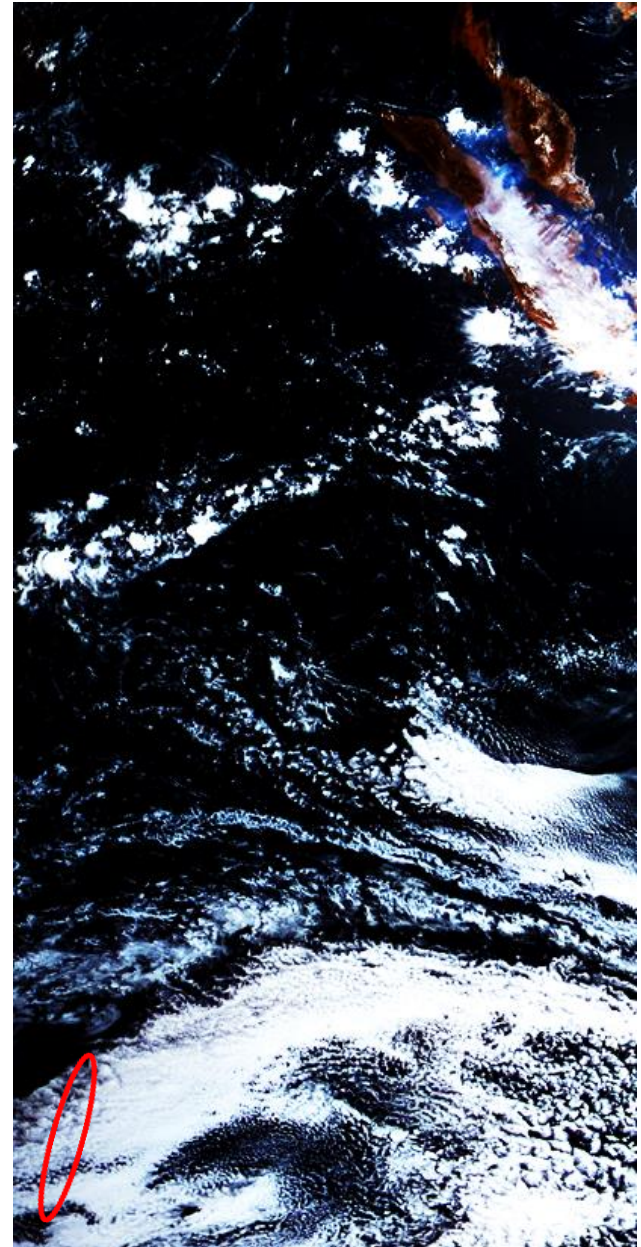


**Addendum #4 –
MH370 Contrail Data
and a New Route Fit**

(The Location of MH370)

**Dr. Bobby Ulich
April 16, 2015**



Summary of Findings

- MH370 contrails have been identified and measured by Kirill Prostyakov and Bobby Ulich
- High-resolution long-wave infrared imagery was used to detect nighttime contrails and to trace the path of 9M-MRO during the final maneuvers from 18:22 – 18:40 UTC on 7 March 2014
 - 3 Turns were made between 18:22 and 18:37
 - A climb to higher altitude (~FL390) also probably occurred from ~18:25 to just before 18:28 (based on contrail path and BFO data)
 - The first turn (~60 deg left) occurs immediately after reaching the last radar contact position and is toward Banda Aceh (WITT) or possibly Maimun Saleh (WITN)
 - The second turn (~80 deg right) is toward waypoint SAMAK
 - The third and final turn (~110 deg left) is directly to waypoint IGEB0
- Additional infrared and visible images also showed the aircraft track during its southward journey into the SIO
- Detection of a contrail extending from 31S to 38S provides an estimated 7th arc crossing at approximately (39.9S,84.5E)
- Preliminary route fitting based on BTOs and steady Mach 0.84 speed indicates a great circle route through IGEB0 passes within a few miles of the contrail locations
 - Equivalent Still Air Distance traveled from 17:07 to 00:16 is 3,541 NM and indicates an average engine PDA of 2.4%
 - RMS variation in TAS from Mach 0.840 is < 1 knot from 18:22 to 00:11 after compensation for wind and temperature
 - Approximate BTO and BFO values calculated using the contrail maneuvers (plus a climb) appear to be consistent with the known satellite data
- A preliminary estimate of the 7th Arc crossing based on the computer route fit through IGEB0 is (39.63S,85.00E)

The contrails and route fits demonstrate that 9M-MRO is outside the current ATSB Priority Search Zone.

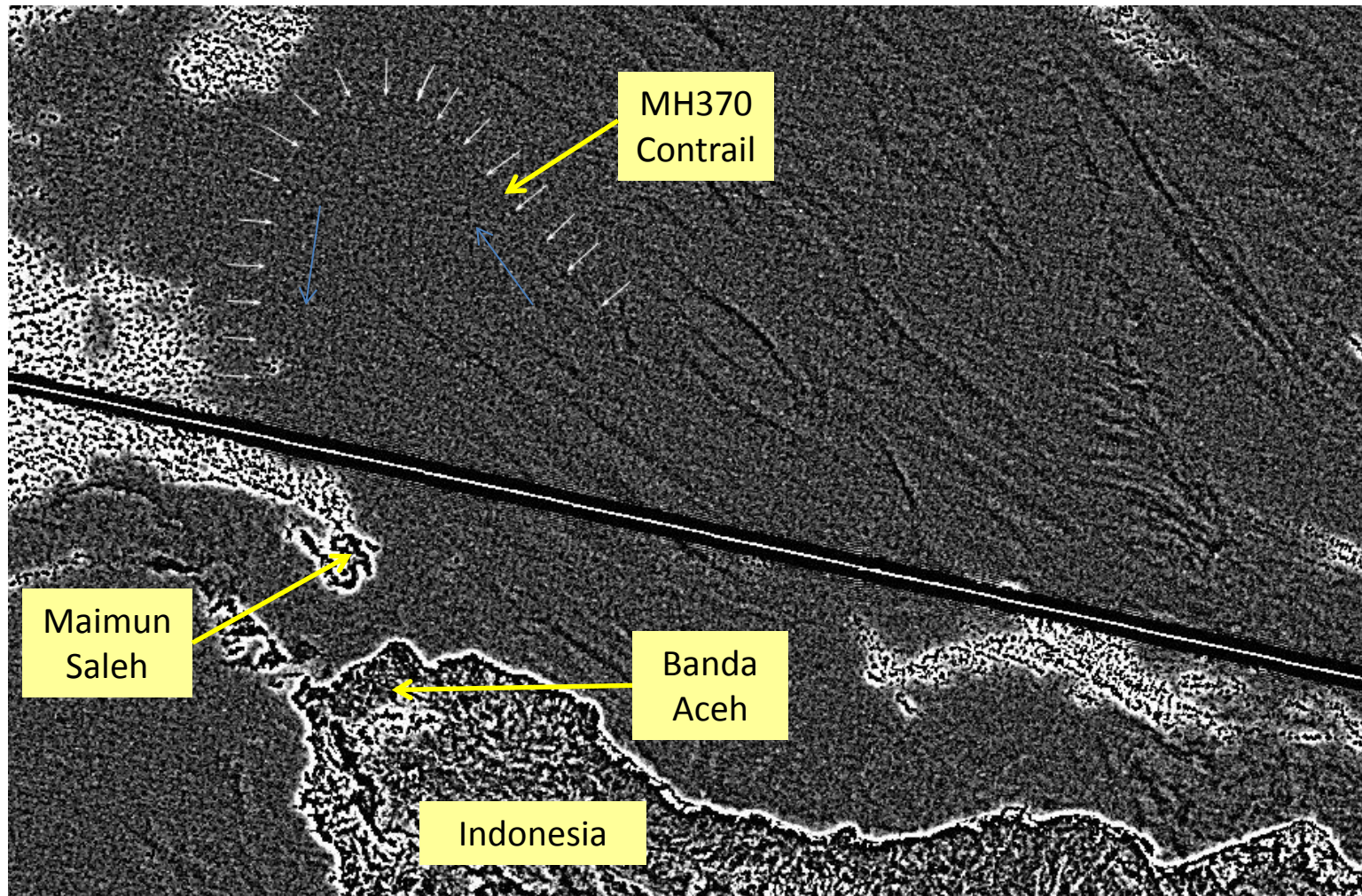
I recommend a new search area be established from 84.0E to 85.5E along the 7th Arc.

New MH370 Contrail Results

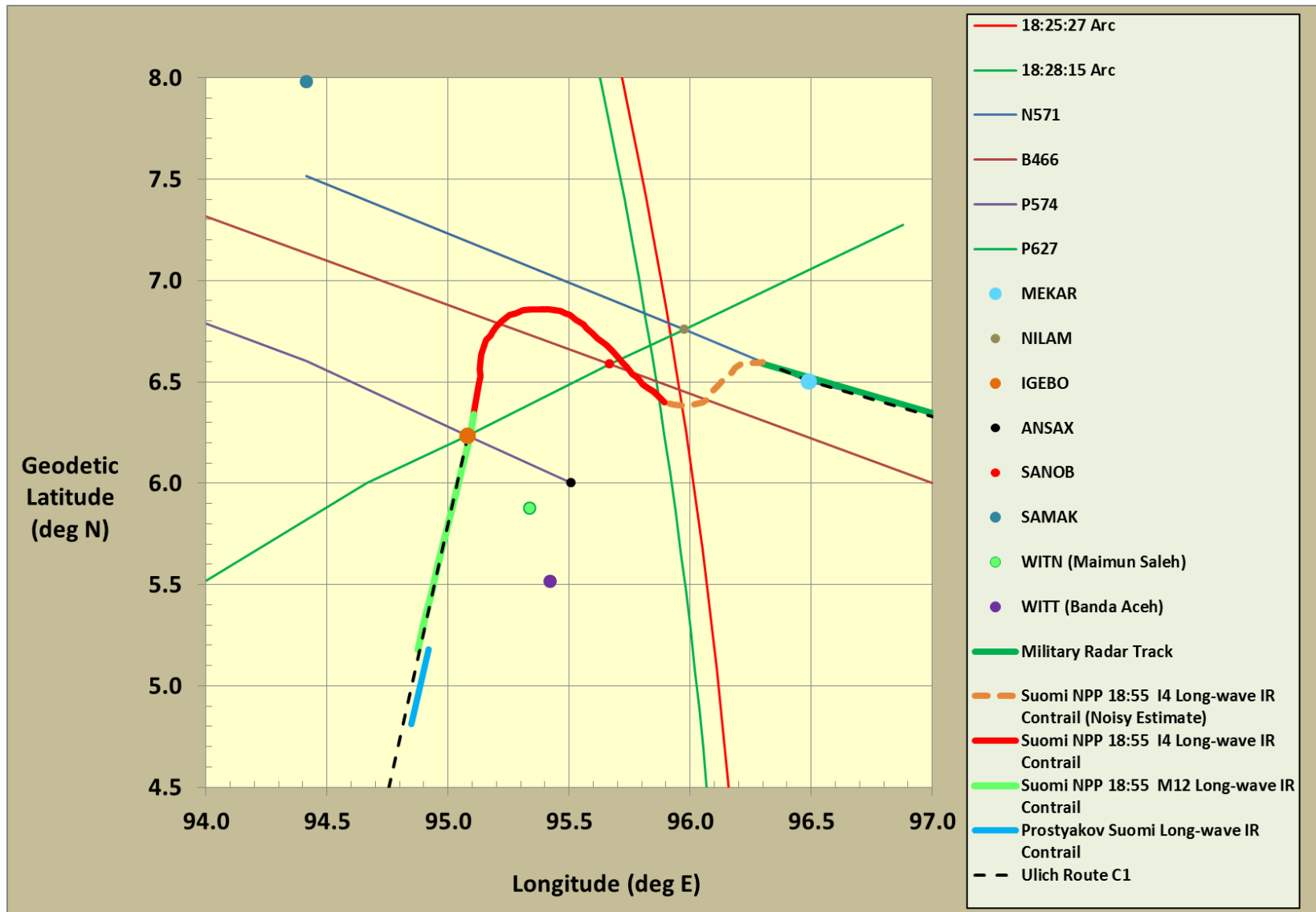
- Multiple contrails have been identified from satellite images taken during and immediately after the flight of MH370
- These contrails are unique because:
 - They do not fall on commercial airways
 - They occur in areas known to be otherwise acceptable as a MH370 flight path based on the satellite data
 - They have a unique shape, location, and/or orientation indicating they were likely created by MH370
 - In combination, they closely define the actual flight path taken by MH370
- The first contrail displays a circular arc near (7N,95E) which appears to be the Final Major Turn
 - It was imaged at 18:55 UTC in long-wave IR with 375 m spatial resolution by the Suomi NPP satellite and the VIIRS camera
 - The arc bearing changes from WNW to SSW
 - A portion of the arc was first identified by Prostyakov
 - Ulich has made precise coordinate measurements and extended the contrail in both directions using medium-wave and long-wave infrared images
- Ulich has identified **three turns** between 18:22 and 18:37 UTC on 7 March 2014
 - It is now apparent that the BTO and the BFO data near 18:25-18:28 seem to be accurate and reliable
 - The sole exception is the 18:25:34 BFO previously discounted by Inmarsat
 - Three turns and a climb to higher altitude occurred in this brief period
- The second contrail identified is below the turn arc at about 5N latitude
 - It is straight and runs slightly west of south
 - Prostyakov has measured the coordinates of the two ends of this long-wave IR contrail
- The third contrail was first identified by Prostyakov and then measured by Ulich using five visible satellite images taken at 00:00-01:00 UTC (just after sunrise) in the SIO
 - It is a slightly curved dark line (perhaps the shadow of the contrail on the cloud deck below) slightly running SSW extending from 31S to 38S latitude
 - This particular contrail provides a relatively precise stand-alone estimate of the 7th arc crossing location (39.9S,84.5E)

Final Major Turn Contrail

Long-Wave Infrared Image (18:55 UTC Suomi NPP VIIRS Band I4)

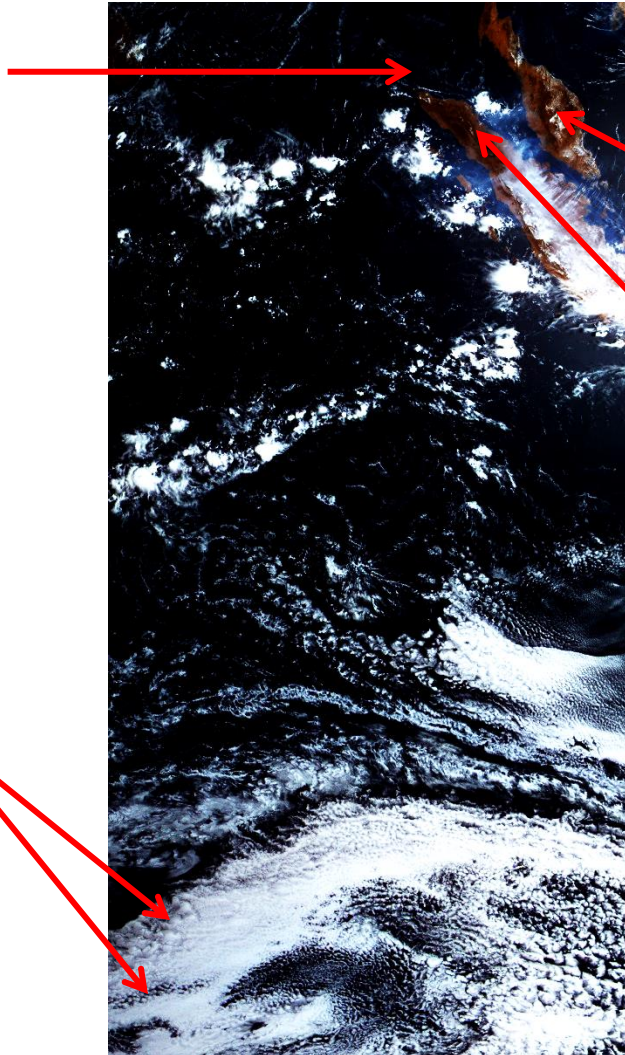


Map of Final Major Turns (3)



RGB Image from Malaysia to South Indian Ocean on 8 March 2014 at 01:30 UTC from Electro-L satellite

MH370 Final Maneuvers



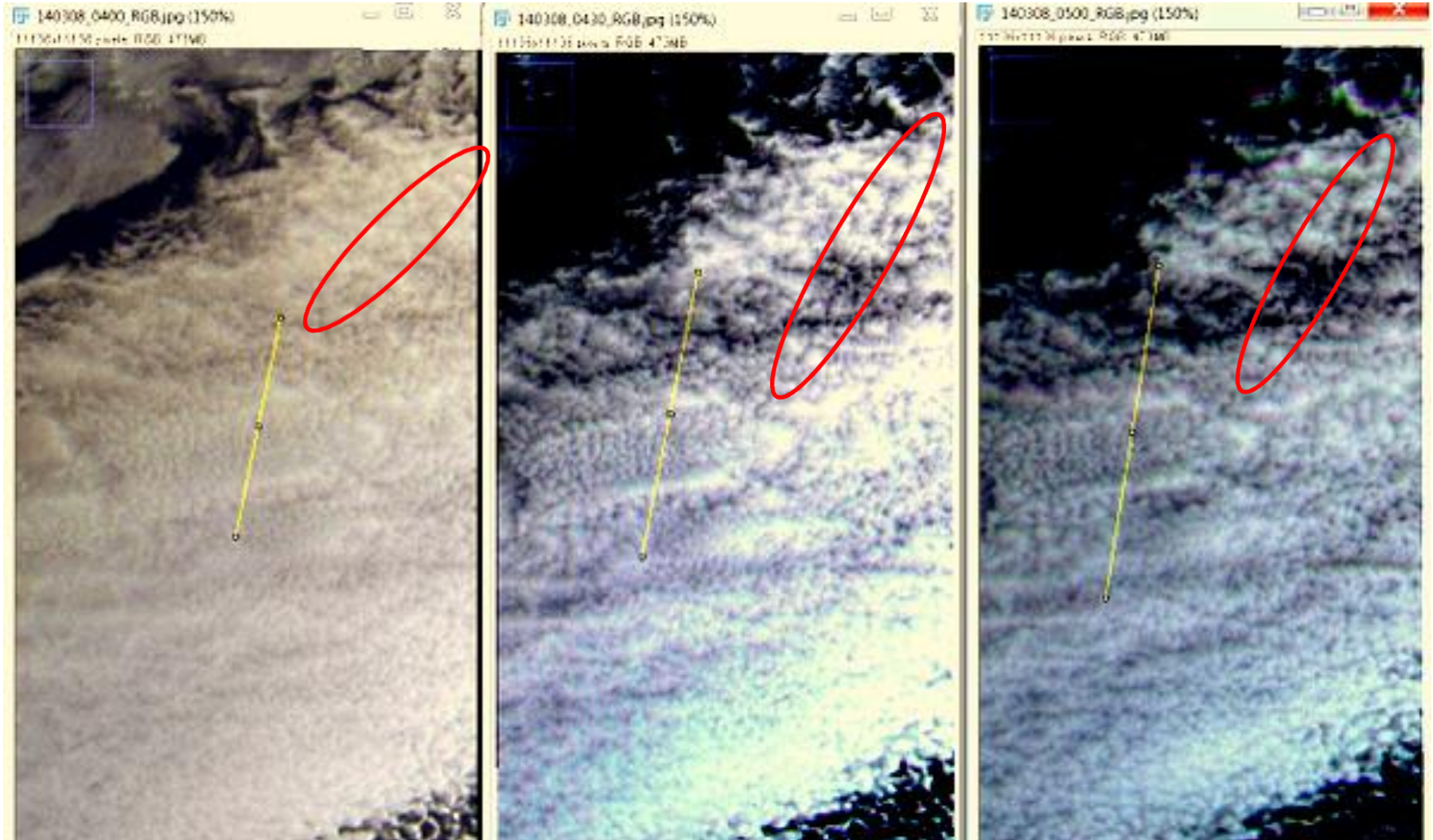
Malaysia

Indonesia

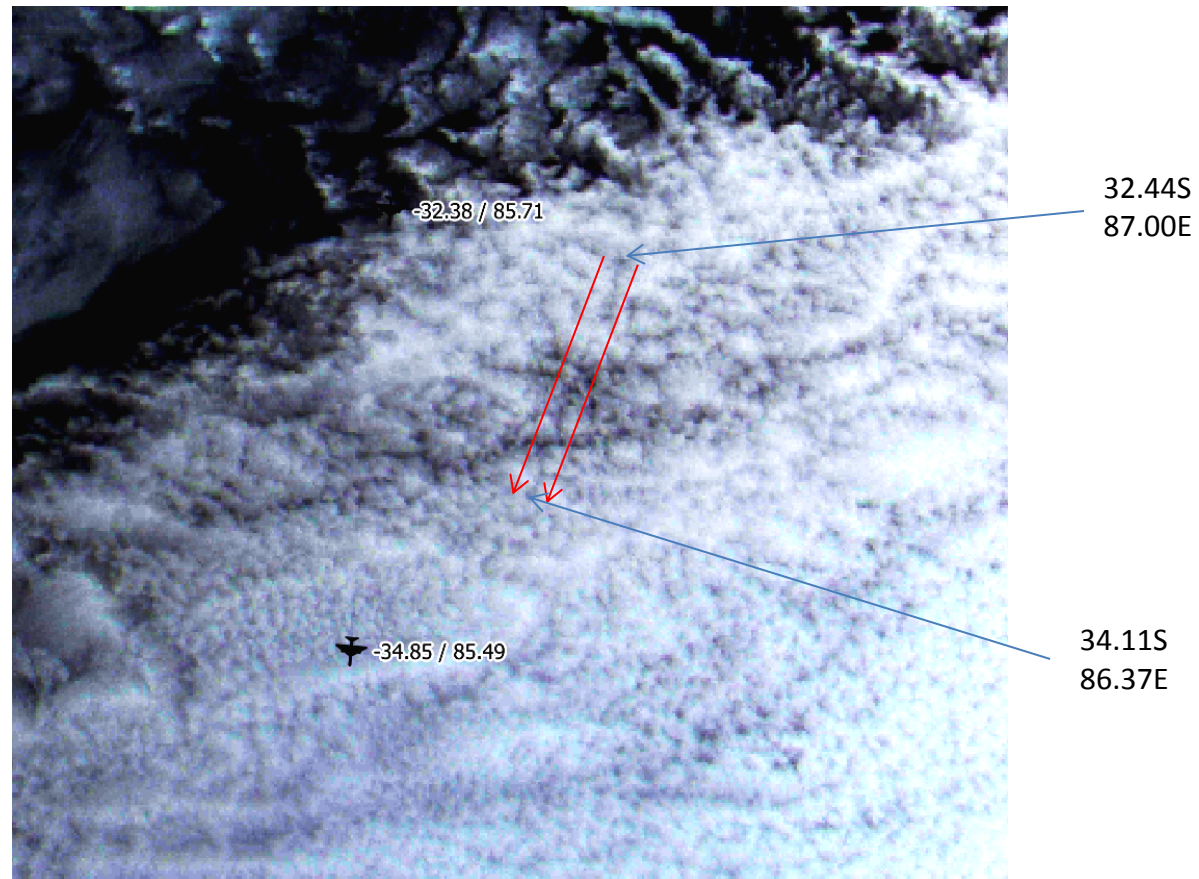
MH370 Contrail
on Cloud Deck

MH370 Contrails in Visible Images Taken After Sunrise in SIO

(Images taken at 00:00, 00:30, and 01:00 UTC on 8 March 2014 by Electro-L Satellite)



Linear Contrail in Visible Color Image After Sunrise Also Matches the Best-Fit Great Circle Route Through IGEBO

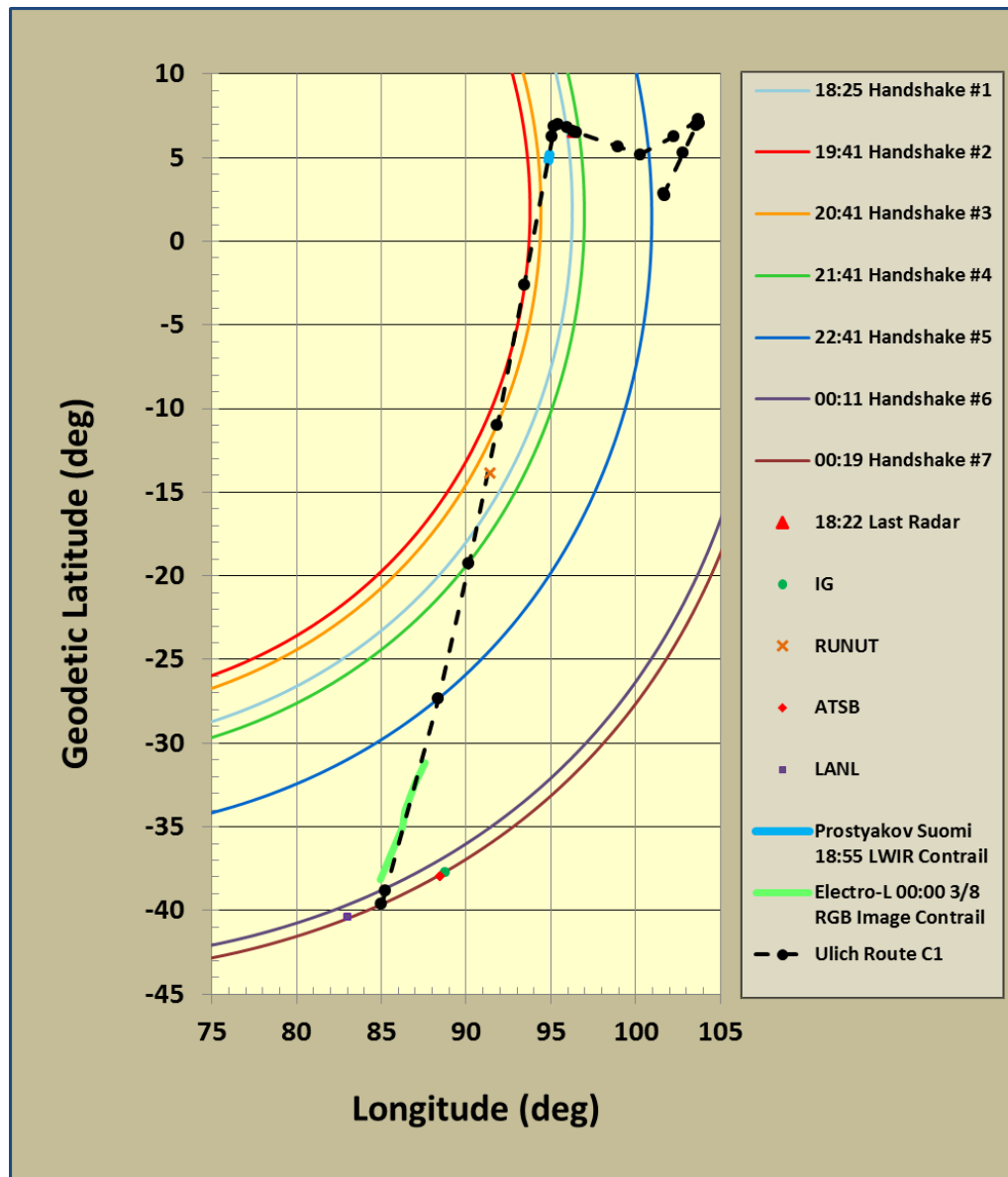


New MH370 Route Fitting Results

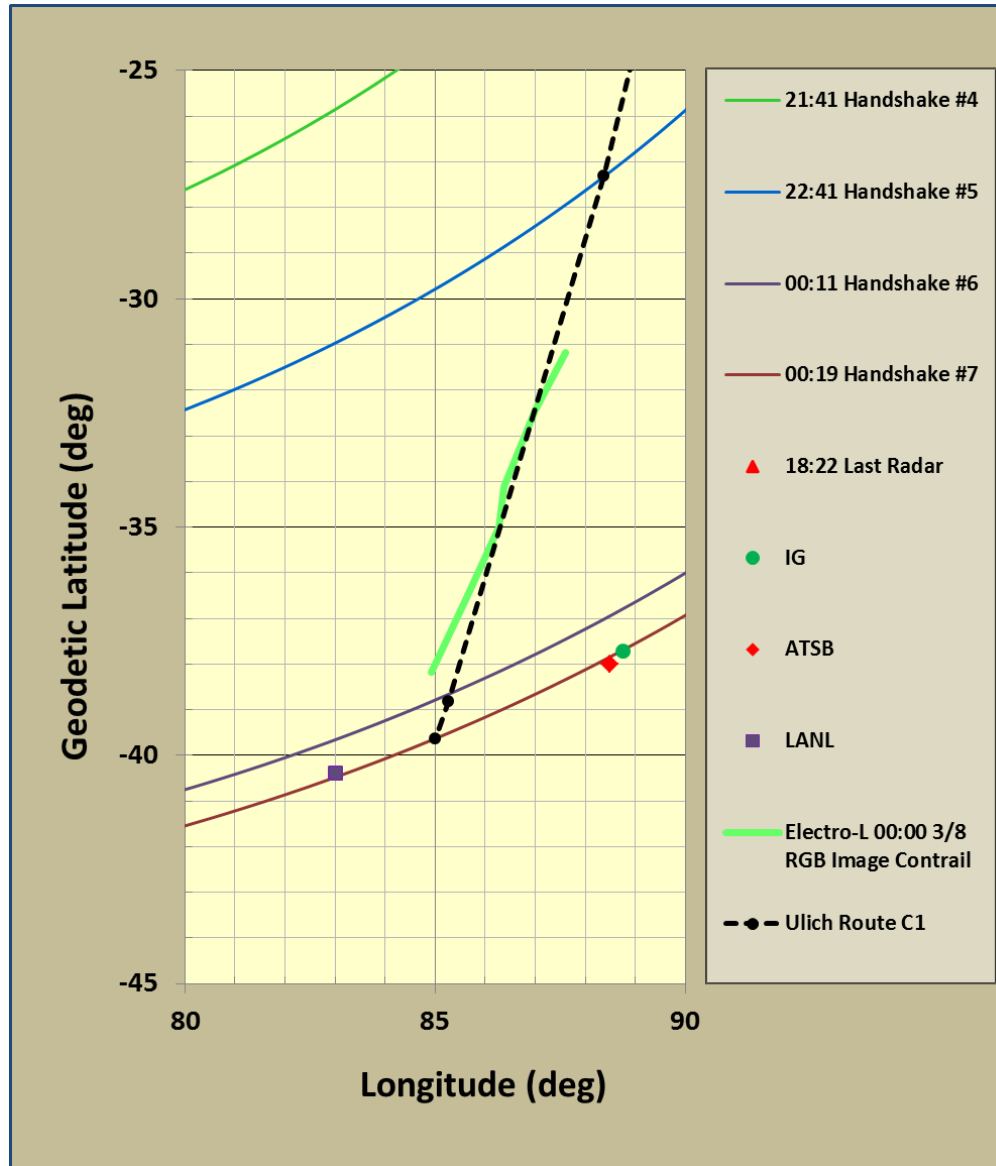
Based on FMTs Contrail Path

- MH370 routes were fitted with the turn location constrained to be consistent with the FMTs contrail path
- Both great circles and True Track paths were fitted by Ulich using his usual method of satisfying the BTO data while simultaneously minimizing the speed variations
 - The True Track fits were all unsatisfactory due to excessively variable air speeds
- A great circle route with an initial bearing of ~191 degrees provides < 1 knot RMS air speed variation from 18:22 UTC (last military radar contact) until the 6th handshake at 00:11 UTC
- The speed profile was assumed to be Long Range Cruise at a constant Mach 0.84 with step climbs from 35,000 feet to ~39,000 feet
- A climb from 35,000 to ~39,000 feet occurred during the second turn at ~18:25-18:28
 - A 1500 FPM climb underway at 18:25 and at 18:27 satisfies the BFO data then
 - The ~2 min 40 sec climb probably occurred roughly between 18:25 and 18:28
 - The climb was completed prior to the 18:28:06 BFO data
- Based on the contrails, the third and “final” turn occurred at ~18:33UTC
 - Contrail after last turn goes directly through waypoint IGEB0
- A preliminary estimate of the 7th Arc crossing based on the computer route fit through IGEB0 is (39.63S,85.00E)

Map of Fitted Route and Contrails



Map of Fitted Route and Contrail Near 7th Arc



The contrails and route fits demonstrate that 9M-MRO is outside the current ATSB Priority Search Zone.

I recommend a new search area be established from 84.0E to 85.5E along the 7th Arc.