Management of Operations under Visual Flight Rules in UTM for Disaster Response Missions

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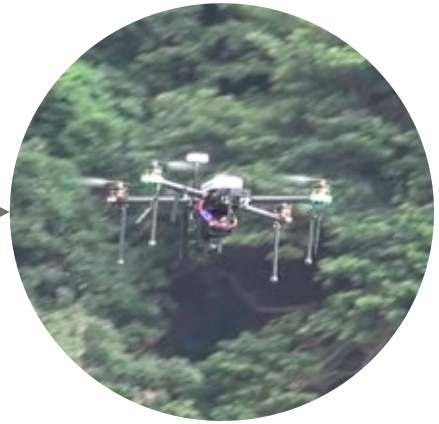
Introduction: towards integrated disaster response

- Aircraft are essential for efficient disaster response
- UAS usage has increased
- Currently, UAS and manned vehicles cannot operate together
- Vehicle integration and coordination pose major challenges

Coordination needed

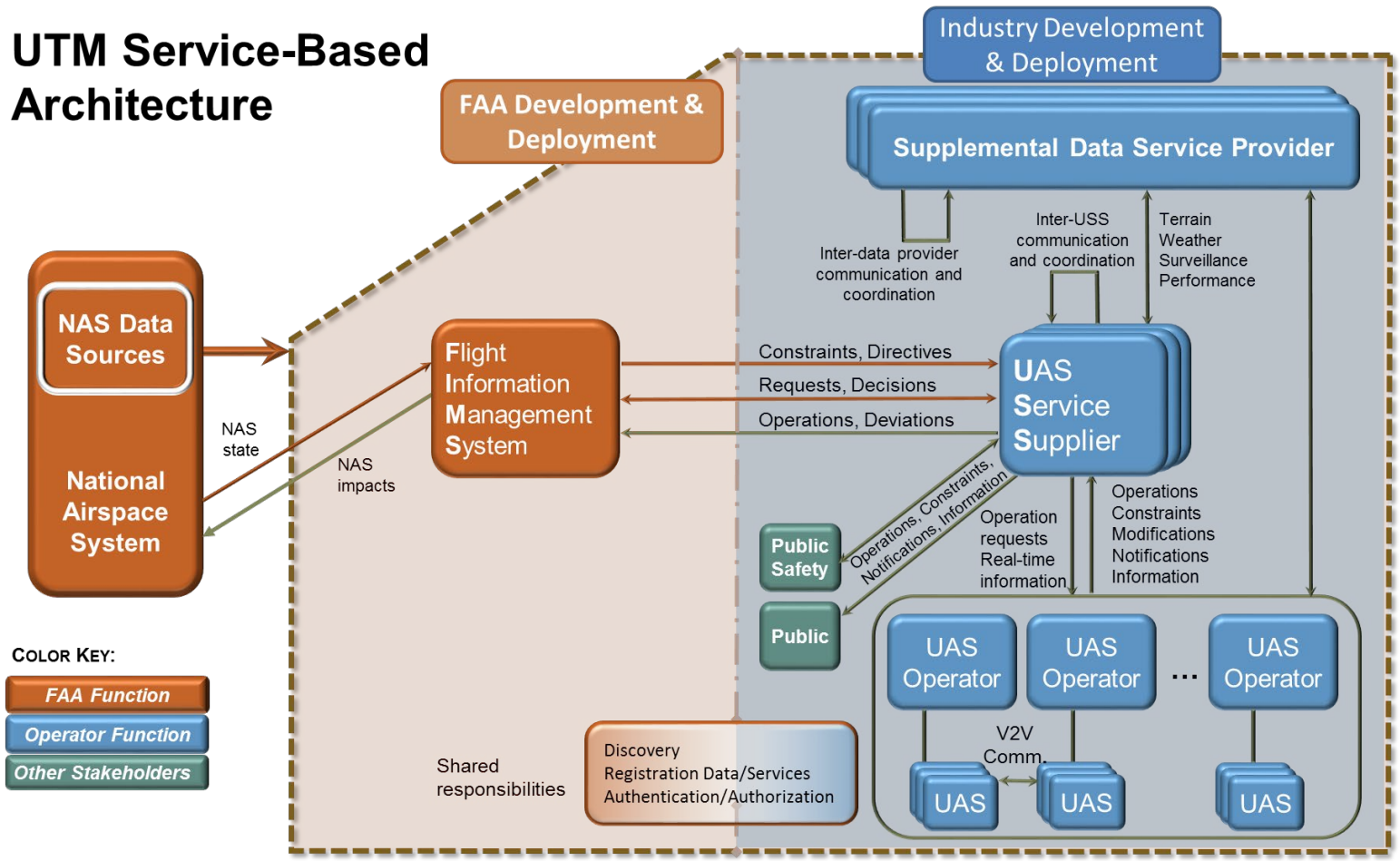


UAS: Unmanned Aircraft System

Current research goal

- Our proposal: use mission planning and traffic management technology to coordinate manned aircraft and UAS in disaster response
- Define and share operation volumes used to describe the intended flight plan of helicopter missions operating under VFR
- The current work presents:
  1. Design of operation volumes to match the characteristics of VFR helicopter operations
  2. Flight test conducted in December 2019 near Tokyo

Background: UAS Traffic Management (UTM)



Flight Information Management System

→ Enables airspace controls, facilitates requests for an Air Navigation Service provider

UAS Service Supplier

→ Federated Structure

→ Cloud-based automated system

→ Supports UAS with services (e.g. separation, weather, flight planning, contingency management,, etc.)

Supplemental Data Service Provider

→ Supplies supplemental data to USS and UAS Operator to support operations

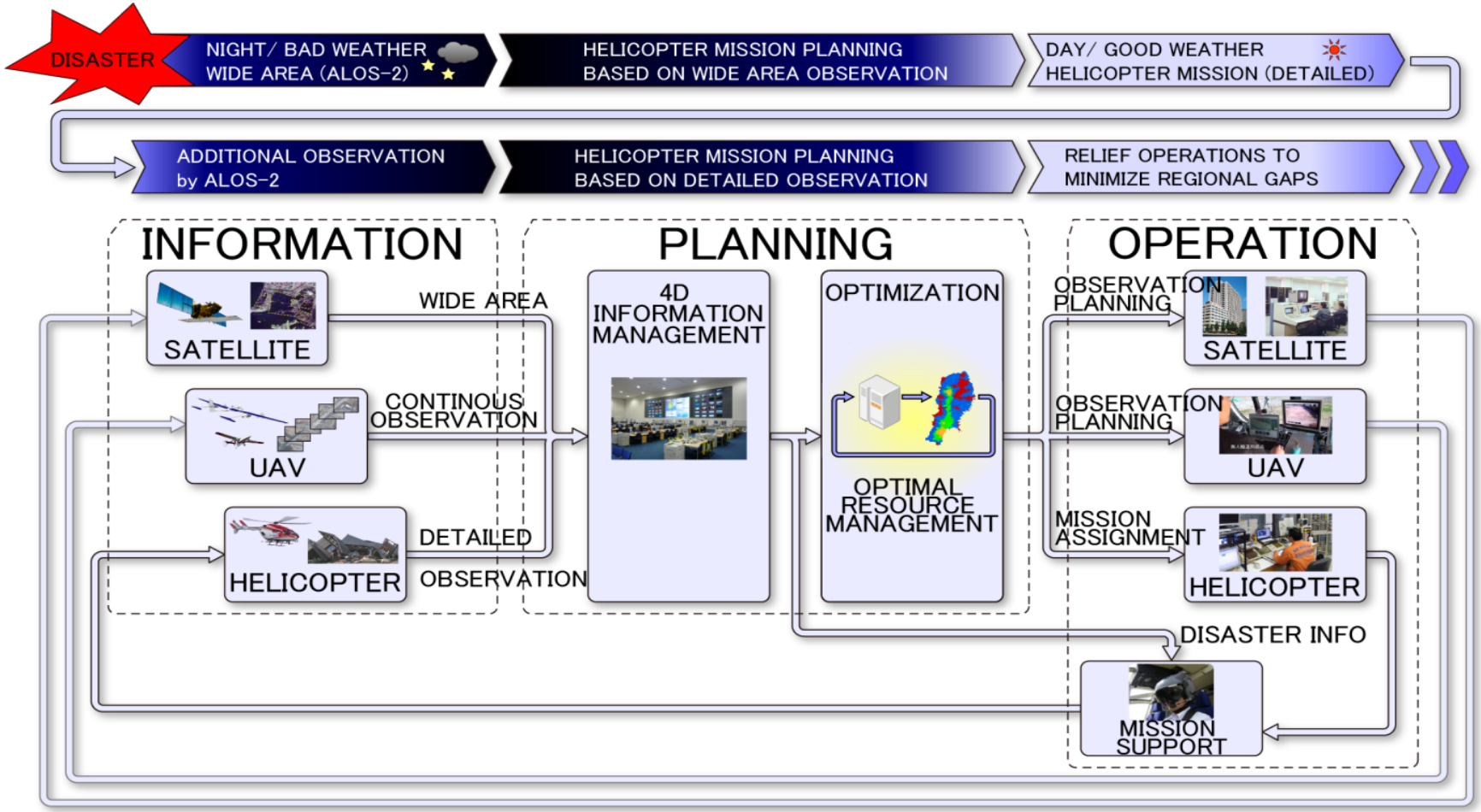
UAS / UAS Operator

→ Individual Operator

→ Fleet Management

→ On-board capabilities to support safe operations

Background: Disaster Relief Aircraft Information Sharing Network (D-NET)

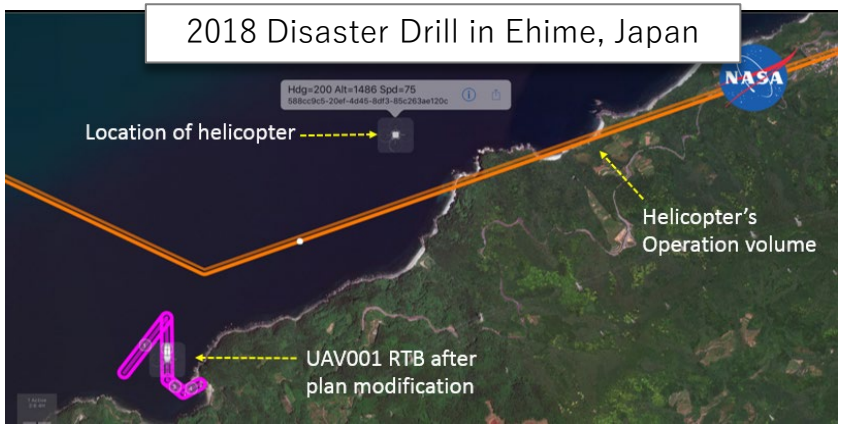


Background: prior D-NET and UTM integrated flight testing

Objectives

- Demonstrate the performance of UTM in disaster relief operations through integration with JAXA's DNET system to enable the effective use of UAS in support of response efforts.

Live view from Operations Center in Ehime, Japan of D-NET display with integrated UTM operations and response helicopter in flight as part of 2018 large-scale disaster drill.

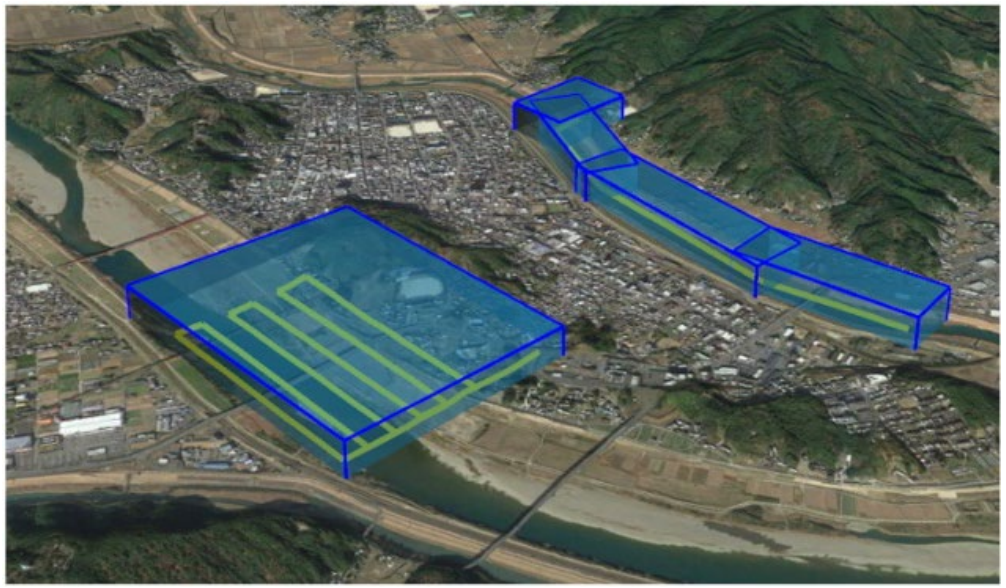


Accomplishments

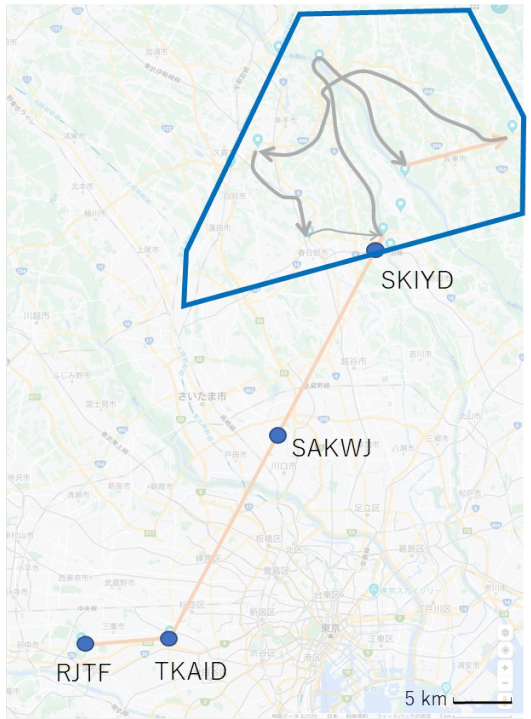
- Established connectivity between D-NET system in Japan and UTM system at NASA ARC that enabled real-time data exchanges for international simulation and testing.
- Participated in live, large-scale disaster drill in Japan with helicopter and sUAS operations managed by integrated D-NET and UTM systems.
- First recorded instance of live manned flight supported by a UTM operation.
- Published and presented multiple conference and journal research papers.

Operation volume concept and design

- UAS Operation Volumes in UTM



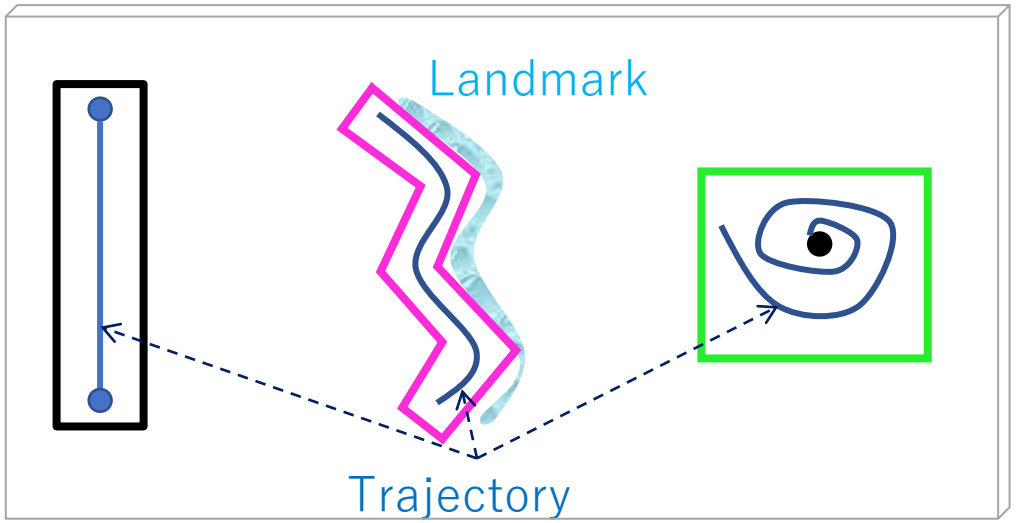
- VFR Flight Plans: contain only limited information

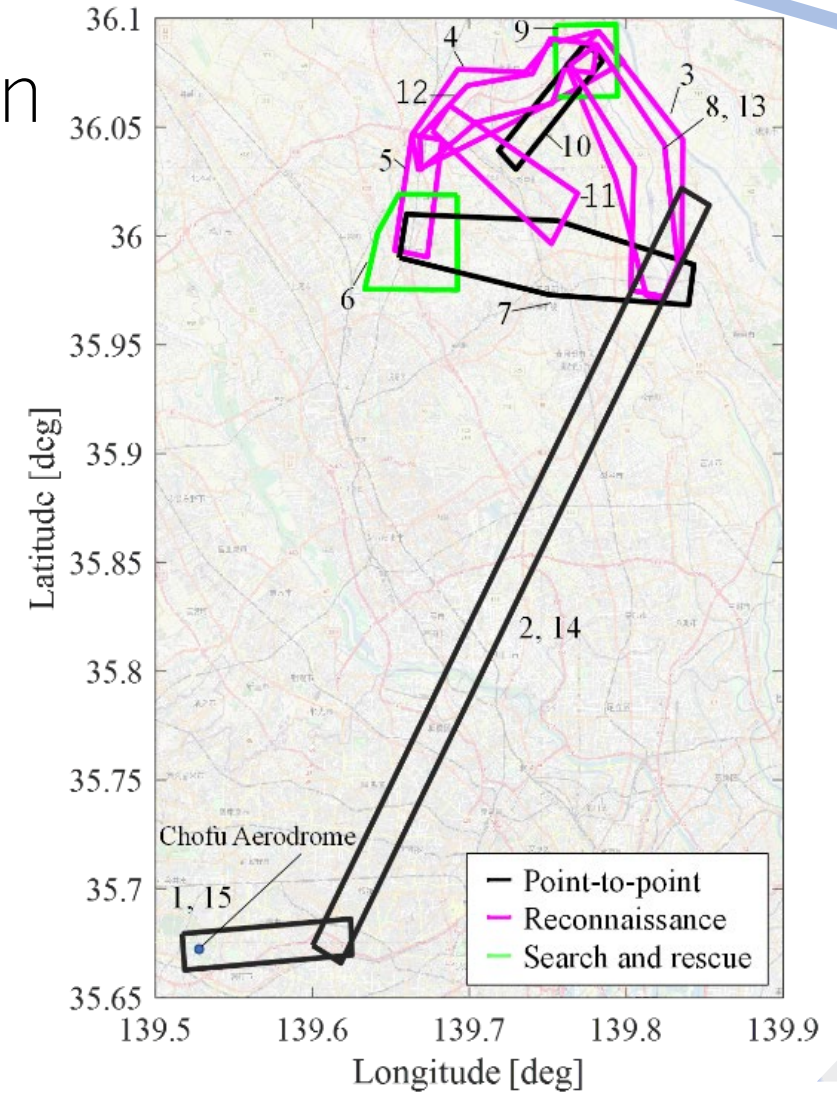


Helicopter mission operation volume design

Mission-dependent operation volume design!

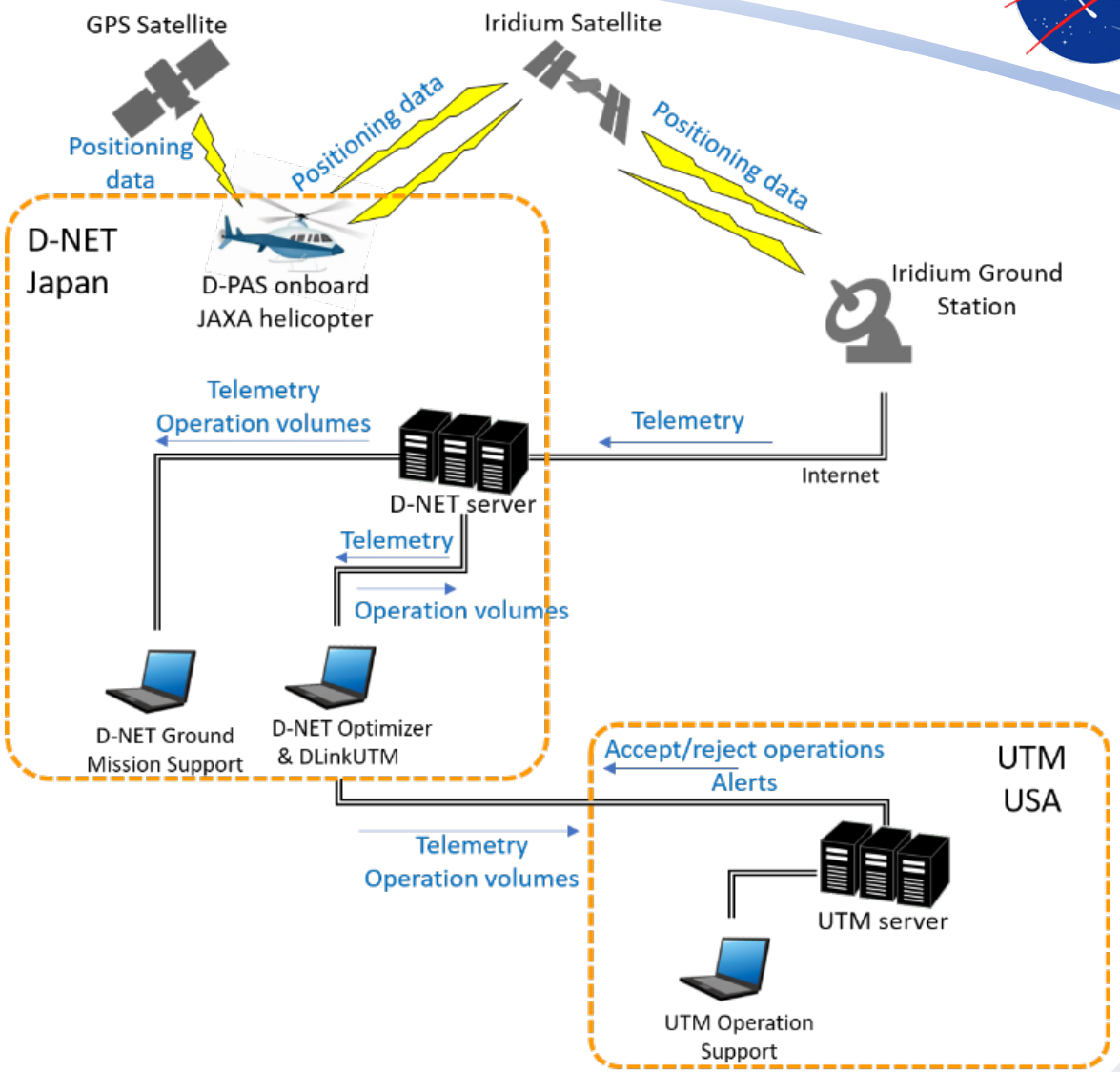
- Point-to-point movement (transfer)
- Reconnaissance
- Search and rescue (SAR)





Data flow configuration

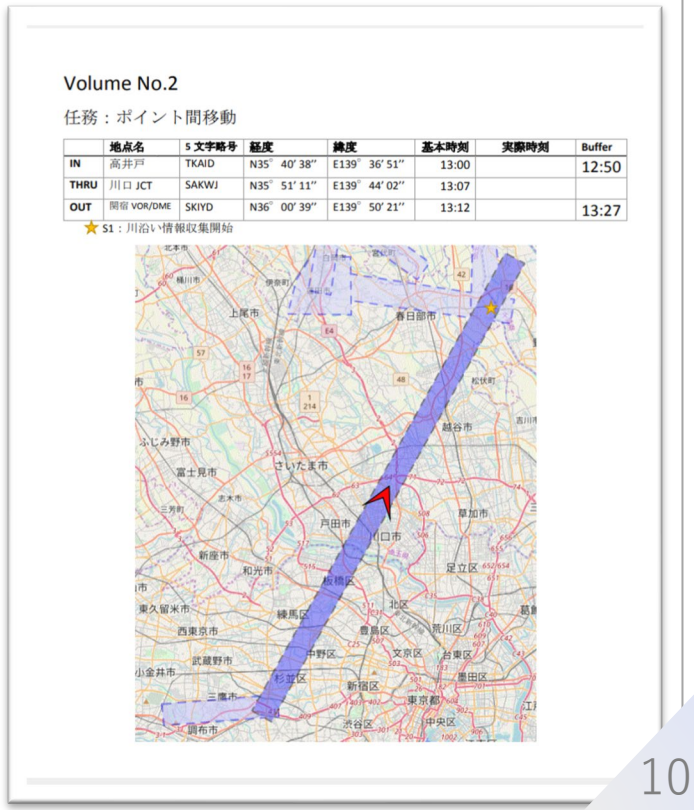
- Interactions among the aircraft, D-NET systems, and the UTM system
- D-NET's onboard D-PAS provides telemetry data
- Real-time communication between D-NET and UTM enabled by DLinkUTM



Flight test: preparations

- One mission per volume
- Volumes designed based on pre-flight estimates of:
  - entry and exit times
  - trajectory
- Some “unplanned for” missions assigned in flight

A booklet containing each volume’s information provided to pilots prior to the flight



Volume No.2

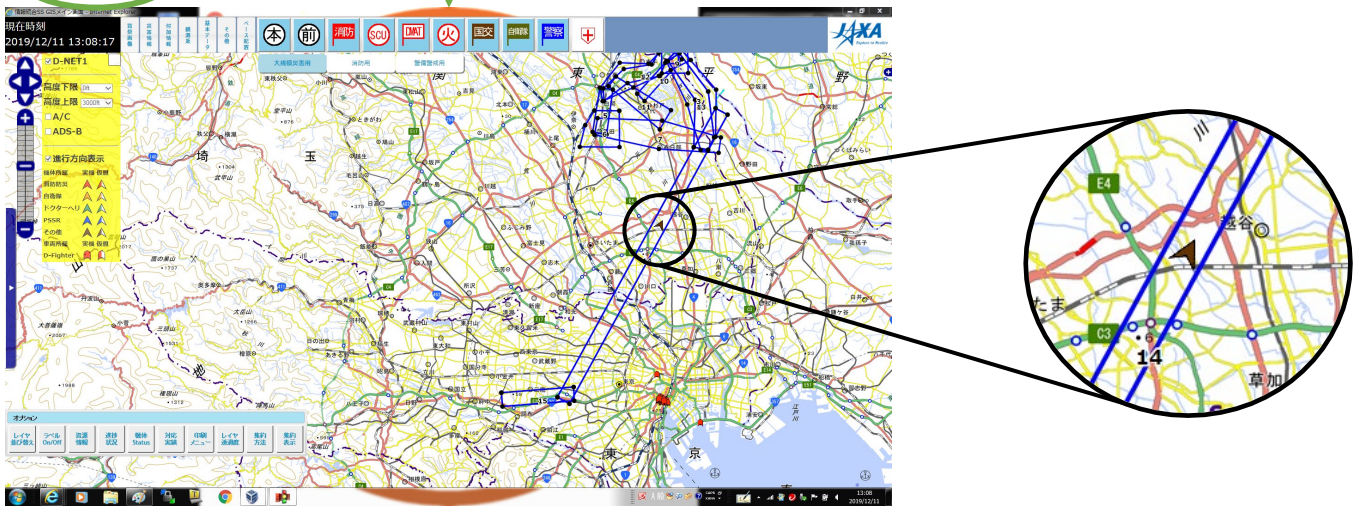
任務：ポイント間移動

	地点名	5 文字略号	経度	緯度	基本時刻	実際時刻	Buffer
IN	高井戸	TKAID	N35° 40′ 38″	E139° 36′ 51″	13:00		12:50
THRU	川口 JCT	SAKWJ	N35° 51′ 11″	E139° 44′ 02″	13:07		
OUT	間宿 VOR/DME	SKIYD	N36° 00′ 39″	E139° 50′ 21″	13:12		13:27

★S1：川沿い情報収集開始

Results

- Primary flight: the test helicopter took off from Chofu Aerodrome at 12:55 JST and landed at 14:55 JST without incident
- The helicopter‘s plan submitted to UTM via DLinkUTM
- While in flight, telemetry available through D-PAS
- Co-pilot was using the booklet to provide verbal support
- Conformance monitoring by ground-based D-NET and UTM



Results: volume violations

a) when performing a reconnaissance mission in segment 8, went non-conforming for 55 s and subsequently transitioned to ROGUE

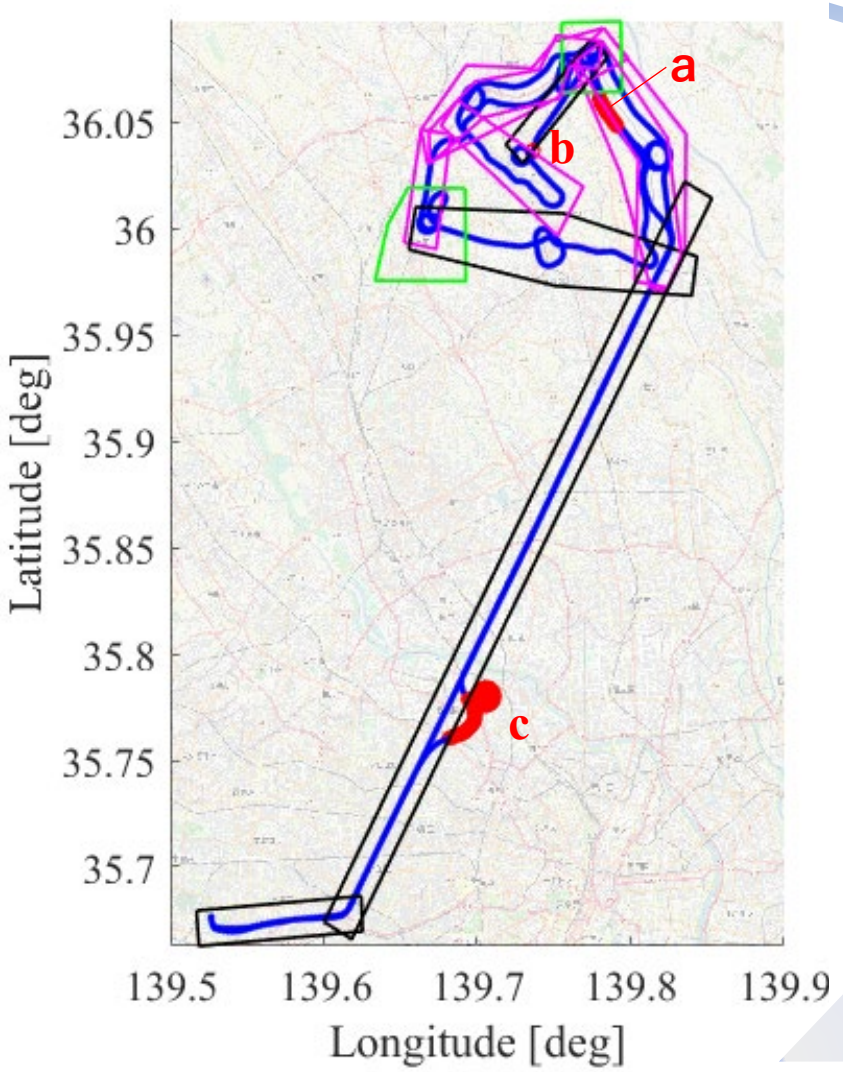
c) in operation volume segment 14 where the helicopter was outside of the volume bounds and returned 190 s later

13:58

13:49

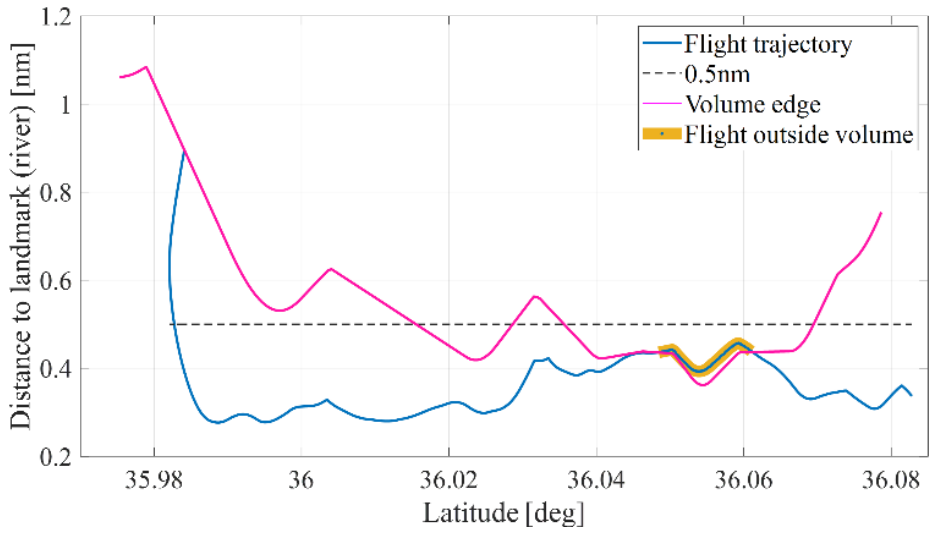
14:37

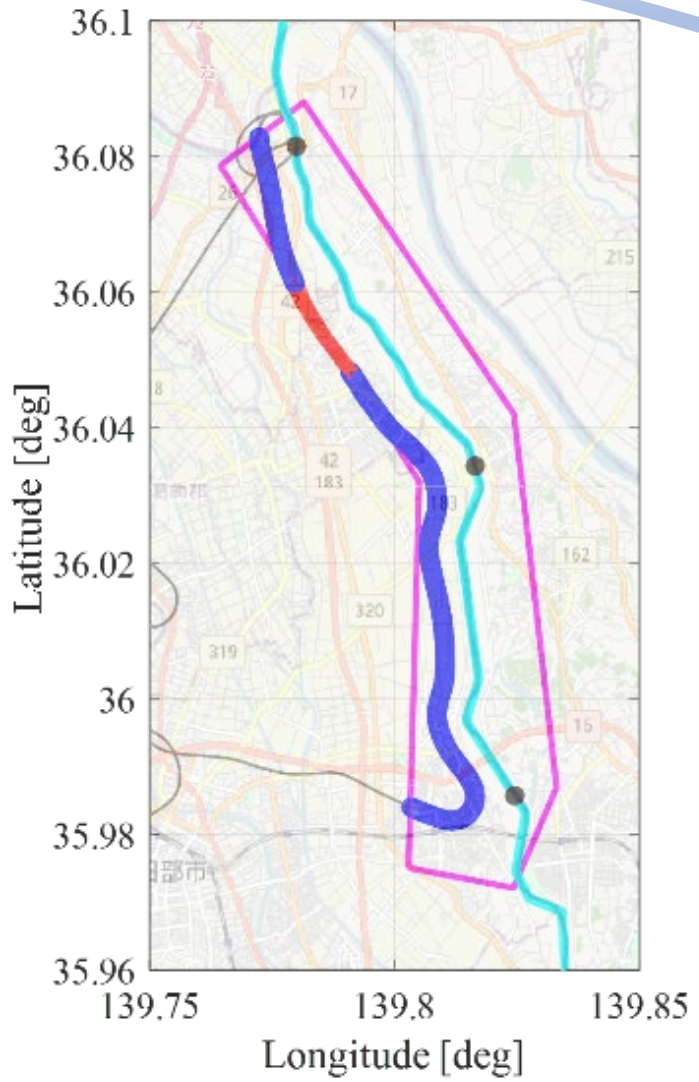
b) when leaving operation volume segment 10 and entering segment 11 where the vehicle was outside of the expected volume for 2 s



Results: violation (a)

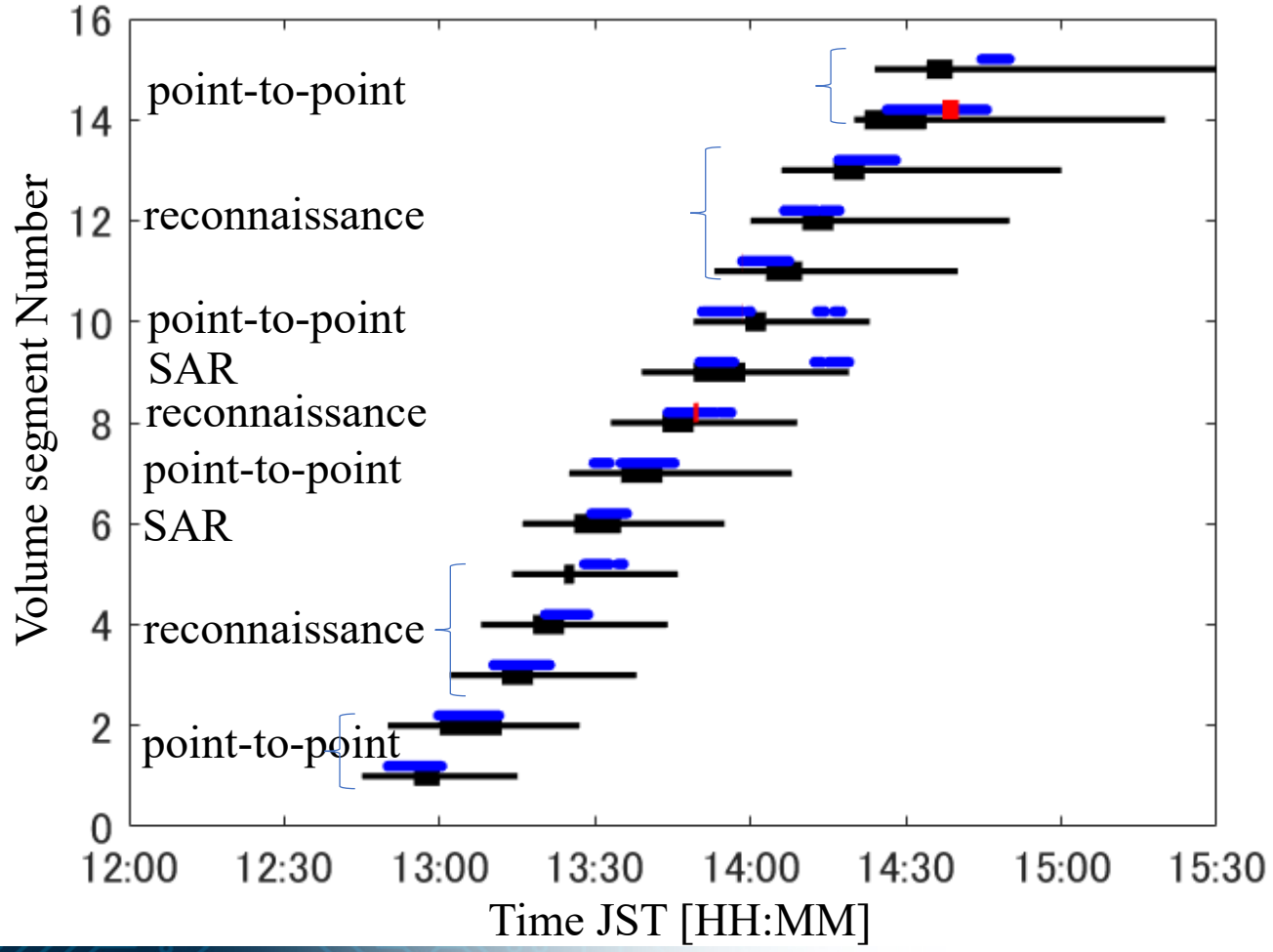
- Reconnaissance mission along the river
- Visual confirmation of the landmark
- Distance to landmark varied
- Real-time situational awareness is the key





Results: use of airspace

- Pre-flight time estimates
- UTM volume times
- Actual times
- Violations



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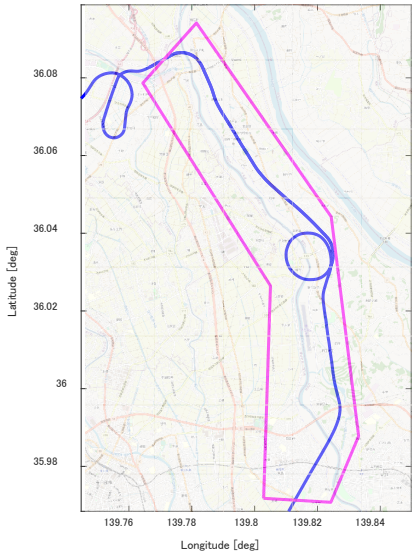
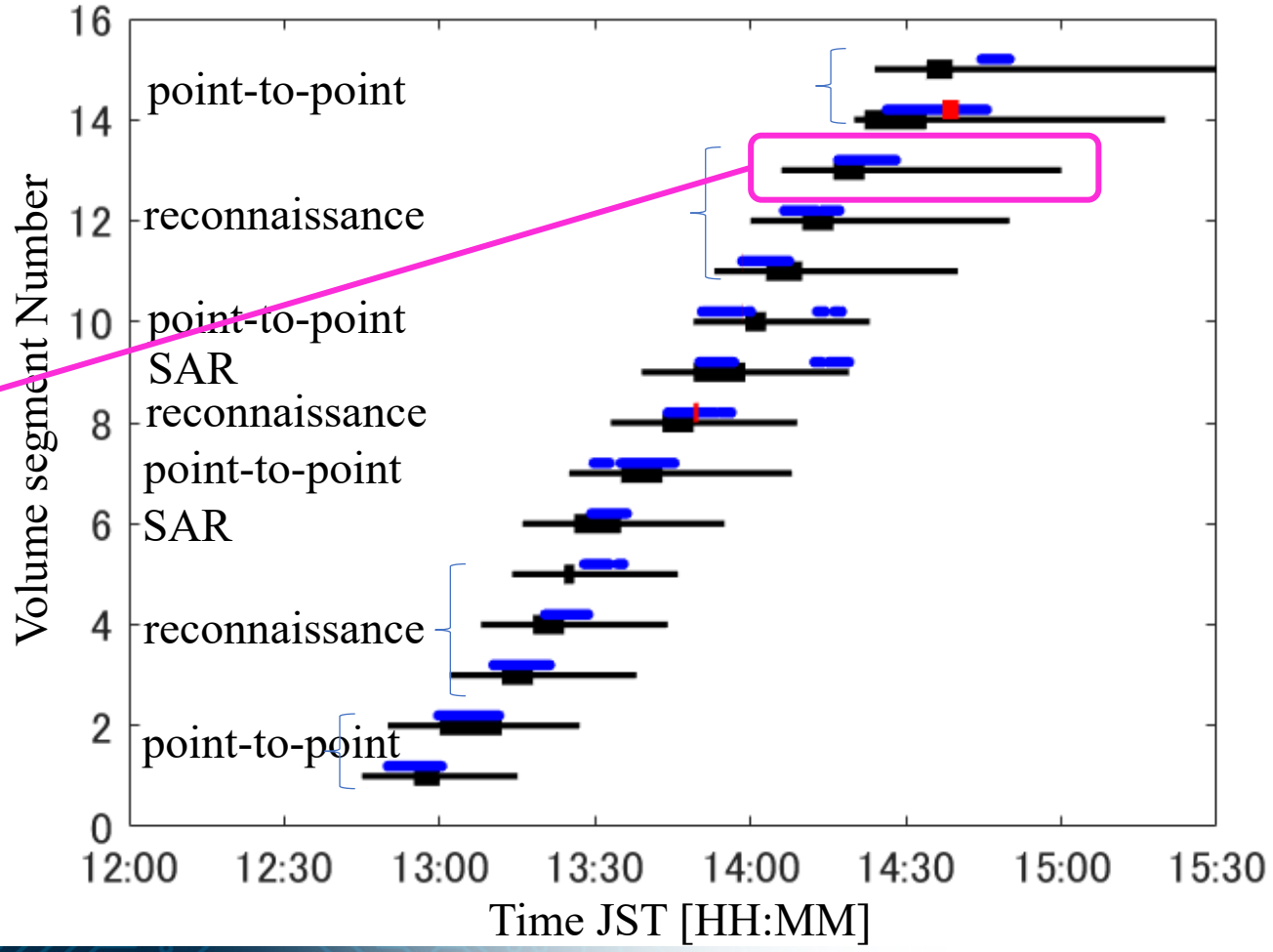




Pilot debrief and recommendations

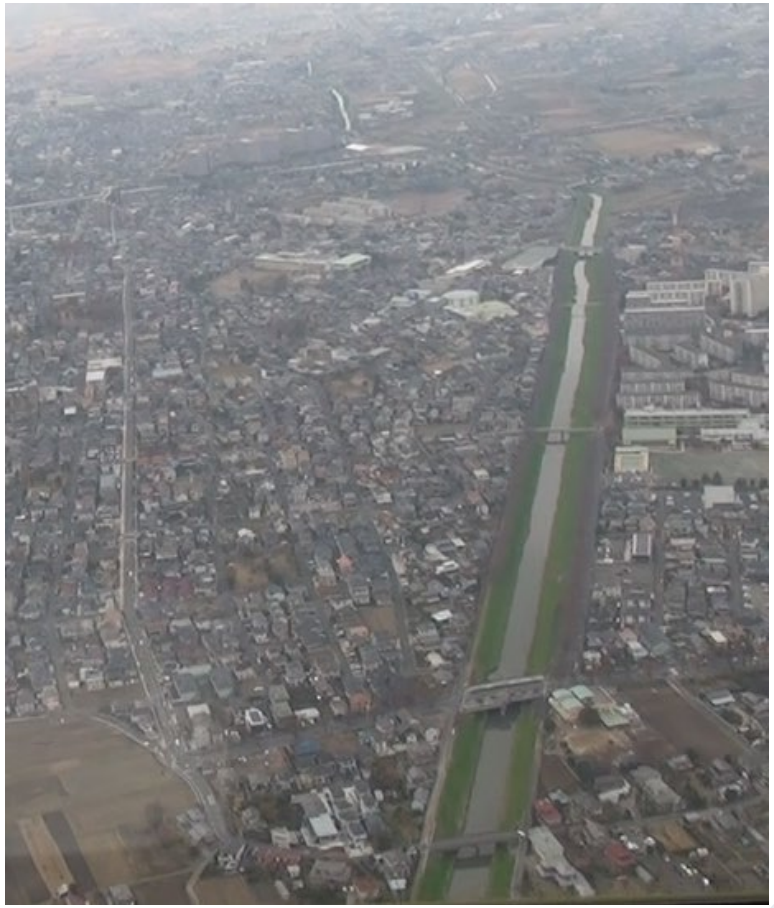
- Pilots participated in the volume design
- The co-pilot was looking at the operation volumes shown in the mission flight booklet and provided oral advisories to the main pilot
- The pilot had awareness of each volume, but he did not rely on an advisory display tool to remain within the volume

Pilots' comments

- Temporal conformance
  - Relatively straightforward when considering the available temporal buffer
  - Pilots are used to making speed adjustments to meet time constraints
- Spatial conformance
  - A visualization tool, such as a head-mounted display could increase positional awareness
  - Salient alerts could also be provided through the display or with auditory cues
  - Predicting non-conformance events is not straightforward
- Volume modification in flight
  - Provide needed flexibility
  - Modify volumes without significant increase in pilots' workload
  - Introduce "volume release" capability

Pilots' comments

- Role of landmarks
  - Large rivers, railroads, and highways provided clear guidance when the disaster did not affect their visibility
  - Bridges are clear and visible, but identification of specific bridges remain a challenge.
  - Geographic landmark situation awareness can be better supported by a mission support system



Concluding remarks

- The flight tests examined the concept of landmark-based design of operation volumes when applied to manned flight operations under VFR within a D-NET and UTM-integrated environment.
- Test results suggest that the approach taken to operation planning may have helped the pilots maintain conformance with their operation volumes.
  - This conformance is important for the integration of manned air assets and UAS within a UTM-supported disaster response environment for predictability and planning.
- Situation awareness and usability challenges were identified during the flight test that warrant further refinement moving forward.
- The results also highlighted the need for better understanding and further research into the trade space between pilot flexibility and more structured airspace to support UAS operations in the same operational area.