DESIGN DESCRIPTION FOR THE DFCS MULTIPLE-DATALINK ARCHITECTURE

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1. OVERVIEW

This document describes a software design for migrating the current DFCS software to a multiple data-link architecture. The current DFCS design has a CYCLE process that creates uplinks and downlinks (command and control) for the drones. CYCLE sends the uplinks and downlinks to the drones through a Data-Link Interface (DLI) process that interfaces with the data-link hardware and handles timing issues related to the data-link. The proposed design will expand this architecture to add another CYCLE and DLI process for the 1350 data-link. All the processes will run independently and simultaneously controlling their respective data-links. Software will be modified so that other data-links can be easily integrated in the future. The proposed design also moves the simulation software to the DLI process isolating it from the DFCS control software and providing an indispensable and reliable testing tool. The design also proposes the simulation of 915 and 1350 data link format and timing.

The proposed design provides a solution that:

(1)Minimize Changes: The current software has been used successfully and tested for the past ten years. This design enhances the original design to incorporate multiple data-links. New code will be added to support new data-links, and less than 5% of the existing code will be changed.

(2)Data-link Code Isolation: The design isolates code specific for each data-link in separate threads so changes to one data-link are isolated to that data-link only. This will avoid costly re-certification of all data-links after a change has been made.

(3)New data-link will be transparent to end-user: Other than a few additional commands needed to assign drones to different data-links, the operation of the system for the end user will remain the same.

(4)Flexible: The design for the Air Force 1350 MHZ data-link is still being finalized. The proposed design is flexible enough to be modified to accommodate future changes in the 1350 data link design.

(5) Expandable: After the initial data-link has been added, other data-link can be easily incorporated.

(6) Maintains Air Force Compatibility: The Air Force provides command and control software for drones. Currently these changes are easily integrated into the system since they are

compatible with the DFCS architecture. The proposed design for the 1350 data-link will maintain this compatibility, while allowing DFCS to interface with other data-links not used by the Air Force. .

(7)Testable: The majority of the code modifications can be tested using available and the proposed simulations, thus avoiding the need to test changes with live drones.

2. DESIGN DETAIL

2.1 System Description

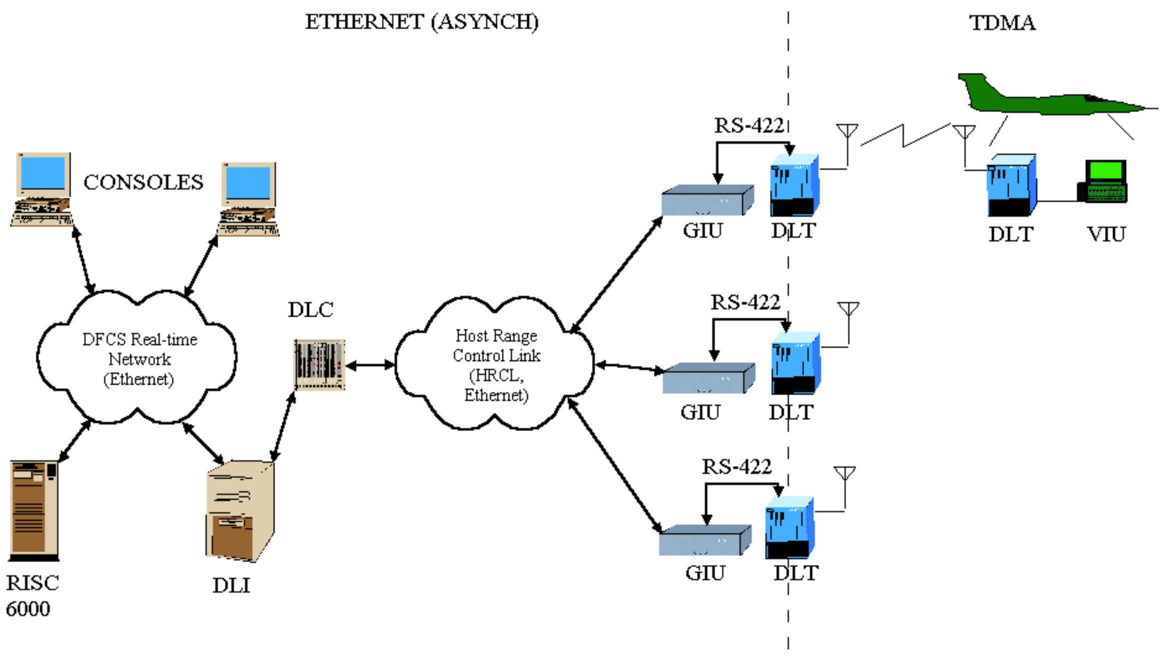

Figure 1. 1350 Data-link Layout

The above figure depicts all the components of the future DFCS / 1350 Data-link system. All the DFCS components remain the same as used by the current 915 MHZ data link system. The new components for the data-link are[1]:

Data-link Controller (DLC): Provides the control, scheduling and distribution of the appropriate data messages between the reference receiver, the participants, GIU, and DFCS.

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Host Range Control Link (HRCL): Provides a data communication channel between the DLC and all GIUs. All data input into the HRCL must reach the desired destination within 6.06 ms. The HRCL is specific to the range, so it is up to the individual range to decide on how it needs to be implemented.

Ground Interface Unit (GIU): Accepts uplink messages and transfers them to DLT and receive downlinks to be transferred to DLC. The GIU uses a GPS receiver for control and message transfers from the DLT.

Data-link Transponder (DLT): Time Division Multiple Access (TDMA) transponder to transmit or relay uplinks and downlinks to desired target.

Vehicle Interface Unit (VIU): Performs internal functions and convert DLT data to satisfy the functional requirements and characteristics of the target and its payload.

It is assumed that a complete 1350 data-link system will be delivered, and the range is responsible for the developing the HRCL and adding functionality to DFCS to support new target. There exist today an infrastructure to develop a HRCL using existing fiber optic links to a majority of the current DFCS sites on the range. The proposed design describes how the software will be changed to support multiple data-links.

2.2 Multiple Data-Link Software Design

Figure 2 depicts the extension to the current software design that will support the multiple data-links. Two major components of the current system are MISSION and the CONSOLES; MISSION generates command and control data for drones, and CONSOLE interfaces with end users. Both of these components are independent of the data-link; if there was a QF-4 drone flying on a 915 or 1350 data-link, the data presented to these two processes would be the same. The idea is to create a virtual data-link that would handle all the interfacing to the different data-links and isolate these twp processes from how they got the data. Further, by integrating the current simulator into the DLI process, the MISSION and CONSOLE would process simulated and real data in the same manner allowing for improved testing of future software enhancements.

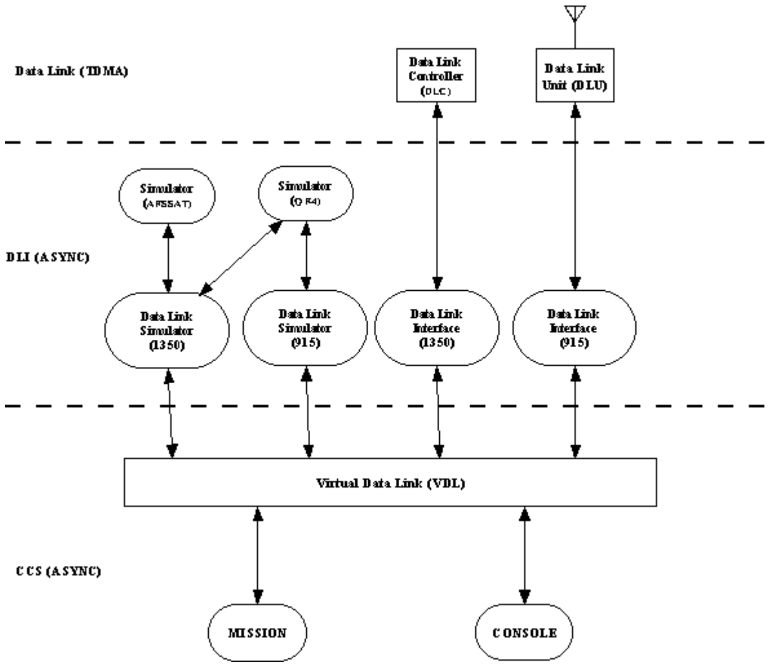

Figure 2. Software Design Description

The implementation of the virtual data links is shown below. Currently there exist a CYCLE process that calls MISSION to produce uplinks and process downlinks from the targets. CYCLE is also responsible for processing data from consoles once every 100ms. The current design lends itself to the creation of a virtual data link since a new CYCLE1350 process can be created to produce uplinks and downlinks for the new 1350 data-link. CYCLE1350 will share console and mission data with the existing 915 CYCLE process, so both processes will call the same MISSION routine and receive the same inputs from the CONSOLE process. The same approach will be used in the DLI, where a separate process will be created for each data-link. Using this approach MISSION and CONSOLE will have separate virtual paths to each data-link.

The software for the current CYCLE process will be changed to allow for the creation of multiple sub-cycle processes to support other future data-links. Less than 5% of the current RTE and DLI code will require modification to support this change, and the new code for the data-links will be isolated from existing 915 code. This provides a great advantage in maintaining the software, since changes or additions to data-link code will only affect that data-link and not require testing of all the other data-links.

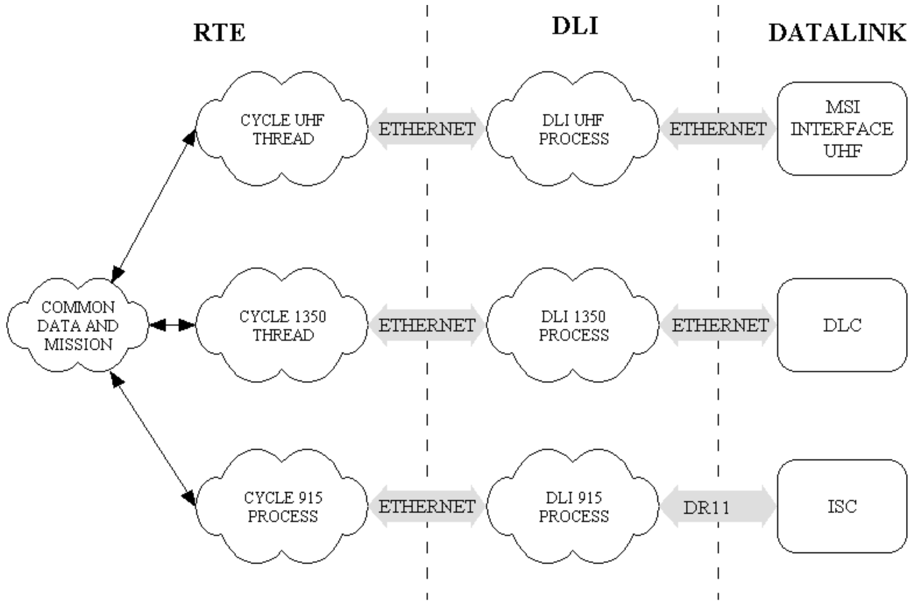

Figure 3. Design Process Description

The present RTE software will be slightly modified to allow multiple cycle processes. There will be separate cycle processes for the 915, 1350 and UHF data links. This design will provide the code inpendance needed to accommodate any future design changes made by the Air Force to the 1350 datalink.

2.3 Processing Capabilities of the Current Architecture

Given the above virtual data-link design, the processing time of the current and future data-link is analyzed. Here is shown that the current processor is capable of processing multiple data-links, and what are the worst case timing issues.

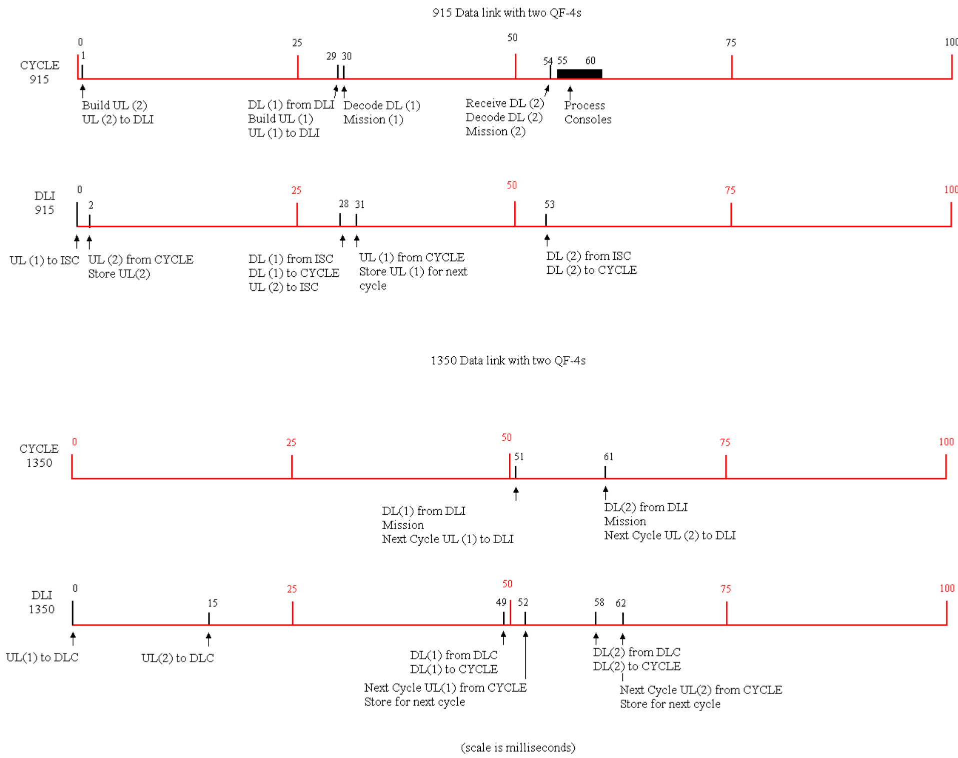

Figure 4. Processing Time

(NOTE: MAKE FIGURE 4 LARGER So PEOPLE CAN READ IT)

The above figure shows the current processing time for the 915 data-link RTE and DLI, and estimated processing time required for the new 1350 data-link RTE and DLI process. Each black line or block indicates the time at which the processor is busy. As seen by the above figure, the processor is not busy 90% of each cycle for the 915 data-link with two QF-4s. The new data-link will add another 5% of processing time for each cycle. The current processor has ample time to process multiple data-links.

In this design, the processes will compete for processor time. If the 915 data-link process has to wait for a 1350 process its maximum wait time should be about 1ms. If the 1350 data-link has to wait for the 915 process, its maximum wait time will be about 6ms.

Using the above maximum wait time, and the following timing[2] for 1350 data-links the slot assignment for the worst case scenario[3] of 4 drones and two relays is presented.

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[3] It is very unlikely (once every 10 years) that a WSMR a mission will use two relays.

ELEMENT	DELAY (3.03ms slots)
Data Transfer to DLC	1
DLC uplink processing	3
GIU processing	3
HRCL transport delay	2
DLC downlink processing	1
DLC to DLI	1
Drone Processing Time	1

Table 1. Timing Data for 1350 Components

SLOT	RTE	DLI	DLC	HRCL	GIU/DLT	R1 DLT	R2 DLT	T1 DLT	T2 DLT	T3 DLT	T4 DLT
1		Tx 1&2	Rx 1 &2								
2			DLC								
3			Processing								
4											
5		Tx 3&4	Rx 3&4	HRCL							
6			DLC	Transmit							
7			Processing		GIU						
8					Processing						
9				HRCL	Tx 1&2	Rx 1& 2					
10				Transmit		Tx 1&2	Rx 1&2				
11					GIU		Tx 1&2	Rx 1&2	Rx 1&2		
12					Processing						
13					Tx 3&4	Rx 3&4					
14						Tx 3&4	Rx 3&4				
15							Tx 3&4			Rx 3&4	Rx 3&4
16							Rx 1	Tx 1			
17						Rx 1	Tx 1				
18					Rx 1	Tx					
19				HRCL			Rx 2		Tx 2		
20				Transmit		Rx 2	Tx 2				
21		Rx 1	Tx 1		Rx 2	Tx 2					
22	Rx 1	Tx 1		HRCL			Rx 3			Tx 3	
23				Transmit		Rx 3	Tx 3				
24		Rx 2	Tx 2		Rx 3	Tx 3					
25	Rx 2	Tx 2		HRCL			Rx 4				Tx 4
26	Tx 1' & 2'	Rx 1'&2'		Transmit		Rx 4	Tx 4				
27		Rx 3	Tx 3		Rx 4	Tx 4					
28	Rx 3	Tx 3		HRCL							
29				Transmit							
30		Rx 4	Tx 4								
31	Rx 4	Tx 4									
32	Tx 3' & 4'	Rx 3'&4'									
33											

Figure 5. Data-link Analysis for four drones and two relays

Using the given timing data, the estimated slot assignment for four drones with two relays is shown in Figure 5. Each row is a 3.03ms time slot for each 100ms cycle and the columns represent the time at which each element in the system will process data. At the start of each cycle the DLI contains a packed uplink for the first two drones and transmits this uplink to the DLC. The DLC will receive the data in the second slot, and use the next 3 slots to process the data. After the DLC has processed the initial uplink it transmits the uplink to the corresponding GIU through the HRCL on slot 5. At this time the DLI will send the next uplink (packed drone 3 and 4) to the DLC (slot 5). Here the HRCL and GIU are working in parallel with DLI and DLC to process uplinks. When the GIU receives the first uplink it will process the uplink during slots 7 and 8, and transmit the uplink to the first relay in the 9th slot. The first uplink is then transmitted to the second relay (slot 10). At the same time the second uplink is being transmitted through the HRCL to the GIUs. The second relay then sends the first uplink to the first two drones during slot 11. By slot 13 the GIU has completed processing the second uplink a proceeds to transmit data through the relays to drones 3 and 4. In slot 16 the first target starts to send its downlink back to the GIU through the relays. After the GIU receive the first downlink in slot 18 and starts to transmit it back to the DLC through the HRCL, the second target can start to send the downlink back to the GIU (slot 19). The remaining targets will also send downlinks to there respective GIUs. When the DLC receives and processes each downlink it will be sent to the DLI and RTE. After the RTE has received both downlinks it can then create a new packed uplink for the next cycle. Given the worst-case wait of 2 slots for the RTE to generate a new uplink for the next, slot shows that the DLI will receive the new uplink for the next cycle in slot 26. Similarly a new uplink for drones 3 and 4 should be create by slot 29.

Since the worst case times were used for each element, t It can be concluded that proposed design will have the capability to control up to four drones through two relays.

3. RELATED DOCUMENTS

TITLE	ORGANIZATION
SYSTEM/SUBSYSTEM SPECIFICATION (SSS) FOR THE MULTI-SERVICE TARGET CONTROL SYSTEM (MSTCS) AIRFORCE ENHANCEMENT (AFE).	MSTCS Program Office 46th Test Wing Eglin AFB, FL 32542
GRDCS Software Requirements Specification for the MSTCS Air Force Enhancement.	96 CG/SCTOP – Drone Control Section 96th COMMUNICATIONS GROUP EGLIN AIR FORCE BASE, FLORIDA