AERONAUTICAL TELECOMMUNICATION NETWORK PANEL

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Transport Timer and Protocol Parameter Settings

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SUMMARY

This document summarizes results of transport timer simulation testing performed by both MITRE/CAASD and Mayflower Communications Inc. Test results for AMSS, ATIS and CPDLC simulation scenarios indicate that it is possible to propose transport timer settings which result in successful and efficient end-to-end operation across varied applications scenarios. This paper therefore recommends that a table outlining example timer settings be included in Chapter 5 of the ATN SARPs.

REVISION HISTORY

Section	Date	Issue	Reason for Change
	10 June 1995	Issue 1.0	Document Creation
	01 October 1996	Issue 2.0	Document Revision & Resubmission

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1. Scope and Purpose of this Paper

This document presents and discusses simulation testing results using ATN applications scenarios with specified sets of COTP timer values. It is intended to provide guidelines for recommending new sets of timer values for the connection oriented transport (COTP) layer timers and protocol paramters.

This document also proposes inclusion of a new section 5.5.4.1 of the ATN SARPS to present recommended COTP timer values.

2. Initial Simulation Test Activity

In the ATNP WG2 Working Paper 263, ***COTP Timer Analysis in the ATN/AMSS Computer Model***, presented at the Brussels meeting, 22-26 April 1996, current analysis of Transport Timer settings was outlined based upon a series of simulation scenarios using the ATN/AMSS model. The goal of the study was to determine if an optimal set of timer values could be specified which would provide normal operation not just for AMSS but for other potential ATN applications. Study results indicated that, while it was desirable to acknowledge multiple data TPDUs with one AK TPDU, the acknowledgment timer would have to be very large (1000 seconds), since traffic per aircraft is infrequent in AMSS. This requirement far exceeds the values for other types of subnetworks. Further effort was deemed necessary to to find a set of timer values which could provide adequate performance over all ATN subnetworks.

2.1 Acknowledgment Timer Value

Based upon the results of this study, Mayflower Communications reevaluated the assumptions and criteria for timer selection and conducted an extensive set of further AMSS simulations. The paper presented as Appendix A, ***COTP Timers Settings for the ATN CNS/ATM-1 Package***, summarized results of this analysis. It was shown that operational values for the AMSS Acknowledgment timer setting could be set to 20 seconds which was large enough to capture multiple segments of large messages, but not necessarily multiple Data TPDUs.

2.2 Maximum Transit Delay Values

Based upon an Acknowledgment timer value of 20 seconds, the optimum value for the Maximum Transit Delay ($E_{LR} + E_{RL}$) was 100 seconds, which was selected based upon average transit delay for Normal priority data messages for a 600 bps channel rate. This combined E_{LR} and E_{RL} value of 200 seconds was large enough to prevent unnecessary retransmissions caused by delayed acknowledgments.

2.3 Inactivity Timer Value

In the AMSS simulation scenario, tests indicated that the Inactivity Timer value necessary to maintain the connection had to be set to a large number (4500 seconds) to match the long periods of non-transmission in the Transport Connection. It was estimated that such a large Inactivity timer value would not seriously affect other scenarios which would rely upon the application itself to terminate a connection.

2.4 Window Update Timer Value

In the AMSS scenario, with the probability of packet loss very small (10^{-6}), testing showed that it was not necessary to have multiple window updates within one inactivity timer period. Operational values for the window timer were therefore set to be close to I - E_{LR}, (4000 seconds). It was also expected that such a large Window timer setting would not have adverse affects on other applications.

3.0 Additional Simulation Test Activity

The new set of timer values proposed by the Mayflower simulation testing activity, prompted MITRE/CAASD to produce transport timer simulation test runs using the Mode-S based ATN simulation model. The results of this testing are presented in Appendix B, ***Transport Layer Timers and Protocol Parameters***. Simulations were run for both the ATIS and CPDLC scenarios and were conducted using the Mayflower proposed timer values and also multiple other possible values.

3.1 MITRE/CAASD Test Design

Simulation tests were run in the following manner:

1) Using the proposed (Mayflower) timer values;

2) Varying one timer value while keeping all others at MITRE (default) values. This was repeated for all other timers.

The testing included simulations using guideline timer values (as presented in Chapter 8 of the ATN Guidance Material), proposed values, and default values used in MITRE ATN simulation runs. Specifically, tests were performed using the different sets of values as described below:

1) Set 1-0: MITRE values, which are called “default” values (column 6 of Table 1)
Set 1-1: MLR = MRL = 26, 100, 200, 600 and all others are default values.
Set 1-2: ERL = ELR = 100, 120, 150 and all others are default values
Set 1-3: AL = AR = 2, 20, 400 and all others are default values.
Set 1-4: IL = IR = 600, 1000, 2000, 6000 and all others are default values
Set 1-5: W = 599, 1000, 2000, 6000 and all others are default values

2) Set 2: Proposed (Mayflower) values (column 5 of Table 1)

3.2 Test Results

Simulation results (end-to-end delays) for both MITRE values and proposed (Mayflower) values were not much different from each other. Most of the ATIS and CPDLC end-to-end delays were shown to be not much affected by varying timer values, except in the case of CPDLC for extremely large values of the acknowledgment (AK) timer.

4.0 Proposed Timer Value Specification

Based upon the simulation activities presented in the proceeding sections of this paper, it is proposed to add a section to the Chapter 5 of the ATN SARPS which would include a table specifying “example” timer values which could be used as the basis for initial application settings. Additionally, minimum and maximum values for each timer/parameter would be detailed This information, originally planned to be presented in Guidance Material, is of significant importance in establishing initial application activities under ATN and should not be tied to issuance of the Guidance Material, which may be available at a much later date than the SARPs.

4.1 Proposed New Section 5.5.2.2.12

Additional proposed text for Chapter 5 of the SARPs is as follows:

5.5.4.1 Timers and Protocol Parameters **Replace current 5.5.2.2.12 with:**

5.5.2.2.12 Implementations of the transport protocol shall support configurable values for all timers and protocol parameters, rather than having fixed values, in order to allow modification as operational experience is gained.

Add:

5.5.2.2.13 When intended for operation over Air/Ground subnetworks, transport protocol implementations shall support the minimum - maximum ranges for COTP timer values presented in Table 5.5.-2.

5.5.2.2.13.1 Recommendation. — *Nominal values indicated in Table 5.5-2 should be used.*

5.5.2.2.13.2 Recommendation. — *The assignment of optimized values for timers and parameters other than the nominal values indicated in Table 5.5-2 should be based on operational experience.*

5.5.2.2.14 When intended for operation exclusively over Ground/Ground subnetworks, implementations of transport protocol timer values should be optimized to insure interoperability.

Name	Description	Minimum Value	Nominal Value	Maximum Value
M_{RL} M_{LR}	NSDU Lifetime, seconds	26	400	600
E_{RL}, E_{LR}	Maximum Transit Delay, seconds	1	100	150
A_L, A_R	Acknowledgment Time, seconds	1	20	400
T1	Local Retransmission Time, seconds	12	221	300
R	Persistence Time, seconds	1	443	2710
N	Maximum Number of Transmissions	1	3	10
L	Time bound on reference and/or sequence numbers, seconds	160	1263	3000
I	Inactivity Time, seconds	600	4500	6000

W	Window Time, seconds	160	4000	6000

Table 5.5-2

Note 1. — In Table 5.5-2, the subscripts "R" and "L" refer to "remote" and "local", respectively. the variable E_{RL}, for example, refers to the maximum transit delay from the remote entity to the local entity. The variable E_{LR} is the maximum transit delay from the local entity to the remote entity. It is assumed that these values may be different.

Note 2. — Several of the timers and variables listed in Table 5.5-2 are not directly configurable, but may be determined based on the values of other timers and variables. These computed values are:

$T1 = (E_{LR} + E_{RL} + A_R + x)$
$R = (T1 * (N-1) + x)$
$L = (M_{LR} + M_{RL} + R + A_R)$
$W = (I - E_{LR} - offset)$
x = Local processing time
offset = Unanticipated delay exceeding E_{LR} values

APPENDIX A

COTP Timers Settings for the ATN CNS/ATM-1 Package

Scope and Purpose of this Paper

In this paper we present and discuss simulation results using the ATN computer model with a specified set of COTP timer values. The simulations were conducted for the ATN/AMSS oceanic scenario. However, the recommended set of timer values is intended to provide adequate performance of ATN over all air/ground subnetworks.

Background

As described in the ANTP WG 2 Working Paper 263[1], the analysis of the Transport Protocol timers has been performed in several steps, in accordance with the evolution of requirements for the ATN end-to-end performance. Results from previous analysis were presented to the ATN Panel audience through several Working Papers. One of the CNS/ATM-1 Package SARPs requirements is to recommend one set of COTP timer values, regardless of the air/ground subnetwork. In response to this recommendation, Mayflower reevaluated the assumptions and criteria for timers selection and conducted an extensive set of simulations.

Simulation Scenarios

Simulations for 10,500 bps AMSS channel rate are performed with 300 AES logged on to one GES. Data transfer is conducted using one P channel for uplink, and one T channel and 6 R channels for downlink. This resulted in P and T channel load of approximately 30%, and R channel load close to 10%.

Simulations conducted for 600 bps AMSS channel rate were run with 40 AES logged on to one GES which resulted in P and T channel load of 60-70%, and 4 R channels with load of 10-15% each.

For both channel rates, the selected maximum TPDU size is 1024 octets.

It is possible to define 15 different data priorities within the ATN. This would require the establishment of 15 Transport Connections at the Transport entity level. However, the oceanic traffic model[2] specifies use of only 5 different traffic types, which are mapped into 5 different priority levels. Thus, 5 Transport Connections (TC) are established. At the remaining 10 priorities, if TCs were to be established, the only traffic transferred on them would be signaling aimed at maintaining the connections, while the AES is still logged on. The TCs are maintained through the Window update timer expirations, which generate AK TPDUs. To avoid unnecessary ATN overhead over the AMSS caused by a large amount of keepalive AK TPDUs, we established TCs only for those priorities for which messages are actually generated.

2)

[1] "COTP Timers Analysis in the ATN/AMSS Computer Model", ATNP WG2, Brussels, 22-26 April 1996.

[2] RTCA, "SATCOM/HDFL Traffic Model", SC165, WG3-WP308, 22 May 1995.

Results

In Figures 1 to 4 we present the mean and 95% transmission delays for 600 and 10,500 AMSS channel rate, “from” and “to”-aircraft directions. Delays are shown for four priority groups, Urgent, Flight Safety, Other Safety and Normal priority data messages.

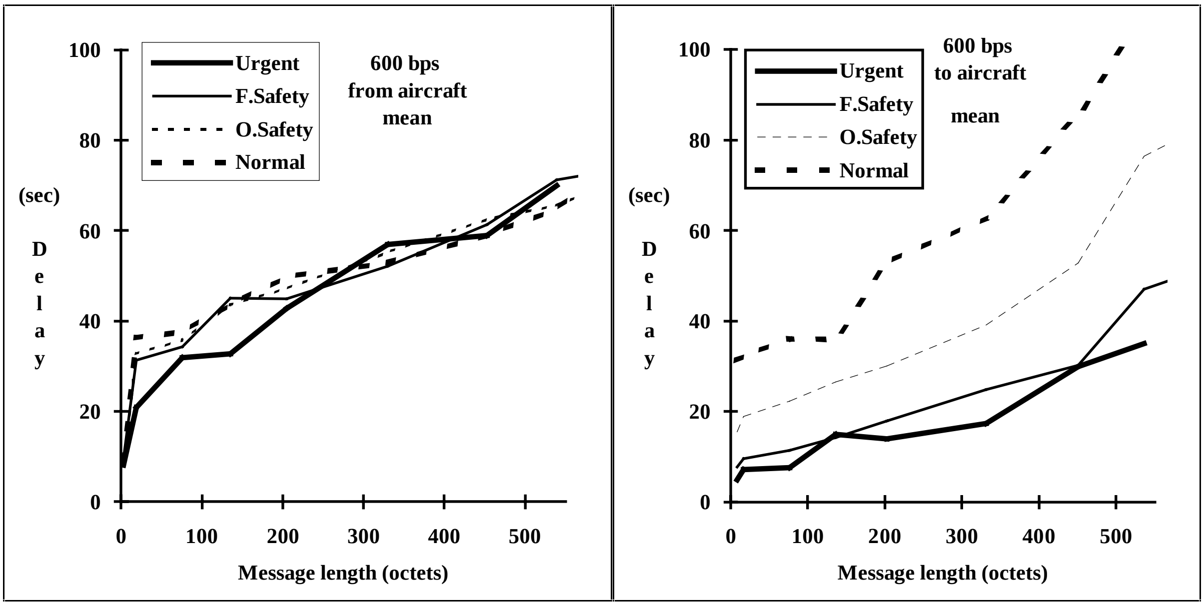

Figure 1. Mean end-to-end transit delay from-aircraft (left) and to-aircraft (right) direction, for Urgent, Flight Safety, Other Safety and Normal priority and 600 bps AMSS channel rate.

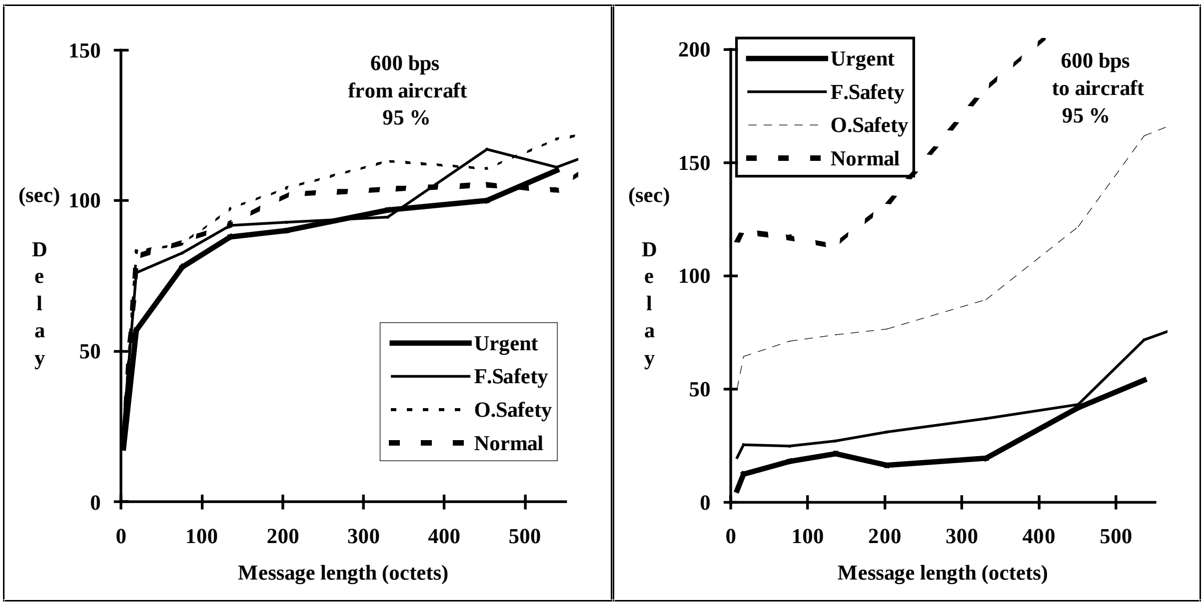

Figure 2. 95% end-to-end transit delay from-aircraft (left) and to-aircraft (right) direction, for Urgent, Flight Safety, Other Safety and Normal priority and 600 bps AMSS channel rate.

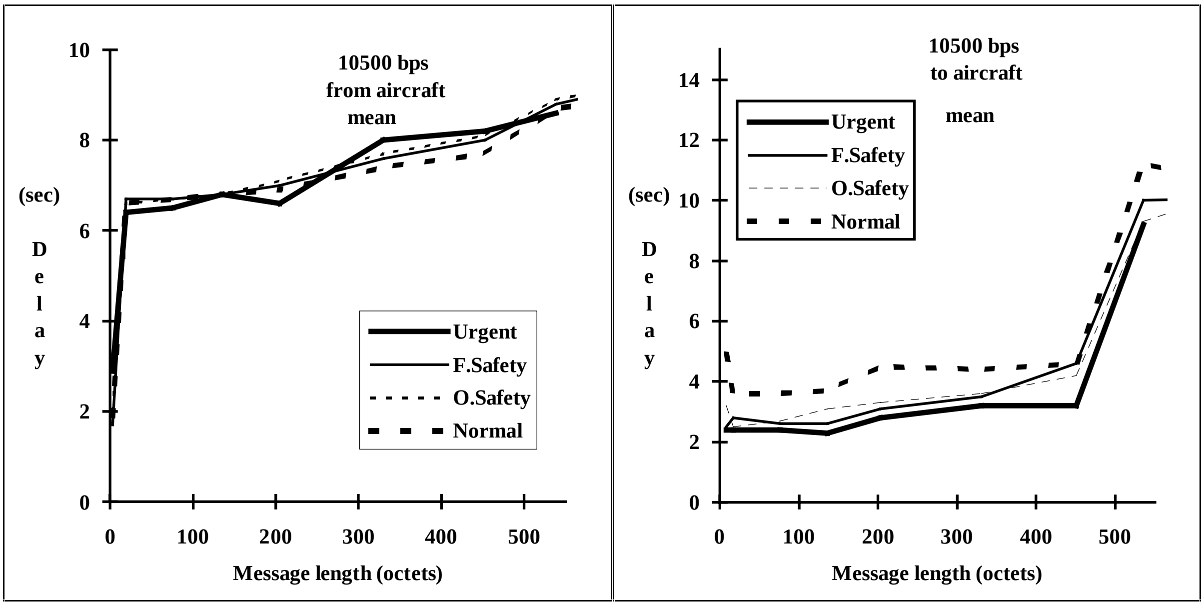

Figure 3. Mean end-to-end transit delay from-aircraft (left) and to-aircraft (right) direction, for Urgent, Flight Safety, Other Safety and Normal priority and 10,500 bps AMSS channel rate.

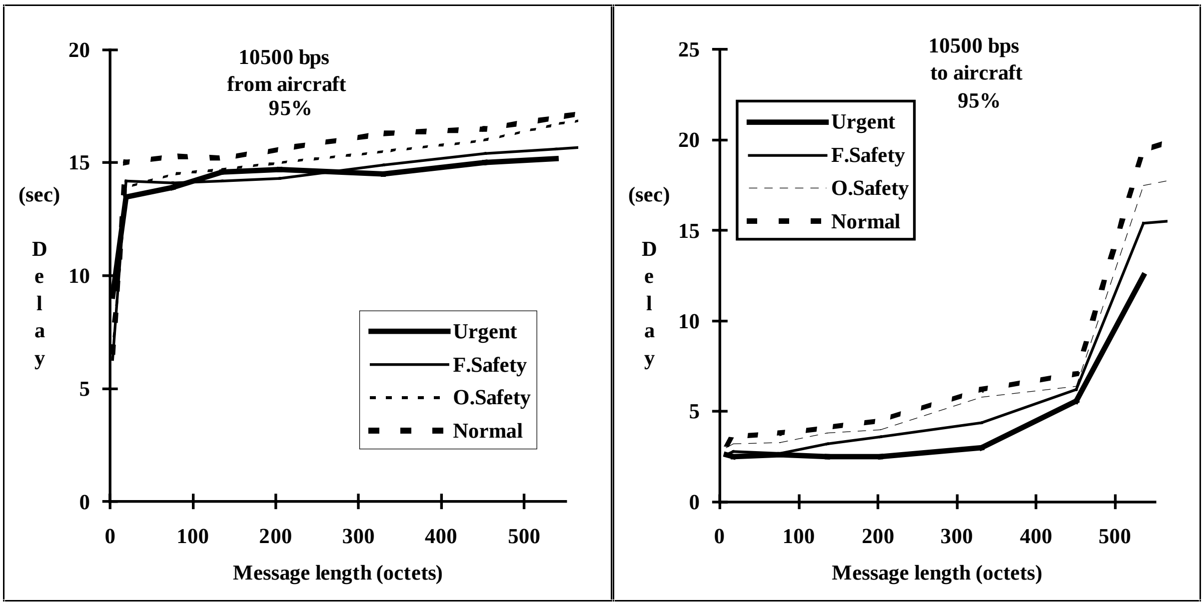

Figure 4. 95% End-to-end transit delay from-aircraft (left) and to-aircraft (right) direction, for Urgent, Flight Safety, Other Safety and Normal priority and 10,500 bps AMSS channel rate.

Discussion

The simulation experiments for the given scenario show that the successful and efficient end-to-end operation of the ATN is sensitive to the settings of the transport protocol timer values. We propose the timer values as presented in Table 1. In the following, we discuss each COTP timer setting.

Acknowledgement timer (A)

To maintain the AMSS P and T channel load at 65-70%, previously we used a network of 90 AES, each of them generating 8 times the normal traffic, i.e., a network equivalent to 720 AES. Therefore, the interarrival time of messages on a given TC got reduced (by the same factor). Large number of acknowledgements in the uplink direction, each of them acknowledging one data TPDU, caused the flow control mechanism in the AMSS to delay uplink Flight Safety messages more than messages with lower priority. In order to correct that, we increased the Acknowledgement timer values (approx. 300 s) so that we were able to acknowledge multiple TPDUs with one AK TPDU and thus reduce the number of AKs. However, in the case of normal traffic distribution per AES, it would require the Acknowledgement timer to be very large (approx. 1000 s) in order to acknowledge multiple TPDUs. In the network with a total of 300 AES, each generating normal amount of traffic, P and T channel loads are at about 30%, and we do not observe high uplink delays for Flight Safety messages. Therefore, operational values for Acknowledgement timers are set to 20s, large enough to capture multiple segments of large messages, but not necessarily multiple Data TPDU. A capacity of 300 AES per P cannel set is perceived to be more than adequate for oceanic region.

Retransmission timer (T)

By setting the acknowledgement timer to 20s, the predominant factor in the retransmission timer calculation became the estimated round trip delay ($E_{LR} + E_{RL}$), which is set to 200s. The value for $E_{LR/RL}$ is selected according to the average transit delay for Normal priority data messages for 600 bps channel rate. This prevents unnecessary retransmissions caused by delayed acknowledgements.

Inactivity timer (I)

In the oceanic traffic, which is characterized by very sparse message interarrival distribution at certain priorities, the Inactivity timer value necessary to maintain the connection is set to large value (4500s) matching the silence periods on the TC.

Window update timer (W)

The ISO 8073 document recommends that the Window timer value be set sufficiently less than Inactivity timer minus E_{LR}, such that the inactivity control procedure can be operated taking into consideration the possibility of TPDU loss. In subnetworks such as AMSS, with packet loss probability very small (10^{-6}), it is not necessary to have multiple window updates within one inactivity timer period. Moreover, since each window timer expiration generates one AK TPDU, it is very likely that in a sparse traffic such as oceanic, these AKs could become a significant, sometimes even a predominant portion of the channel load. Operational values for the Window timer are set to be close to $I - E_{LR}$.

Symbol for Component	Definition	Value
MLR	Max NSDU life, local to remote	400
MRL	Max NSDU life, remote to local	400
ELR	Max transit delay, local to remote	100
ERL	Max transit delay, remote to local	100
AL	AK time, local	20
AR	AK time, remote	20
IL	Inactivity time, local	4500
IR	Inactivity time, remote	4500
N	Number of transmissions	3
x	Local processing time	1
Computed Values		
T1	Retransmission time (ELR+ERL+AR+x)	221
R	Persistence time (T1*(N-1)+x)	443
L	MLR+MRL+R+AR	1263
W	Window time (IR-ELR-offset)	4000

Note: All times are in seconds

Table 1. Selected COTP Timer values

APPENDIX B

Transport Layer Timers and Protocol Parameters

The ATN manual (2nd edition, 19 November 1993) and subsequent development (ATNP/WG2/WP/234, 31 January 1996) provide guidelines for values of the connection oriented transport (COTP) layer timers and protocol parameters. A new set of COTP timer values were recently proposed (Mayflower), which are based on simulation results of the ATN/AMSS oceanic scenario.

This memo summarizes results of transport timer simulations performed by MITRE using the ModeS-based ATN simulation model. Simulations have been run in the following manner.

1) Vary one timer value while keeping all others at MITRE (default) values. Repeat this for other timers.

2) Use of the proposed (Mayflower) values

Detailed results of the simulation tests are given in the Appendix to this paper. In summary, most of ATIS and CPDLC end-to-end delays are not much affected by varying timer values except in the case of CPDLC for extremely large values of acknowledgment (ACK) time. For example, while MRL (and MLR) varies from 26 (MITRE value) to 600 (Mayflower uses 400), ATIS uplink mean delay varies only by 5.3 percent (14.0 vs. 13.3 seconds).

Simulation results (end-to-end delays) for both MITRE values and proposed (Mayflower) values are not much different from each other. Two worst cases show 11 percent deviation (Table 2: 8.3seconds of set 1 vs. 9.2 seconds of set 2 for ATIS, downlink, 95th percentile) and 13 percent deviation (6.9 seconds of set 1 vs. 7.8 seconds of set 2 for CPDLC, uplink, 95th percentile). As to why delay performance is insensitive to these timer/parameter values, it may be because the MITRE simulation model does not include channel (bit) errors. All that is in the model is “congestion”. However, Mayflower’s AMSS model includes noisy channels, and yet they show results similar to the MITRE results.

Appendix

Detailed input timer values and output performance results are given in this appendix. Table 1 shows those guideline values given in ATN Guidance Material (Chapter 8), proposed values (Mayflower), and values used in MITRE ATN simulation runs. It has been believed that these values may be optimized using operational testing. MITRE attempted this optimization using MITRE’s ATN simulation model. The timers and parameters shown in Table 1 were varied over certain ranges, including the newly proposed values. Specifically, simulation tests were performed using different sets of values as described below:

1) Set 1-0: MITRE values, which are called “default” values (column 6 of Table 1)
   Set 1-1: MLR = MRL = 26, 100, 200, 600 and all others are default values.
   Set 1-2: ERL = ELR = 100, 120, 150 and all others are default values
   Set 1-3: AL = AR = 2, 20, 400 and all others are default values.
   Set 1-4: IL = IR = 600, 1000, 2000, 6000 and all others are default values
   Set 1-5: W = 599, 1000, 2000, 6000 and all others are default values

2) Set 2: Proposed (Mayflower) values (column 5 of Table 1)

Table 1. Timer and parameter values (seconds)

Symbol	|------------- ATN manual ---------------| Minimum	Example	Maximum	Newly Proposed	MITRE (default)
MRL, MLR 5	40	135	400	26	
ERL + ELR 0	35	150			
ERL, ELR				100	100
AL, AR	0	2	20	20	2
IL, IR	300	960	3000	4500	600
N	1	3	10	3	3
X				1	1
Computed values					
T1	12	37	300	221	203
R	0	75	2710	443	407
L	160	160	3000	1263	461
W	160	160	400	4000	4000

where

MLR: NSDU lifetime, local ->remote
MRL: NSDU lifetime, remote -> local

ELR: Transit delay, local -> remote
ERL: Transit delay, remote -> local
(ERL + ELR = Round trip transit delay)

AL: Acknowledgment time, local
AR: Acknowledgment time, remote

IL: Inactivity time, local
IR: Inactivity time, remote

N: Maximum number of retransmissions
X: Local processing time for a TPDU
T1: Retransmission timer (= ERL + ELR + AR + x)
R: Persistence time (= T1*(N-1) + X)
L: Frozen reference time (= MLR + MRL + R + AL)
W: Window time (= IR - ELR - offset)

Simulation outputs:

Output parameters of interest are end-to-end delays for two applications--Automatic Terminal Information Service (ATIS) and Controller-to-Pilot Data Link Communication (CPDLC). Detailed simulation methodology and application statistics are described in references [1], [2]. Both mean and 95th percentile delays are produced for both uplink and downlink as summarized in Table 2.

Table 2. End-to-end delay performance (seconds) of ATIS and CPDLC messages

timer/param		ATIS (mean)		ATIS (95%ile)		CPDLC (mean)		CPDLC (95%ile)	
		uplink	down	uplink	down	uplink	down	uplink	downlink
set 1 (MITRE)		13.3	3.6	24.4	8.3	3.3	2.6	6.9	4.9
set 1-1									
MRL, MLR	26*	13.3	3.6	24.4	8.3	3.3	2.6	6.9	4.9
	100	13.0	3.6	24.0	8.0	3.6	2.7	7.9	5.0
	200	13.3	3.6	24.4	8.3	3.3	2.6	6.9	4.9
	600	14.0	3.7	28.7	8.3	3.3	2.6	6.9	4.9
set 1-2									
ERL, ELR	100*	13.3	3.6	24.4	8.3	3.3	2.6	6.9	4.9
	120	13.2	3.9	24.2	8.5	3.3	2.6	7.0	4.9
	150	13.8	3.6	28.7	8.2	3.4	2.6	7.3	4.9
	200	(not allowed: “specified time is less than current time” error occurs)							
set 1-3									
AL, AR	2*	13.3	3.6	24.4	8.3	3.3	2.6	6.9	4.9
	20	12.9	3.7	23.9	8.0	3.6	2.7	7.9	5.0
	400	13.2	6.1	24.0	13.9	**153.7**	**53.4**	**557.5**	**302.6****
set 1-4									
IL, IR	600*	13.3	3.6	24.4	8.3	3.3	2.6	6.9	4.9
	1000	12.9	3.6	24.1	8.2	3.3	2.6	6.8	4.9
	2000	12.9	3.7	24.0	8.2	3.3	2.6	6.9	4.9
	6000	12.6	3.7	24.1	8.2	3.2	2.6	6.8	4.9
set 1-5									
W	599*	13.3	3.6	24.4	8.3	3.3	2.6	6.9	4.9
	1000	13.0	3.9	24.1	9.2	3.2	2.6	6.8	4.9
	2000	12.6	3.7	24.1	9.2	3.2	2.6	6.8	4.9
	6000	13.3	3.6	24.4	8.3	3.3	2.6	6.9	4.9
set 2 (Mayflower)		12.6	3.9	23.8	9.2	3.6	2.7	7.8	5.0

* MITRE (default) values

** CPDLC for extremely large values of Acknowledgment (i.e., AL = AR = 400) is very much affected. This is probably because CPDLC messages arrive 30 times more frequently than ATIS messages and the resulting CPDLC congestion in conjunction with large Acknowledgment time lengthens the end-to-end delay significantly.

REFERENCES:

1. Y. K. Hong, “ATN Simulation With Realistic Automatic Terminal Information Service (ATIS) Message Statistics,” presented at ATN Panel (ATNP) Working Group 2, ATNP WG 2 (ATNP/WG2-IP 220), Brisbane, Australia, 5-9 February 1996.

2. W. R. Rice, "End-to-end Data Link Delays Using Mode S," presented at ATN Panel (ATNP) Working Group 1, ATNP WG 1 WP, Banff, Canada, 9 - 13 October 1995.