NASA
AERONAUTICS

THE ADVANCED GENERAL AVIATION TRANSPORT EXPERIMENTS (AGATE)

SYSTEM STANDARD

FOR THE

AGATE AIRPLANE AVIONICS DATA BUS

Version 1.0

16 October 01

Reference Number - AGATE-WP01-001-DBSTD

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Preface

This document describes the Advanced General Aviation Transport Experiments (AGATE) Avionics Databus System Standard. This standard is a sub-set of the Controller Area Network Aerospace (CANaerospace), an open, royalty-free protocol.

The AGATE data bus protocol defines the application layer (layer seven) in the International Standards Organisation (ISO) Open Systems Interconnect (OSI) reference model. Protocol Data Units (PDUs) are used to communicate data between avionics. The PDUs are characterised and their intended use is defined in this standard.

The Controller Area Network (CAN) standard is used to define both the physical and data link layers (layers one and two in the OSI reference model). CAN is an open, licence-free standard that is generally implemented in silicon to ensure speed, robustness and interoperability at the hardware level.

Alternative physical and data link layers are possible, with byteflight being endorsed as another implementation in place of CAN. In either instance, the AGATE data bus protocol would be used for the application layer in the OSI model.

Copyright Statement

The AGATE data bus standard is an interface standard open to everyone. No copyrights are reserved and no licenses are necessary for its implementation, use or distribution. Stock Flight Systems, developer of CANaerospace, refuses any responsibility arising from the use of this standard in any application.

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1 Introduction

The AGATE data bus standard defines lightweight protocol/data format definition which was designed for the highly reliable communication of microcomputer-based systems in airborne applications via the Controller Area Network (CAN). The purpose of this definition is to create a standard that allows interoperability of avionics from different manufactures. The definition is kept widely open to allow implementation of user-defined message types and protocols. The AGATE data bus standard can be used with CAN 2.0A and 2.0B (11-bit and 29-bit identifiers) and any supported bus data rate. The AGATE data bus protocol message packets can be used on other data bus systems, in particular byte flight, under development by BMW for automotive applications. Annex A provides an overview of the Controller Area Network.

2 Message/data types and identifier assignment

2.1 Message types

The data format definition specifies six basic message types, which are used for different network services. Each AGATE data bus message type has an associated CAN-identification (CAN-ID) range defining the message priority as shown in Table 2.1-1. As noted in Annex A, the CAN-ID is an 11-bit unique value that is associated with one, and only one, message sent on the bus.

Table 2.1-1. CANaerospace Message Types

Message Type	CAN-ID Range	Explanation
Emergency Event Data (EED)	0 – 127 ($000 - $07F)	Transmitted asynchronously whenever a situation requiring immediate action occurs.
High Priority Node Service Data (NSH)	128 – 199 ($080 - $0C7)	Transmitted asynchronously or cyclic with defined transmission intervals (36 channels). Can be unique to an avionic or suite of avionics.
High Priority User-Defined Data (UDH)	200 – 299 ($0C8 - $12B)	Message/data format and transmission intervals entirely user-defined. Can be unique to an avionic or suite of avionics.
Normal Operation Data (NOD)	300 – 1799 ($12C - $707)	Transmitted asynchronously or cyclic with defined transmission intervals for operational and status data.
Low Priority User-Defined Data (UDL)	1800 – 1899 ($708 - $76B)	Message/data format and transmission intervals entirely user-defined. Can be unique to an avionic or suite of avionics.
Debug Service Data (DSD)	1900 – 1999 ($76C - $7CF)	Transmitted asynchronously or cyclic for debug communication & software download actions.
Low Priority Node Service Data (NSL)	2000 – 2031 $7D0 - $7EF	Transmitted asynchronously or cyclic for test & maintenance actions (16 channels), or other user- defined actions.

This allows all messages defined for the AGATE data bus to have a unique, single CAN-ID and, therefore, a unique, defined priority. CAN is a peer-to-peer network. Thus, if two nodes transmit simultaneously, the message of highest priority is transmitted. The node transmitting the lower priority stops and tries again when the bus is unused.

Each node (avionic) on the bus is assigned a unique node identification value. Additionally, only one node is allowed to transmit any one of the messages, therefore preventing simultaneous transmission of the same CAN-ID (data bus message).

2.2 Data Types

The standard data types are defined in Table 2.2.1. Additionally, combined data types (i.e. two 16 bit or four 8 bit data types in one CAN message) are supported, others can be added to the type list as required. The type number in the range of 0-255 is used for data type specification as described in section 3.1.

Table 2.2-1. Data Types

Data Type	Range	Bits	Explanation	Type #
NODATA	n.a.	0	"No data" type	0 ($00)
ERROR	n.a.	32	Emergency event data type	1 ($01)
FLOAT	-8388607×10^{127} to $+8388607 \times 10^{127}$	32	Single precision floating-point value according to IEEE-754-1985	2 ($02)
LONG	-2147483647 to +2147483648	32	2's complement integer	3 ($03)
ULONG	0 to +4294967295	32	Unsigned integer	4 ($04)
BLONG	n.a.	32	Each bit defines a discrete state. 32 bits are coded into four CAN data bytes	5 ($05)
SHORT	-32767 to +32768	16	2's complement short integer	6 ($06)
USHORT	0 to +65535	16	Unsigned short integer	7 ($07)
BSHORT	n.a.	16	Each bit defines a discrete state. 16 bits are coded into two CAN data bytes	8 ($08)
CHAR	-127 to +128	8	2's complement char integer	9 ($09)
UCHAR	0 to +255	8	unsigned char integer	10 ($0A)
BCHAR	n.a.	8	Each bit defines a discrete state. 8 bits are coded into a single CAN data byte	11 ($0B)
SHORT2	-32767 to +32768	2 x 16	2 x 2's complement short integer	12 ($0C)

Table 2.2-1. Data Types (Concluded)

Data Type	Range	Bits	Explanation	Type #
USHORT2	0 to +65535	2 x 16	2 x unsigned short integer	13 ($0D)
BSHORT2	n.a.	2 x 16	2 x discrete short	14 ($0E)
CHAR4	-127 to +128	4 x 8	4 x 2's complement char integer	15 ($0F)
UCHAR4	0 to +255	4 x 8	4 x unsigned char integer	16 ($10)
BCHAR4	n.a.	4 x 8	4 x discrete char	17 ($11)
CHAR2	-127 to +128	2 x 8	2 x 2's complement char integer	18 ($12)
UCHAR2	0 to +255	2 x 8	2 x unsigned char integer	19 ($13)
BCHAR2	n.a.	2 x 8	2 x discrete char	20 ($14)
MEMID	0 to +4294967295	32	Memory ID for upload/download	21 ($15)
CHKSUM	0 to +4294967295	32	Checksum for upload/download	22 ($16)
ACHAR	0 to 255	8	ASCII character	23 ($17)
ACHAR2	0 to 255	8	2 x ASCII character	24 ($18)
ACHAR4	0 to 255	8	4 xASCII character	25 ($19)
RESVD	n.a.	xx	Reserved for future use	26-99 ($1A-$63)
VARIABLE3	n.a.	3x8	Defined for 17 to 24-bits of signed, 2's complement integer	100 ($64)
UVARIABLE3	n.a.	3x8	Defined for 17 to 24-bits of unsigned integer	101 ($65)
UDEF	n.a.	xx	User-defined data types	102-255 ($66-$FF)

3 Message structure

The coding of the data bytes into the CAN message is according to the "Big Endian" definition as used by Motorola 68K, SPARC, PowerPC and MIPS architectures. All CAN messages consist of 4 header bytes for identification and between 1 to 4 bytes for the actual data.

3.1 General Message Format

The general message format is shown in Figure 3.1-1, and uses a 4-byte message header for node identification, data type, message code and service code (for Normal Operation Data (NOD), the service code field is user-defined). The protocol provides for a self-identifying message format that allows identification of each message by any receiving unit without the need for additional information. However, in the interest of interoperability, the basic set of messages for the AGATE data bus standard are completely defined. Users can develop their own unique messages that take full advantage of the self-identifying message capability. Every message type uses the same layout for the message header bytes 0-3, while the number of bytes and the data type for the data payload in bytes 4-7 is user-defined.

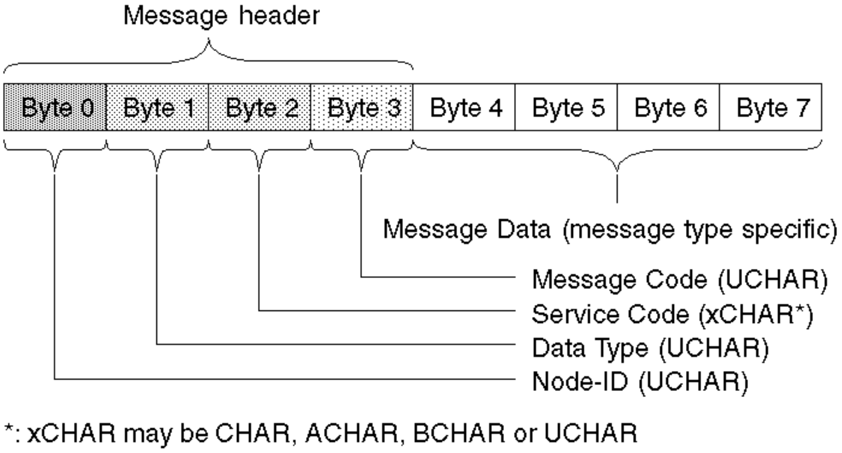

Figure 3.1-1. AGATE Data Bus General Message Format

The header data fields have the following meaning:

- The node-ID is in the range of 1-255 while node-ID 0 refers to “all nodes”. Note that for Emergency Event Data (EED) and normal operation data (NOD) messages, the node-ID identifies the *transmitting* station, while for node service data Node Service High/Node Service Low (NSH/NSL) messages the node-ID identifies the *addressed* station.
- The data type number is taken from the data type list (see Table 2.2-1).
- The message code is incremented by one for each message and may be used to monitor the sequence of incoming messages. The message code rolls over to zero after passing 255. This feature allows any node in the network to determine the age of a message and the proper sequence for monitoring purposes.
- For Normal Operation Data (NOD) messages, the service code consists of 8-bits which may be used as required by the specific data (should be set to zero if unused). For node service data (NSL/NSH) messages, the service code contains the node service code for the current operation per Table 4.3-1.

3.2 Emergency Event Data (EED) Message Format

Emergency Event Data (EED) is transmitted asynchronously by the affected unit whenever an error situation occurs. The corresponding data contains information about the location within the unit at which the error occurred, the offending operation and the error code. The message header is the same as shown in Figure 3.1-1 with the Data Type (byte 1) set for the Error type, and the Service Code (byte 2) set to zero unless user defined.

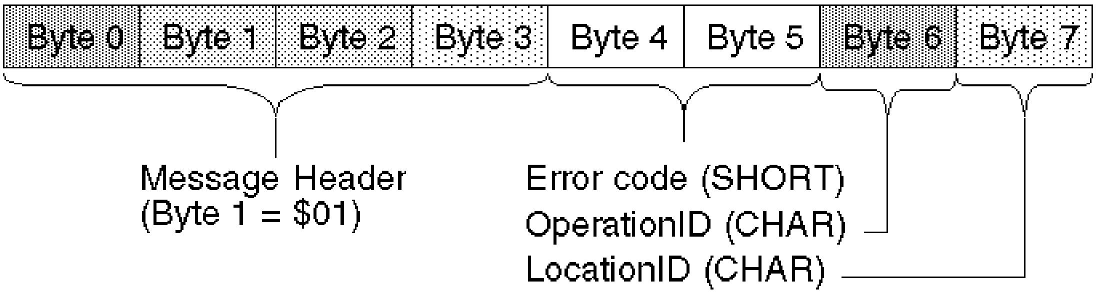

Figure 3.2-1. AGATE Data Bus Emergency Event Message Format

3.3 Normal Operation Data (NOD) Message Format

Normal Operation Data (NOD) is transmitted during normal operation, either cyclic or asynchronously. The data type, byte 1, is taken from the data type list in Table 2.2-1. The NOD message format is shown in Figure 3.3-1. While the header is of fixed length (4 bytes), the data type will define the number of data bytes to be transmitted (1-4) in bytes 4-7. Unused bytes in the range of bytes 4-7 are not transmitted.

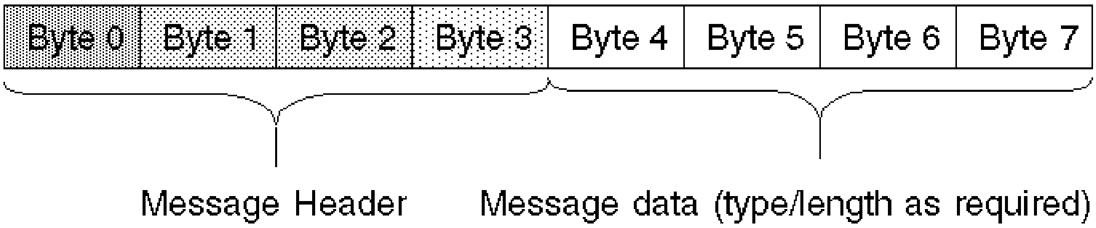

Figure 3.3-1. AGATE Data Bus Normal Operation Data Message Format

3.4 Node Service Data (NSH/NSL) Message Format

Node Service Data (NSH/NSL) is data associated with the node service protocol as specified in Section 4. The message format is similar to NOD. Node service data, however, is transmitted on specific identifiers only:

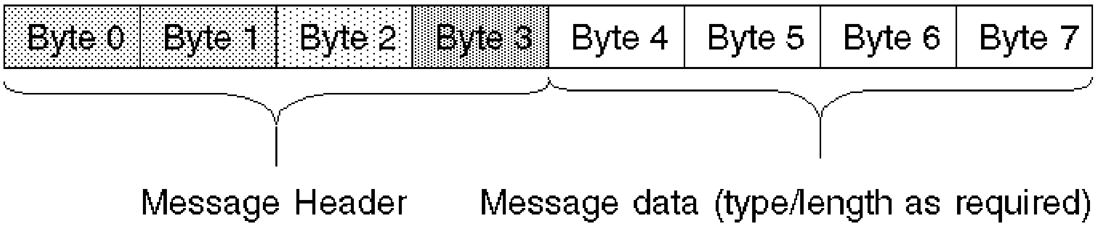

Figure 3.4-1. AGATE Data Bus Node Service Message Format

3.5 Debug Service Data (DSD) Message Format

The Debug Service Data message format is entirely user-defined because of the specific requirements resulting from the various host/target communication protocols.

3.6 User-Defines Data Message Format

User-Defined Data message formats may be created for specific purposes. Aside from using the specified identifier range, no restrictions apply.

4 Node Service Protocol

In parallel to the data transfer during normal operation (Emergency Event Data, Normal Operation Data), the node service protocol provides a connection-oriented communication capability using a handshake mechanism. This protocol has been implemented to support command/response type connections between two nodes for specific operations, i.e. for data download or client/server actions. Note that node service requests requiring action but no response are possible as well. Requests of this type may be sent to a specific node or all nodes (broadcast).

The node service protocol may be run either in high priority or low priority mode, selected by the CAN-ID. For the high priority mode, 36 node service communication channels are available, while the low priority mode offers 16 communication channels. Each communication channel uses one CAN identifier for the node service request and the immediately following one for the node service response. The identifier assignments for the high-priority node service channels are provided in Table 4-1 and the identifier assignments for the low-priority node service channels are provided in Table 4-2. The approach to handling large (>4 bytes) messages due to interaction with the National Airspace System or other aircraft is described in Section 5.10, Native Format Message Channels. The concepts described for the Node Service protocol apply to the Native Format Message Channels as well.

Table 4-1. AGATE Data Bus High-Priority Node Service Assignments

Node Service Channel	Node Service Request CAN-ID	Node Service Response CAN-ID
0	128 ($080)	129 ($081)
1	130 ($082)	131 ($083)
2	132 ($084)	133 ($085)
....	....	......
....	....	......
33	194 ($0C2)	195 ($0C3)
34	196 ($0C4)	197 ($0C5)
35	198 ($0C6)	199 ($0C7)

Table 4-2. AGATE Data Bus Low-Priority Node Service Assignments

Node Service Channel	Node Service Request CAN-ID	Node Service Response CAN-ID
100	2000 ($7D0)	2001 ($7D1)
101	2002 ($7D2)	2003 ($7D3)
102	2004 ($7D4)	2005 ($7D5)
....	....	......
115	2030($7EE)	2031 ($7EF)

A node service is initiated by a node service request message, transmitted on the corresponding identifier. All nodes attached to the network are obliged to continuously monitor these identifiers and check if received messages contain the own personal node-ID. If a match is detected, the corresponding node has to react by performing the required action and transmitting a node service response message on the corresponding identifier within 100ms (if this was required by the request type). The node service response must again contain the personal node-ID of the addressed node. Any node in the network is allowed to initiate node services. It is recommended, however, that each node in the network initiating node service requests use a dedicated node service channel to avoid potential hand-shaking conflicts. The channel on which a particular node service is run may be defined by the user. If only one service channel is used, node services should be run on channel 0 by default. Defined types of node services are specified in Table 4-3, other services may be added as required.

IMPORTANT NOTE: Each CANaerospace unit must support at least the Identification Service (IDS) on Node Service Channel 0. This makes sure that a CANaerospace network can be scanned for attached units to determine their status, header type and identifier assignment.

Table 4-3. Types of AGATE Data Bus Node Service Identifiers

Node Service	Service Code	Response Required	Action
IDS	0	Yes	Identification service. Requests a “sign-of-life” response from the addressed node.
NSS	1	No	Node synchronisation service, used to trigger a specific node or to perform a network wide time synchronisation.
DDS	2	Yes	Data download service. Sends a block of data to another node.
DUS	3	Yes	Data upload service. Receives a block of data from another node.
XXS	4-99		Reserved for future use.
	100-255		User-defined services.

4.1 Identification Service (IDS)

The identification service is a client/server type service. It is used to obtain a “sign-of-life” indication from the addressed node. The addressed node returns four bytes of status information about the system and the identifier distribution (default/other) used along with user-defined information. Accordingly, the data type of the response message is UCHAR4, as shown in Table 4.1-1.

Table 4.1-1. AGATE Data Bus Identification Service Message Format

Message Header and Data Bytes	Data Field Description	Service Request (Byte Value)	Service Response
0	Node-ID	<node-ID>	<node-ID>
1	Data Type	NODATA	UCHAR4
2	Service Code	0	0
3	Message Code	<0-255>	<as in request>
4-7	Message Data	n.a.	Byte 0: Hardware Revision Byte 1: Software Revision Byte 2: Identifier Distribution (0 = default) Byte 3: Header Type (0 = AGATE Databus message header), other values are user-defined.

4.2 Node Synchronisation Service (NSS)

The node synchronisation service is a connectionless service (no service response required) used to perform time synchronisation of all nodes attached to the network. Therefore, the node-ID is set to 0. The time stamp may be used to submit a 32-bit value for clock settings. The message format is shown in Table 4.2-1.

Table 4.2-1. AGATE Databus Node Synchronisation Service Message Format

Message Header and Data Bytes	Data Field Description	Service Request (byte values)
0	Node-ID	0
1	Data type	ULONG
2	Service Code	1
3	Message Code	0
4-7	Message Data	<time stamp>

4.3 Data Download Service (DDS)

The data download is a connection-oriented service and is used to initiate the ***transmission*** of a block of data to another node. The message format is shown in Table 4.3-1. The size of the data block may be in the range of 1-1020 bytes (1-255 messages), specified in the message number field (Message Code) of the header. To initiate the service, the requesting station sends a “start download request message” to the addressed node (NODE-ID, in byte 0), specifying a memory destination identifier, the type of data to be downloaded and the number of messages which will be transmitted. It then waits for the response. If the service response is received within 100ms and the message data is XON, the requesting station may transmit the specified number of data messages.

Table 4.3-1. AGATE Databus Data Download Service Message Formats for the Requesting (Transmiting) and Responding (Receiving) Nodes

Message Data Bytes	Data Field Description	Service Request (byte values)	Service Response (byte values)
0	Node-ID	<node-ID>	<node-ID>
1	Data Type	MEMID	LONG
2	Service Code	2	2
3	Message Code	<0-255>	<as in request>
4-7	Message Data	<memory destination identifier>	-2 = INVALID -1 = ABORT 0 = XOFF 1 = XON

The addressed node now accepts data until the final message number has been reached. To control download speed, the addressed node may send a service response at any time during the download process, specifying the current message number and XOFF or XON. By specifying ABORT or INVALID, the download is cancelled immediately without further action. The transmitting station has to react correspondingly by stopping or resuming data transmission.

Note that the transmitter must use the appropriate data type in the last message in order to get the proper number of bytes (1-4) in the last message. After the last message has been received, the addressed node transmits a DDS service response with a checksum calculated from summing up all received data as shown in Table 4.3-2. This allows the requesting node to determine if all data has been received properly.

Table 4.3-2. AGATE Databus Download Data Service Message Format Checksum Response

Header and Message Data Bytes	Data Field Description	Service Request	Service Response
0	Node-ID	<node-ID>	<node-ID>
1	Data type	<any>	CHKSUM
2	Service Code	2	2
3	Message Code	<last number>	<last number>
4-7	Message Data	<download data>	<checksum>

4.4 Data Updoad Service (DUS)

The data upload is a connection-oriented service and is used to initiate the ***reception*** a block of data from another node. The message format is shown in Table 4.4-1. The size of the data block may be in the range of 1-1020 bytes (1-255 messages), specified by the message number field (Message Code) of the header. To initiate the service, the requesting station sends a “start upload request message” to the addressed node, specifying the source memory identifier, the data type and the number of messages which is expected to be received. It then waits up to 100ms for a service response. After having transmitted the service response, the addressed station waits 10ms and then transmits the requested number of data messages.

Table 4.4-1. AGATE Databus Data Upload Service Message Formats for the Requesting and Responding Nodes

Header and Message Data Bytes	Data Field Description	Service Request	Service Response
0	Node-ID	<node-ID>	<node-ID>
1	Data Type	MEMID	LONG
2	Service Code	3	3
3	Message Code	<0-255>	<as in request>
4-7	Message Data	<source memory identifier>	-1 = ABORT 0 = OK

The requesting node now accepts data at the maximum transmission speed until the final message number has been reached. The requesting node continuously checks the proper message number sequence during the process to detect failures. By specifying ABORT, the upload is cancelled immediately without further action. After the last data message, the addressed node transmits a service response with a checksum calculated from summing up all transmitted data. This allows the requesting node to determine if all data has been received properly.

Table 4.4-2. AGATE Databus Data Upload Service Message Format Checksum Response

Message Data Byte	Data Field Description	Service Response
0	Node-ID	<node-ID>
1	Data Type	CHKSUM
2	Service Code	3
3	Message Code	<last number>
4-7	Message Data	<checksum>

5 Default Identifier Assignment

To support interoperability, the most commonly used datum have been assigned fixed identifiers. For this purpose, the available identifiers for normal operation data have been grouped for the various aircraft systems in identifier range 300-1499. The identifiers from 1500-1799 are unassigned and may be used for other aerospace specific data at the user's discretion. Note that other identifier assignments besides the default one may be added.

The AGATE Databus standard defines the data type and resolution for each parameter to aid interoperability. This does not preclude the use of other data types for the messages defined in this standard; however, the cost will be loss of interoperability. The node receiving a message should multiply the value in the datafields by the resolution to obtain the value of the parameter. Likewise, a transmitting station should divide the parameter value by the resolution and transmit the multiplier in the datafields. If the avionic cannot provide the specified resolution, the least significant bits should be set to zero as required.

If the data type defined for a CAN-Identifier is inadequate, the manufacturer is encouraged to define a new message by selection of an unused CAN Identifier and specifying the appropriate datatype and resolution. When defining new messages, the self-identifying feature can be used.

If analog parameters are transmitted as SHORT2, the first SHORT variable contains the current value, while the second SHORT variable contains the maximum value of this parameter to support parameter scaling for the receiving nodes.

5.1 Flight State/Air Data

Table 5.1-1. Flight State/Air Data CAN Identifiers

CAN Identifier	Flight State Parameter Name	Data Type	Units	Range	Resolution
300 ($12C)	Body longitudinal acceleration	SHORT	g	+/- 16 + Forward	0.000488 $(16/2^{15})$
301 ($12D)	Body lateral acceleration	SHORT	g	+/- 16 + Right	0.000488 $(16/2^{15})$
302 ($12E)	Body normal acceleration	SHORT	g	+/- 16 + Up	0.000488 $(16/2^{15})$
303 ($12F)	Body pitch rate	SHORT	deg/s	+/- 512 + Nose Up	0.015625 $(512/2^{15})$
304 ($130)	Body roll rate	SHORT	deg/s	+/- 512 + Rt. Wing Down	0.015625 $(512/2^{15})$
305 ($131)	Body yaw rate	SHORT	deg/s	+/- 512 + Nose Right	0.015625 $(512/2^{15})$
306 ($132)	Rudder position	SHORT	deg.	+/- 90 + Right	0.002747 $(90/2^{15})$
307 ($133)	Stabilizer position	SHORT	deg.	+/- 90 + Up	0.002747 $(90/2^{15})$
308 ($134)	Elevator position	SHORT	deg.	+/- 90 + Up	0.002747 $(90/2^{15})$
309 ($135)	Left aileron position	SHORT	deg.	+/- 90 + Up	0.002747 $(90/2^{15})$
310 ($136)	Right aileron position	SHORT	deg.	+/- 90 + Up	0.002747 $(90/2^{15})$
311 ($137)	Body pitch angle	SHORT	deg.	+/- 180 + Nose Up (Earth Referenced)	0.005493 $(180/2^{15})$
312 ($138)	Body roll angle	SHORT	deg.	+/- 180 + Rt. Wing Down (Earth Referenced)	0.005493 $(180/2^{15})$
313 ($139)	Body sideslip	SHORT	deg.	+/- 45 + Right	0.001373 $(45/2^{15})$
314 ($13A)	Altitude rate	SHORT	Ft/min	- 32767 to +32768 +Up	1 $(32{,}768/2^{15})$
315 ($13B)	Indicated airspeed	SHORT	kts.	0-1024 + Always Positive	0.03125 $(1024/2^{15})$
316 ($13C)	True airspeed	SHORT	kts.	0-1024 + Always Positive	0.03125 $(1024/2^{15})$
317 ($13D)	Calibrated airspeed	SHORT	kts.	0-1024 + Always Positive	0.03125 $(1024/2^{15})$

Table 5.1-1. Flight State/Air Data CAN Identifiers (Concluded)

CAN Identifier	Flight State Parameter Name	Data Type	Units	Range	Resolution
318 ($13E)	Mach number	SHORT	Mach	0-4 Always Positive	0.000122 $(4/2^{15})$
319 ($13F)	Baro Correction (Altimeter Setting)	SHORT	In. Hg	0-65.535 Always Positive	0.001 $(65.535/2^{16}-1)$
320 ($140)	Baro corrected altitude	VARIABLE3 Signed 18-bit	ft	-5000 to +131,072	1 $(131{,}072/2^{17})$
321 ($141)	Heading angle	USHORT	deg	0-360	0.005093 $(360/2^{16}-1)$
322 ($142)	Standard altitude	VARIABLE3 Signed 18-bit	ft	-5000 to +131,072	1 $(131{,}072/2^{17})$
323 ($143)	Total air temperature	SHORT	°C	+/- 512	0.015625 $(512/2^{15})$
324 ($144)	Static air temperature	SHORT	°C	+/-512	0.015625 $(512/2^{15})$
325 ($145)	Differential pressure	SHORT	in. Hg	0-65.535 Always Positive	0.001 $(65.535/2^{16}-1)$
326 ($146)	Static pressure	SHORT	hPa	0-65.535 Always Positive	0.001 $(65.535/2^{16}-1)$

5.2 Flight Controls Data

The flight controls section also contains aircraft engine controls as shown in Table 5.2-1. This data is divided into sections A and B to support dual redundant engine control systems (ECS). All engine data is available with two different CAN identifiers so that it may be transmitted on the same bus without interference.

In case this feature is not used, ECS channel A may also be interpreted as "starboard engines" and ECS channel B as "port engines" so that in total, up to eight engines per aircraft may be supported.

Table 5.2-1. Flight Controls Data CAN Identifiers

CAN Identifier	Flight Controls Parameter Name	Data Type	Units	Range	Resolution
400 ($190)	Pitch control position	SHORT	Norm[1]	-1/+1 aft: +/ fwd: -	0.000031 (2^{-15})
401 ($191)	Roll control position	SHORT	Norm	-1/+1 right: + / left: -	0.000031 (2^{-15})
402 ($192)	Lateral stick trim position command	SHORT	Norm	-1/+1 right: + left: -	0.000031 (2^{-15})
403 ($193)	Yaw control position	SHORT	Norm	left fwd: + right fwd: -	0.000031 (2^{-15})
404 ($194)	Reserved[2]				

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[1] Norm – Normalized to +/- 1 or 0-1 as indicated

[2] Used for Rotorcraft. Refer to CAN aerospace V1.7 or latest issue for definition.

Table 5.2-1. Flight Controls Data CAN Identifiers (Continued)

CAN Identifier	Flight Controls Parameter Name	Data Type	Units	Range	Resolution
405 ($195)	Longitudinal stick trim position command (Pitch)	SHORT	Norm	-1/+1 aft: + fwd: -	0.000031 (2^{-15})
406 ($196)	Reserved				
407 ($197)	Reserved				
408 ($198)	Reserved				
409 ($199)	Lateral trim speed (Roll)	SHORT	Norm	-1/+1 +Faster	0.000031 (2^{-15})
410 ($19A)	Longitudinal trim speed (Pitch)	SHORT	Norm	-1/+1 +Faster	0.000031 (2^{-15})
411 ($19B)	Reserved				
412 ($19C)	Reserved				
413 ($19D)	Nose wheel steering handle position	SHORT	Norm	-1/+1 right: + / left: -	0.000031 (2^{-15})
414 – 417 ($19E - $1A1)	Engine #n throttle lever position (1 < n <= 4) ECS channel A	USHORT	Norm	0-+1 +1 is maximum	1.525×10^{-5} ($1/2^{16}-1$)
418 – 421 ($1A2 - $1A5)	Reserved	SHORT	Norm		
422 – 425 ($1A6 - $1A9)	Engine #n throttle lever position (1 < n <= 4) ECS channel B	USHORT	Norm	0 to +1 +1 is maximum	1.525×10^{-5} ($1/2^{16}-1$)
426 – 429 ($1AA - $1AD)	Reserved	SHORT	Norm		
430 ($1AE)	Flaps lever position	USHORT	Norm	0 to +1 +1 is maximum	1.525×10^{-5} ($1/2^{16}-1$)
431 ($1AF)	Slats lever position	USHORT	Norm	0-1 1- Fully Deployed	1.525×10^{-5} ($1/2^{16}-1$)
432 ($1B0)	Park brake lever position	USHORT	Norm	0-1 1-Fully Engaged	1.525×10^{-5} ($1/2^{16}-1$)
433 ($1B1)	Speedbrake lever position	USHORT	Norm	0-1Fully Deployed	1.525×10^{-5} ($1/2^{16}-1$)
434 ($1B2)	Reserved				

Table 5.2-1. Flight Controls Data CAN Identifiers (Concluded)

CAN Identifier	Flight Controls Parameter Name	Data Type	Units	Range	Resolution
435 ($1B3)	Pilot left brake pedal position	USHORT	Norm	0-1 1- Fully Depressed	1.525×10^{-5} $(1/2^{16}-1)$
436 ($1B4)	Pilot right brake pedal position	USHORT	Norm	0-1 1- Fully Depressed	1.525×10^{-5} $(1/2^{16}-1)$
437 ($1B5)	Copilot left brake pedal position	USHORT	Norm	0-1 1- Fully Depressed	1.525×10^{-5} $(1/2^{16}-1)$
438 ($1B6)	Copilot right brake pedal position	FLOAT USHORT	Norm	0-1 1- Fully Depressed	1.525×10^{-5} $(1/2^{16}-1)$
439 ($1B7)	Trim system Switches	BLONG SHORT			
440 ($1B8)	Trim system lights	BLONG SHORT			
441 ($1B9)	Reserved				
442 ($1BA)	Stick shaker stall warning device	BLONG SHORT			

5.3 Aircraft Engine/Fuel Supply System Data

Aircraft engine data is divided into sections A and B to support dual redundant engine control systems (ECS). All engine data is available with two different CAN identifiers so that it may be transmitted on the same bus without interference.

In case this feature is not used, ECS channel A may also be interpreted as “starboard engines” and ECS channel B as “port engines” so that in total, up to eight engines per aircraft can be supported.

Table 5.3-1. Aircraft Engine/Fuel Supply System Data CAN Identifiers

CAN Identifier	Engine Parameter Name	Data type	Units	Range	Resolution
500 - 503 ($1F4 - $1F7)	Engine #n N1 $(1 < n <= 4)$ ECS channel A	Variable3 18-bit Unsigned Integer	1/min N1 for jet engines, crankshaft RPM for piston engines		0.152588 $(40,000/2^{18}-1)$
504 - 507 ($1F8 - $1FB)	Engine #n N2 $(1 < n <= 4)$ ECS channel A	Uvariable3 18-bit Unsigned	1/min N2 for jet engines, propeller RPM for piston engines		0.152588 $(40,000/2^{18}-1)$
508 - 511 ($1FC - $1FF)	Engine #n torque $(1 < n <= 4)$ ECS channel A	SHORT	Norm	0 to +32768	3.05×10^{-5} (2^{-15})
512 - 515 ($200 - $203	Engine #n turbine inlet temperature $(1 < n <= 4)$ ECS channel A	SHORT	°C	0-2048 TIT	0.0624 $(2048/2^{15})$
516 - 519 ($204 - $207)	Engine #n inter turbine temperature $(1 < n <= 4)$ ECS channel A	SHORT	°C	0-2048 ITT	0.0624 $(2048/2^{15})$
520 - 523 ($208 - $20B)	Engine #n turbine outlet temperature $(1 < n <= 4)$ ECS channel A	SHORT	°C	0-2048 TOT for jet engines, exhaust gas temperature for piston engines	0.0624 $(2048/2^{15})$
524 - 527 ($20C - $20F)	Engine #n fuel flow rate $(1 < n <= 4)$ ECS channel A	SHORT	gal/hr	0-512	0.051625 $(512/2^{15})$
528 - 531 ($210 - $213)	Engine #n manifold pressure $(1 < n <= 4)$ ECS channel A	SHORT	in. Hg	0-65.357 piston engines only	1.525×10^{-5} $(1/2^{16}-1)$

Table 5.3-1. Aircraft Engine/Fuel Supply System Data CAN Identifiers (Continued)

CAN Identifier	Engine Parameter Name	Data type	Units	Range	Resolution
532 - 535 ($214 - $217)	Engine #n oil pressure (1 < n <= 4) ECS channel A	SHORT	PSIG	0-512	0.015625 ($512/2^{15}$)
536 - 539 ($218 - $21B)	Engine #n oil temperature (1 < n <= 4) ECS channel A	SHORT	°C	+/-1024	0.03125 ($1024/2^{15}$)
540 - 543 ($21C - $21F)	Engine #n cylinder head temperature (1 < n <= 4) ECS channel A	SHORT	°C	+/-1024 piston engines only	0.03125 ($1024/2^{15}$)
544 - 547 ($220 - $223)	Engine #n oil quantity (1 < n <= 4) ECS channel A	SHORT	Gal.	0-256	0.007813 ($256/2^{15}$)
548 - 551 ($224 - $227)	Engine #n coolant temperature (1 < n <= 4) ECS channel A	SHORT	°C	0-1024	0.03125 ($1024/2^{15}$)
552 - 555 ($228 - $22B)	Engine #n power rating (1 < n <= 4) ECS channel A	USHORT	Norm	0-1 1 is maximum	$1.525x10^{-5}$ ($1/2^{16}$-1)
556 - 559 ($22C - $22F)	Engine #n Status 1 (1 < n <= 4) ECS channel A	BSHORT BLONG		Bit encoding user defined	
560 - 563 ($230 - $233)	Engine #n Status 2 (1 < n <= 4) ECS channel A	BSHORT BLONG		Bit encoding user defined	
564 - 567 ($234 - $237)	Engine #n N1 (1 < n <= 4) ECS channel B	UVARIABLE3 18-bit Signed Integer	1/min	N2 fir jet engines Propeller RPM for piston engines	0.152588 ($40,000/2^{18}$-1)
568 - 571 ($238 - $23B	Engine #n N2 (1 < n <= 4) ECS channel B	UVARIABLE3 18-bit Signed Integer	1/min	N2 fir jet engines Propeller RPM for piston engines	0.152588 ($40,000/2^{18}$-1)
572 - 575 ($23C - $23F)	Engine #n torque (1 < n <= 4) ECS channel B	SHORT	Norm	0-32,768	$3.05x10^{-5}$ (2^{-15})

Table 5.3-1. Aircraft Engine/Fuel Supply System Data CAN Identifiers (Continued)

CAN Identifier	Engine Parameter Name	Data type	Units	Range	Resolution
576 - 579 ($240 - $243)	Engine #n turbine inlet temperature (1 < n <= 4) ECS channel B	SHORT	°C	0-2048 TIT	0.0624 ($2048/2^{15}$)
580 - 583 ($244 - $247)	Engine #n interturbine temperature (1 < n <= 4) ECS channel B	SHORT	°C	0-2048 ITT	0.0624 ($2048/2^{15}$)
584 - 587 ($248 - $24B)	Engine #n turbine outlet temperature (1 < n <= 4) ECS channel B	SHORT	°C	TOT for jet engines, exhaust gas temperature for piston engines	0.0624 ($2048/2^{15}$)
588 - 591 ($24C - $24F)	Engine #n fuel flow rate (1 < n <= 4) ECS channel B	SHORT	gal/hr	0-512	0.015625 ($512/2^{15}$)
592 - 595 ($250 - $253)	Engine #n manifold pressure (1 < n <= 4) ECS channel B	SHORT	in./Hg	0-65.357 piston engines only	10525×10^{-5} ($1/2^{16}-1$)
596 - 599 ($254 - $257)	Engine #n oil pressure (1 < n <= 4) ECS channel B	SHORT	PSIG	0-512	0.015625 ($512/2^{15}$)
600 - 603 ($258 - $25B)	Engine #n oil temperature (1 < n <= 4) ECS channel B	SHORT	°C	+/-1024	0.03125 ($1024/2^{15}$)
604 - 607 ($25C - $25F)	Engine #n cylinder head temperature (1 < n <= 4) ECS channel B	SHORT	°C	+/-1024 piston engines only	0.03125 ($1024/2^{15}$)
608 - 611 ($260 - $263)	Engine #n oil quantity (1 < n <= 4) ECS channel B	SHORT	Gal.	0-256	0.007813 ($256/2^{15}$)
612 - 615 ($264 - $267)	Engine #n coolant temperature (1 < n <= 4) ECS channel B	SHORT	°C	0-1024	0.3125 ($1024/2^{15}$)

Table 5.3-1. Aircraft Engine/Fuel Supply System Data CAN Identifiers (Concluded)

CAN Identifier	Engine Parameter Name	Data type	Units	Range	Resolution
616 - 619 ($268 - $26B)	Engine #n power rating $(1 < n <= 4)$ ECS channel B	SHORT	Norm	0-1 1 is maximum	1.525×10^{-5} $(1/2^{16}-1)$
620 - 623 ($26C - $26F)	Engine #n Status 1 $(1 < n <= 4)$ ECS channel B	BSHORT BLONG		Bit encoding user defined	
624 - 627 ($270 - $273)	Engine #n Status 2 $(1 < n <= 4)$ ECS channel B	BSHORT BLONG		Bit encoding user defined	
628 - 659 ($274 - $293)	Reserved for future use				
660 - 667 ($294 - $29B)	Fuel pump #n flow rate $(1 < n <= 8)$	SHORT	gal/hr	0-256	0.007813 $(256/2^{15})$
668 - 675 ($29C - $2A3)	Fuel tank #n quantity $(1 < n <= 8)$	SHORT	Gal.	0-1024	0.03125 $(1024/2^{15})$
676 - 683 ($2A4 - $2AB)	Fuel tank #n temperature $(1 < n <= 8)$	SHORT	°C	+/- 256	0.007813 $(256/2^{15})$
684 - 691 ($2AC - $2B3)	Fuel system #n pressure $(1 < n <= 8)$	SHORT	PSIG	0-512	0.015625 $(512/2^{15})$

5.4 Power Transmission System Data

Table 5.4-1. Power Transmission System Data CAN Identifiers

CAN Identifier	Transmission System Parameter Name	Data Type	Units	Range	Resolution
700 - 703 ($2BC - $2C0)	Reserved				
704 - 711 ($2BD - $2C7)	Gearbox #n speed $(1 < n <= 8)$	SHORT	1/min	0-16,384	0.5 $(16{,}384/2^{15})$
712 - 719 ($2BC - $2CF)	Gearbox #n oil pressure $(1 < n <= 8)$	SHORT	PSIG	0-512	0.015625 $(512/2^{15})$

Table 5.4-1. Power Transmission System Data CAN Identifiers (Concluded)

CAN Identifier	Transmission System Parameter Name	Data Type	Units	Range	Resolution
720 - 727 ($2D0 - $2D7)	Gearbox #n oil temperature (1 < n <= 8)	SHORT	°C	0-1024	0.03125 (1024/2^{15})
728 - 735 ($2D8 - $2DF)	Gearbox #n oil quantity (1 < n <= 8)	SHORT	Gal	0-256	0.007813 (256/2^{15})

5.5 Hydraulic System Data

Table 5.5-1. Hydraulic Systems Data CAN Identifiers

CAN identifier	Hydraulic system parameter name	Data type	Units	Range	Resolution
800 - 807 ($320 - $327)	Hydraulic system #n pressure (1 < n <= 8)	SHORT	PSIG	0-4096	0.125 (4096/2^{15})
808 - 815 ($328 - $32F)	Hydraulic system #n fluid temperature (1 < n <= 8)	SHORT	°C	0-1024	0.03125 (1024/2^{15})
816 - 823 ($330 - $337)	Hydraulic system #n fluid quantity (1 < n <= 8)	SHORT	Gal	0-256	0.007813 256/2^{15})

5.6 Electric System Data

Table 5.6-1. Electric System Data CAN Identifiers

CAN identifier	Electric system parameter name	Data type	Units	Range	Resolution
900 - 909 ($384 - $38D)	AC system #n voltage (1 < n <= 10)	SHORT	volts	0-1024	0.03125 (1024/2^{15})
910 - 919 ($38E - $397)	AC system #n current (1 < n <= 10)	SHORT	amp.	0-512	0.015625 (512/2^{15})
920 - 929 ($398 - $3A1)	DC system #n voltage (1 < n <= 10)	SHORT	volts	0-1024	0.03125 (1024/2^{15})

Table 5.6-1. Electric System Data CAN Identifiers (Concluded)

CAN identifier	Electric system parameter name	Data type	Units	Range	Resolution
930 - 939 ($3A2 - $3AB)	DC system #n current (1 < n <= 10)	SHORT	amp.	0-512	0.015625 (512/2^{15})
940 - 949 ($3AC - $3B5)	Prop #n ice guard DC current (1 < n <= 10)	SHORT	amp.	0-32	0.977×10^{-3} (32/2^{15})

5.7 Navigation System Data

Table 5.7-1. Navigation System Data CAN Identifiers

CAN Identifier	Navigation System Parameter Name	Data Type	Units	Range	Resolution
1000 ($3E8)	Active nav system waypoint latitude	LONG	deg	-90 to +90 Service code field contains waypoint #	4.191×10^{-8} (90/2^{31})
1001 ($3E9)	Active nav system waypoint longitude	LONG	deg	-180 to +180 Service code field contains waypoint #	8.382×10^{-8} (180/2^{31})
1002 ($3EA)	Active nav system waypoint height above ellipsoid	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 (131,072/2^{17})
1003 ($3EB)	Active nav system waypoint altitude	VARIABLE3 18-BIT Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 (131,072/2^{17})
1004 ($3EC)	Active nav system ground speed (GS)	SHORT	Nm/hr	0-1024 Service code field contains waypoint #	0.03125 (1024/2^{15})
1005 ($3ED)	Active nav system true track (TT)	USHORT	deg	0-360 Service code field contains waypoint #	0.005493 (360/2^{16}-1)
1006 ($3EE)	Active nav system magnetic track (MT)	USHORT	deg	0-360 Service code field contains waypoint #	0.005493 (360/2^{16}-1)

Table 5.7-1. Navigation System Data CAN Identifiers (Continued)

CAN Identifier	Navigation System Parameter Name	Data Type	Units	Range	Resolution
1007 ($3EF)	Active nav system cross track error (XTK)	VARIABLE3 24-bit Signed Integer	Nm	+/-16,384 Service code field contains waypoint # + is Right	0.002 (16,384/2^{23})
1008 ($3F0)	Active nav system track error angle (TKE)	SHORT	deg	+/-180 +is East Service code field contains waypoint #	0.005493 (180/2^{15})
1009 ($3F1)	Active nav system time-to-go	SHORT	min	0-1440 Service code field contains waypoint #	0.044 (1440/2^{15})
1010 ($3F2)	Active nav system estimated time of arrival (ETA)	SHORT	min	0-1440 Service code field contains waypoint #	0.044 (1440/2^{15})
1011 ($3F3)	Active nav system estimated enroute time (ETE)	SHORT	min	0-1440 Service code field contains waypoint #	0.044 (1440/2^{15})
1012 ($3F4)	NAV waypoint identifier (char 0-3)	ACHAR4		Service code field contains waypoint #	
1013 ($3F5)	NAV waypoint identifier (char 4-7)	ACHAR4		Service code field contains waypoint #	
1014 ($3F6)	NAV waypoint identifier (char 8-11)	ACHAR4		Service code field contains waypoint #	
1015 ($3F7)	NAV waypoint identifier (char 12-15)	ACHAR4		Service code field contains waypoint #	
1016 ($3F8)	NAV waypoint type identifier	LONG SHORT		Service code field contains waypoint #	
1017 ($3F9)	NAV waypoint latitude	LONG	deg	-90 to +90 + is North Service code field contains waypoint #	4.191×10^{-8} (90/2^{31})

Table 5.7-1. Navigation System Data CAN Identifiers (Continued)

CAN Identifier	Navigation System Parameter Name	Data Type	Units	Range	Resolution
1018 ($3FA)	NAV waypoint longitude	LONG	deg	-180 to +180 + is to East Service code field contains waypoint #	8.382×10^{-8} ($180/2^{31}$)
1019 ($3FB)	NAV waypoint minimum altitude	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 ($131{,}072/2^{17}$)
1020 ($3FC)	NAV waypoint minimum flight level	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 ($131{,}072/2^{17}$)
1021 ($3FD)	NAV waypoint minimum radar height	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 ($131{,}072/2^{17}$)
1022 ($3FE)	NAV waypoint minimum height above ellipsoid	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 ($131{,}072/2^{17}$)
1023 ($3FF)	NAV waypoint maximum altitude	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 ($131{,}072/2^{17}$)
1024 ($400)	NAV waypoint maximum flight level	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 ($131{,}072/2^{17}$)
1025 ($401)	NAV waypoint maximum radar height	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 ($131{,}072/2^{17}$)
1026 ($402)	NAV waypoint maximum height above ellipsoid	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 ($131{,}072/2^{17}$)

Table 5.7-1. Navigation System Data CAN Identifiers (Continued)

CAN Identifier	Navigation System Parameter Name	Data Type	Units	Range	Resolution
1027 ($403)	NAV waypoint planned altitude	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 (131,072/2^{17})
1028 ($404)	NAV waypoint planned flight level	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 (131,072/2^{17})
1029 ($405)	NAV waypoint planned radar height	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 (131,072/2^{17})
1030 ($406)	NAV waypoint planned height above ellipsoid	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 (131,072/2^{17})
1031 ($407)	Distance to NAV waypoint	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072 Service code field contains waypoint #	1 (131,072/2^{17})
1032 ($408)	Time-to-go to NAV waypoint	SHORT	min	0-1440 Service code field contains waypoint #	0.044 (1440/2^{15})
1033 ($409)	NAV waypoint estimated time of arrival (ETA)	SHORT	min	0-1440 Service code field contains waypoint #	0.044 (1440/2^{15})
1034 ($40A)	NAV waypoint estimated enroute time (ETE)	SHORT	min	0-1440 Service code field contains waypoint #	0.044 (1440/2^{15})
1035 ($40B)	NAV waypoint status information	BLONG BSHORT	User Defined	service code field contains waypoint #	
1036 ($40C)	GPS aircraft latitude	LONG	deg	-90 to +90 + is North	4.191×10^{-8} (90/2^{31})
1037 ($40D)	GPS aircraft longitude	LONG	deg	-180 to +180 + is East	$8.382\text{x}10^{-8}$ (180/2^{31})

Table 5.7-1. Navigation System Data CAN Identifiers (Continued)

CAN Identifier	Navigation System Parameter Name	Data Type	Units	Range	Resolution
1038 ($40E)	GPS aircraft height above ellipsoid	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072	1 (131,072/2^{17})
1039 ($40F)	GPS ground speed (GS)	SHORT	nm/hr	0-1024	0.03125 (1024/2^{15})
1040 ($410)	GPS true track (TT)	USHORT	deg	0-360	0.005493 (360/2^{16}-1)
1041 ($411)	GPS magnetic track (MT)	USHORT	deg	0-360	0.005493 (360/2^{16}-1)
1042 ($412)	GPS cross track error (XTK)	VARIABLE3 24-bit Signed Integer	nm	+/-16,384 + is Right	0.002 (16,384/2^{23})
1043 ($413)	GPS track error angle (TKE)	SHORT	deg	+/-180 + is toward East	0.005493 (180/2^{15})
1044 ($414)	GPS glideslope deviation	SHORT	ft	+/-4096 + is above	0.125 (4096/2^{15})
1045 ($415)	GPS predicted RAIM	ULONG USHORT			
1046 ($416)	GPS vertical figure of merit	VARIABLE3 18-bit Signed Integer	ft	0-32,768 Always Positive	0.024932 (32,768/2^{17})
1047 ($417)	GPS horizontal figure of merit	VARIABLE3 18-bit Signed Integer	ft	32,768 Always Positive	0.024932 (32,768/2^{17})
1048 ($418)	GPS mode of operation	SHORT			
1049 ($419)	INS aircraft latitude	LONG	deg	-90 tp +90 + is North	4.191x10^{-8} (90/2^{31})
1050 ($41A)	INS aircraft longitude	LONG	deg	-180 to +180 + is East	8.382x10^{-8} (180/2^{31})
1051 ($41B)	INS aircraft height above ellipsoid	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072	1 (131,072/2^{17})
1052 ($41C)	INS aircraft ground speed (GS)	SHORT	nm/hr	0-1024	0.03125 (1024/2^{15})
1053 ($41D)	INS aircraft true track (TT)	USHORT	deg	0-360	0.005493 (360/2^{16}-1)
1054 ($41E)	INS aircraft magnetic track (MT)	USHORT	deg	0-360	0.005493 (360/2^{16}-1)

Table 5.7-1. Navigation System Data CAN Identifiers (Continued)

CAN Identifier	Navigation System Parameter Name	Data Type	Units	Range	Resolution
1055 ($41F)	INS aircraft cross track error (XTK)	VARIABLE3 24-bit Signed Integer	Nm	+/-16,384 + is Right	0.002 (16,384/2^{23})
1056 ($420)	INS aircraft track error angle (TKE)	SHORT	deg	+/-180 + is toward East	0.005493 (180/2^{15})
1057 ($421)	INS vertical figure of merit	VARIABLE3 18-bit Signed Integer	ft	0-32,768 Always Positive	0.024932 (32,768/2^{17})
1058 ($422)	INS horizontal figure of merit	VARIABLE3 18-bit Signed Integer	ft	0-32,768 Always Positive	0.024932 (32,768/2^{17})
1059 ($423)	Auxiliary nav system aircraft latitude	LONG	deg	-90 to +90 + is North	4.191 x 10^{-8} (90/2^{31})
1060 ($424)	Auxiliary nav system aircraft longitude	LONG	deg	-180 to +180 + is East	8.382x10^{-8} (180/2^{31})
1061 ($425)	Auxiliary nav system aircraft height above ellipsoid	VARIABLE3 18-bit Signed Integer	ft	-4095 to 131,072	1 (131,072/2^{17})
1062 ($426)	Auxiliary nav system aircraft ground speed (GS)	SHORT	nm/hr	0-1024	0.03125 (1024/2^{15})
1063 ($427)	Auxiliary nav system aircraft true track (TT)	USHORT	deg	0-360	0.005493 (360/2^{16}-1)
1064 ($428)	Auxiliary nav system aircraft magnetic track (MT)	USHORT	deg	0-360	0.005493 (360/2^{16}-1)
1065 ($429)	Auxiliary nav system aircraft cross track error (XTK)	VARIABLE3 24-bit Signed Integer	nm	+/-16,384 + is Right	0.002 (16,384/2^{23})
1066 ($42A)	Auxiliary nav system aircraft track error angle (TKE)	SHORT	deg	+/-180 + is toward East	0.005493 (180/2^{15})
1067 ($42B)	Auxiliary nav system vertical figure of merit	VARIABLE3 18-bit Signed Integer	ft	0-32,768 Always Positive	0.024932 (32,768/2^{17})

Table 5.7-1. Navigation System Data CAN Identifiers (Continued)

CAN Identifier	Navigation System Parameter Name	Data Type	Units	Range	Resolution
1068 ($42C)	Auxiliary nav system horizontal figure of merit	VARIABLE3 18-bit Signed Integer	ft	32,768 Always Positive	0.024932 (32,768/2^{17})
1069 ($42D)	Magnetic heading (MH)	USHORT	deg	0-360	0.005493 (360/2^{16}-1)
1070 ($42E)	Radio Height	SHORT	ft	-4095 to 32,768	1 32,768/2^{15})
1071 - 1074 ($42F - $432)	DME #n distance (1 < n <= 4)	SHORT	nm	0-1024	0.03125 (1024/2^{15})
1075 - 1078 ($433 - $436)	DME #n time-to-go (1 < n <= 4)	SHORT	min	0-1440	0.04395 (1440/2^{15})
1079 - 1082 ($437 - $43A)	DME #n ground speed (1 < n <= 4)	SHORT	nm/hr	0-1024	0.03125 (1024/2^{15})
1083 – 1086 ($43B - $43E)	ADF #n bearing (1 < n <= 4)	USHORT	deg	0-360	0.005493 (360/2^{16}-1)
1087 - 1090 ($43F - $442)	ILS #n localize deviation (1 < n <= 4)	SHORT	deg	-90 to +90 + is Right	0.002747 (90/2^{15})
1091 - 1094 ($443 - $446)	ILS #n glideslope deviation (1 < n <= 4)	SHORT	ft	+/-4096 + is above	0.125 (4096/2^{15})
1095 - 1096 ($446 - $447)	Flight director #n pitch deviation (1 < n <= 2)	SHORT	deg	+/-180 + is Nose Up	0.005493 (180/2^{15})
1097 - 1098 ($448 - $449)	Flight director #n roll deviation (1 < n <= 2)	SHORT	deg	+/-180 + is RT Wing Down	0.005493 (180/2^{15})
1099 ($44A)	Decision height	SHORT	ft	0-2048 AGL	0.0625 2048/2^{15})
1100 - 1103 ($44B - $44F)	VHF #n COM frequency (0 < n < 4)	ACHAR4	MHz		

Table 5.7-1. Navigation System Data CAN Identifiers (Concluded)

CAN Identifier	Navigation System Parameter Name	Data Type	Units	Range	Resolution
1104 - 1107 ($450 - $453)	VOR/ILS #n frequency (1 < n <= 4)	ACHAR4	MHz		
1108 - 1111 ($454 - $457)	ADF #n frequency (1 < n <= 4)	ACHAR4	KHz		
1112 - 1115 ($458 - $45B)	DME #n channel (1 < n <= 4)	ACHAR4			
1116 - 1119 ($45C - $45F)	Transponder #n code (1 < n <= 4)	ACHAR4			
1120 ($460)	Desired track angle	SHORT	deg	+/-180 + is toward East	0.005493 ($180/2^{15}$)
1121 ($461)	Magnetic variation	SHORT	deg	+/-180 + is toward East	0.005493 ($180/2^{15}$)
1122 ($462)	Selected glidepath angle	SHORT	deg	0-32	0.9765×10^{-3} ($32/2^{15}$)
1123 ($463)	Selected runway heading	USHORT	deg	0-360	0.005493 ($360/2^{16}$-1)
1124 ($464)	Computed vertical velocity	FLOAT SHORT2	ft/min	-32,767 to +32,768	1 32,768/2^{15})
1125 ($465)	Selected course	USHORT	deg	0-360	0.005493 ($360/2^{16}$-1)
1126 - 1129 ($466 - $469)	VOR #n radial (1 < n <= 4)	USHORT	deg	0-360	0.005493 ($360/2^{16}$-1)

5.8 Landing Gear System Data

Table 5.8-1. Landing Gear System Data CAN Identifiers

CAN Identifier	Landing Gear System Parameter Name	Data Type	Units	Range	Resolution
1175 ($497)	Gear lever switches	BLONG	User defined		
1176 ($498)	Gear lever lights/ WOW solenoid	BLONG	User defined		
1177 - 1180 ($499 - $49C)	Landing gear #n tire pressure (1 < n <= 4)	SHORT	PSIG	0-256 Service code field contains tire number	0.008 ($256/2^{15}$)
1181 - 1184 ($49D - $4A0)	Landing gear #n brake pad thickness (1 < n <= 4)	SHORT	In	0-2 Service code field contains brake pad number	61.04×10^{-6} ($2/2^{15}$)

5.9 Miscellaneous Data

Table 5.9-1. Miscellaneous Data

CAN Identifier	Miscellaneous Parameter Name	Data Type	Units	Range	Resolution
1200 ($4B0)	UTC	CHAR4		Format: 13h43min22s 13 43 22 00	
1201 ($4B1)	Cabin pressure	SHORT	PSIA	0-16	0.000488 ($16/2^{15}$)
1202 ($4B2)	Cabin altitude	SHORT	ft	-4095-32768	1 ($32{,}768/2^{15}$)
1203 ($4B3)	Cabin temperature	SHORT	°C	-64 to +64	0.001953 ($64/2^{15}$)
1204 ($4B4)	Longitudinal center of gravity	SHORT	% MAC	-512 to +512 + Forward CG	0.001953 ($64/2^{15}$)
1205 ($4B5)	Lateral center of gravity	SHORT	% MAC	-512 to +512 + Right of CG	0.001953 ($64/2^{15}$)
1206 ($4B6)	Date	CHAR4		Format: 12. June 1987 12 06 19 87	

5.10 Native Format Message Channels

Several types of messages must be exchanged with the National Airspace System (NAS) and other aircraft. These include Controller Pilot Data Link Communications

(CPDLC), Differential GPS (DGPS), Automatic Dependent Survelliance - Broadcast (ADS-B), Flight Information Services (FIS), and Traffic Information Services. In each NAS function above, the messages exchanged are greater than the 4-byte payload typically exchanged between on-board avionics. To accommodate these larger messages, the Native Message Format Channels are used and implemented via the Data Download Service (DDS), described in Section 4.3. A native format message is simply the multibyte native format message being treated as a small file. Since the messages can be dozens of bytes in length, the DDS is used over a dedicated channel to simply transfer the native format message as if it were a data file. Table 5.10-1 describes the native format message channels. Note that they are grouped near other messages of similar importance/priority.

Table 5.10-1. Native Format Message Channels

Channel	DDS Request CAN-ID	DDS Response CAN-ID
CPDLC	398	399
DGPS	1140	1141
ADS-B	1150	1151
FIS-B	1300	1301
TIS-B	1302	1303

The above data links include receive-only and transmit/receive configurations. For example, the CPDLC data link is used to exchange messages between the aircraft and Air Traffic control, while the Federal Aviation Administration (FAA) approved weather data link, FIS-B, is a receive-only system. The channel concept can accommodate both types of data links by allowing all relevant nodes to use the channel. For example, a typical CPDLC configuration may consist of a node that contains a CPDLC transceiver and a node that contains a display with a pilot input device. Upon receipt of an error-free CPDLC message from ATC, the transceiver node will send the message to the display node via the CPDLC channel. Message data would be transmitted to the display node on CAN-ID 398 while the xon/xoff flow control and acknowledgement of the data by the display node are transmitted on CAN-ID 399. If the pilot were to acknowledge the ATC message via the pilot input device, the display node would transmit this CPDLC message on the CPDLC channel (CAN-ID 398) to the CPDLC transceiver for transmission. The CPDLC data link transceiver node would transmit the xon/xoff flow control and acknowledgment to the display node via CAN-ID 399.

5.11 Reserved CAN Identifiers

Table 5.11-1. Reserved CAN Identifiers

CAN Identifier	Parameter Name	Data Type	Units	Notes
1300 - 1499 ($514 - $577)	Reserved for future use			

6 Time-Triggered Bus Scheduling

For most installations, the nodes can transmit messages without being synchronized. Bandwidth is adequate for most systems applications and data latency is minimal. The designer should simulate and test the configuration for adequate performance. When data latency cannot be tolerated, a time-triggered bus scheduling design can be implemented with the AGATE Databus. This section describes a sample avionics system for a general aviation aircraft and the resulting AGATA Databus bus implementation. The purpose of this example is to serve as a guideline for the evaluation of system requirements, AGATE Databus bus load, and transmission rates based on the basic systems installed in modern technology general aviation aircraft.

6.1 Baseline System

The baseline system reflects the avionics system as installed in a IFR-equipped single engine general aviation aircraft using flat panel primary flight and navigation displays. This architecture was chosen as an example of a modern instrument panel. This example was kept simple to better serve its purpose as explanatory example. The avionics on the CAN bus are shown in Table 6.1-1.

Table 6.1-1. Example of Baseline System Avionics Components

CANaerospace Node-ID	System Description
1	Attitude/heading reference system (AHRS)
2	Air data computer (ADC)
3	VHF communication transceiver #1
4	VHF communication transceiver #2
5	NAV/ILS/Marker receiver #1
6	NAV/ILS/Marker receiver #2
7	ATC transponder
8	ADF receiver
9	GPS receiver
10	Distance measuring equipment (DME)
11	Engine monitoring system (EMS)
12	Electrical trim system
13	Electric system

To determine the bus schedule, it will be assumed that the maximum transfer rate of parameters is 80Hz (12.5ms). Data can be transmitted at a higher rate but this would make no sense unless there is equipment installed which can make use of this.

6.2 The Transmission Slot Concept

The concept of the time-triggered bus scheduling uses a “minor time frame” (12.5ms in this implementation) and takes advantage of the fact that not all messages in a given system have to be transmitted at this interval. Specifying multiples of the minor time frame transmission interval and associated “transmission slots” allow a substantially larger number of parameters to be transmitted on a single bus. The frequency of each transmission slot is shown in Table 6.2-1.

Table 6.2-1. Transmission Slot Frequency and Identification

Transmission Interval	Parameters/ Transmission Slot	Number of Transmission Slots (equalling 100% bus load)	Transmission Slot Identification
12.5ms (80Hz)	1	100	A0 - A99
25ms (40Hz)	2	200	B0[0] - B99[1]
50ms (20Hz)	4	400	C0[0] - C99[3]
100ms (10Hz)	8	800	D0[0] - D99[7]
200ms (50Hz)	16	1600	E0[0] - E99[15]
400ms (2.5Hz)	32	3200	F0[0] - F99[31]
1000ms (1.0Hz)	80	8000	G0[0] - G99[79]

With this transmission slot concept, either 100 parameters transmitted each 12.5ms or 8000 parameters transmitted once a second would generate 100% bus load. Note that there are 8000 transmit opportunities per second (125uS per message) and 100 transmit opportunities during each 12.5 ms interval. More likely, however, a combination of parameters in the various transmission slot groups from this table (A-G) will be used. For our baseline system, we identified the following data and assigned them the transmission slot groups A, D and G as shown in Table 6.2-2.

Table 6.2-2. Example Time Slot Allocation for Baseline System Example

Tx Slot	Parameter Name	Unit	Trans-mission Interval	CAN-ID	Data Type
A0	Body longitudinal acceleration	g	12.5ms	300 ($12C)	FLOAT
A1	Body lateral acceleration	g	12.5ms	301 ($12D)	FLOAT
A2	Body normal acceleration	g	12.5ms	302 ($12E)	FLOAT
A3	Body pitch rate	deg/s	12.5ms	303 ($12F)	FLOAT
A4	Body roll rate	deg/s	12.5ms	304 ($130)	FLOAT
A5	Body yaw rate	deg/s	12.5ms	305 ($131)	FLOAT

Table 6.2-2. Example Time Slot Allocation for Baseline System Example (Continued)

Tx Slot	Parameter Name	Unit	Trans-mission Interval	CAN-ID	Data Type
A6	Body pitch angle	deg	12.5ms	311 ($137)	FLOAT
A7	Body roll angle	deg	12.5ms	312 ($138)	FLOAT
A8	Heading angle	deg	12.5ms	321 ($141)	FLOAT
D0[0]	Altitude rate	ft/m	100ms	314 ($13A)	FLOAT
D0[1]	True airspeed	kts	100ms	316 ($13C)	FLOAT
D0[2]	Computed (calibrated) airspeed	kts	100ms	317 ($13D)	FLOAT
D0[3]	Baro correction	in. Hg	100ms	319 ($13F)	FLOAT
D0[4]	Baro corrected altitude	ft	100ms	320 ($140)	FLOAT
D0[5]	Standard altitude	ft	100ms	322 ($142)	FLOAT
D0[6]	Lateral stick trim position command	%	100ms	402 ($192)	FLOAT
D0[7]	Longitudinal stick trim position command	%	100ms	405 ($195)	FLOAT
D1[0]	Engine RPM	1/min	100ms	500 ($1F4)	FLOAT
D1[1]	Propeller RPM	1/min	100ms	504 ($1F8)	FLOAT
D1[2]	Engine exhaust gas temperature (EGT)	°C	100ms	520 ($208)	FLOAT
D1[3]	Engine fuel flow rate	Gal/hr	100ms	524 ($20C)	FLOAT
D1[4]	Engine manifold pressure	in. Hg	100ms	528 ($210)	FLOAT
D1[5]	Engine oil pressure	in. Hg	100ms	532 ($214)	FLOAT
D1[6]	Engine oil temperature	°C	100ms	536 ($218)	FLOAT
D1[7]	Engine cylinder head temperature (CHT)	°C	100ms	540 ($21C)	FLOAT
D2[0]	Fuel tank #1 quantity	gal	100ms	668 ($29C)	FLOAT
D2[1]	Fuel tank #2 quantity	gal	100ms	669 ($29D)	FLOAT

Table 6.2-2. Example Time Slot Allocation for Baseline System Example (Continued)

Tx Slot	Parameter Name	Unit	Trans-mission Interval	CAN-ID	Data Type
D2[2]	Fuel system pressure	PSIG	100ms	684 ($2AC)	FLOAT
D2[3]	DC voltage	V	100ms	920 ($398)	FLOAT
D2[4]	DC current	A	100ms	930 ($3A2)	FLOAT
D2[5]	GPS height above ellipsoid	ft	100ms	1030 ($40E)	FLOAT
D2[6]	GPS aircraft latitude	deg	100ms	1036 ($40c)	FLOAT
D2[7]	GPS aircraft longitude	deg	100ms	1037 ($40D)	FLOAT
D3[0]	GPS ground speed	kts	100ms	1039 ($40F)	FLOAT
D3[1]	GPS true track	deg	100ms	1040 ($410)	FLOAT
D3[2]	DME distance	nm	100ms	1071 ($42F)	FLOAT
D3[3]	DME time-to-station	Min	100ms	1075 ($433)	FLOAT
D3[4]	DME ground speed	kts	100ms	1079 ($437)	FLOAT
D3[5]	ILS #1 localizer deviation	deg	100ms	1087 ($43F)	FLOAT
D3[6]	ILS #2 localizer deviation	deg	100ms	1088 ($440)	FLOAT
D3[7]	ILS #1 glideslope deviation	deg	100ms	1091 ($443)	FLOAT
D4[0]	ILS #2 glideslope deviation	deg	100ms	1092 ($444)	FLOAT
D4[1]	VOR #1 radial	deg	100ms	1126 ($466)	FLOAT
D4[2]	VOR #2 radial	deg	100ms	1127 ($467)	FLOAT
D4[3]	ADF #1 relative bearing	deg	100ms	1083 ($43B)	FLOAT
G0[0]	Static air temperature	°C	1s	324 ($144)	FLOAT
G0[1]	Trim system switches		1s/ event	439 ($1B7)	BSHORT
G0[2]	Trim system lights		1s/ event	440 ($1B8)	BSHORT
G0[3]	Engine status		1s/ event	556 ($22C)	BSHORT

Table 6.2-2. Example Time Slot Allocation for Baseline System Example (Concluded)

Tx Slot	Parameter Name	Unit	Transmission Interval	CAN-ID	Data Type
G0[4]	VHF COM #1 frequency	MHz	1s/ event	1100 ($44B)	FLOAT
G0[5]	VHF COM #2 frequency	MHz	1s/ event	1101 ($44C)	FLOAT
G0[6]	Transponder #1 code	BCD	1s/ event	1116 ($45C)	FLOAT
G0[7]	ADF #1 frequency	kHz	1s/ event	1108 ($454)	FLOAT
G0[8]	VOR/ILS #1 frequency	MHz	1s/ event	1104 ($450)	FLOAT
G0[9]	VOR/ILS #2 frequency	MHz	1s/ event	1105 ($451)	FLOAT

A transmission interval of “1s/event” means that the respective parameter is transmitted once upon every state change and additionally once a second if the state is unchanged. Analyzing the “Tx Slot” fields, we find out that our baseline system requires nine parameters to be transmitted each 12.5ms, 32 parameters to be transmitted each 100ms and 10 parameters to be transmitted once a second. This results in the transmission slot allocation shown in Figure 6.2-1.

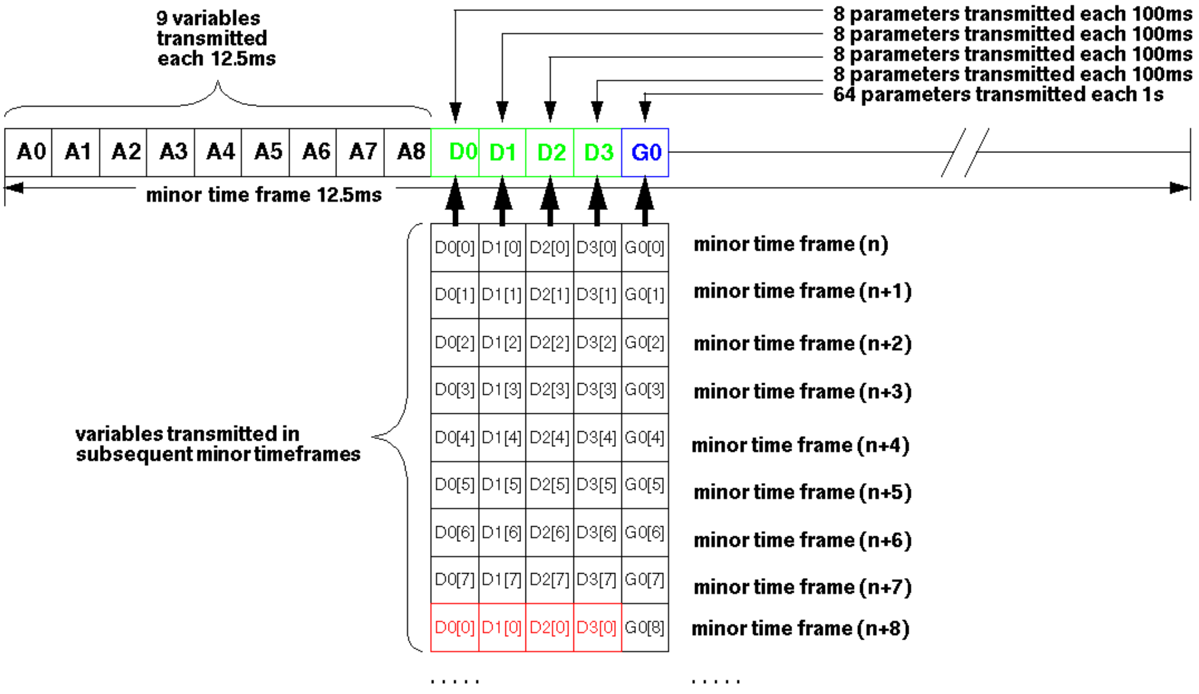


Figure 6.2-1. Timing Diagram for Baseline System Example

6.3 Bus Load Computation

The CAN bus data frame (11-bit identifier) is shown in Figure 6.3-1.

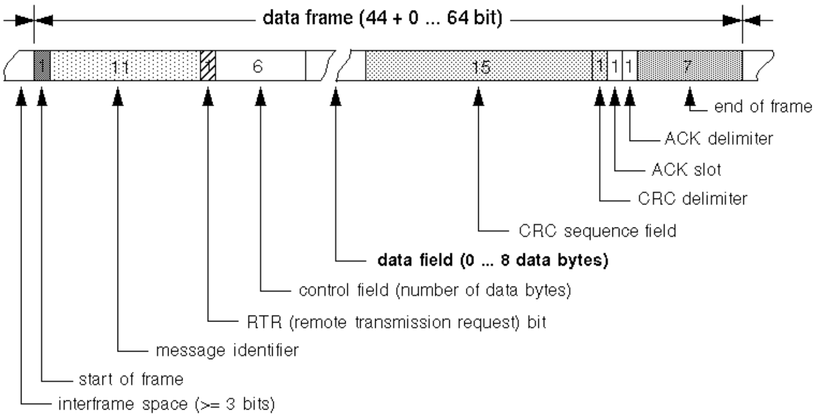


Figure 6.3-1. CAN Bus Frame Description

Most AGATE Databus messages use all 8 bytes of the data field which results in a message length of 44bits + 64bits = 108bits. To compute the maximum bus capacity, we have to add the interframe space (3-bits) and a number of stuff bits (a maximum of an additional 18-bits, we assume an average of 14-bits) which gives a message length of 108-bits + 3-bits + 14-bits = 125-bits. Assuming the maximum data transfer rate of 1Mbit/s, a CANaerospace message takes 125µs to transmit. Hence, the data bus capacity is 8,000 messages/second.

Defining a minor time frame of 12.5ms (80Hz) results in 100 parameters which can be transmitted during this interval. This number can be considered 100% bus load as shown in Table 6.3-1.

Table 6.3-1. Bus Loading Parameters

CANaerospace message time	125µs
Selected minor time frame	12.5ms
100% bus load	12.5ms/125µs = 100 messages

For 29-bit identifier CAN messages (CAN 2.0B), the message time is 145µs, which results in 16% less bus capacity than for 11-bit identifier CAN messages. If both 11-bit and 29-bit messages are used at the same time, the calculation should be done for each identifier type separately and combined afterwards to assemble the resulting bus schedule data. The baseline system example uses the parameter/transmission interval matrix shown in Table 6.3-2.

Table 6.3-2. Parameter/Transmission Matrix for the Baseline System Example

Transmission Interval	Parameters	Required Transmission Slots	Parameters/ Transmission Slot
12.5 mS	9	9	1
100 mS	36	5 (4.5)	8 (0.1s/12.5*10^{-3}s)
1 s	10	1 (0.125)	80 (1s/12.5*10^{-3}s)
Total			

As the baseline system uses 13.625 out of 100 available transmission slots, the corresponding bus load is: 13.625%

Keeping in mind that asynchronous event data or node service data might require additional bus capacity, some margin should be reserved for this (around 15%). Therefore, systems with more nodes than used in this example should not continuously exceed 85% bus load, allowing for the 15% reserve for asynchronous event or node service data.

7 System Redundancy Support

The probability of an undetected data corruption in a CAN network is approximately 1 * 10-13 per message transmission. Assuming 100% bus load (around 8,000 messages per second), this will result in a probability of 2.9 x 10^{-6} undetected failures per flight hour, making the AGATE data bus a candidate for mission and flight critical systems.

While this figure is better than for any other bus system available today, it shows that a single bus (like all other buses) will most likely not be adequate for flight critical systems, especially for those requiring fail-operational behaviour. For those applications, system redundancy is inevitable to demonstrate a required level of functional safety.

7.1 Redundant Message Identifier Assignment

A system architecture as used by many modern integrated avionics and electronic flight control systems is shown in Figure 7.1-1. In this architecture, two redundant units of the same type communicate via an equal number of communication channels. Proper design provided, this system will prevent a single failure to cause a complete loss of function.

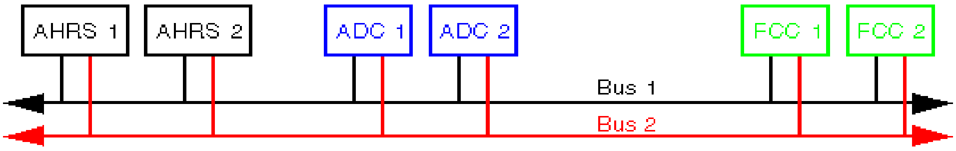


Figure 7.1-1. Redundant Avionics Architecture

Using the standard identifier distribution, each AGATE data bus parameter has assigned a single, unique identifier (e.g. 304 for body roll rate). This means that only one unit (e.g. AHRS1) would be allowed to transmit a particular parameter on the bus. The AGATE data bus standard provides CAN-IDS for redundant avionics with a few exceptions. To add a new or redundant avionics, the designer has several options. The first would be to define a new message for an unused CAN-ID. For high priority functions, e.g., a second attitude gyro, the User Data High CAN-IDS could be used in the range of 200-299. Or, as redundant functions, new messages could be inserted in the first unused CAN-ID in the Normal Operating Data (NOD) range of 300-1799. Using the NOD CAN-IDSIds??? would allow the new messages to be grouped with similar avionics of comparable priority. The designer should endeavor to use the same message format/type used by the primary function to help ensure interoperability.

A second approach to a redundant system architecture is supported by the AGATE data bus, if the 29-bit identifiers are used. In this case, a “redundancy level offset” value of 10000 is added to each identifier so that the same parameter can be transmitted by several units using multiple unique identifiers as shown in Table 7.1-1.

Table 7.1-1. Redundancy Level Offset for Redundant Avionics

Redundancy Channel	**Redundancy Level Offset**	**Example:** **Body Roll Rate ID**
1	0	304 (AHRS1)
2	10000	10304 (AHRS2)
3	20000	20304 (AHRS3)
4	30000	30304 (AHRS4)
n	10000 * (n-1)	(n-1)0304 (AHRSn)

7.2 System Redundancy and the AGATE data bus

Unlike other buses like ARINC429, ARINC629 or MIL-STD-1553B, the AGATE data bus is a dynamic network with a bus schedule that varies within certain limits. Certification in flight safety critical applications, however, requires the applicant to demonstrate the proper function of the data transmission under all conditions. Monitoring AGATE data bus messages during normal operation and processing the header information assists in providing the required information for certification.

Additionally, the header information improves flexibility and supports dynamic network reconfiguration. Power down/up situations are handled gracefully, units may be added to the network without software changes. Taking advantage of the header information, bus analyzers and simulators can be inserted even into a running network and will immediately have all information about network structure, units and data. This ensures fast and cost-effective maintenance. The AGATE data bus header is shown in Figure 7.2-1.

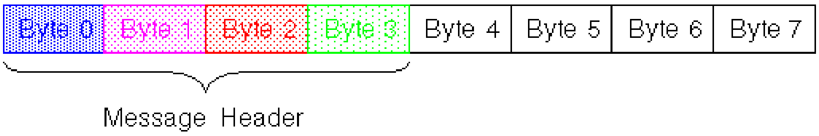


Figure 7.2-1. AGATE Data Bus Message Emphasizing the Header Structure

The header bytes include:

- Node-ID (Byte 0): Some system architectures employ backup units which become active if the main unit fails. The Node-ID allows??? to immediately identify this situation and react accordingly (i.e. mode change within redundancy management).
- Data Type (Byte 1): the AGATE data bus supports multiple data types for every message. Backup units (or units from different vendors) may use different data types while performing identical functions. Specifying the data type with each message allows automatic system configuration, even during runtime.
- Service Code (Byte 2): For Normal Operation Data, this byte should continuously reflect the status of the data (or the transmitting unit) to support data integrity monitoring within receiving units. With this information, the validity of data is known at any given time.
- Message Code (Byte 3): Message numbering allows??? to detect if messages are missing and if the transmitting unit is operating properly. Also, it can be used to compare the "age" of messages from redundant sources.

8 Physical Connector Definition

For the AGATE data bus, a physical connection suitable for airborne connector types has been defined (connectors according to CAN in Industry (CiA) DS102 are also supported). Note that unlike most other definitions for CAN connections, the AGATE data bus connector configurations allow the supply of +28VDC power to the units via the CAN connector (+28VDC, Power Ground). The RS-232 connection present on some of the connector types is optional and may be used for maintenance or debug interfaces. *Note also that the use of CAN Ground is supported by the connector pin-out but strongly discouraged due to potential EMC problems in airborne applications as shown in Figure 8-1.*

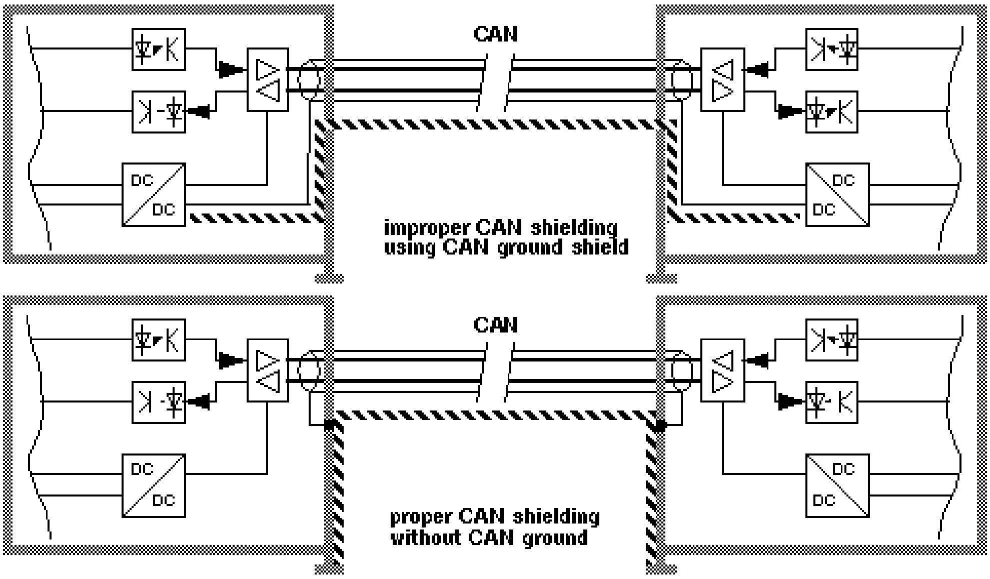


Figure 8-1. CANaerospace Bus Shielding Conventions

Strongly encouraged is the use of optically isolated CAN interfaces for all units in the network. For the wiring, AWG 22 aerospace standard shielded twisted pair (STP) or shielded twisted quadruple (STQ) should be used.

The pinout of the CANaerospace connectors is shown in Figures 8-2 through 8-4.

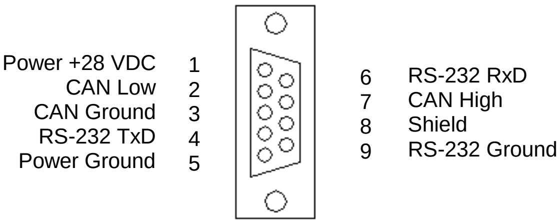
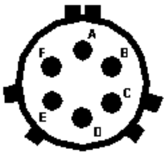
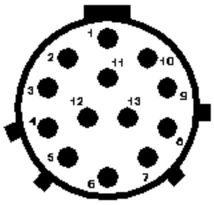


Figure 8-2. MIL-24308/8 connector (similar to CiA DS102)



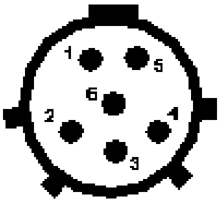
Pin A	Power Ground
Pin B	+28 VDC
Pin C	Shield
Pin D	CAN High
Pin E	CAN Low
Pin F	CAN Ground

Figure 8-3. MIL-C-26482 connectors MS3470L1006PN (wall mount receptacle) and MS3476L1006SN (mating straight plug)



Pin 1	+28 VDC	Pin 6	RS-232 RxD
Pin 2	CAN Low	Pin 7	CAN High
Pin 3	CAN Gnd	Pin 8	Shield
Pin 4	RS-232 TxD	Pin 9	RS-232 Gnd
Pin 5	DC Gnd	Pins 10-13	Unused

Figure 8-4. MIL-C-38999 connectors D38999/20FB35PN (wall mount receptacle) and D38999/26FB35SN (mating straight plug)



Pin 1	+28 VDC
Pin 2	CAN Low
Pin 3	CAN Gnd
Pin 4	CAN High
Pin 5	DC Gnd
Pin 6	Shield

Figure 8-5. MIL-C-38999 connector D38999/20FA35PN (wall mount receptacle) and D38999/26FA35SN (mating straight plug)

A sample interconnection of multiple AGATE data bus systems using D38999/20FB35PN wall mount receptacles and D38999/26FB35SN straight plugs is shown in Figure 8-6.

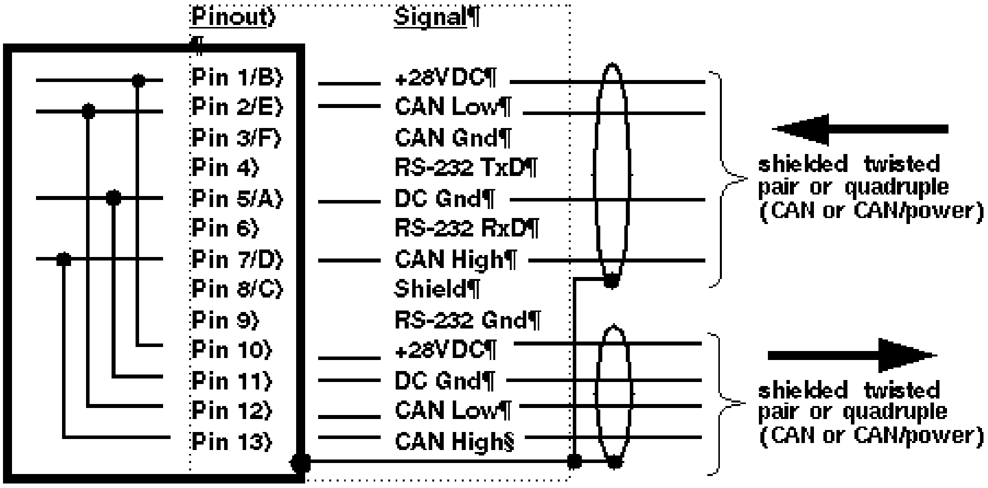


Figure 8-6. Sample Interconnection of Multiple AGATE Databus Avionics

Note: The RS-232 lines defined for this connector type are optional and may be used for device programming, configuration, etc. They have no relationship to CAN or the AGATE data bus.

AGATE data bus systems requiring high reliability or live-insertion capabilities should be connected as shown below. The preferred CAN bus topology is a shielded, twisted pair single line, terminated at both ends. Units are connected via simple stubs within the connector. Transformer coupling can also be used.

Using this method, removing a unit from the bus (or reattaching it) will not adversely affect the others: The bus is not opened by unplugging the connectors as shown in Figure 8-7.

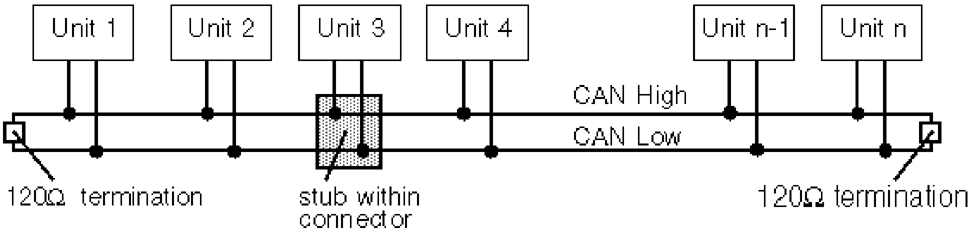


Figure 8-7. CAN Bus Topology for Live Insertion

ANNEX A

Controller Area Network (CAN) Overview

Annex A Controller Area Network Overview

A1 What is the Controller Area Network?

- Two-wire multi-transmitter serial data bus
- Designed by Bosch in 1985 as an automobile network
- No central bus controller required
- Configurable data rate (5k Bits/sec to 1 MBits/sec)
- Bus length 0.2 m to 10,000 m (with linear data reduction)
- Message-oriented transmission
- 2031 unique message identifiers for CAN 2.0A (11-bits)
- >500 x 10^6 unique identifiers for CAN 2.0B (29-bits)
- Point-to-point and broadcast messaging supported
- >200 bus participants

A2 Major Characteristics of CAN

- Effective data through put is 576kBits/sec (1 MBits/sec transmission, bus length less than 40 meters)
- Extremely low probability of undetected data corruption ~ 10^{-13} per message.
- Low chip set costs. Network interfaces available in stand alone configurations and also integrated into popular micro controllers.

A3 The CAN Transmission Frame and Arbitration

The basic data frame for a CAN 2.0A message is provided in Figure A3-1. CAN 2.0 A supports 11-bit identifiers and CAN 2.0B supports 29-bit identifiers. Note that mixed identifier lengths are allowed under CAN 2.0B.

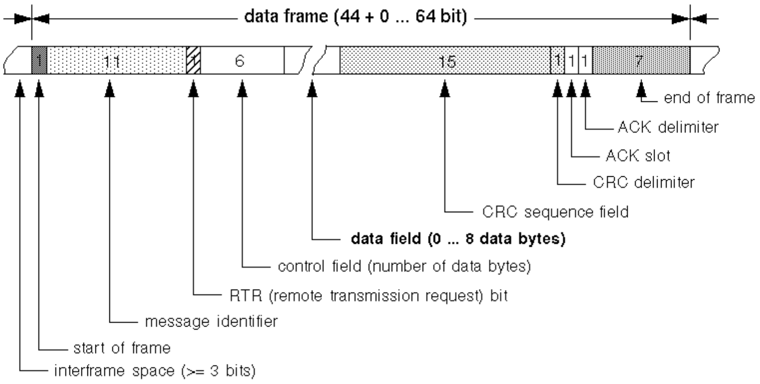


Figure A3-1. CAN2.0A Transmission Frame Format

Shown in Figure A3-1 is the description of the data field (0 – 8 bytes) defined for the AGATE databus standard. These messages are variable in length from a minimum of four bytes (header only) to a maximum of eight bytes. Generally, only one parameter is transmitted in a single message, similar to ARINC 429 label transmissions.

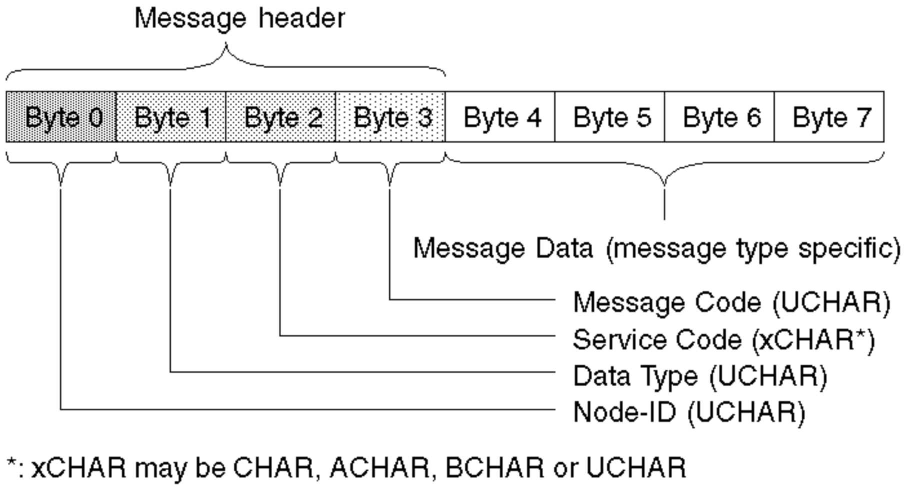


Figure A3-2. AGATE Databus Message Structure

The CAN bus employs a concept called bit-wise arbitration used in resolution of collisions (simultaneous transmission by two or more nodes). This is possible since each message has a unique identifier (11-bit and 29-bit for CAN 2.0A and CAN 2.0B respectively). When designing a system with CAN (like the AGATE databus), messages are allocated to the range of identifiers based on a priority scheme. For example, in the AGATE databus, a Pitch Angle message was assigned to the 11-bit identifier of 311, meaning that to convey the current pitch angle, a gyro would transmit the AGATE data bus message beginning with CAN-ID 311 and would include the current pitch angle in the data payload. Likewise, a lower priority GPS Aircraft Latitude message was assigned an identifier of 1036 with the current GPS latitude in the AGATE databus message structure. Thus, the lower the identifier number, the higher the priority.

When one or more nodes begin to transmit a message simultaneously, each node first transmits the 11-bit identifier. As each bit of the identifier is clocked on the databus, each node “listens” to the information being clocked on to the bus. When a node finally detects that the other identifier is of a higher priority it ceases transmission immediately, allowing the higher priority message to be transmitted. Once the bus is again free, the node wishing to transfer the lower priority message tries again.

Key to the CAN concept is that only one node can transmit a given set of CAN identifiers, e.g. only node 2 can transmit identifier 311 and no other. This convention must be enforced as the bit-wise arbitration would fail (the identifiers are the same) and both nodes would then be free to simultaneously transmit different data payloads thus causing bus errors.