Initial Approach to Collect Small Unmanned Aircraft System Off-nominal Operational Situations Data

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Outline

- Why collect Unmanned Aircraft System (UAS) off-nominal operational situations data
- NASA UAS Traffic Management (UTM) project's off-nominal data collection approach
- What were collected
- Findings
- Next steps

Russian postal drone crashes into wall on maiden flight
https://tinyurl.com/yaefsunb

Major League Baseball responds after drone makes crash landing during San Diego Padres game
https://tinyurl.com/n5bscpn

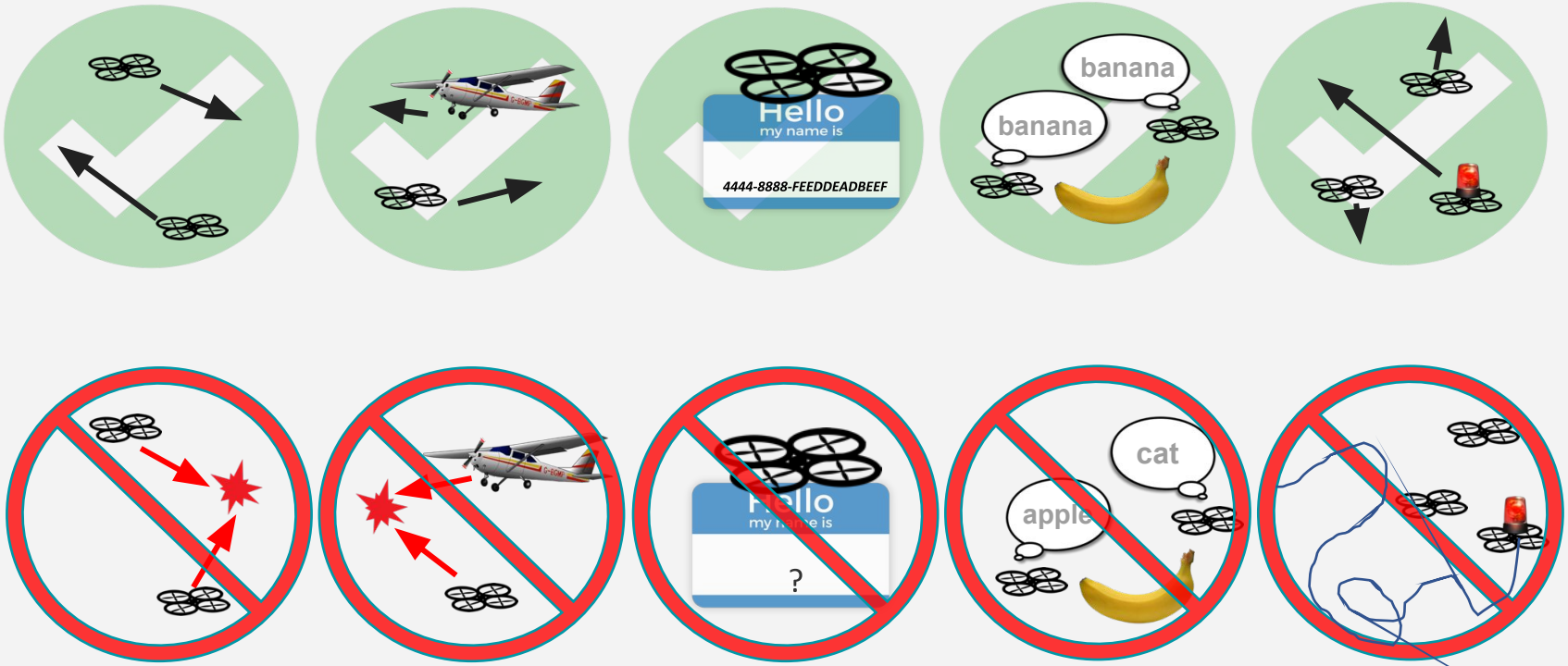
Stadium and team owners see drones as major league threat
https://tinyurl.com/yd64zkx6

Why America's drone problem may not be as bad as some think
https://tinyurl.com/yb6nkn3d

Collecting Off-Nominal Operational Situations Data

- Overarching goals:
  - **Reduction in off-nominal situations incidence**
  - **Safe resolution of off-nominal situations**
- Initial focus of the UAS Traffic Management (UTM) effort: Communications and Navigation, to ensure that
  - **Unmanned Aircraft (UA) are under operational control of the remote pilot**
  - **UA remain within a defined area**

UTM Principles



UTM Project Overview

TCL1 (Remote)

- Visual Line of Sight
- Notice of Operation
- Position-Sharing (Optional)

TCL 2 (Rural)

- Beyond Visual Line of Sight
- Intent Sharing
- Strategic De-confliction
- Geographic Containment

TCL 3 (Suburban)

- Beyond Visual Line of Sight
- Intent Sharing
- Strategic De-confliction
- Geographic Containment
- Conflict Alert
- Detect and Avoid (DAA)

TCL 4 (Urban)

- Beyond Visual Line of Sight
- Intent Sharing
- Strategic De-confliction
- Geographic Containment
- Detect and Avoid (DAA)
- Vehicle-to-Vehicle (V2V)

TCL: Technical Capability Level

UTM National Campaign II, May ~ June 2017

- Demonstrate the UTM TCL 2
  - Test scenarios across a wide range of UAS platforms and locations
  - Validate further the scalability of the UTM concept and architecture
- Off-nominal data collection
  - Variables added to Data Management Plan for digital data
  - Voluntary **online report form** developed for contextual data

Example Variables for the Digital Data Collection

c2RssiAircraft_dBm	Command and Control (C2) link **Received Signal Strength** Indicator (RSSI) measured in dBm at aircraft
c2RssiGcs_dBm	C2 link RSSI measured in dBm at Ground Control Station (GCS)
c2NoiseAircraft_dBm	Sum of Thermal noise power and Radio Frequency (RF) interference power, measured in dBm at aircraft
c2NoiseGcs_dBm	Sum of Thermal noise power and RF interference power, measured in dBm at GCS
hdop_nonDim	HDOP: Horizontal dilution of precision of GPS constellation
vdop_nonDim	VDOP: Vertical dilution of precision of GPS constellation
numGpsSat_nonDim	**Number of GPS satellites** tracked by GPS receiver

Example Questionnaire from the Online Form

1. If you were the Pilot In Command (PIC), were you the…

- ○ RC Pilot
- ○ GCS Operator

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8. What are the Aircraft & Associated Control Systems?

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14. Which of the following occurred?

- ☐ Loss/Degradation of vehicle to GCS communication
- ☐ Loss/Degradation of GCS to vehicle communication
- ☐ GPS Satellite or other navigation system signal loss/degradation
- ☐ Other navigation system failure
- ☐ Lateral Deviation from flight geography
- ☐ Vertical Deviation from flight geography

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Reporter Narrative

Off-nominal Operational Situations Data from the NC II

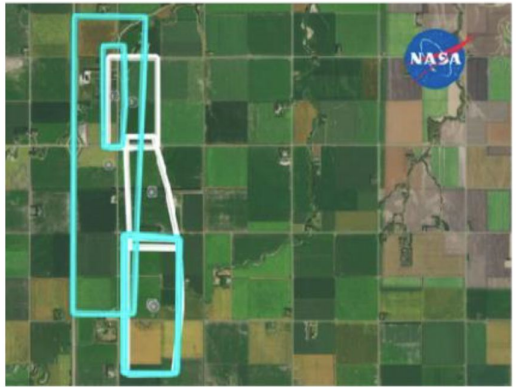
Data collected from 118 operations, 15 online forms received

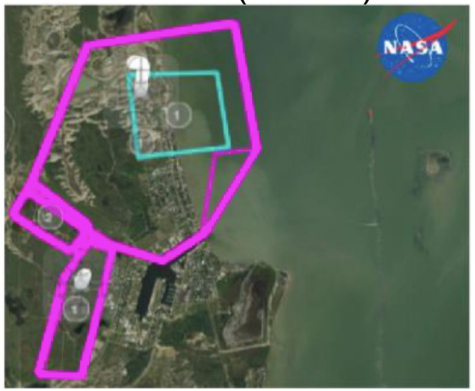
Alaska

New York

Nevada (top)
Texas (bottom)

North Dakota



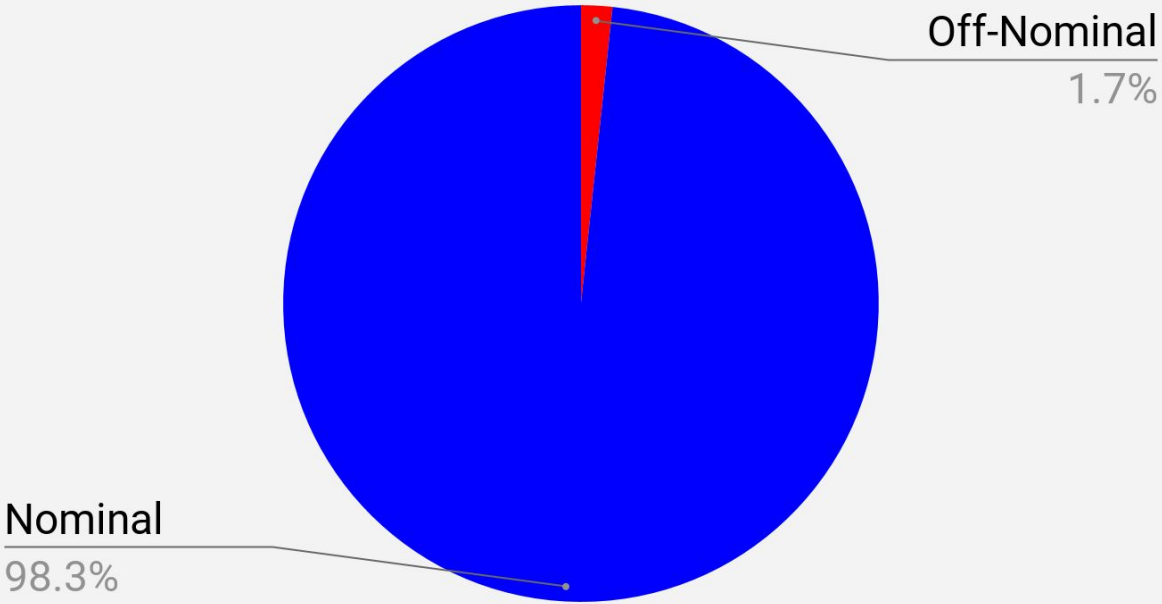


Virginia

Findings

- Digital Data
  - Loss of Navigation
  - Loss of Command and Control (C2) link
- Online forms: Safety expert analysis

Loss of Navigation: Analysis of 118 Operations

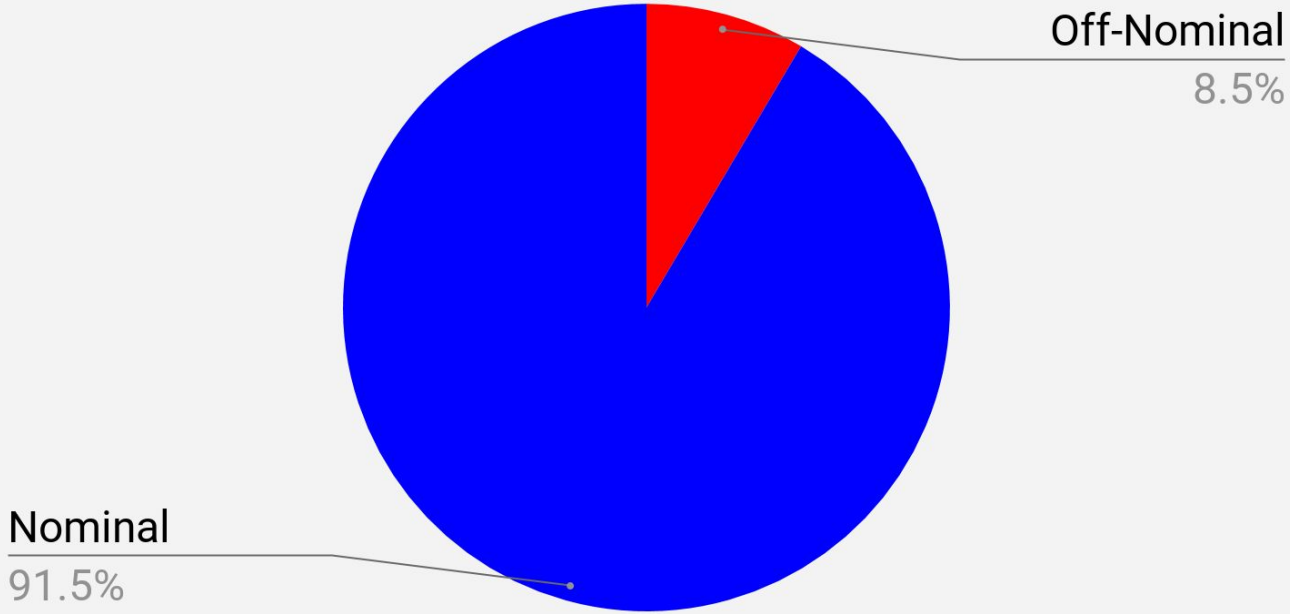


- Criteria: Number of GPS satellites <= 6 for more than 10 seconds
- GPS navigation system sufficient for the NC II environment
- Unobstructed view of the sky likely contributed to small incidence

Loss of Navigation: Going Forward

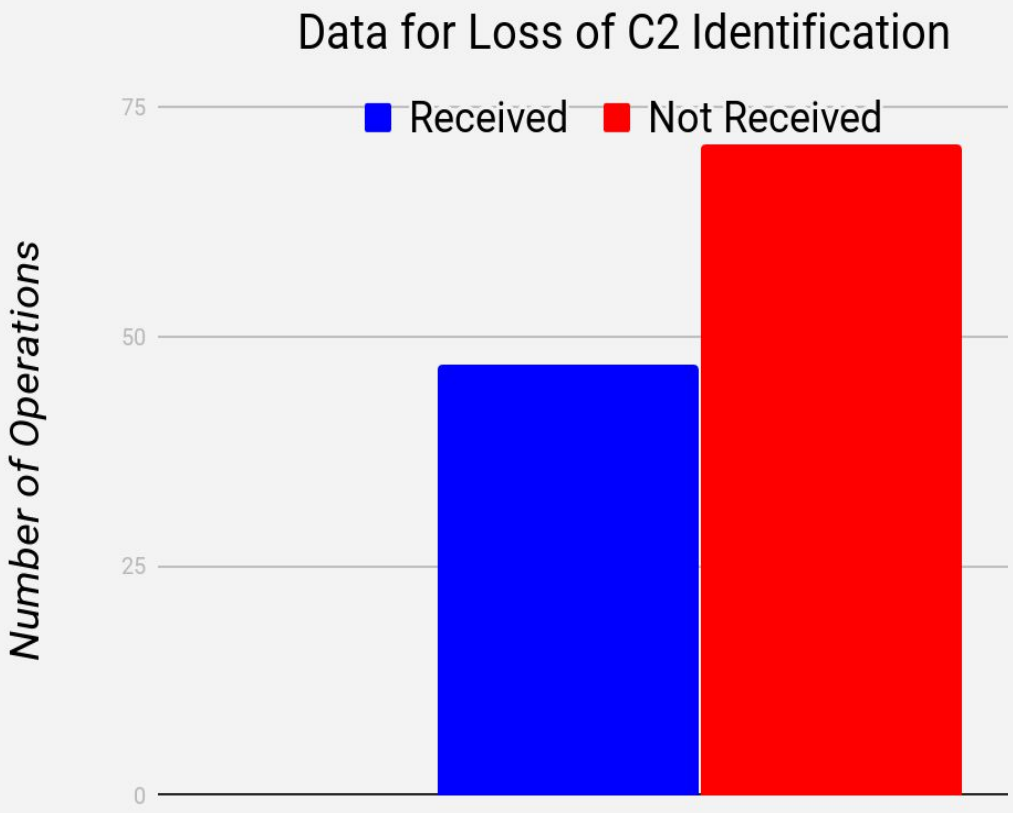
- Line-of-sight (LOS) necessary for navigation using Global Navigation Satellite System (GNSS) such as GPS
- Maintaining LOS may be difficult for low altitude operations in hilly terrain or urban area
- Non-GNSS navigation to cope with loss of LOS to GNSS satellites may be needed for operations in hilly terrain/urban area
  - Light Detection and Ranging (Lidar)
  - Radar

Loss of C2 Link: Analysis of 47 operations



- Signal strength <= -90 dBm for more than 10 seconds
- Communications systems used in the NC II sufficient to cover up to 4300 feet separation between GCS and UA
- Unobstructed radio line of sight likely contributed to small incidence

Loss of C2 Link: Going Forward



- Lack of data, 71 operations:
  - Not monitoring performance
  - Not aware of performance parameter to monitor
  - Different performance parameter to monitor
- Further engagement with the operator community
- Development of De-facto standard

Online Form: Safety Expert Analysis

Event	Count
GPS or other navigation system signal loss/degradation	2
Other navigation system failure	4
Loss/Degradation of GCS to vehicle communication	3
Loss/Degradation of vehicle to GCS communication	3

Online Form: Events and Trends (lack of)

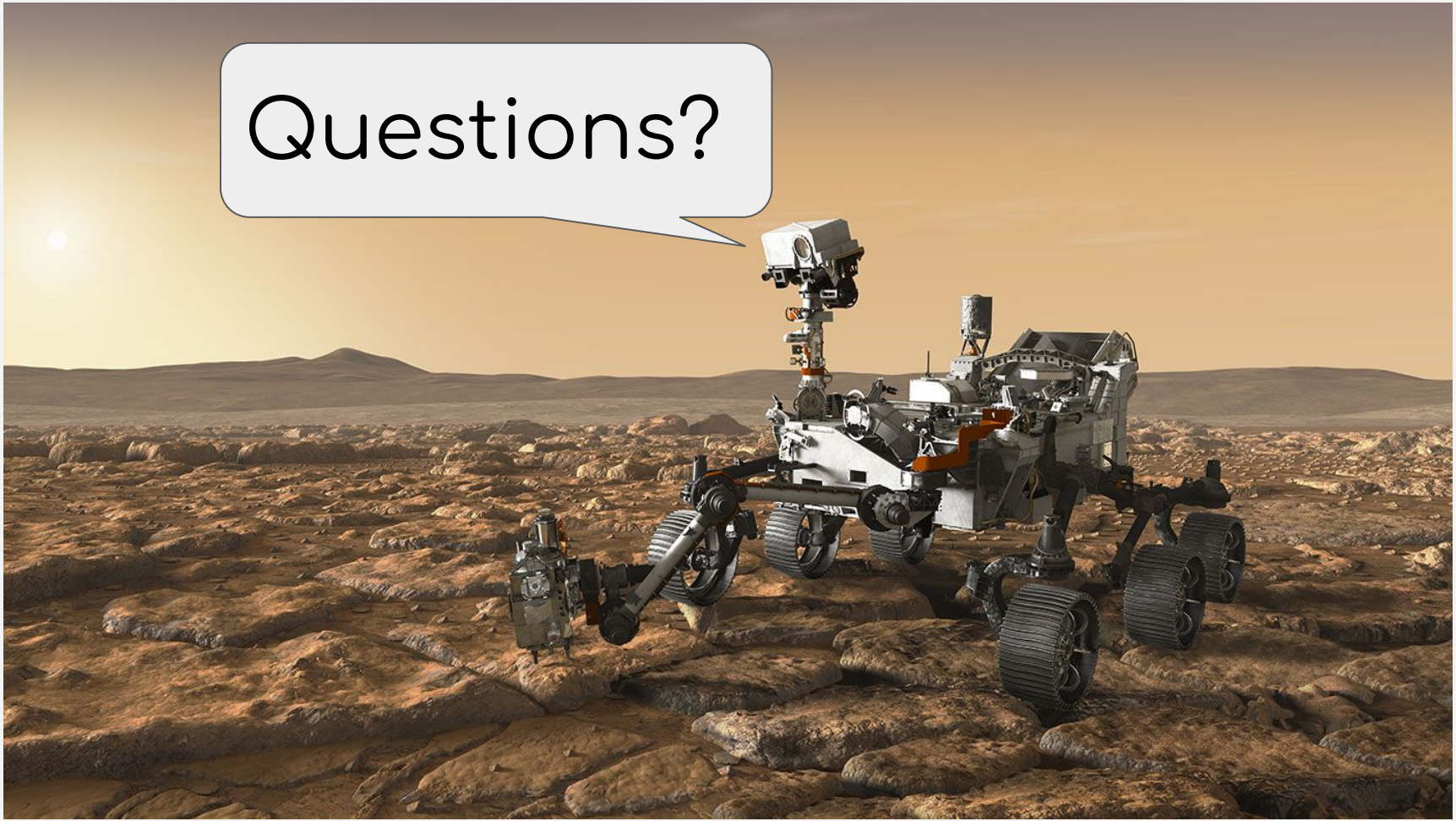
- 9 originated from the Remote-Control Pilot, 4 from the GCS Operator
- Distribution of events among aircraft types was unremarkable
- Due to the low number of reports, no significant trends emerged and uncertain what might be potential underlying common contributors to off-nominal situations

Online Form: Going Forward

- Number of potential improvements to the report form identified
- Future form will display different sets of questions to match operator role
- Questions that were deemed too specific, such as the version of autopilot software and GCS software, will be removed

Next Steps

- Digital(What)/Contextual(Why) Data Fusion to further increase insights into off-nominal operational situations
- Data collection mechanism improvements
  - Ingestion
  - Filtering
  - Validation
- Online-form improvements
- 2018 National Campaign Data Collection


Questions?