Lessons Learned from a Scan Eagle Inadvertent Departure from Controlled Flight

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Human / Machine Interface:

Upcoming Projects.wmv

Overview

- Scan Eagle UAS Background
- Mishap Test Background
- Mishap Incident
- Causal Factors
- Lessons Learned / Risk Mitigation
  - How they apply to manned and unmanned Flight Test
- Summary / Conclusion

Scan Eagle Background

- Manufactured by Insitu Corporation
- 44 pounds, 10’ wingspan
- EO or IR nose-mounted camera
- Ceiling 17K’ MSL, Max speed 90 kts (70 kts Flight Clearance Limit)
- Cruise speed approximately 50 kts
- Catapult launched
- Recovery via a vertical tether system “skyhook” approximately 20’ AGL.

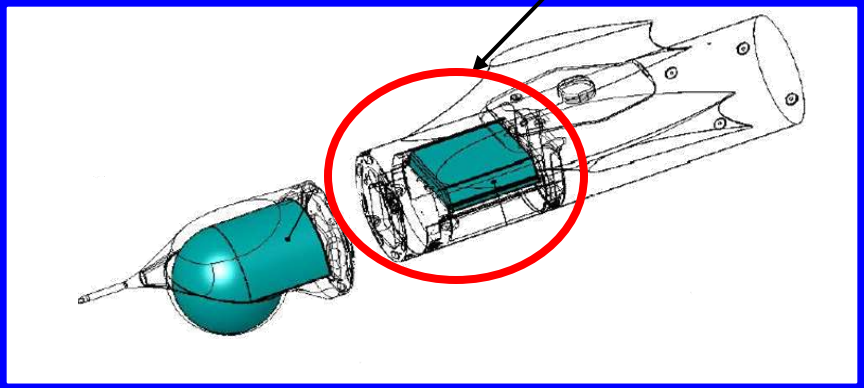
Scan Eagle Background

Test Background Facts

- Scan Eagle Test Team
  - Three members do it all (Fly, Mx, Test Plan, RTR…)*
- Test payload was a "critical need item" ISO GWOT
  - Payload consisted of special RF emitters
  - Payload function/end use Classified*
  - Delivery to theatre was to immediately follow testing*
- Ground and flight testing (May 2008) to verify:
  - Electromagnetic compatibility (EMC)
  - Payload in-flight function within RF environment*
  - Aircraft stability with payload installed*
    - Payload antenna modified outer mold line of A/C

*Holes in the "Swiss Cheese"

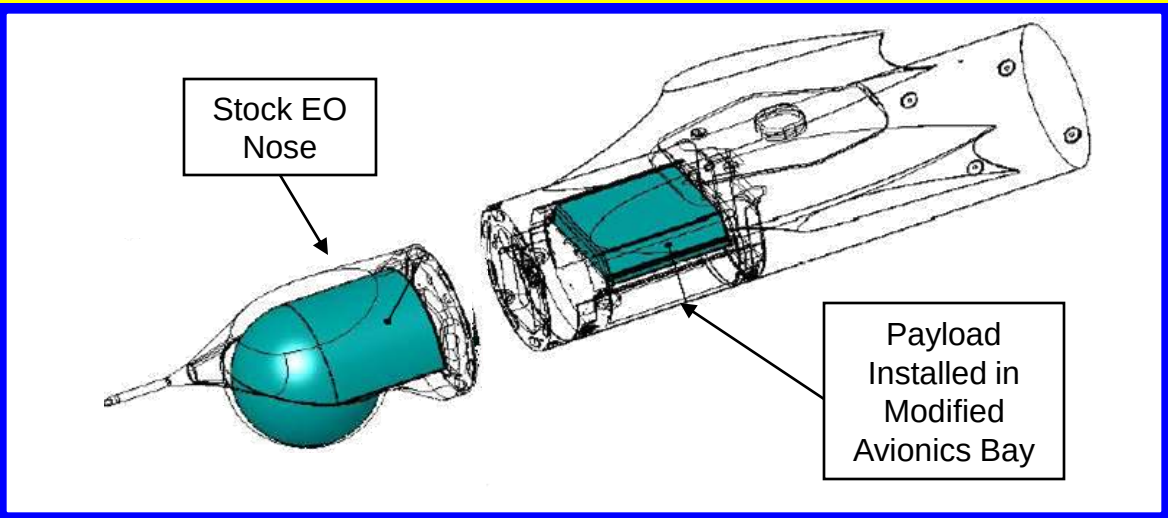
Mishap Payload Configuration



- Payload installed in avionics bay
  - No loss of ISR capability
  - Recommended by Manufacturer*
  - Parts readily available *

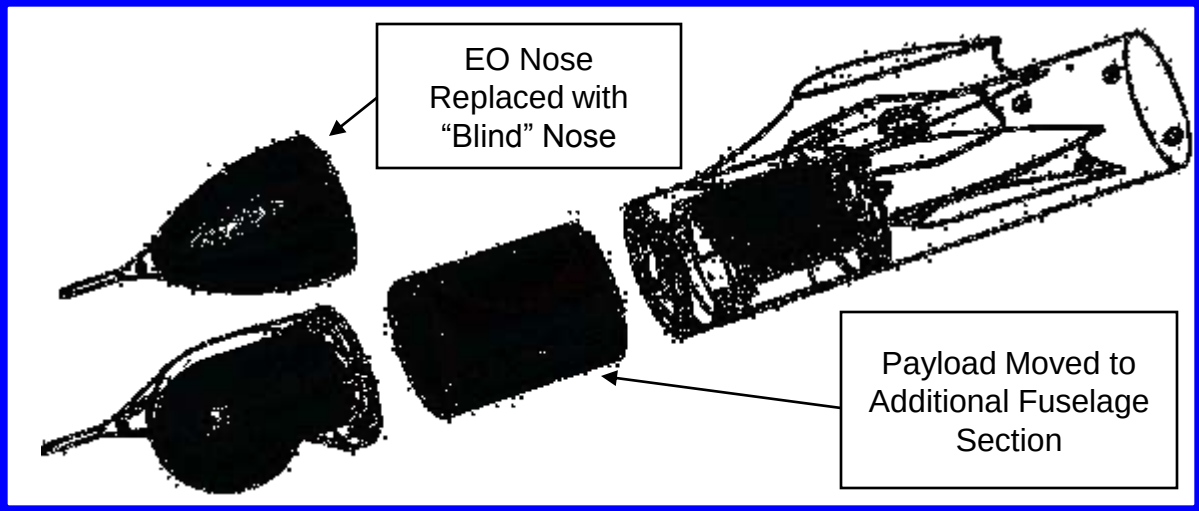
*Holes in the "Swiss Cheese"

Mishap vs. Final Payload



- A/C loses no ISR capability
- Emitters less than ½" from yaw rate gyro
- Many delicate/sensitive parts inside avionics bay

- Emitters 12 times farther away from sensors
- New payload bay is a carbon fiber tube…



“Classic Style” Swiss Cheese

Holes included (but not limited too):

1. Payload Classification = Poor communication, perceived blocks
2. Immediate Delivery = Get ‘er done NOW! Accept poor payload location & poor test discipline
3. Manufacturer Approved = It’s probably FINE
4. Ground test RF environment different from flight test = unknowingly invalidated ground test (see #1)
5. Inexperienced Crew = Inexperienced Crew…

Incident

- Dark-o'-thirty start, 2 hour launch delay to troubleshoot payload.
- Power applied to avionics bay while payload adjusted/installed/removed (bay had to be removed to turn payload on)
- Various warning and cautions throughout troubleshooting.
- Recurring yaw rate warning coincident with payload reinstallation events.
- Normal to have multiple cautions during pre-start sequence → yaw rate warnings ignored.

Incident (cont)

- Eventually decided payload would be flown in "non-operative" mode.
  - Violated test plan no-go criteria
  - Senior member (ex-military) said "Go"
- "Ready for Launch" indication was received. Normal launch ensued.
- 13 seconds after launch, yaw rate warning was observed – Scan Eagle departed controlled flight.
- Result – loss of only Scan Eagle test asset in VX-31 inventory and 7 month delay before testing resumed.

Incident Summary

- Ground testing indicated payload was green for flight, crew elected to fly
  - Ground testing was invalid
  - No-Go criteria not adhered to
  - Launched anyway
- After launch, RF emissions from the payload caused spurious yaw rate data to be passed to the autopilot
  - Departure from controlled flight
  - Splat….
- Many places where mishap could have been avoided

Causal Factors, Lessons Learned, Conclusions

Causal Factors

- Material Factor: Yaw rate sensor gave erroneous rudder inputs +/- 114 deg to autopilot.
- Material Factor: Installed payload produced internal EMI which caused yaw rate sensor anomalies.
  - After successful ground test, payload was adjusted to transmit on a different frequency, invalidating EMI results of ground test.

Causal Factors (cont)

- Aircrew Factor: Aircrew could not discriminate validity of multiple spurious warnings and cautions on the flight control display.
  - Color coded Warnings and Cautions listed in scrolling format on control display.
  - Only most recent 3 displayed.
  - Creates tendency to ignore Warnings / Cautions prior to preflight diagnostic check on catapult.

Causal Factors (cont)

- Aircrew Factor: Lead operator (PIC) had Human Factors (HFAC) issues that were ignored to “get the job done”.
  - Family member died 1 week prior.
  - Extensive winter driving over previous 10 days to funeral etc.
  - Fit to fly?

Causal Factors (cont)

- Aircrew Factor: Aircrew did not abort flight despite multiple yaw rate sensor warnings prior to launch.
  - 6 warnings prior to launch, attributed to removing avionics bay.
  - Decision to ignore warnings until vehicle was on catapult based on accepted practice of ignoring spurious erroneous warnings when aircraft is being jostled by ground crew.
  - No documentation stating yaw rate sensor should trigger an abort. Experience based knowledge.

Causal Factors (cont)

- Aircrew Factor: Aircrew felt pressured to fly in order to stay within SOP currency requirements.
  - SOP states 1 flight in previous 30 days to maintain currency.
  - Currency set to expire in 9 days.
  - Though test was determined not possible (no-go), and due to difficulty in scheduling range time, aircrew elected to fly payload in “non-operative” mode to maintain currency.

Causal Factors (cont)

- Maintenance Factor: Flight test team did not have an effective configuration control or QA policy.
  - Initial ground tests showed no payload EMI effects on rate sensors.
  - No procedures in place to freeze configuration.
  - Customer changed payload transmission frequency and disassembled avionics bay.
  - Invalidated ground tests and calibration efforts. Aircrew not informed, no guidance given to customer.

Lessons Learned

- No substitute for sound NATOPS, systems, and procedural knowledge.
  - Critical especially in test environment. What is your airplane telling you? What does it mean? Have I met abort criteria?

Lessons Learned (cont)

- Operational Risk Management (ORM) is a tool to mitigate risks. Use it.
  - What is different about today's flight (snakes in the grass)? What can possibly bite us today? What can we watch for? When will we cry uncle?

Lessons Learned (cont)

- Is test aircrew experience adequate for given test? If not, how do we mitigate that?
  - Multi-place cockpits, thorough briefs, currency/proficiency matrices, THA's, ORM.

Lessons Learned (cont)

- Don’t let outside influences over-ride Go/No-Go criteria.
  - Maintaining currency should have been irrelevant.
  - Lack of standardization and documentation of training contributed.
  - Difficulty scheduling range periods contributed.

Lessons Learned (cont)

- Documented Configuration Control is essential.
  - Aircrew need to understand limits, importance, and receive training.
  - Customers need to understand limits and be held accountable for configuration changes.
  - 2 way flow of communication.

Lessons Learned (cont)

- Maintenance needs to be documented thoroughly and aircrew need to be familiar with the status of their aircraft.
  - NAMP procedures do not exist for non-POR UAS platforms.
  - Quality/completeness of manufacturer provided maintenance procedures vary.
  - At VX-31, manufacturer's documentation was adapted to accepted NAMP formats and NAMP-like procedures were implemented to extent possible.
    - Nalcomis tracking, MAF's, Safe for Flight

Lessons Learned (cont)

- Adhere to and fly your Test Plan.
  - Would have avoided this mishap.
  - UAS acceptance, familiarization, proficiency, and currency flights were not covered under fully reviewed plans.
  - “Operations Plan”, using NAVAIRINST Test Plan format, was developed.

Lessons Learned (cont)

- Know your Mishap Response Plan (MRP).
  - Response from on-site personnel was inadequate and untimely.
  - Non-military aircrew were unfamiliar with VX-31 MRP, military mishap reporting procedures.
  - Highlighted the need for periodic mishap training / drills, especially for non-military personnel.

Lessons Learned (cont)

- Communication is a must-have for a successful test program.
  - Warfighter ←→ Acquisition folks
  - Acquisition folks ←→ Requirements folks
  - Requirements folks ←→ Engineers
  - Engineers ←→ Testers
  - Testers ←→ Leadership

Lessons Learned - Summary

- Why did this happen?
  - "Just a UAV" culture in manned aviation
  - Doesn't cost too much (< $150K)
  - OK to take shortcuts and violate No-Go, EMI testing

- Real cost
  - Not $$$
  - Delay in critical need item to the warfighter
  - Credibility as a test program

Subsequent Tests

- Payload was redesigned
  - Smarter and better
- Test team re-organized
  - Lessons learned implemented
- Valid ground testing conducted
  - Configuration control maintained
- Successful flight testing in November 2008
  - Payload delivered to theatre **7 months late!!!**

Conclusion

- Lessons Learned have been learned before.
- Applicable to unmanned and manned aviation alike.
- “Best practices” applicable to all aviation test events.

Questions?