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AFTS 629/11/14/RPRT-002

KALKARA LAUNCH FLIGHT DATA ANALYSIS, POST-CHANGE ECP KAL-007A, ROLL-LIMIT PITCHOVER, FLIGHTS 26 & 27

DRAFTED BY: Anthony P Brown

CHECKED BY: Nick C Frost

APPROVED BY: P. A. Goon

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1. EXECUTIVE SUMMARY

1.1 Flight test data for the launch of the Kalkara aircraft for flights 26 and 27 have been reduced and analysed to determine the effects of the changes introduced into the launch sequence by ECP KAL-007a. The ECP was intended to reduce the lateral deviation due to uncommanded rolling motion which is consistent with being caused by wing flow separation. This report provides the results of that analysis.

1.2 Analysis of previous flights has indicated that wing flow separation occurred during the launch phase at angles of incidence of at least ±10º (and possibly less), causing negative roll stability and ineffective roll power due to aileron deflection. The observed effect was an uncommanded and uncontrolled roll displacement of the aircraft of over 20º.

1.3 Modification ECP KAL-007a was introduced to reduce the uncommanded roll experienced by the Kalkara aircraft with particular payload configurations. The ECP introduced a GCS-monitoring of roll angle through the launch phase of flight. In response to the detected exceedance of a roll angle of 20°, the GCS commands a pitch-down manoeuvre, to level flight. Being a reactive modification, the ECP did not inhibit the flight incidence envelope of the aircraft. The analysis of Flight 27 indicated that, for this reason, there is no change in the inherent aerodynamic characteristics of the aircraft, which have given rise to the observed uncontrollable roll instability.

1.4 Both flights were undertaken in light (5-8 kt) cross wind conditions and were required to be "hands off" during the launch as a test requirement. Flight 26 was similar to previous flights, having the same payload configuration, with the roll angle reaching 17º. The early pitch over command was not initiated. This was in accordance with the ECP where the early pitchover is only initiated if the roll angle exceeds 20º. On Flight 26, total heading change, from launch to the achievement of level flight at 30 seconds, was 50°. Incidence throughout the Flight 26 launch phase varied between about 5° and 11°, the latter occurring at 16 seconds flight time. Although the heading could have been controlled at some stage by controller/pilot manual input, the high incidence values would have resulted in reduced margins of controllability against inducing further uncommanded roll.

1.5 The configuration on Flight 27 was similar that on Flights 3 and 20. Analysis of the data shows that the aircraft incidence reached a negative value of -11º followed by an uncommanded roll and unassociated incidence change from -11° to+6°, during which the airflow over the wing reattached and the ailerons corrected the roll. A maximum roll angle of 21º was achieved concurrently with the peak incidence value of +6° and the initiation of the pitch over sequence, in accordance with the ECP. In accordance with DAP characteristics, a delay of 1.3 seconds occurred before a pitchdown rate was initiated, as part of the ECP early pitchover, by which time incidence was +5°. Thereafter, during the early pitchover iteration, corrective aileron and roll angles monotonically converged to low values.

1.6 At the request of the Kalkara Project Office, a comparison has been undertaken of the data from Flights 3 and 20, drawing inferences from the data along with the related observations derived from Flight 27. By the nature of the data and variances between the flights, this comparison was principally qualitative in nature with quantitative observations (though somewhat tenuous) being offered to provide a better understanding of the trends within the qualitative observations and associated inferences. At best, the application of ECP KAL-007a to Flights 3 and 20 would have had marginal, if any, utility in controlling or reducing the lateral deviation due to the uncommanded rolling motion. In the case of Flight 03, the application of the early pitchover would, at best, retard recovery from the associated aerodynamic hysteresis and, at worse, increase the magnitude of the negative incidence leading to increased excursions in roll with the possibility of fully departed flight.

1.7 Within the scope of the data and analysis of Flight 27 only, determination as to whether the early initiation of the pitchover had any significant effect upon the control of lateral deviation is not possible. Further flight tests are recommended to establish that the ECP changes are effective. Additionally, further testing is recommended to determine the effects of the early pitch over under certification limit wind and gust conditions.

1.8 As expected, the height achieved by the Kalkara from launch to level flight when influenced by an early pitch over was less than any previous flight with a normally timed pitch over. Further flight tests are recommended to provide an acceptable and supportable confidence level in the minimum height that may occur.

1.9 In addition to recommending further testing (both ground and flight), AFTS also recommends the application of additional instrumentation and flight test rigour to such testing to minimise data variances and tailor the scope to meet, as a minimum, the certification requirements.

1.10 The aircraft has inherent aerodynamic problems such as negative lateral stability and a limited attached-flow incidence range of approximately ±7º, which is exceeded during most launches. A hard fix is therefore recommended to improve the airflow over the wing and the stability of the aircraft.

1.11 Should a hard aerodynamic fix not be considered viable, then a more responsive threshold than the current ECP-activating roll angle threshold of 20º is recommended. A derived incidence threshold, differentiating between positive and negative incidence, blended by pitchrate, is recommended.

2. INTRODUCTION

2.1 Purpose

2.1.1 Subsequent to the incorporation of ECP KAL-007a, additional proving flight tests of Kalkara have been conducted as part of the Kalkara Type Certification programme, leading to the issue of an Australian Military Type Certificate. A kinematic and aerodynamic analysis of the launch flight test data has been conducted, for the purpose of conducting a review of the flight mechanic and dynamic changes that have been introduced by ECP KAL-007a.

2.2 Scope

2.2.1 This report covers the launch phases of Kalkara Flights 26 and 27, and for comparison, reviews Flights 3 and 20.

2.3 References

A. AFTS 808/11/05/PROC-002, Document Control Procedure.
B. System Safety Hazard Analysis for the Kalkara Target System. Tracor Systems Division, Document No TSD-0347, Rev A, 2 April 1998.
C. AFTS Letter Report 619/14/01 (12), 8 February 1999, Preliminary and Subsequent Review, Kalkara System Safety Hazard Analysis.
D. Kalkara SSHA Review Report. AFTS 629/11/14/RPRT-001. A P Brown & N C Frost, 9 March 1999.
E. Kalkara FQT Launch Flight Data Aerodynamic Reduction. AFTS 629/11/14/RPRT-001/ANNEX A, Issue 2. A P Brown, 22 March 1999.
F. Kalkara Engineering Change Proposal ECP KAL-007a, GCS-Monitored Launch, 13 September 1999.
G. Right roll Software Tests. Gndtst.xls, 9 September 1999.
H. Flight 26 Data File. flt26_rdf, 22 September 1999.
I. Flight 27 Data File. flt27_rdf, 22 September 1999.
J. Launch Analysis Comparing Actual Launch Data and Predicting Performance for GCS-Monitored Automatic Launch. Tracor Flight Systems.

2.4 Amendments

2.4.1 This controlled document will be amended in accordance with the procedures detailed in Reference A.

2.5 Glossary of Terms

2.5.1 <u>Abbreviations</u>

AFQT	Australian Flight Qualification Test
AMTC	Australian Military Type Certificate
DAP	Digital Autopilot
DGTA	Directorate General Technical Airworthiness
JBRF	Jervis Bay Range Facility
SSHA	System Safety Hazard Analysis

3. BACKGROUND

3.1 The Commonwealth of Australia has contracted Tracor Systems Division to provide twenty Kalkara Unmanned Aerial Target (UAT) systems to the Royal Australian Navy to replace the Jindivik target aircraft. The UAT are to be operated from two sites in Australia for training purposes for the RAN and the RAAF. The Directorate General Technical Airworthiness (DGTA) has responsibility for Technical Airworthiness Regulation and provides advice to the Airworthiness Board for issuance of Australian Military Type Certificates (AMTC).

3.2 Australian Flight Test Services Pty Ltd was contracted by DGTA to conduct a review of the Contractor-furnished SSHA (Reference B). The review was reported upon in References C and D. In addition, the review included (in Reference E) a kinematic and aerodynamic analysis of the launch data, pursuant to an understanding of the roll-off and turn phenomenon, which was observed upon a number of launches.

3.3 In order to improve the lateral/directional controllability of Kalkara during the launch phase of flight, a software Engineering Change to the Kalkara Type Design has been conducted by the System manufacturer, Tracor (Reference F). ECP KAL-007a has introduced an automatic initiation of a pitchover function, which is initiated by the GCS, whenever the roll attitude telemetry data equals or exceeds an indicated magnitude of 20º, or greater, during launch. Once initiated, the pitchover rate is maintained at a nominal 2 °/sec until level flight is attained.

3.4 As part of the ECP certification process, the Kalkara has successfully undergone a range of ground tests (Reference G), aimed at demonstrating the functioning of the GCS pitchover rate command, for a range of roll angles. Following upon the ground tests, two flight tests were planned, as follows:

a. Firstly, a flight (Flight 26) in the long-tow configuration, for which, previously, the launch roll-off angle has been less than 20° – chosen on the expectation that the roll angle would again remain less than 20° and the new GCS pitchover –initiated command would not be activated; and

b. Secondly, a flight in the tip burner and chaff dispenser configuration, for which, previously, a roll angle in excess of 20° has been demonstrated (*eg.* a roll angle of 40° on Flight 20) – chosen on the expectation that the roll angle would exceed 20° and the new pitchover command would be activated, thereby providing a flight demonstration of the software change.

4. RESULTS AND DISCUSSION

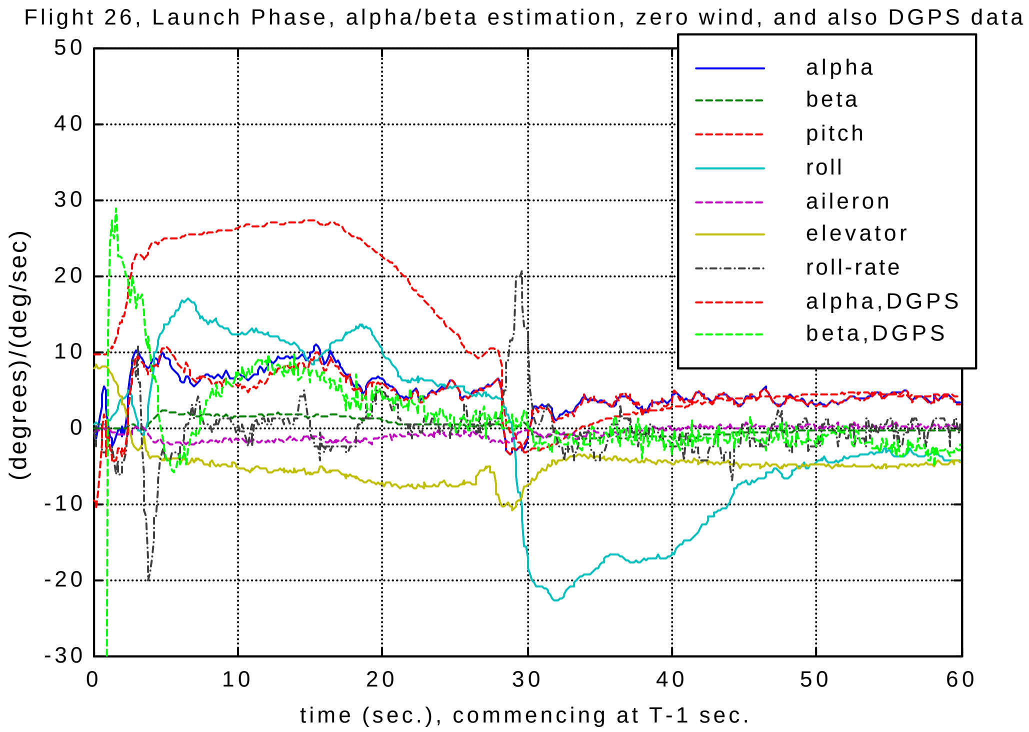
4.1 General

4.1.1 The analysis of Reference E consisted of two methodologies, the second of which included a DGPS-data analysis, with an assumed vertical wind profile, in an effort to improve the estimation of sideslip and to validate the estimation of incidence. The second methodology has been applied to the present kinematic and aerodynamic analysis of the flight data from Flights 26 and 27.

4.1.2 The analysis has been conducted upon data files flt26_rdf and flt27_rdf (References H and I). As the launches were designated as “hands off”, no manual roll or pitch commands are assumed in the following analysis. The pitch commands have been inferred from particular elements of the data, in particular, the GCS-initiated early pitchover has been inferred by pitch rate.

4.2 Flight 26, Long IR Tows

4.2.1 Aircraft S/No. 003 was used for Flight 26. The results of the kinematic and aerodynamic analysis are shown in the following figures.

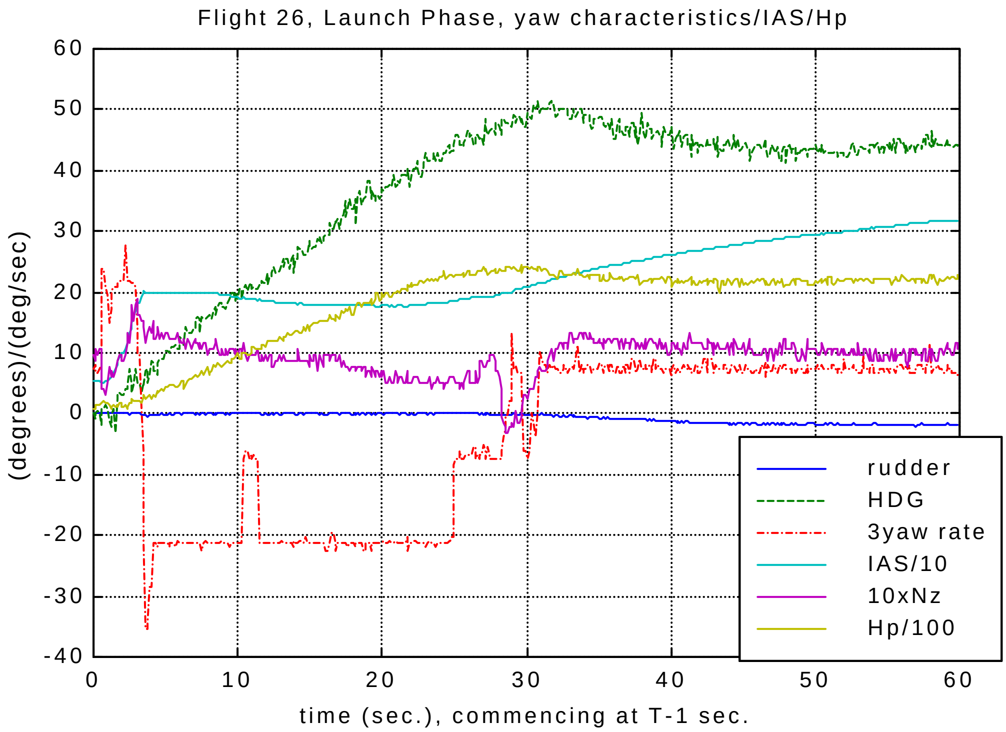


4.2.2 The above figure illustrates that, through the launch manoeuvre, the incidence reached a negative peak of about -4°, followed by a maximum value of about 10.5°, after which the aircraft rolled-off to a peak roll angle of about 17°. As seen from the above figure, the uncommanded roll-rate was promptly followed by an aileron deflection, of approximate magnitude –2.5° opposing the roll. Concurrently, the incidence reduced to about 6° and the roll-rate was arrested. However, although an aileron deflection of sufficient magnitude to promptly reverse the roll was maintained, the roll angle did not reduce. This was typical of the aerodynamic hysteresis effect of separated flow, observed and discussed in the earlier flight data analysis of Reference E.

4.2.3 Subsequently, the incidence monotonically and gradually increased through the climb, to a second peak of 10.5°, with the opposing aileron deflection of -2° maintained. At this point, namely immediately preceding the normally-scheduled pitchover point, a negative roll damping event occurred, manifested as a second uncommanded roll-off. The normally-scheduled pitchover promptly reduced the incidence. Positive roll damping (L_P) and roll power ($L_{\delta a}$) returned at an incidence of 5° (demonstrating a separated-flow hysteresis loop of incidence magnitude 5°). Such aerodynamic characteristics are typical of the behaviour observed from the analysis of earlier launches (Reference E).

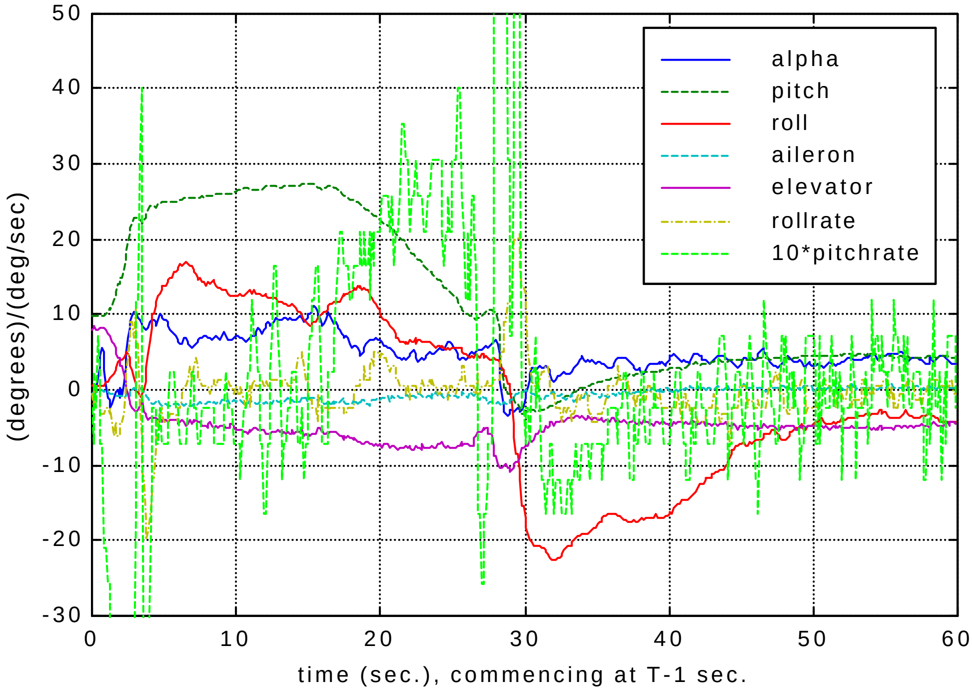
4.2.4 As seen in the following figure, the total heading change through the launch manoeuvre was approximately 50°, which is considered excessive for a closed-loop auto-flight control system. It is noted that the heading hold function of the DAP is normally not engaged during launch. In order to improve launch tracking, at some reasonable time during the launch phase, manual control could be used to correct heading and recover the launch track. However, the flight data illustrates that the DAP was attempting to control heading, but the aileron deflection was ineffective between time 4 and 22 seconds (by which time, the heading error was approximately 40°), until the incidence reduced below about 5° at time 22 seconds (indicative of a separated flow hysteresis loop of incidence extent 10° to 5°), and roll angle subsequently responded to the aileron deflection.

4.2.5 The above observation is indicative of a low margin of controllability. As such, both manual roll control and DAP heading-hold would not only be ineffective, but additional aileron deflection of manual control or, possibly DAP heading hold, could also precipitate greater flow separation and, hence, further loss of control. However, more data from specifically focused flight testing would be required to establish whether this would occur or not.



4.2.6 Of relevance to ECP KAL-007a, the following figure, which includes the pitchrate (in amplified scale), confirms that the aircraft did not, at any stage through the launch manoeuvre, experience an early pitchover at a specific pitchrate of -2° per second. As the roll angle did not exceed 20°, this is in accordance with the intent of ECP KAL-007a.

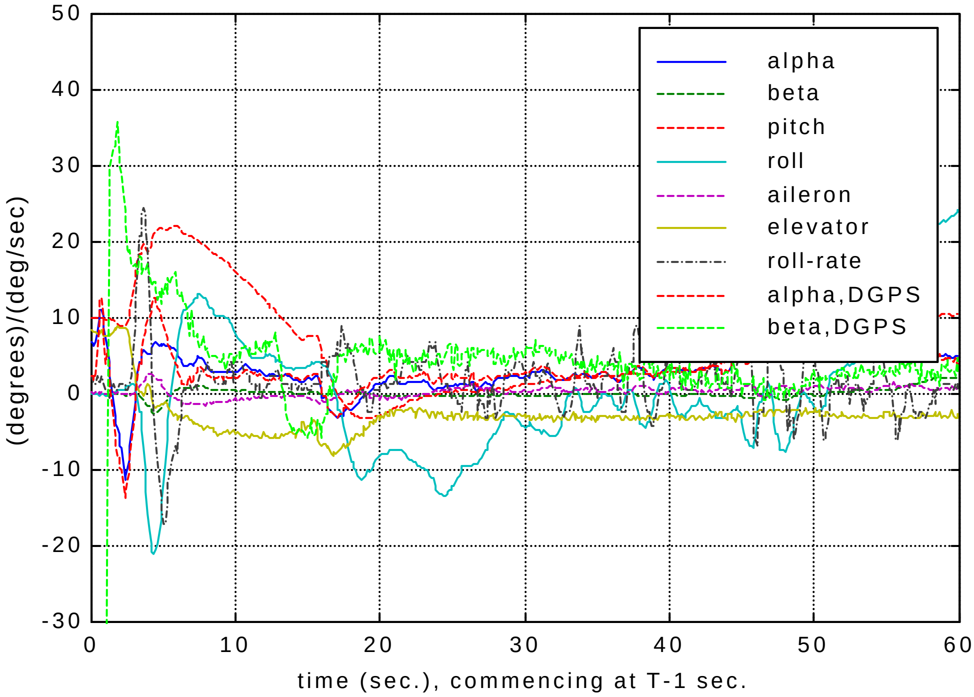
Flight 26, Launch Phase, alpha/beta estimation, zero wind, and also DGPS data



4.3 **Flight 27, Tip Burners and Chaff Dispensers**

4.3.1 The analysed flight data for Flight 27 indicates that, through the initial part of the launch, the aircraft achieved a sharp and high-value negative incidence peak of -11°, at which point an uncommanded left roll-off occurred. A correcting aileron-deflection occurred, immediately following the uncommanded roll rate onset. Following the negative incidence peak, the computed incidence sharply reduced to a peak positive incidence of +6°, at which point it can be expected that the negative-incidence flow separation would have re-attached.

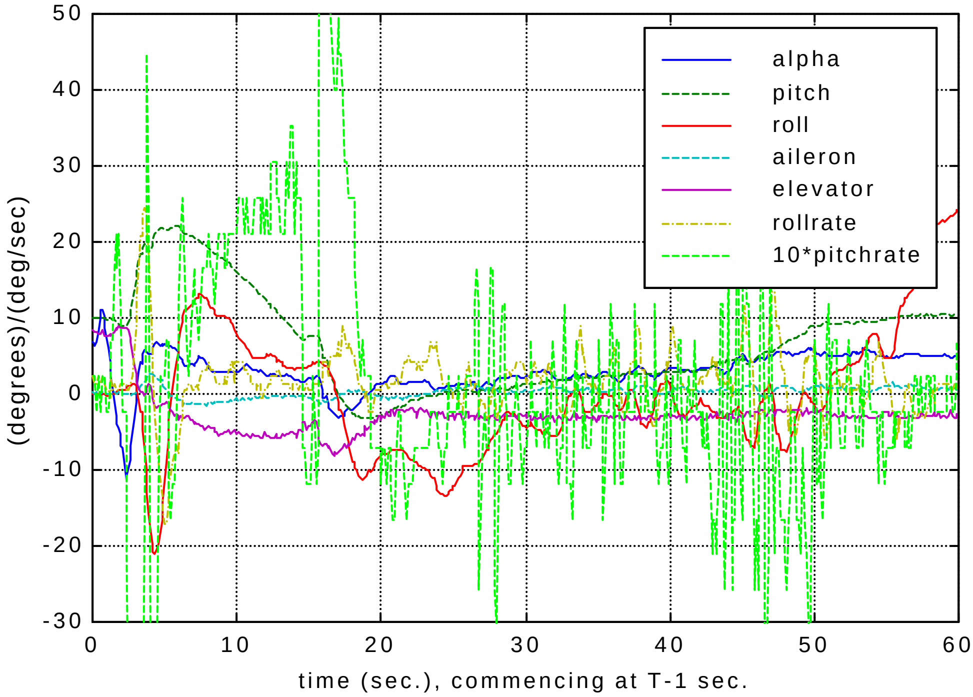
Flight 27, Launch Phase, alpha/beta estimation, zero wind, and also DGPS data

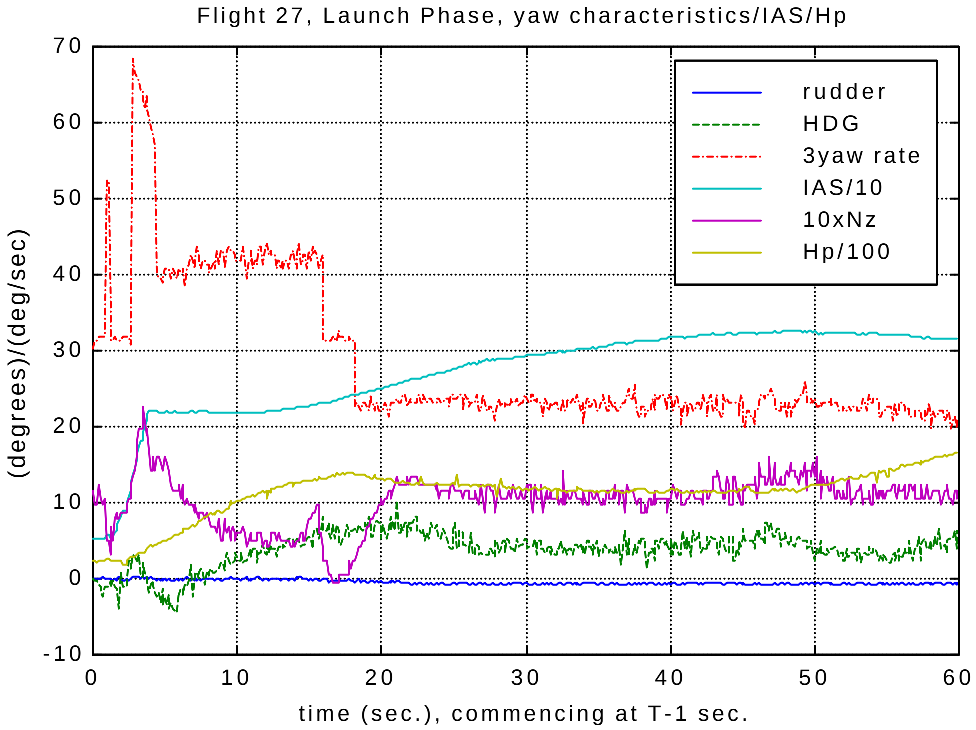


4.3.2 The first figure below indicates that, by this time, positive roll power had returned – in other words, the roll angle was reduced by the aileron deflection. Reference to the following figures demonstrates that the roll-correction followed the inherent incidence reduction, as described above, before the ECP KAL-007a early pitchover rate command was initiated by the GCS. The pitchover was initiated approximately 1.3 seconds after a roll magnitude of 20° was exceeded. The pitchover manoeuvre resulted in the incidence being maintained at low values thereafter (nominally averaging 3 to 4°). In particular, following the activation of the GCS-triggered pitchover, in accordance with the ECP, the aircraft exhibited an "at best" mean incidence reduction rate of approximately 0.4 degrees per second (diminishing to a mean of 0.2 degrees per second over the total pitchover iteration). With the incidence reduced below about 5°, the roll displacement and aileron deflection monotonically reduced to low values.

4.3.3 The second figure below indicates that the overall heading change through the automated launch phase was 7°, which is considered to be a nominally-low value. The figure also shows that, as on Flight 26, the yaw rate indications, as sensed from the yaw damper, exhibited a significant offset, during directionally-quasi-steady flight.

Flight 27, Launch Phase, alpha/beta estimation, zero wind, and also DGPS data





4.3.4 The above figure shows that the maximum height through the automated launch phase was approximately 1400 feet, compared to that of approximately 2380 feet upon Flight 26, without roll-limiting pitchover. On Flight 27, the delta-height between the first observed nose-downwards pitchrate (ie. excluding the 1.3 second DAP delay, following the Pitchdown Conf flag) and level flight was 760 feet. This is slightly greater than the estimated minimum delta-height value of 734 feet (Reference J).

4.4 Comparison with FQT 03 and 20

4.4.1 At the request of the Kalkara Project Office, a comparison has been undertaken of the data from Flights 3 and 20, drawing inferences from the data along with the related observations derived from Flight 27. By the nature of the data and variances between the flights, this comparison was principally qualitative in nature with quantitative observations (though somewhat tenuous) being offered on a worst and best case basis to provide a better understanding of the trends within the qualitative observations and associated inferences.

4.4.2 FQT 03 and 20 were conducted in similar configurations to Flight 27. Based upon the observed response on Flight 27, under the control of the ECP early pitchover, a number of inferences have been drawn about the possible effects of the ECP upon the flight dynamics of FQT 03 and 20. However, it should be noted that the ECP KAL-007a induced pitch over on FQT 27 occurred after the incidence of the aircraft had inherently recovered from a peak negative incidence of –11 degrees to a peak positive incidence of +6 degrees. At this point, as previously stated, it would be reasonable to expect the flow over the wing had re-attached. In other words, the early pitchover was initiated after and outside what has been described previously as the aerodynamic hysteresis. Therefore, to rigidly apply any observed quantitative values from FQT 27 to either FQT 20 or 03 could be somewhat tenuous since, as described below, if the ECP were installed, initiation of the early pitchover would occur while the aircraft was experiencing separated flow over the wing ie. still within the aerodynamic hysteresis.

4.4.3 On FQT 20, a 20° roll angle was reached at time 4.5 seconds. Allowing for a 1.3 second DAP delay, and thereafter, a mean incidence reduction rate, under the pitchover control, of 0.4°/sec (assuming this to be the same as observed on Flight 27), the attached flow incidence of 4° would have been reached at approximately 13.3 seconds (4.5+1.3+{7°-4°}/0.4), by which time the heading change was approximately 53°. This inferred 13.3 seconds would represent a 4 second advance on the return of lateral controllability, which occurred at about 17.3 seconds on the original FQT 20. Based upon the flight data of FQT 20, under the control of an ECP KAL-007a induced early pitchover, no correcting roll motion could be expected before this time (13.3 seconds) since aileron deflection had no effect until incidence reduced below about 4°. Assuming a mean recovery roll-rate of 5°/sec thereafter (based upon Flight 27, 3°/sec, and FQT 20, initially 6°/sec), the completion of the recovery from the 40 deg roll angle to wings level flight could be expected by approximate time 21.3 seconds. The resulting total heading change would then be in the order of 80°. Within the scope of this analysis and comparison, this is considered to be a slow recovery. Within the scope of this analysis and comparison, no significant utility or improvements would have been forthcoming if ECP KAL-007a had been fitted to FQT 20.

4.4.4 On FQT 03, the initial roll upset occurred as a negative incidence flow separation (peak value of about -16°). A 20° roll angle was reached at about 3.6 seconds. If ECP KAL-007A007a was assumed to be installed, then, following a 1.3 second DAP delay, the early pitchover would have been initiated at about 4.9 seconds, when the roll angle was about 27° and increasing, and incidence at -7°. On FQT 03, at approximately 5 secs, the incidence started to reduce in magnitude (an increase in the positive incidence sense), initially at a rate of 4 deg/sec, resolving to a mean rate of approximately +2°/sec. The FQT 03 data indicated that a rise to a positive incidence of +6.5° was required in order to recover to attached flow. The GCS-triggered pitchdown would have reduced the incidence rise rate, at best perhaps to 2-0.4=1.6°/sec, delaying the achievement of +6.5° incidence to about 4.9+{6.5-(-7)}/1.6=13.3 seconds, compared to about 11 seconds on FQT 03, without any GCS-triggered pitchover. Therefore, within the scope of this comparison, ECP would have resulted in a greater heading deviation.

4.4.5 Since the wing would still be at relatively high negative incidence (-7 deg) and also experiencing separated flow at the time of early pitchover initiation, a more appropriate worse case (though conservative) view would be to consider the pitchover as the dominant influence on incidence. In this case, the pitchover induced change in incidence (at 0.4 deg/sec and probably greater) which is opposite in sense to that required for recovery would exacerbate the roll excursion by increasing the magnitude of negative incidence. Such an increase could lead to additional controllability issues and the possibility of fully departed flight; with limit winds and/or gusty conditions increasing the probability of such issues arising. Within the scope of this comparison, delays in recovery and greater deviations would have been experienced on FQT 03 with ECP-007a installed.

5. CONCLUSIONS

5.1 Kinematic and aerodynamic analysis of flight data from Flights 26 and 27 has been conducted, using the methodology applied to the analysis of previous Kalkara AFQT flights. During the Flight 26 launch phase, the maximum uncommanded roll angle was approximately 17°. As expected, no automatic, roll-recovery, early pitchover manoeuvre was executed.

5.2 During the Flight 27 launch phase manoeuvre, the roll angle magnitude exceeded 20° and an automatic roll-recovery pitchover manoeuvre was executed, as described in ECP KAL 007a.

5.3 The analysis of the data for Flight 27 has indicated that the previously-observed inherent aerodynamic characteristics of the Kalkara aircraft are also observed during a launch with the automatic early pitchover function activated. This is indicative of the ECP being a reactive rather than an anticipatory software modification which (for example) could limit the incidence flight envelope. In particular, these observations include :

a. significant wingflow separation occurred at positive and negative incidences of approximately ±10°;

b. the aerodynamic hysteresis loop was substantial (of approximate magnitude 5° of incidence reduction, for an incidence peak of 10°); and

c. within this separated flow regime, aileron roll power is zero and can readily precipitate a negative roll stability, L_P, in turn leading to further roll-off.

5.4 Therefore, given that there is no change in incidence scheduling through the launch phase, other than the roll-recovery pitchover of ECP KAL-007a, it remains possible that:

a. A substantial turn may occur during the launch phase, either without controller intervention, or as induced by controller intervention (due to zero $L_{\delta a}$, roll power, and negative roll damping, L_P, during flight in the separated-flow regime, with an attendant large aerodynamic hysteresis loop). In this regard, Flight 26 demonstrated a heading change of 40° through the period of reduced controllability in the regime of the indicated separated flow over the wing. Greater heading excursions could be possible, particularly in gusty conditions.

b. At best, following a roll-off initiated at ±10° incidence and at the roll recovery pitchover rate of 2° per second, the aerodynamic hysteresis loop would be nullified in a time of 2.5 seconds (plus activation-delay) after a roll magnitude of 20° is reached. Flight 27 exhibited an activation-delay of approximately 1.3 seconds after the achievement of 20° roll angle – in total, a time interval of approximately 3.5 seconds before the aerodynamic hysteresis loop was nullified. Within this time, in more extreme launch conditions such as a limit wind strength and gusty environments, fully-departed flight could be possible (more data would be required to establish whether this would occur).

c. The launch height, through the roll recovery pitchover manoeuvre, could be less for limit wind and gustiness conditions than that predicted by the manufacturer. These conditions should be investigated for certification purposes. In addition, as the minimum worst case altitude to level flight is based on only one flight there is insufficient data to give confidence to that figure.

5.5 To summarise, this report covers the observations from the Flight 27 data reduction which indicates that the roll excursion to -21º emanated from a negative incidence peak of -11º. For a negative incidence, a roll threshold pitch command (eg the fix introduced by ECP KAL-007a) should respond to the negative incidence by pitching up – not down. However, in this case the natural flight dynamics limited and then sharply reversed the incidence, naturally returning to attached flow over the wing. The incidence had returned positive and passed a peak of about 6 degrees and was monotonically, but slightly, reducing in magnitude before the pitch-rate indicated scheduling of a reasonably constant value of 2 deg/sec in accord with the design of ECP KAL-007a. How or where the flight path would have progressed without the intervention of the early pitchover is unknown. Unfortunately, Flight 27 is not a good example of the viability of the 'fix'. Comparison with FQT 20 indicates ECP KAL-007a may have, at best, marginal utility in reducing the effects of the roll deviation. However, in the case of negative incidence initiation (FQT 03), the ECP acts in the opposite sense to that required for recovery. This leads to the conclusion that, for more-aggravated negative-incidence 'stalling' such as on FQT 03, the ECP would delay the recovery and, in the worst case, could possibly exacerbate the roll excursion, by increasing the magnitude of the negative incidence.

6. RECOMMENDATIONS

6.1 In order to provide a satisfactory 'hard' fix against departure from controlled flight, the following actions are recommended :

a. Increase, by aerodynamic fixing, the attached wingflow incidence range;

b. Reduce, by aerodynamic fixing, the magnitude of the separated-flow hysteresis loop; and

c. Provide a more responsive software based limitation of flight envelope parameters, in particular:
   (1) a limit on incidence (inferred by computation, as not sensed directly), and
   (2) use the limit to initiate a pitchover rate command, in order to maintain an incidence no greater than approximately 8°, depending upon the incidence computational time and upon incidence rise-rate.

6.2 ECP KAL-007a introduces a roll-recovery pitchover rate command to zero degrees pitch, in response to a roll magnitude occurrence of 20°. As a roll magnitude threshold does not change the magnitude of the separated-flow aerodynamic hysteresis loop, within which,

a. in extreme launch conditions, or

b. in response to manual aileron-input corrections from the controller,

the aircraft could depart fully from controlled flight, it is desirable that the threshold be altered to a more-responsive threshold. Preferably this threshold should be a derived-incidence, with incidence rate anticipation, threshold (as recommended above), otherwise, a rollrate threshold. In reasonably benign conditions, an automatically-controlled heading deviation of ±5° would be a reasonable benchmark, compared to the 40° magnitude on the sub-threshold Flight 26, during the launch period of reduced controllability in the regime of separated flow.

6.3 In order to provide acceptable confidence in the aircraft performance in situations where the early pitchover is initiated, further test flights are recommended with the same payload.

6.4 The launch height through the present roll-recovery pitchover manoeuvre could be less in limit wind or gust conditions than that predicted in the analysis by the manufacturer. AFTS recommends this possibility should be reflected in the system safety hazard analysis considerations. Test flights in such limit wind or gust conditions are recommended, as an appropriate part of the Type Certification program, in order to provide an acceptable and supportable confidence level in the minimum height that may occur.

6.5 As well as recommending further testing (both ground and flight, as in Reference D), AFTS also recommends the application of additional instrumentation for acquiring actual aerodynamic parameters (as opposed to derived eg. incidence) and flow visualisation data. Further, AFTS recommends the application of additional flight test rigour in such testing. The aim would be to minimise data variances, standardise conditions and methods of test between test activities, and tailor the scope of the test and evaluation to give appropriate weighting and independent consideration to the certification requirement and process, as a minimum.