# Daytime Dynamo Rocket Investigation

## Daytime wind profile measurement with a lithium trail release

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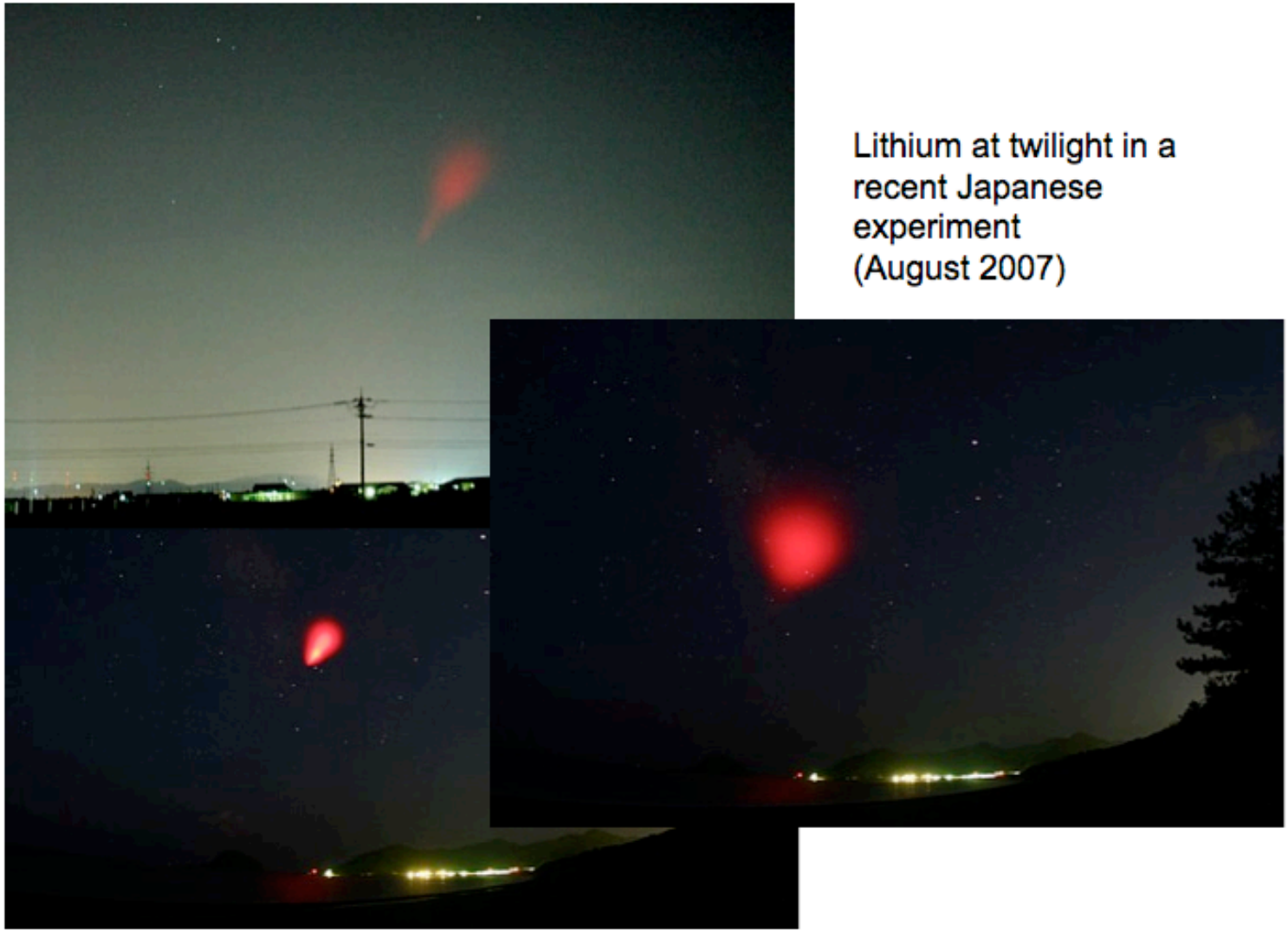
# Joint Japanese-U.S. Rocket Experiments
# A long history of fruitful collaborations

| Experiment | Launch site | Year |
|---|---|---|
| SEEK-1 | Uchinoura, Japan | 1996 |
| SEEK-2 | Uchinoura, Japan | 2002 |
| WIND-1 | Uchinoura, Japan | 2007 |
| DELTA-2 | Andøya, Norway | 2009 |
| Dynamo-1 | Wallops Island | 2011 |
| WIND-2 | Uchinoura, Japan | 2012 |
| Test Flight | Wallops Island | 2013 |
| EVEX | Kwajalein Atoll | 2013 |
| Dynamo-2 | Wallops Island | 2013 |
| Moonlight | Uchinoura, Japan | 2013 |
| C-REX | Andøya, Norway | 2014 |



Lithium at twilight in a recent Japanese experiment (August 2007)

## Daytime lithium release experiments

The bright narrow-band emissions at 670.7 nm produced by lithium make it possible to track the chemical optically, even when viewed against the bright daytime background.

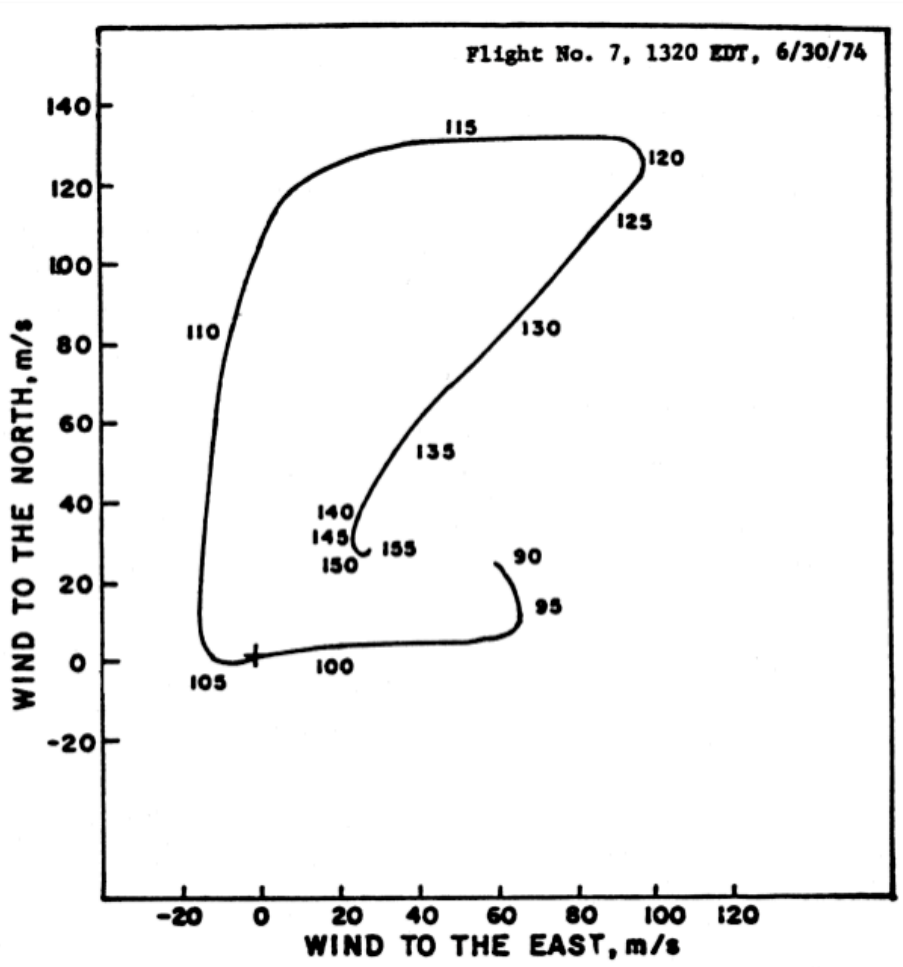
Several groups carried out such experiments:

- In the U.S.
  - Best (1970), Bedinger (1973, 1976)
  - launches from Wallops Flight Facility
  - narrow band filter camera deployed on high-altitude aircraft
  - effective field of view only 5 degrees

- In India (collaboration between U.K. and India)
  - Rees et al. (1972, 1976)
  - launches from Thumba
  - raster scanning photometer with narrow-band filter

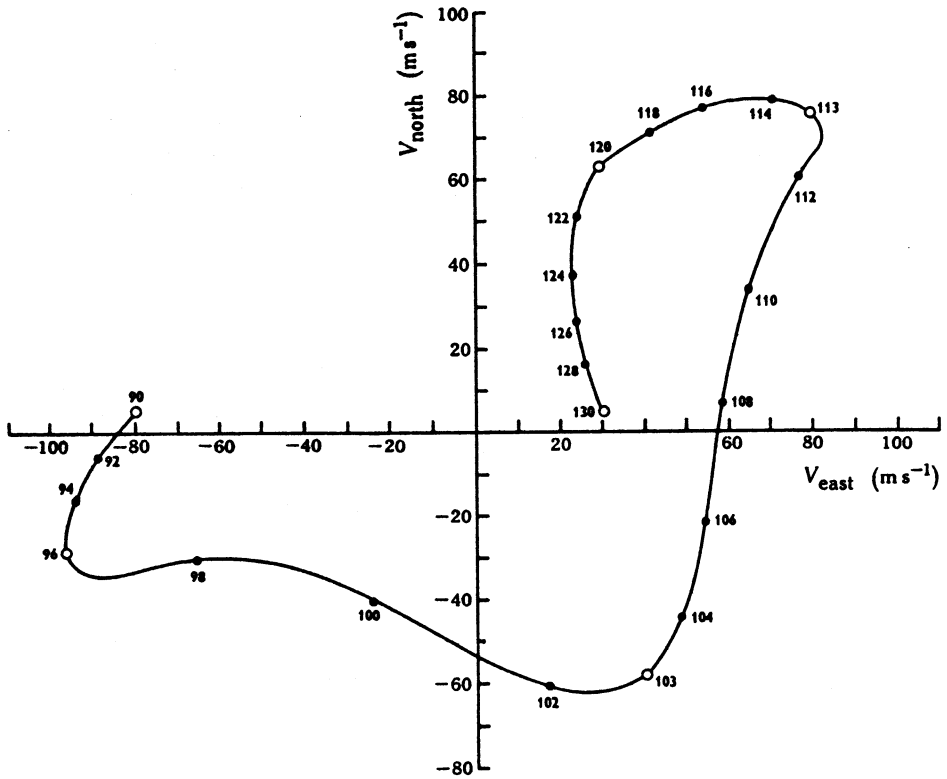
- In Australia
  - Hind and Lloyd (1973, 1974)
  - launches from Woomera
  - raster scanning photometer with narrow-band filter

# Daytime neutral wind measurements

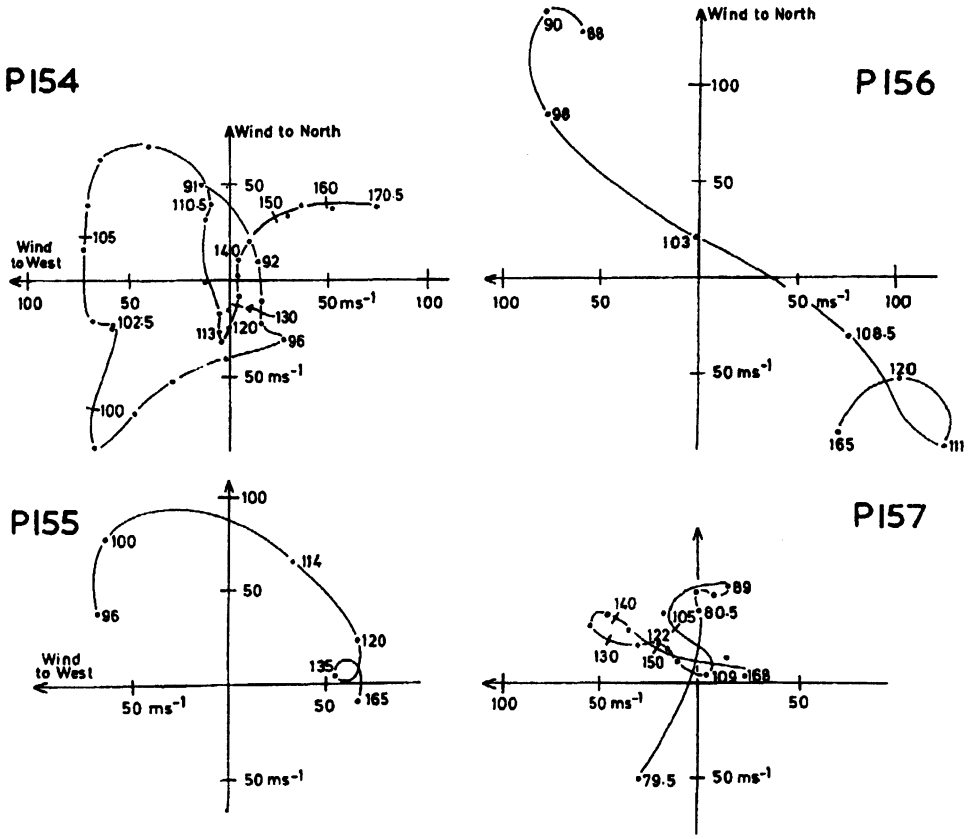



Bedinger, 1976

Trail is from Lithium chemical release from Wallops as part of ALADDIN campaign in 1974 (Philbrick, 1974).




Measurement by Hind




P 154 9 Feb. 75, 0554 morning twilight TMA trail release
P 155 9 Feb. 75, 1105 lithium trail release
P 156 19 Feb. 75, 1415 lithium trail release
P 157 19 Feb. 75, 1902 evening twilight TMA trail release

Measurement by Rees

## Chemical components

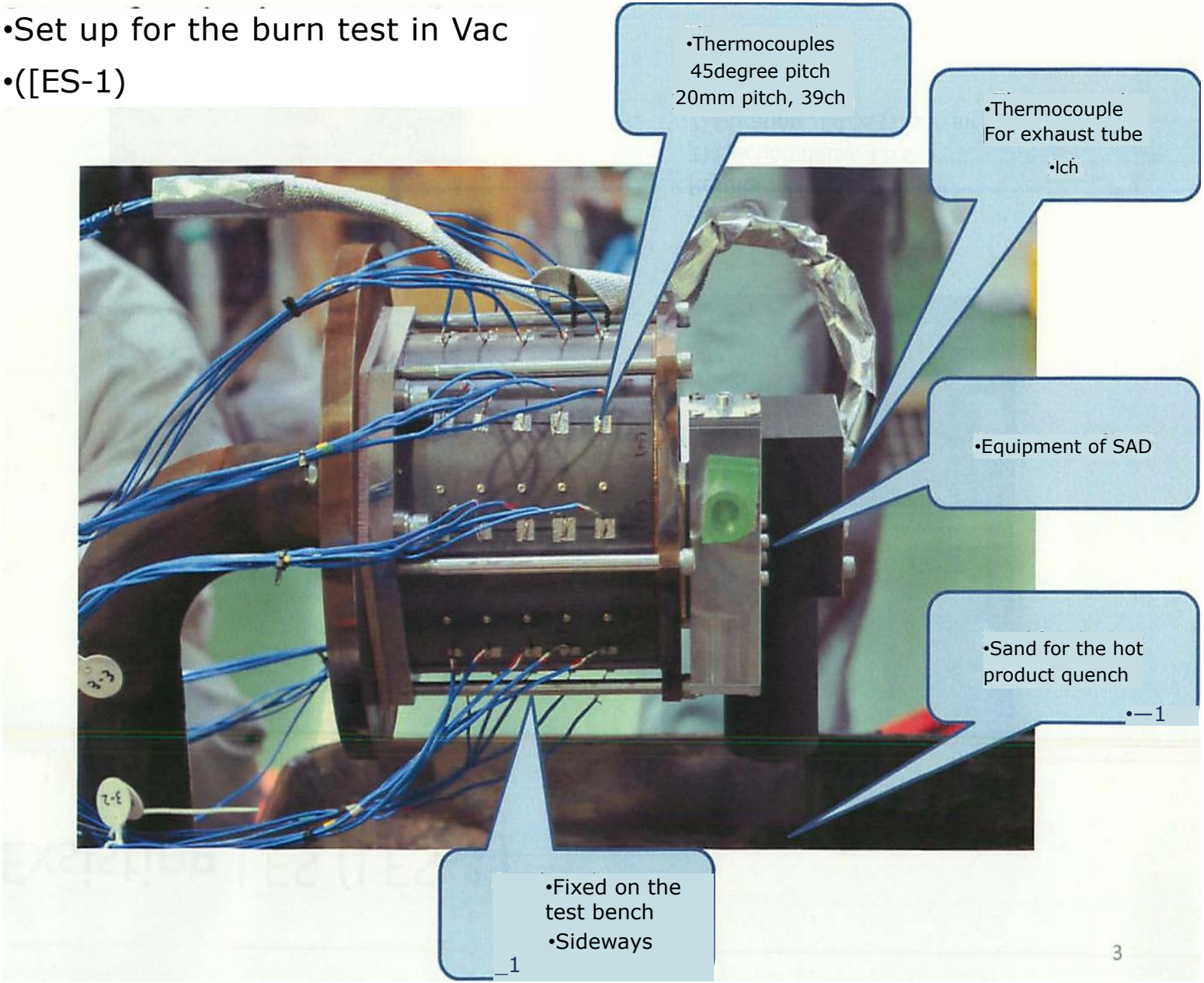
Mixture of thermite and lithium, small pellets of uniform size, usually approximately 8 to 1 ratio (thermite:lithium)

Thermite mixtures used in earlier experiments include:

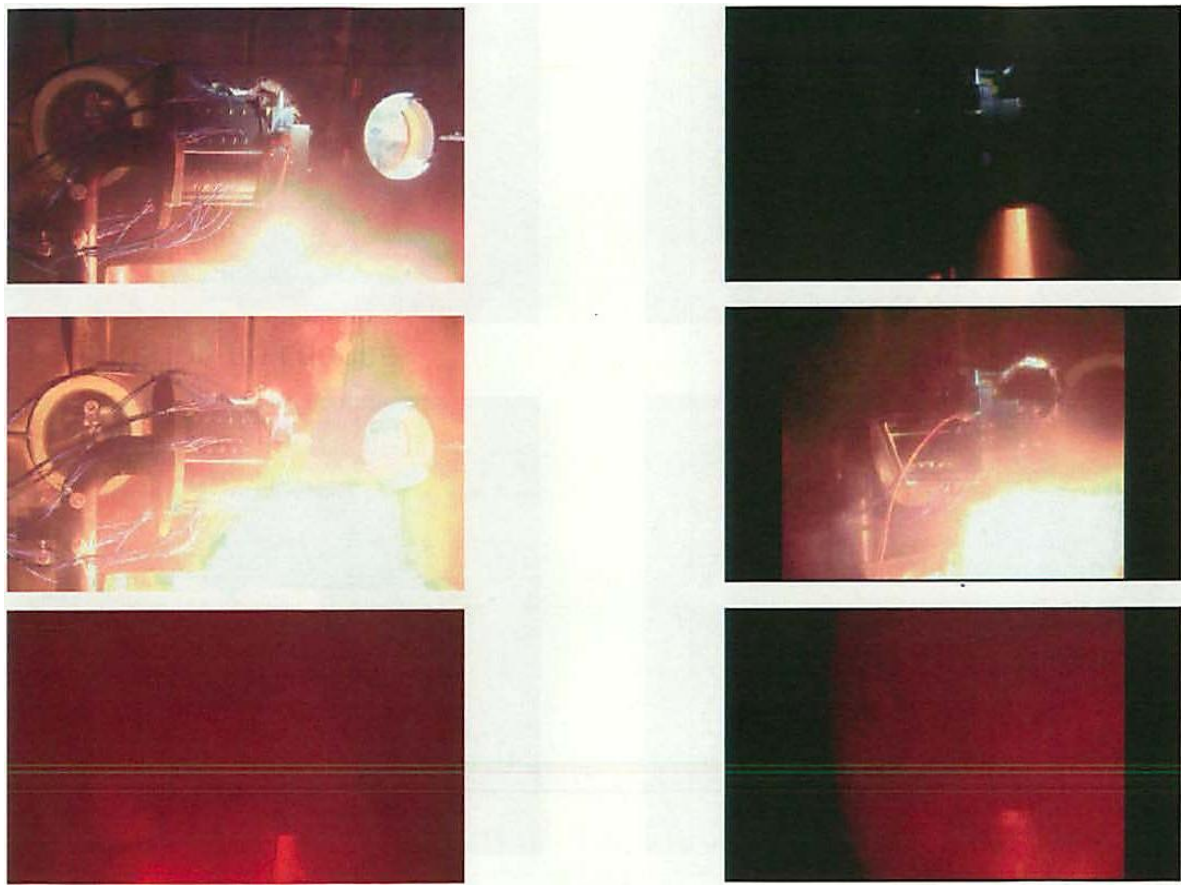
- Iron oxide
- Cupric oxide
- Titanium boride

•Set up for the burn test in Vac

•([ES-1)



•**LES-R**



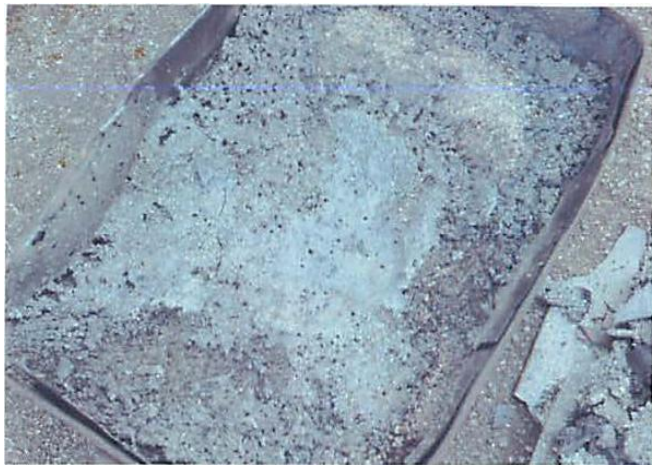
•Normal VTR High speed camera

•Ignition delay: 0.7s, Duration: 1.5 sx

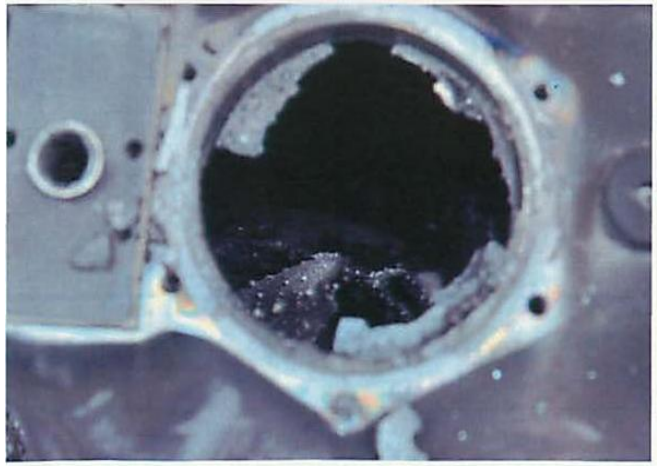
•X From the video data

•After the test

•Exterior, no change



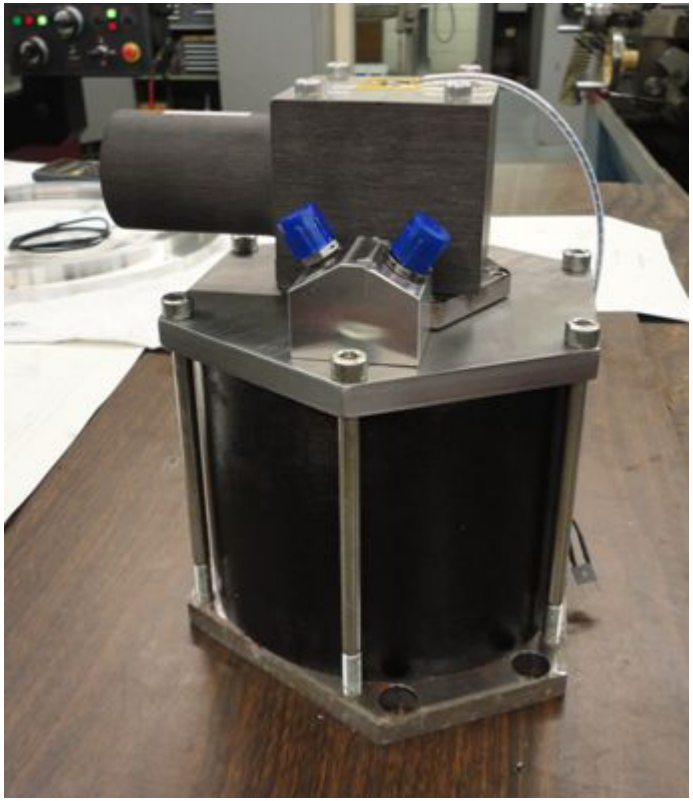
•Reaction Products



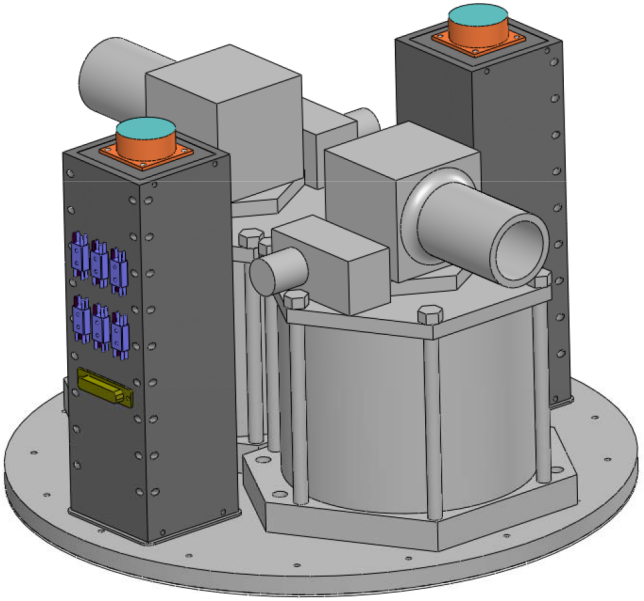
•Inner tube was melted

•Flange was eroded by the hot products

# Canister design used on the flight



A total of 125 g of lithium per canister
Two canisters per trail
Three trails



Optical tracking of the releases requires

Narrow-band 2 nm optical filter centered at 671 nm

Telecentric optics for lens system with 40 deg horizontal field of view

Camera system Nikon D90 with factory IR filter removed

Requirements include

- Aircraft to reduce effect of aerosol scattering
- Angle mapping within field of view, using star field calibration, e.g.
- Aircraft position from GPS
- Aircraft orientation from IMU (roll, pitch, and heading information)

NASA King Air used as camera platform for observations

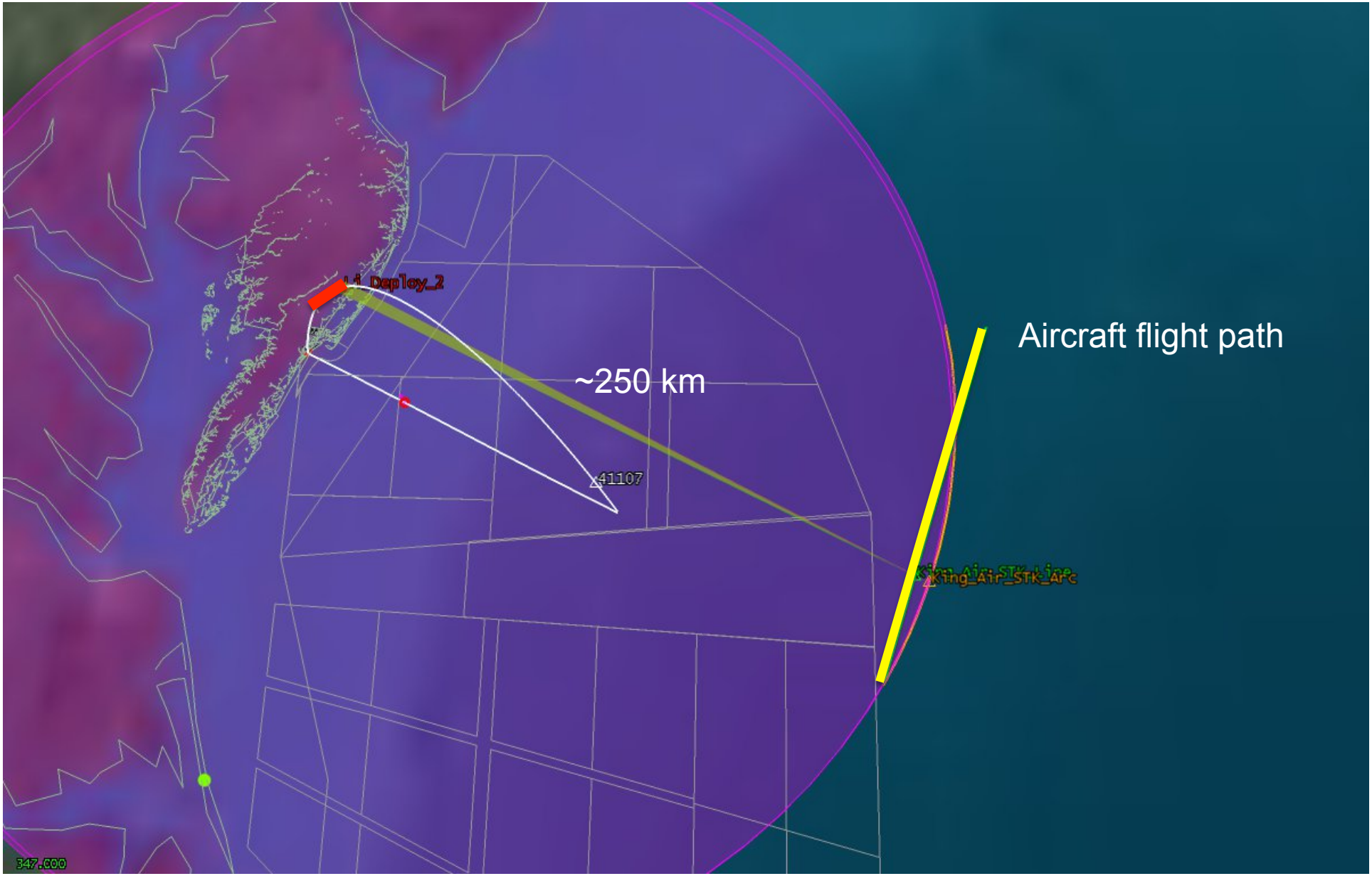
# B-200 King Air: Daytime Dynamo Sounding Rocket Photo Support

- The B-200 supported the Terrier-Orion Pfaff Daytime Dynamo mission between 6/24 and 7/4.
- The aircraft was configured with four cameras to record chemical releases in flight, as previously conducted in January 2013.

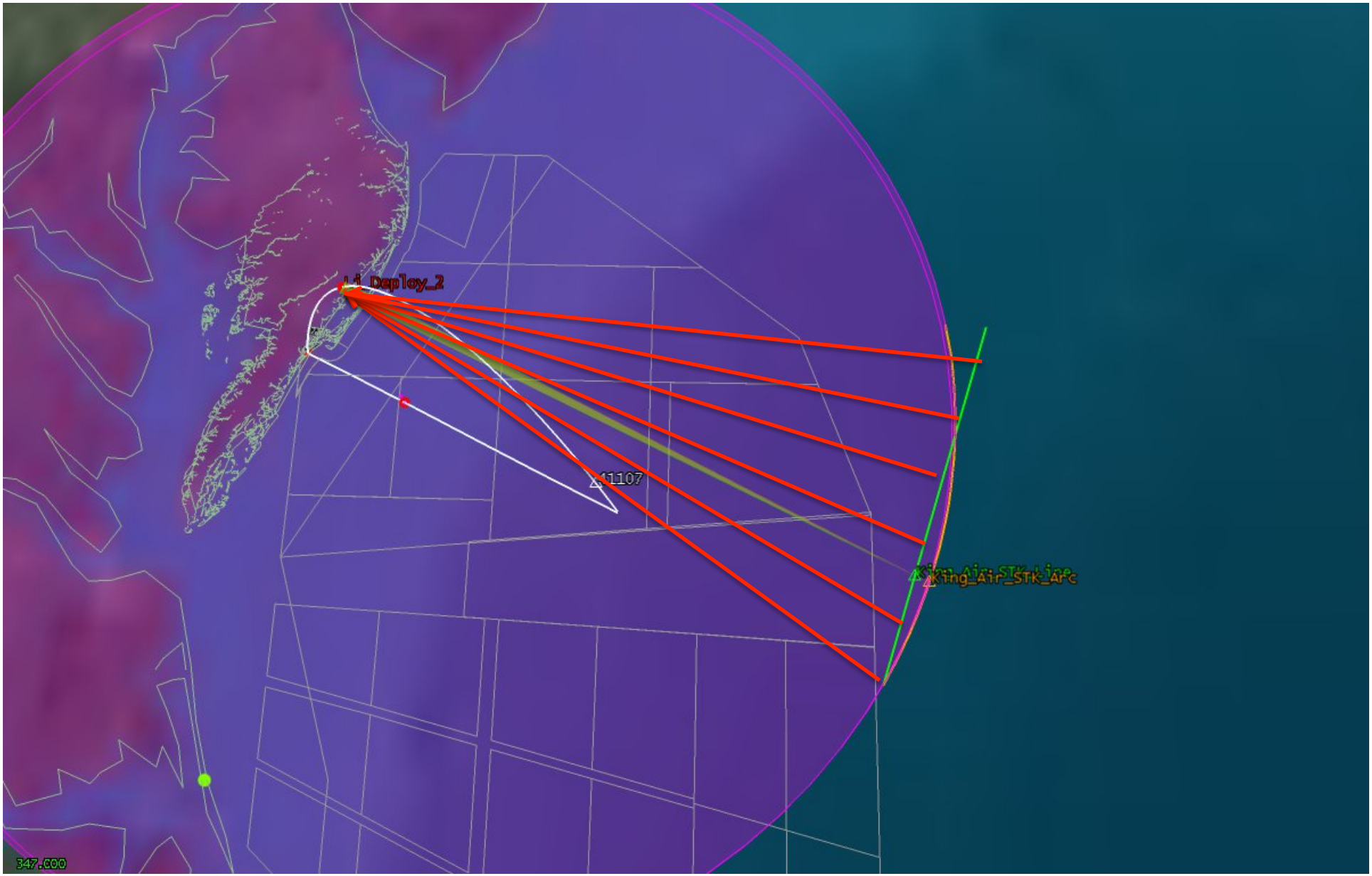
***B-200 Camera Mounts***

***One of Two Chemical Trails Photographed In January 2013***

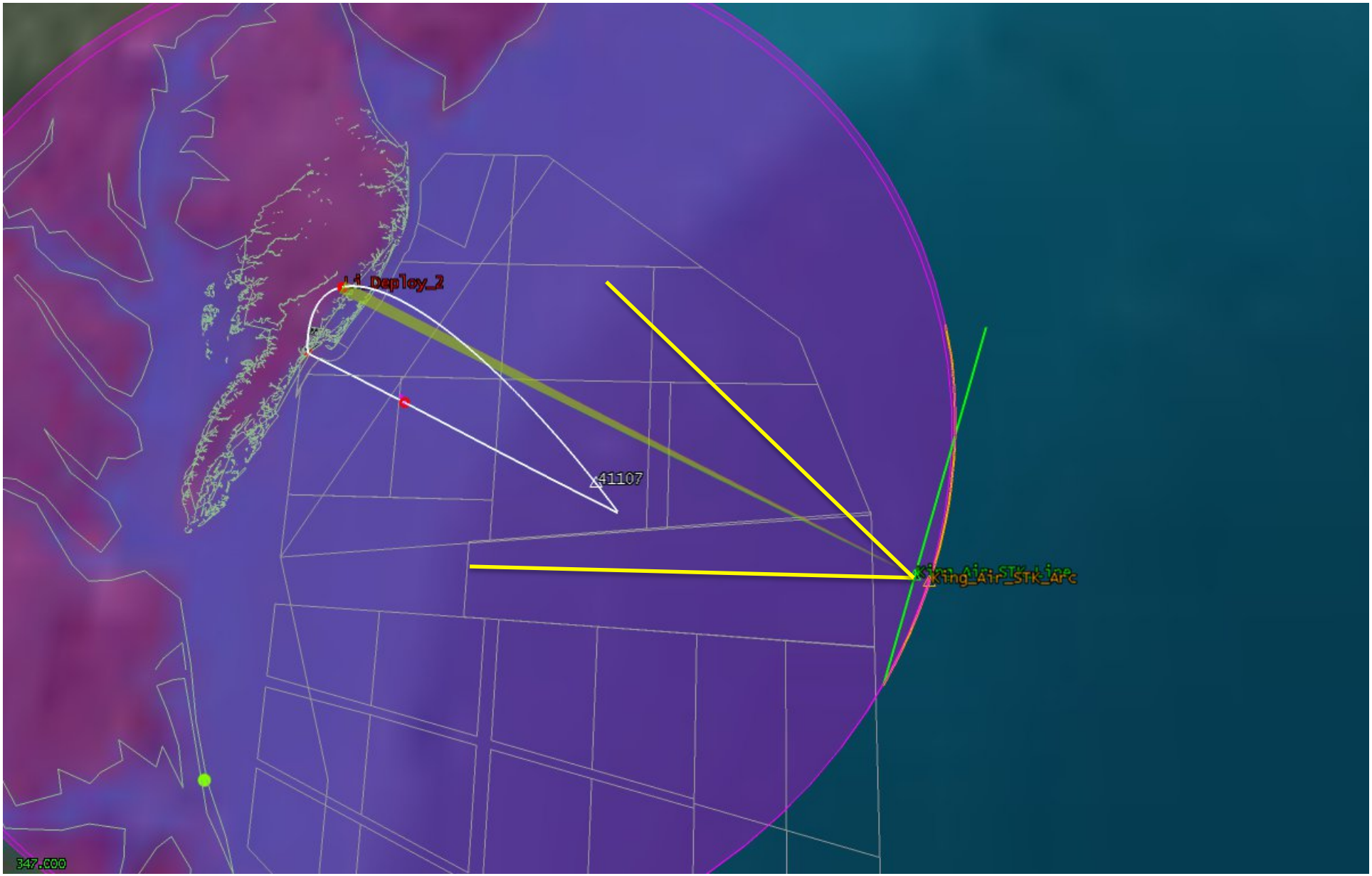
Narrow-band (2-nm) lithium filter observation of lithium trails from aircraft at 1434 UT (1034 LT) – 1/30 sec exposure


Deploy_2
~250 km
41107
Aircraft flight path
347.000

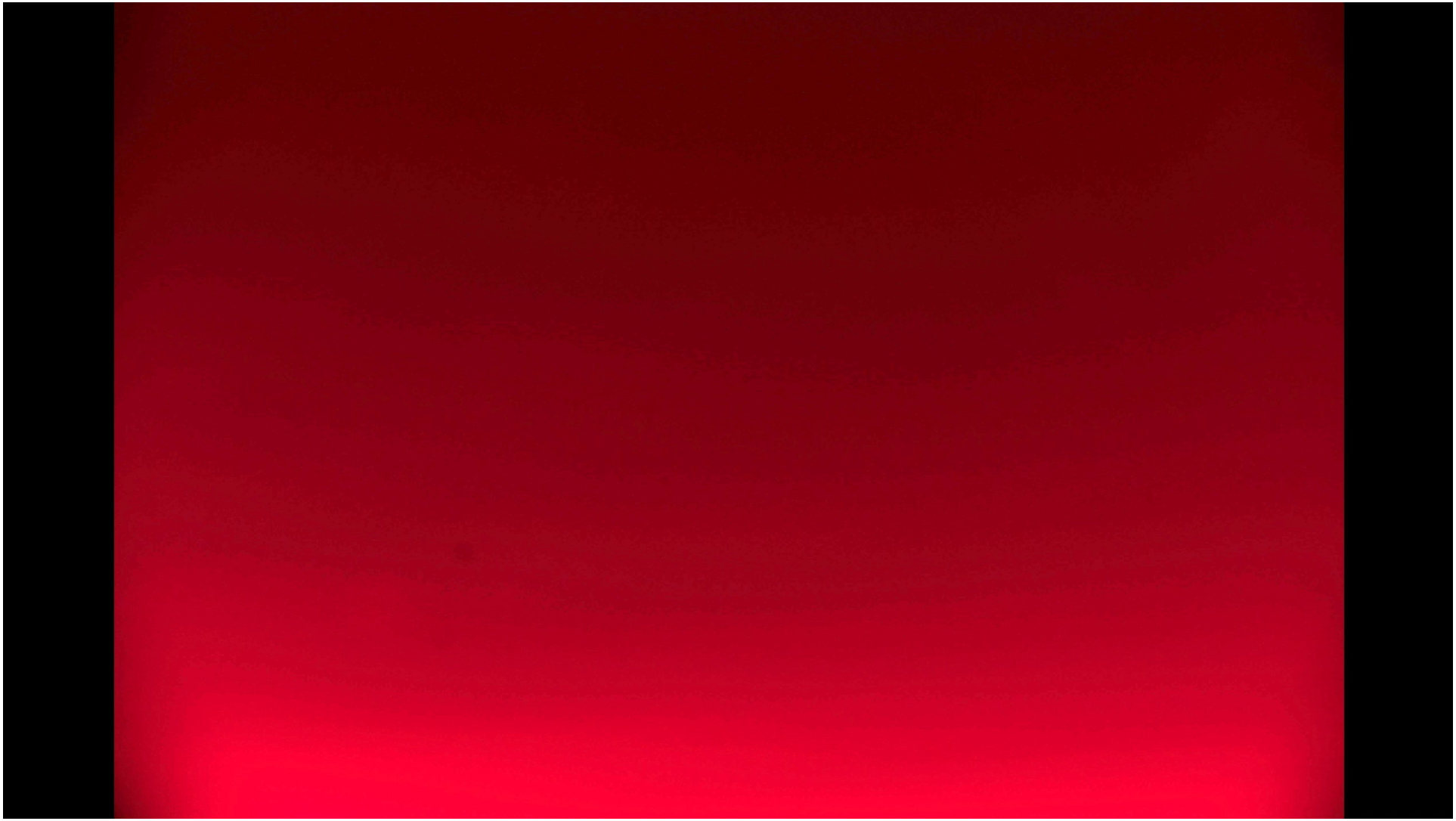
Original plan for triangulation:  Combine data from a range of azimuths at different times to produce a solution for the profile of horizontal winds



…but within a few minutes, sections of the trail had already passed outside the field of view (~40 deg of the lithium-filter cameras on the aircraft.



Aircraft image sequence (1 image every 5 sec cadence)



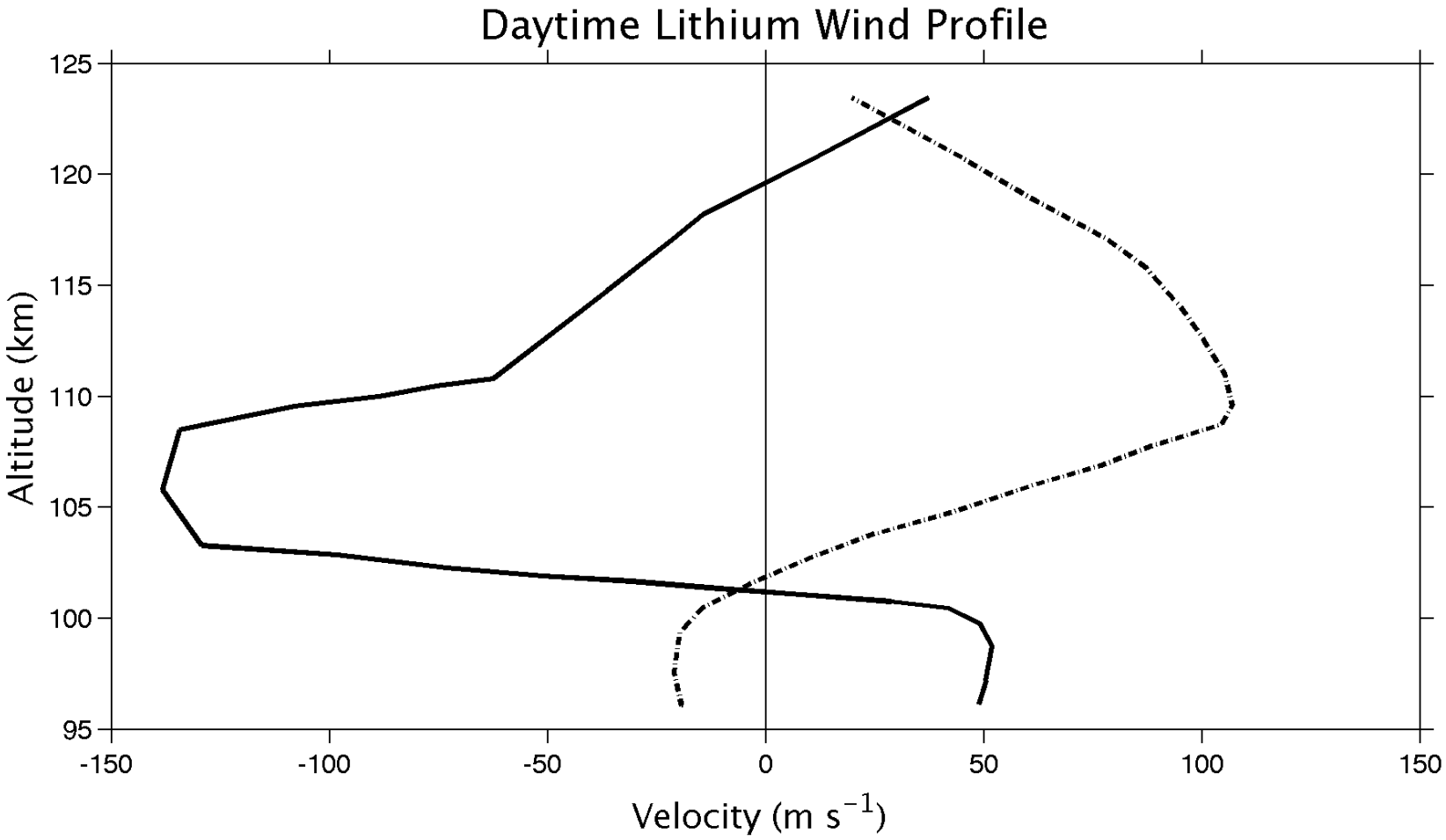
Plan B:  Locate the top of the trail in images taken every 5 sec as trails are released.

Use radar track to identify altitude for that point

Assume altitudes of trail features are constant and track in time

Radar track position for trail immediately after first release starts gives an initial pointing direction for the camera(s).

Aircraft IMU data gives relative changes in camera pointing for each consecutive image/ aircraft GPS gives camera lat/long




Wallops Island, Virginia, 10:31 LT, July 4, 2013