hour (2015 $)</td>
<td>$500</td>
</tr>
<tr>
<td>UAS Vehicle Price (2015 $)</td>
<td>$50,000</td>
</tr>
<tr>
<td>Current Visual Patrol Cost (per mile)</td>
<td>$109.69</td>
</tr>
<tr>
<td>Inspection Time Reduction</td>
<td>20%</td>
</tr>
<tr>
<td>Production Downtime Reduction</td>
<td>10%</td>
</tr>
</tbody>
</table>
Third step: establish the business case for the proposed sector:

- For power lines, current industry costs were determined through the published financials.
- UAS service costs were estimated from SME information, available published rates, or a cost based approach.

<table>
<thead>
<tr>
<th>Pylon Inspection Business Case Data</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>UAS Fee per Hour (2015 $)</td>
<td>$150</td>
</tr>
<tr>
<td>UAS Vehicle Price (2015 $)</td>
<td>$20,000</td>
</tr>
<tr>
<td>Current Pylon Inspection Cost (per pylon)</td>
<td>$72.71</td>
</tr>
</tbody>
</table>
Unlike previous UAS market analyses, a variety of market parameters were utilized to provide a holistic picture of the potential impact of UAS on the sector.

The first two metrics concern the market opportunity available to a UAS service provider (internal or external to a client):

1. **Total Addressable Market (TAM)** – Revenue opportunity for a UAS service provider if 100% market penetration were achieved.

2. **Serviceable Addressable Market (SAM)** – Revenue opportunity for a UAS service provider considering limitations such as market penetration, service scalability, and non-UAS competition.
Market Analysis Methodology

Total UAS Market

Sector TAM

Sector SAM
3. **UAS Application Industry Size** – Number of UAS service providers needed to meet the market service demands

4. **UAS Capital Investment** – Manufacturer sales of UAS equipment necessary to meet the demands of the UAS service provider

5. **Operations Savings Potential** – financial savings switching to UAS services from conventional services

6. **Revenue Recovery Potential** – Value of “production recovery” or “failure avoidance” due to switch to UAS

7. **Safety Improvement Potential** – Value of safety improvements resulting from UAS operation
Power Line Visual Inspection Sector Size

- **Base:** 20% Inspection Rate
- **Medium:** 35% Inspection Rate
- **High:** 50% Inspection Rate

<table>
<thead>
<tr>
<th>Service Providers</th>
<th>UTM TCL 2</th>
<th>UTM TCL 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>20% Inspection</td>
<td>2</td>
<td>5</td>
</tr>
<tr>
<td>35% Inspection</td>
<td>4</td>
<td>9</td>
</tr>
<tr>
<td>50% Inspection</td>
<td>6</td>
<td>13</td>
</tr>
</tbody>
</table>
Power Line Pylon Inspection Sector Size

# of UAS Service Providers

- Base: 10% Inspection Rate
  - UTM TCL 2: 26
  - UTM TCL 4: 34

- Medium: 25% Inspection Rate
  - UTM TCL 2: 65
  - UTM TCL 4: 86

- High: 50% Inspection Rate
  - UTM TCL 2: 129
  - UTM TCL 4: 172
Search and Rescue TCL 2 Market Analysis

- UAS Capital Investment
- Servicable Addressable Market
- Operations Savings Potential

Market Penetration:
- High
- Medium
- Base

MILLIONS

$0 $50 $100 $150 $200
Sector Snapshots for UTM TCLs 1 & 2

- Servicable Addressable Market
- Capital Investment
- Operations Savings
- Revenue Recovery

- Construction
- Maritime Surveillance and Scouting
- Search and Rescue
- Heavy Industry Inspection
- Communication Tower Inspection
- Bridge/Trestle/Dam Inspection
- Rail Inspection
- Solar Farm Inspection
- Wind Turbine Inspection
- Pylon Visual Inspection
- Visual Patrol
- Oil & Gas Pipeline Inspection
- Aerial Application
- Pasture/Range Management
- Cropland Precision Agriculture
UTM TCL 1 Sector SAM Snapshot

Assumptions
- base level market penetration
- independent service provider model

Total SAM: $215,000,000
UTM TCL 2 Sector SAM Snapshot

Assumptions
- base level market penetration
- independent service provider model
Comparison to FAA Aerospace Forecast
Top 5 sUAS sectors

<table>
<thead>
<tr>
<th>FAA 2016 Aerospace Forecast</th>
<th>TCL 2 Study Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Government</strong> 2%</td>
<td><strong>Government</strong> 0%</td>
</tr>
<tr>
<td><strong>Real Estate/Aerial Photography</strong> 22%</td>
<td><strong>Real Estate/Aerial Photography</strong> 16%</td>
</tr>
<tr>
<td><strong>Insurance</strong> 15%</td>
<td><strong>Agriculture</strong> 34%</td>
</tr>
<tr>
<td><strong>Agriculture</strong> 19%</td>
<td><strong>Industrial Inspection</strong> 50%</td>
</tr>
<tr>
<td><strong>Industrial Inspection</strong> 42%</td>
<td></td>
</tr>
</tbody>
</table>

**Assumptions**
- base level market penetration
- mixed service provider model
Communications Tower Inspection
Operating Altitude Constraint Sensitivity

- **TCL 1+**
  - (2000 ft ceiling)
- **TCL 1**
  - (500 ft ceiling)

- Serviceable Addressable Market
- Capital Investment
- Operations Savings

**Millions**

- $0
- $2
- $4
- $6
- $8
Aerial Application Maximum Takeoff Weight Operating Constraint Sensitivity

Serviceable Addressable Market  Capital Investment  Operations Savings

TCL 1+ (>55 lb MTOW)

TCL 1 (<=55 lb MTOW)

$0  $100  $200  $300  $400

MILLIONS
Communications Tower Inspection
Population Density Overflight Sensitivity

- Capital Investment
- Serviceable Addressable Market
- Operations Savings Potential

TCL 4 (urban)
TCL 3 (suburban)
TCL 1 (rural)
Can a market analysis of the commercial UAS industry through 2020 provide insight into the economic impacts of UAS traffic management operational constraints?

- 16 leading market sectors were defined that are *enabled* by UTM Technology Capability Level (TCL) 1 or 2.
- Agricultural UAS sectors represent the largest early adopter markets.
- Sensitivity studies found population overflight and line of sight constraints to have a significant impact on numerous sectors.
- Maximum ceiling and takeoff weight constraints significantly impacted a few specific sectors.
QUESTIONS?
References
**Provider Model Sensitivity**

**Independent Service Provider Model**

Total SAM: $284,000,000

- Heavy Industry Inspection: 3%
- Communication Tower Inspection: 2%
- Bridge/Trestle/Dam Inspection: 3%
- Solar Array Inspection: 1%
- Wind Turbine Inspection: 1%
- Pylon Visual Inspection: 1%
- Oil & Gas Pipeline Inspection: 15%
- Aerial Application: 14%
- Pasture/Range Management: 8%
- Construction: 10%
- Cropland Precision Agriculture: 33%

**Mixed Service Provider Model**

Total SAM: $169,000,000

- Heavy Industry Inspection: 5%
- Communication Tower Inspection: 3%
- Bridge/Trestle/Dam Inspection: 4%
- Solar Array Inspection: 1%
- Wind Turbine Inspection: 2%
- Pylon Visual Inspection: 2%
- Construction: 12%
- Aerial Application: 15%
- Oil & Gas Pipeline Inspection: 25%
- Cropland Precision Agriculture: 19%
- Pasture/Range Management: 4%

**Assumptions**

- UTM TCL 2 supported sectors
- Base level market penetration
Provider Model Sensitivity

### Independent Service Provider Model

**Total Capital Investment:** $89,000,000

- Construction 1%
- Maritime Surveillance and Scouting 21%
- Search and Rescue 13%
- Bridge/Trestle/Dam Inspection 1%
- Rail Inspection 4%
- Oil & Gas Pipeline Inspection 6%
- Aerial Application 9%
- Pasture/Range Management 8%
- Cropland Precision Agriculture 35%

### Mixed Service Provider Model

**Total Capital Investment:** $2,856,000,000

- Construction 3%
- Maritime Surveillance and Scouting 1%
- Aerial Application 1%
- Pasture/Range Management 27%
- Cropland Precision Agriculture 67%

**Assumptions**
- UTM TCL 2 supported sectors
- Base level market penetration
Sector Snapshots for UTM TCLs 1 & 2

- Construction
- Maritime Surveillance and Scouting
- Search and Rescue
- Heavy Industry Inspection
- Communication Tower Inspection
- Bridge/Trestle/Dam Inspection
- Rail Inspection
- Solar Farm Inspection
- Wind Turbine Inspection
- Pylon Visual Inspection
- Visual Patrol
- Oil & Gas Pipeline Inspection
- Aerial Application
- Pasture/Range Management
- Wind Turbine Inspection
- Solar Farm Inspection
- Rail Inspection
- Construction

- Serviceable Addressable Market
- Capital Investment
- Operations Savings
- Revenue Recovery

-40% -20% 0% 20% 40% 60% 80% 100%
UTM TCL 2 Sector SAM Snapshot

Assumptions
- medium level market penetration
- independent service provider model

Total SAM: $542,000,000
Assumptions
- high level market penetration
- independent service provider model

Total SAM: $1,987,000,000