Investigation Report on
Dual Flight Data Processor Server Failure on 8 April 2017

1.   Observation

1.1 The Air Traffic Management System (ATMS) has commenced full operations since 14 November 2016 and Air Traffic Control (ATC) operation has been smooth in general. CAD reported an observation of dual Flight Data Processor (FDP) server failure of the ATMS on 8 April 2017 while running in Main System (i.e. ATMS SYS2) (Occurrence). Details are given in the ensuing paragraphs.

At CAD's request, Raytheon promptly collected relevant system logs and recorded data and conducted an investigation into the occurrence.

1.2 Description of Occurrence

Date/Time: 8 April 2017/11:28 (Local Time)

1.2.1   Description: At 11:26, the ATMS was running with SYS2 as the MAIN system. A user initiated a "Save" action to store a new user preference setting (Preference). The action caused the FDP primary server in SYS2 to shut down. This was followed by automatic switchover of operation to the duplicated FDP (FDP secondary server) per system design, which at the time was transparent to the controller with an audible alert and a system level alert. At 11:28, the same action was repeated by the user, which in a similar fashion, caused the operating FDP server to shut down with a similar system alert displayed. By design, the ATMS then entered into what is named as "an Emergency State[1]" operation, which allowed for restricted flight data

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[1] In addition to multiple fallback systems, to minimize impact on operation and ease transition of system operation to the fallback system, during FDP failure, an Emergency State becomes available automatically to allow controllers to continue to interact with and manipulate flight data in the interim.

processing and display at controllers' workstations in the interim. With both FDP servers of SYS2 having shut down, CAD activated the Fallback ATMS (SYS1) as the operational ATMS to resume full ATMS operation per established procedures. SYS1 was activated and became Main ATMS at 11:40 for full air traffic operation.

1.2.2 During the Occurrence, the Ultimate Fallback System (UFS) was operating normally and available at all times. The Surveillance Data Processors (SDP) both of ATMS SYS1 and SYS2, which operated independently of the FDP were running normally to continuously provide situation awareness. All flights were still continuously displayed on the radar screens throughout the Occurrence, and most of the flights had their full information shown on radar screens, with 8 flights[2] showing only essential data, i.e. their position and altitude information.

2. Detailed Investigation and Findings

2.1 Details of the investigation are provided in the following:

2.1.1 **Causal Factors and Root Cause** – there is a class of Data Objects designed in the system software to store Preferences with a preset system limit of 5500. Prior to the Occurrence, the number of saved Preferences had reached the preset limit. Initiation of the "Save" action of the 5501st Preference at user workstation at 11:26, which would have exceeded the preset limit of 5500, triggered exception handling in the FDP primary server with issuance of a system level alert and shut down of the FDP process to preserve

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[2] While most of the flights had their full information shown on radar screens, these 8 flights just entered the Hong Kong Flight Information Region, during the Occurrence, did not obtain full information from the failed FDP thus showing only essential data, i.e. their position and altitude information.

database integrity as per design. This was followed by the automatic switchover of operation to the FDP secondary server, which had been synchronized up to the 5500th Preference. When "Save" action of the 5501st Preference was repeated at 11:28 on the secondary server as the user had no knowledge of the Preference creation having led to the shutdown of the FDP primary server earlier, the FDP secondary server behaved in a similar manner as the FDP primary server.

2.1.2 The root cause is readily reproducible and is unrelated to (a) system performance, (b) new software build (Build 6) in use since 20 March 2017 or (c) prevailing system loading. The UFS and other sub-systems of ATMS were all operating normally during the Occurrence.

2.1.3 **Immediate Mitigation Controls and Actions Taken** – the root cause was promptly and correctly determined shortly by Raytheon's on-site staff after the Occurrence with immediate and effective mitigation controls taken to prevent recurrence as summarized below:

(a) temporarily halt the creation of new Preferences

(b) review and conduct housekeeping work to remove obsolete or unwanted Preferences

(c) replace the Preference system file in the Fallback System (SYS2) with a known copy with fewer Preferences stored to increase the buffer to the preset Preference limit

(d) conduct hourly checks to monitor any increasing trend in the utilization of Preferences, and take early mitigating actions, if necessary

(e) switch over to Fallback system should the number of Preferences approach the preset system limit

(f) to ensure system robustness, commence a system review of bounded Data Objects which could lead to potential system issues

3. Workarounds and Fix

3.1 **Workarounds** – given the positive identification of the root cause, before a software update is launched, the workarounds detailed in Para. 2.1.3 (a) to (f) above would be effective in preventing recurrence.

3.2 **Immediate Fix** – given the positive identification of the root cause and reproducibility of the occurrence at Raytheon factory, development of the software fix in an urgent software upgrade will be completed in 2 weeks for testing at factory to rectify the issue and enhance system behaviour and, potentially in a combination of the following, subject to further reviews between Raytheon and CAD and also timing and management of software change considerations:

(i) Enhance warnings at different threshold values to alert technical staff of potential issue

(ii) Enhance alert messages in terms of contents and prominence of display to users

(iii) Reject Preference creation if preset limit is reached without affecting normal operation of FDP servers, and thus ATMS as a whole

(iv) Increase the limit of Preferences allowed

4. Availability of Fix

The fix will be available in 2 weeks to include items as stated in Para. 3.2.

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