



**Simulation Interoperability
Standards Organization**

"Simulation Interoperability & Reuse through Standards"

Workshop theme for 2019: "Simulation for the Next Generation"

Compressed DIS V1.3

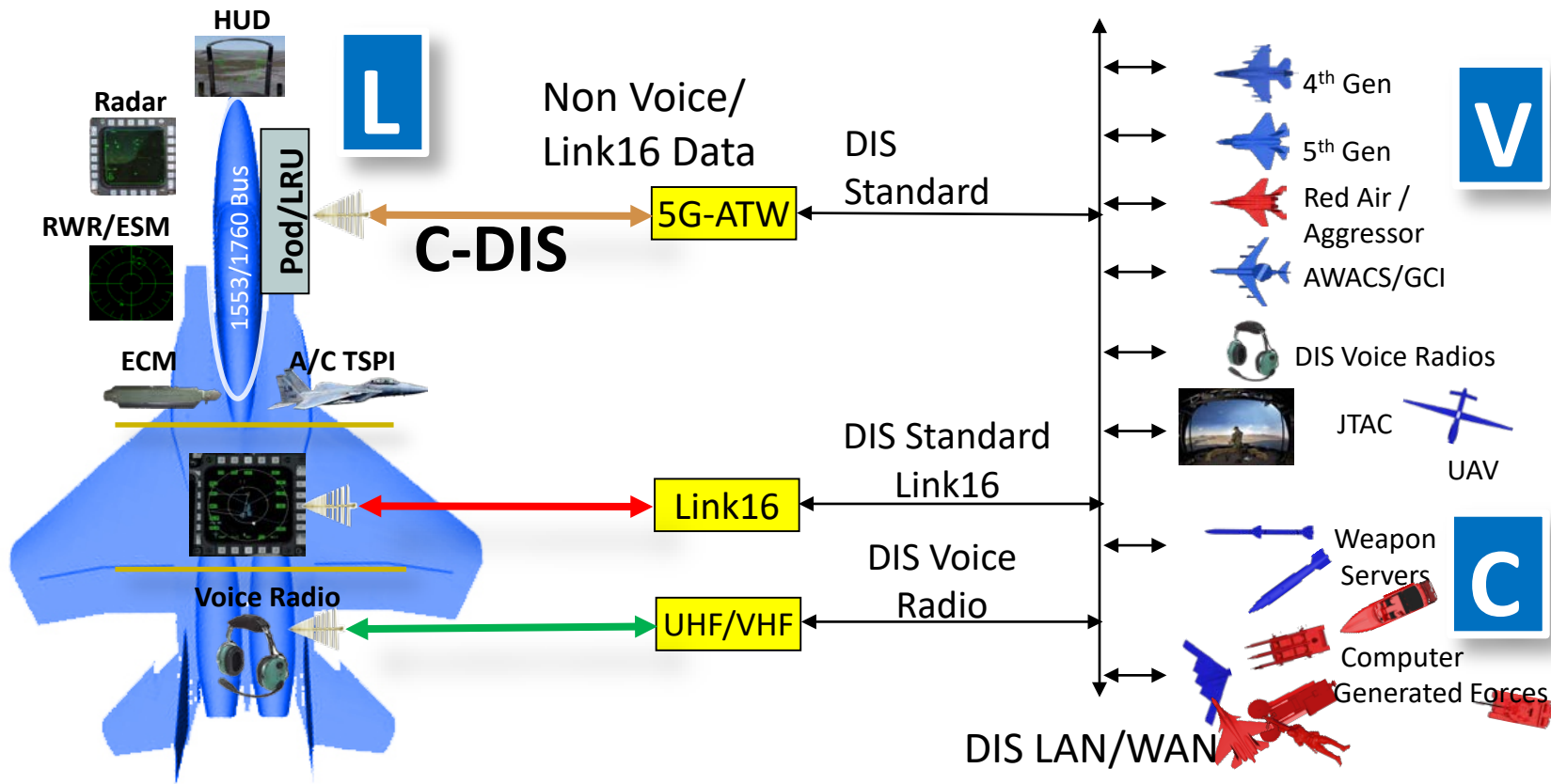
2019-SIW-Presentation-xxx

Lance Call, L3 Technologies – Air Force Research Lab(AFRL), USA





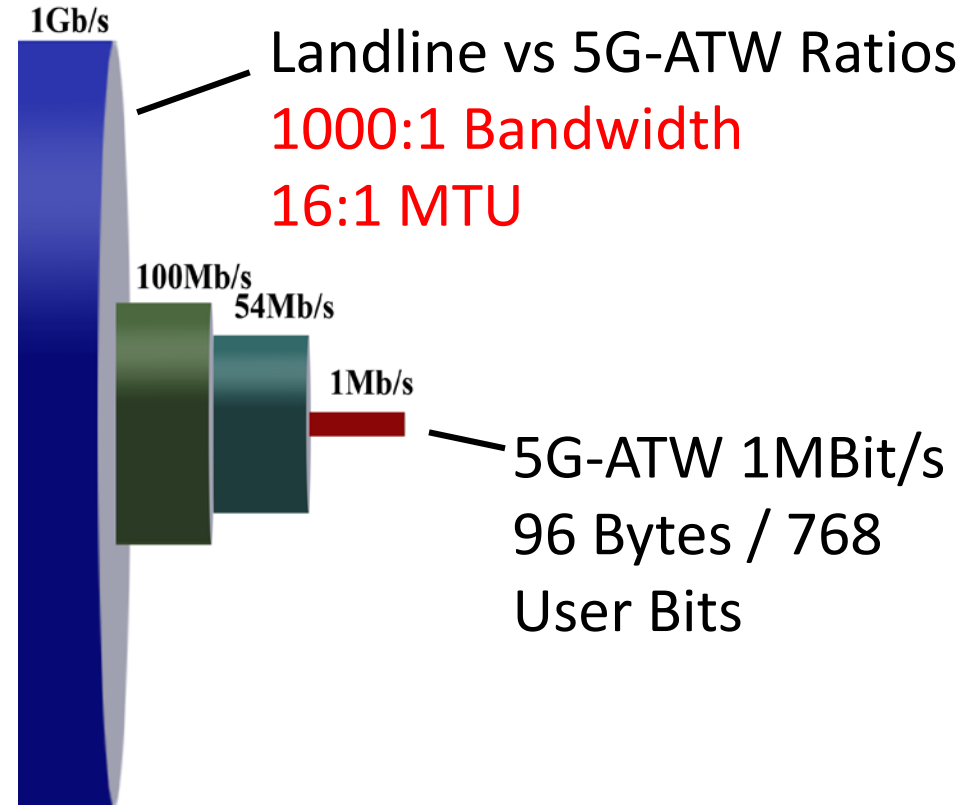
Secure Live Virtual Constructive Advanced Training Environment (SLATE)





Why Bother with Compression?

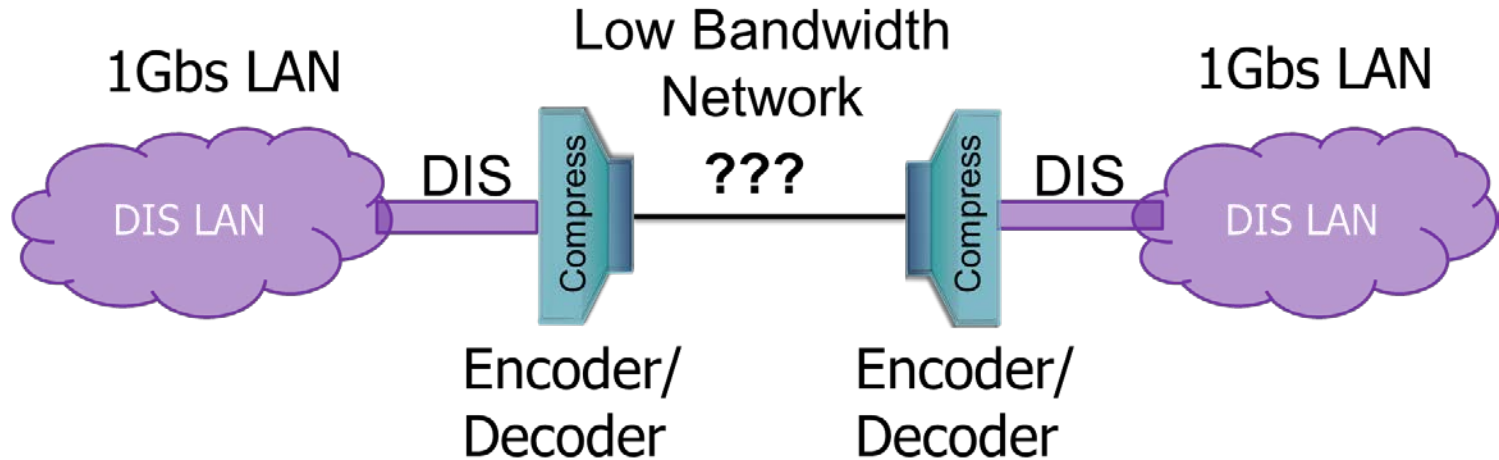
- Long Range Broadcast RF Network Bandwidths are much smaller than Fiber Optic or Wired Networks
- Maximum Transmission Unit (MTU) may be smaller than 1500 bytes/12000 bits typically used for Ethernet MTU





Main Goal

Create a compression scheme to allow connectivity of two standard Distributed Interactive Simulation (DIS) networks that run standard unmodified DIS applications, over a relatively low bandwidth connection, using less bandwidth than standard DIS. Target at least 50% compression.





Alternative Approaches

- **IEEE 1278 Live Entity (LE Information/Interaction Protocol)**
 - Not all DIS Protocol Data Units (PDU's) supported
 - Significant mapping between Entity State and LE Time Space Position Information PDU
- **General Purpose Compression**
 - Lempel-Ziv-Welch, etc
 - Small number of Bits in DIS PDU insufficient for compression ratio desired
 - Required to be Lossless which limits the compression ratio
- **Compressed DIS (C-DIS)**
 - Based on a knowledge of DIS data, required precision and common usage



Status

- C-DIS was first created in 2013 for use in SLATE
- Version C-DIS V1.2 (Implemented in 2014)
- New Proposed Version is C-DIS V1.3 Sept 2017 (~100 pages)
- **Government Non-Proprietary standard that supports**
 - Entity State, Fire, Detonate, Collision, All Simulation Management (SIMAN) PDUs, Emission, Designator, Transmitter, Signal, Receiver, and IFF Layers 1,2,3,4 & 5. Compressed Variable Records in V1.3.
 - Service Request, Resupply, and Reliable PDUs not required for SLATE are not yet supported.
- **Both AFRL and Cubic have implemented C-DIS V1.2 encoder/decoders**
- **C-DIS V1.2 used in SLATE flight test with 16 live aircraft in September 2018 at Nellis, AFB and also at Naval Air Station Patuxent River**





C-DIS Goals

- Maintain existing PDU timing, simplicity, and fidelity
- One-for-one mapping of every DIS field, but compressed
- Direct mapping from DIS to C-DIS and back without complex translations, or new enumerations
- Support all DIS PDU's and Simulation Interoperability Standards Organization (SISO) and Combat Air Forces Distributed Mission Operations (CAF DMO) enumerations
- Compress as much as possible with a target of $\geq 50\%$
- Retain as much precision as possible
- Fit into the 768 bit (96 byte) (*690 bit original estimate) user payload size of the 5th Generation Advanced Tactical Waveform (5G-ATW) network



C-DIS – Compression Techniques

- Make C-DIS a bit-based standard with no byte boundary requirements
- Reduce data field sizes as much as possible
- Remove padding and other unnecessary fields
- Replace floating point with scaled integers or custom Floating points
- Uses Lat/Lon/Alt instead of Geocentric Earth Centered Earth Fixed (ECEF)
- Add bit flags to indicate the presence of seldom used, optional, or non-applicable fields
- Add Units flag if necessary to support a large range of values
- Allow partial updates



Selected Precision / Max Values

Item	Precision	Maximum Value
Position	1 cm/ Dekameters	8388607
Velocity	0.1 m/s	6369 Knots
Acceleration	0.1 m/s/s	83.5 G
Angle	0.0439°	180°, 360°
Angular Velocity	0.35°/s	720°/s
Frequency/ Frequency Range	4 or 5 decimal places	131071/16777215 x10 ¹⁵
PRF	100 Hz	102.3 KHz
Pulse Width	0.1 μs	102.3 μs
Power	1 dBm	255 dBm



Full vs Partial Updates

- **Full Update Mode**
 - All required fields are passed in every update (Static entities would still not pass velocities or accelerations or rotation rates for example)
 - Decoders don't need to maintain the state of any object
- **Partial Update Mode**
 - Only items that change are sent every update & decoders maintain state
 - Follow partial update rules
- **No Mixed Mode (Partial/Full) operations are allowed**
 - All Encoders/Decoders on a network must operate in one or the other modes



Partial Update Rules

- The first update is always a full update
- There must be at least one full update before a DIS timeout period is reached (12 second default for aircraft)
- Decoders must create and store and update the state of stateful objects (i.e., Entity State, Emissions, Transmitters, & IFF)
- Decoders will set C-DIS specified values for data items that are not received (typically 0)
- Decoders must be able to remove stateful objects and timeout stateful objects as needed



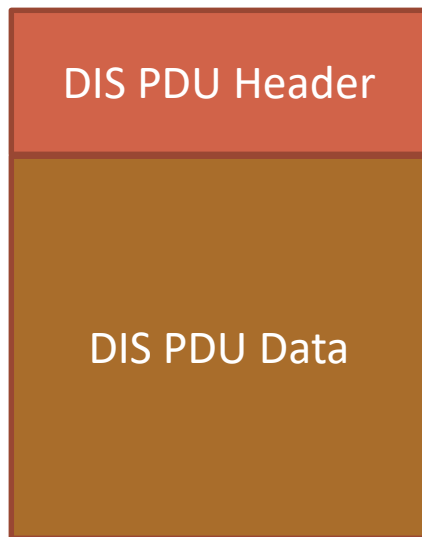
Partial Update Encoder/Decoder Requirements

- Significantly more complex
- Encoder must track how long it's been since last full update and decide if a full or partial update is required
- More CPU intensive because have to track and update objects in the database
- Adds some latency due to lookup and update of objects
- More memory intensive because every object has to be stored for quick reference. Particularly a concern with large scenarios or limited physical memory situations.
- Have to monitor and timeout objects if necessary
- Full Update encoder/decoders used for SLATE demonstration

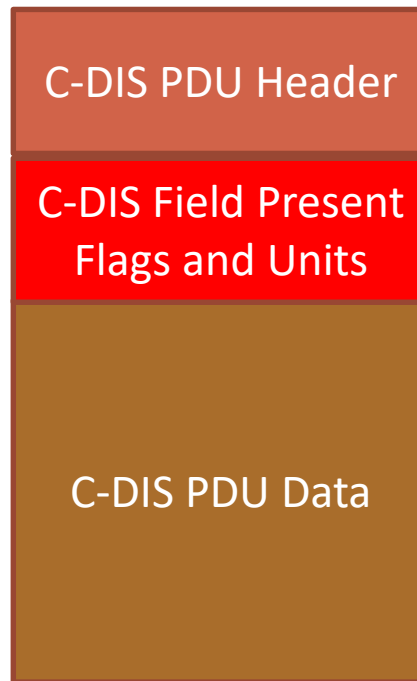


C-DIS – General PDU Format

Standard DIS



C-DIS



New C-DIS
fields added only if
needed





Color Key

Meaning of Text colors

Red Text indicates new items that have been added to the DIS Standard PDUs or indicates that field sizes have been altered.

Blue Text Indicates items that are optional for most updates but are required as part of a "Full" update. "Full" updates are required for the first PDU update, at least once during the PDU Timeout period, and for the final PDU update.

Orange Text indicates items that are completely optional and are not required as part of a "Full" PDU update. These items may simply not be applicable for a particular entity or system being modeled and may never be provided.

Green Text indicates items that are new in the DIS 2012 Standard

Purple indicates Field sizes that are variable depending on a bit flag

Black Text indicates items that are the same as the DIS 2012 standard.

Grayed out Text indicates items that are not used in compressed DIS such as padding fields.



Entity State



Entity State

Original DIS Info/Misc Black Text

C-DIS Differences, Required - BlueText

Field Name		DIS Size (Bits)	C-DIS Size Required Bits	Optional Bits	Notes
PDU Header	Protocol Version	8	2		4 simultaneous, enumerated versions; old ones would have to be retired eventually
	Exercise ID	8	3		8 exercises
	PDU Type	8	8		
	Protocol Family	8	0		Not necessary - Derive from the PDU type using a local lookup if needed
	Time Stamp	32	26		107 us smallest time unit (LSB = Absolute Time Flag just like DIS, DIS 31 bits = 1.67us)
	Length	16	14		Length in bits 16383 max = 2047 bytes (not bytes like standard DIS)
	PDU Status	8	8		DIS 2012 new field
	Padding	8	0		Not applicable
Compression Statistics					
	Total Size	96	61	61	
		100.00%	63.54%	63.54%	% Packet Size VS Standard DIS

C-DIS Unused Red Text



C-DIS – Entity State Added Fields (Field Present & Units Flags)

Field Name		DIS Size (Bits)	C-DIS Size Required Bits	Optional Bits	Notes
PDU Header	See Compressed DIS PDU Header Definition				
Field Present Flags	Variable Parameters		1		Num Variable Param Records, Variable Param Records 0=None 1=All Present
	Entity Type		1		0=None 1=Present
	Alternate Entity Type		1		0=None 1=Present
	Entity Appearance		1		0=None 1=Present
	Entity Linear Velocity		1		0=None 1=Present
	DR Params-Other		1		0=None 1=Present
	DR Params- Entity Linear Acceleration		1		0=None 1=Present
	DR Params- Entity Angular Velocity		1		0=None 1=Present
	Entity Marking		1		0=None Present 1=Entity Marking Present
	Capabilities		1		Capabilities 0=None 1=Present
Units	Entity Location Altitude		1		0=Centimeters (cm) 1=Dekameters (dam)



C-DIS – Entity State

(Standard DIS Fields in Standard Order)

Field Name		DIS Size (Bits)	C-DIS Size Required Bits	Optional Bits	C-DIS Variable Size Field Purple Text Notes
Entity ID	SAE Size		1		0=Standard DIS SAE 1=Small SAE
	Site	16	8		small max 255
	Application	16	8		small max 255
	Entity	16	12		small max 4095
Force ID		8	2		0=Other, 1=Friendly, 2=Opposing, 3=Neutral
Number of Variable Params		8		8	C-DIS Optional Data (May never be provided) Orange Text Present only if Variable Parameters present flag is true
Entity Type	Kind	8		4	CAF DMO max 9, SISO Max 9 - Allow 15 Max
	Domain	8		4	CAF DMO max 11, SISO Max 12 - Allow 15 Max
	Country	16		9	CAF DMO max 225, SISO Max 266 - Allow 511 Max
	Cat	8		8	CAF DMO max 89, SISO max 101
	Subcat	8		8	CAF DMO max 246
	Specific	8		8	CAF DMO max 102
	Extra	8		4	CAF DMO max 7, SISO Max 190- Allow 15 Max

Added in 2015 Lifeforms



C-DIS – Entity State Continued

Field Name		DIS Size (Bits)	C-DIS Size Required Bits	Optional Bits	Notes
Alternate Entity Type	Kind	8		4	CAF DMO max 9, SISO Max 9 - Allow 15 Max
	Domain	8		4	CAF DMO max 11, SISO Max 12 - Allow 15 Max
	Country	16		9	CAF DMO max 225, SISO Max 266 - Allow 511 Max
	Cat	8		8	CAF DMO max 89, SISO max 101
	Subcat	8		8	CAF DMO max 246
	Specific	8		8	CAF DMO max 102
	Extra	8		4	CAF DMO max 7, SISO Max 190- Allow 15 Max



C-DIS – Entity State Continued

Field Name		DIS Size (Bits)	C-DIS Size Required Bits	Optional Bits	Notes
Entity Linear Velocity	X	32		16	± 32767 dm/s (6369.59 kt max)
	Y	32		16	± 32767 dm/s (6369.59 kt max)
	Z	32		16	± 32767 dm/s (6369.59 kt max)
Entity Location	X (Lat)	64	31		$\pm 90^\circ$ Lat (approx 0.93 cm accuracy)
	Y (Lon)	64	32		$\pm 180^\circ$ Lon (approx 0.93 cm accuracy)
	Z (Alt MSL)	64	24		± 8388607 cm (275Kft) or Dekameter as indicated by Entity Location Altitude Units Flag
Entity Orientation	Psi	32	13		0.0439° resolution
	Theta	32	13		0.0439° resolution
	Phi	32	13		0.0439° resolution



C-DIS – Entity State Continued

Appearance		32	32		
Dead Reckoning Parameters	Algorithm	8	3		Only support World Based DR Algorithms (0 to 5) (Body based 6-9 not supported)
	Other	120		120	Present only if DR Param Other Flag = 1
	Entity Linear Acceleration X	32		14	+/-8191 decimeters/sec/sec (Aprox 83.5 g)
	Entity Linear Acceleration Y	32		14	+/-8191 decimeters/sec/sec (Aprox 83.5 g)
	Entity Linear Acceleration Z	32		14	+/-8191 decimeters/sec/sec (Aprox 83.5 g)
	Entity Angular Velocity Psi	32		12	+/-720 degrees per second max 0.35 degrees/sec resolution
	Entity Angular Velocity Theta	32		12	+/-720 degrees per second max 0.35 degrees/sec resolution
	Entity Angular Velocity Phi	32		12	+/-720 degrees per second max 0.35 degrees/sec resolution



C-DIS – Entity State Continued

Field Name		DIS Size (Bits)	C-DIS Size Required Bits	Optional Bits	Notes
Entity Marking	Marking Length			4	Number of characters in the Marking. Example "Viper1" = 6.
	Char Set	8		8	
	Marking	88		0-88	Marking Length*8
Capabilities		32		32	



C-DIS V1.2 vs V1.3 Variable Record

SLATE Tested V1.2

C-DIS V1.2 Variable Parameter Records					
Variable Parameter Record #N	Record Type	8		8	No Compression Applied to Variable Parameter Records
	Record- Specific Fields	120		120	

Proposed V1.3

C-DIS V1.3 Variable Parameter Records					
Variable Parameter Record #N	Compressed Flag		1		0=Normal, 1=Compressed Record Type - SISO MAX 5 Allow 8 Params of variable bit length \neq 120
	Record Type	8		3	
	Record-Specific Fields	120		NN	



Emission PDU



Emission PDUs are made up of Parts

- **Emission PDU - Basic**

- System
 - *Beam*
Track/Jam List

- **Emission PDU - Complex**

- System 1
 - *Beam 1*
 - *Beam 2*
Track/Jam List
 - *Beam 3*
Track/Jam List
- System 2
 - *Beam 1*
Track/Jam List
- System 3
 - *Beam 1*



C-DIS - Emission PDU

Compressed DIS MESSAGE Format - Emission PDU

Field Name		DIS Size (Bits)	Smallest Possible Message	Optional Bits	Notes
PDU Header	See Compressed DIS PDU Header Definition				
Emitting ID	SAE Size		1		0=Standard DIS SAE 1=Small SAE
	Site	16	8		
	Application	16	8		
	Entity	16	12		
Event ID	SAE Size		1		0=Standard DIS SAE 1=Small SAE
	Site	16	8		
	Application	16	8		
	Event Number	16	12		



Emission PDU Continued

Field Name		DIS Size (Bits)	Smallest Possible Message	Optional Bits	Notes
State Update Indicator		8	1		SISO 0=State Update 1=Changed Data Update
Number of Systems		8	5		31 Emitter Systems per PDU
Padding		16	0		Not applicable



Emission PDU Continued – Emitter System

Emitter System					
System Field Present Flags	Emitter System Details		1		Emitter System Name and Function 0=None 1=All Present
	Location with Respect to Entity		1		0=None 1=Present
System Data Length		8	0		Informational Not required to Parse- Byte Count N/A
Number of Beams		8	5		31 Max Beams per PDU
Padding		16	0		Not applicable
Emitter System	Emitter Name	16		16	65535 Max (CAF DMO max = 65044)
	Emitter Function	8		8	CAF DMO max =71, siso max = 97
	Emitter ID Number	8	8		Could make 5 bits if only Sequential ID's are used
Location with Respect to entity	X	32		10	+- 511 meters
	Y	32		10	+- 511 meters
	Z	32		10	+- 511 meters



Emission PDU Continued – Emitter Beam Part 1 of 4

Emitter Beam					
Beam Field Present Flags	Fundamental Parameters-Frequency and Power Details		1		Fundamental Parameters - Frequency, Frequency Range and ERP 0=None 1=All Present
	Fundamental Parameters-Pulse Details		1		Fundamental Parameters - PRF and Pulse Width 0=None 1=All Present
	Beam Data Details		1		Beam Data - Beam Az Center, Beam Az Sweep, Beam El Center, Beam El Sweep, Beam Sweep Sync 0=None 1=All Present
	Jamming Technique		1		0=None 1=All Present
Beam Data Length		8	0		Informational Not required to Parse-Byte Count N/A
Beam ID Number		8	8		Could make 5 bits if only Sequential ID's are used
Beam Parameter Index		16	16		Full BPI support



Emission PDU Continued – Emitter Beam Part 2 of 4

Fundamental Params	Frequency	Mantissa	32		17	Frequency * 10Exponent
		Exponent			4	Exponent
	Frequency Range	Mantissa	32		17	Frequency Range * 10Exponent
		Exponent			4	Exponent
	ERP		32		8	0 to 255 dBm
	PRF		32		10	Freq *100 (Max 102.3 KHZ)
	Pulse Width		32		10	tenths of Micro second (102.3 usec max)



Emission PDU Continued – Emitter Beam Part 3 of 4

Beam Data	Beam Az Center	32		13	0.00076 Radian = 0.0439 degrees resolution
	Beam Az Sweep	32		13	0.00076 Radian = 0.0439 degrees resolution
	Beam El Center	32		13	0.00076 Radian = 0.0439 degrees resolution
	Beam El Sweep	32		13	0.00076 Radian = 0.0439 degrees resolution
	Beam Sweep Sync	32		10	Percent of the scan (0.097 percent max accuracy)



Emission PDU Continued – Emitter Beam Part 4 of 4

Beam Function		8	5		Allow 31 (SISO-REF-10 2011 17 beam functions, CAF DMO 17)
Number of Targets in Track Jam Field		8	4		If more than 15 list first 15, 10 is High Density
High Density Track Jam		8	1		Bit Flag
Beam Status		8	1		Beam Active Flag 0=No 1=Yes
Jamming Technique	Kind	8		8	(optional all or no Jamming Technique)
	Category	8		8	(optional all or no Jamming Technique)
	Sub Category	8		8	(optional all or no Jamming Technique)
	Specific	8		8	(optional all or no Jamming Technique)



Emission PDU Continued – Track Jam List

Track Jam List					
Track Jam	SAE Size		1		0=Standard DIS SAE 1=Small SAE
	Site	16	8		
	Application	16	8		
	Entity	16	12		
	Emitter number	8	8		Could make 5 bits if only Sequential ID's are used
	Beam number	8	8		Could make 5 bits if only Sequential ID's are used



Variable Records



5 Variable Record Types

- **Articulated Part VP Record**
- **Attached Part VP Record**
- **Entity Separation VP Record**
- **Entity Type VP Record**
- **Entity Association VP Record**



C-DIS V1.2 vs V1.3 Variable Record

SLATE Tested V1.2

C-DIS V1.2 Variable Parameter Records					
Variable Parameter Record #N	Record Type	8		8	No Compression Applied to Variable Parameter Records
	Record- Specific Fields	120		120	

Proposed V1.3

C-DIS V1.3 Variable Parameter Records					
Variable Parameter Record #N	Compressed Flag		1		0=Normal, 1=Compressed Record Type - SISO MAX 5 Allow 8 Params of variable bit length \neq 120
	Record Type	8		3	
	Record-Specific Fields	120		NN	



Variable Records – Articulated Part VP Record

Compressed DIS MESSAGE Format -Articulated Part VP Record

Field Name		DIS Size (Bits)	Smallest Possible Message	Optional Bits	Notes
Compressed Flag			1		Indicate if Variable Record is compressed 0 = Normal 128 bits, 1=Compressed
Type	Articulated Part Record Type = 0	8	3		SISO defines 5 types Allow 8 (Record Type = 0)
Change Indicator		8	8		Increments all values
ID Part Attached to		16	10		Allow up to 1023 subparts



Variable Records – Articulated Part VP Record Continued

Parameter Value		32	14		Type Class + Type Metric SISO Defines 8128 Allow 16383
Parameter Value	Mantissa	32	15		Signed Value $\pm 16383 \times 10^{\text{Exponent}}$ (Approx Four Decimal Place accuracy 9999) Smallest = 1×10^{-4} Largest 16383×10^3
	Exponent		3		Signed Exponent +3,-4
Padding		32	0		
Compression Statistics					
	Size	128	53	53	
	Header	0	0	0	
	Total Part Size	128	53	53	
		100.0%	41.4%	41.4%	Percentage of Packet Size VS Standard DIS



Variable Records – Attached Part VP Record Continued

Compressed DIS MESSAGE Format -Attached Part VP Record

Field Name		DIS Size (Bits)	Smallest Possible Message	Optional Bits	Notes
Compressed Flag			1		Indicate if Variable Record is compressed 0 = Normal 128 bits, 1=Compressed
Type	Attached Part Record Type = 1	8	3		SISO defines 5 types Allow 8 (AP Record Type = 1)
Detached Indicator		8	1		0=Attached, 1=Detached
ID Part Attached to		16	10		Allow up to 1023 Subparts
Parameter Type		32	11		SISO [UID 57] Max 1023 Allow 2047



Variable Records – Attached Part VP Record Continued

Attached Part Type	Kind	8	4		CAF DMO max 9, SISO Max 9 - Allow 15 Max
	Domain	8	4		CAF DMO max 11, SISO Max 12 (Munition) - Allow 15 Max
	Country	16	9		CAF DMO max 225, SISO Max 266 - Allow 511 Max
	Cat	8	8		CAF DMO max 89, SISO max 101
	Subcat	8	8		CAF DMO max 246
	Specific	8	8		CAF DMO max 102
	Extra	8	4		CAF DMO max 7 - Allow 15 Max
Compression Statistics					
	Size	128	70	70	
	Header	0	0	0	
	Total Part Size	128	70	70	
		100.0%	54.7%	54.7%	Percentage of Packet Size VS Standard DIS



C-DIS DIS V-8 and SISO

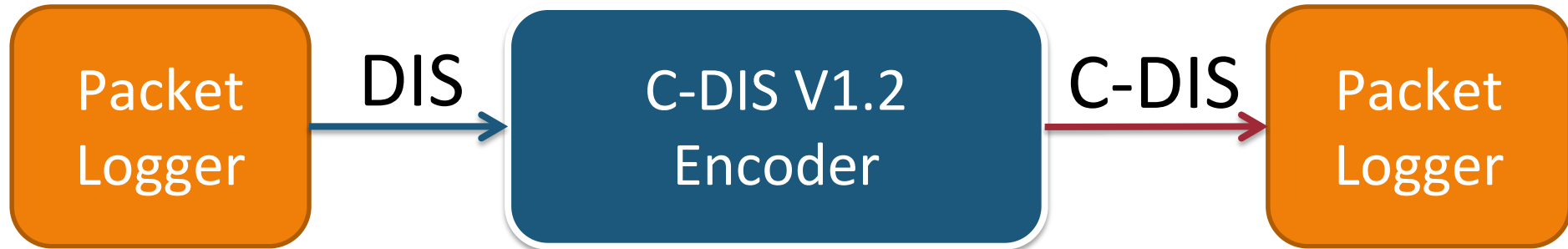
- C-DIS techniques could be applied to DIS V8
- Just beginning to look at this
- Looking into making C-DIS V1.3 a SISO or IEEE standard



C-DIS Compression Testing Results



C-DIS Performance Test Setup

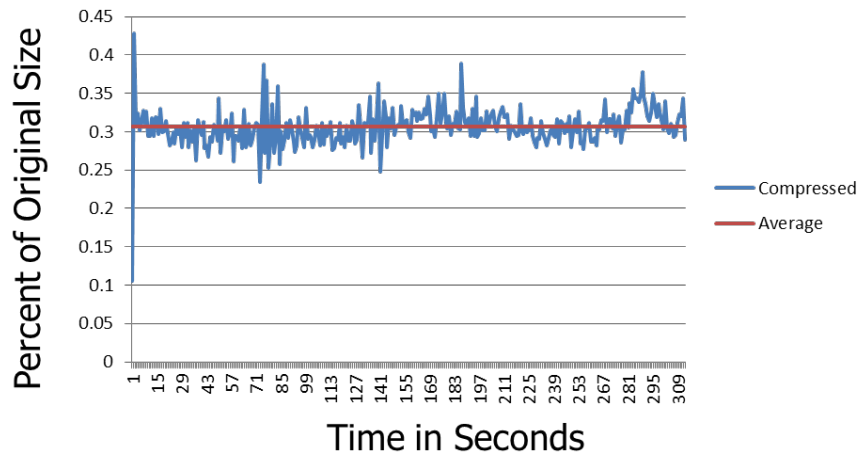
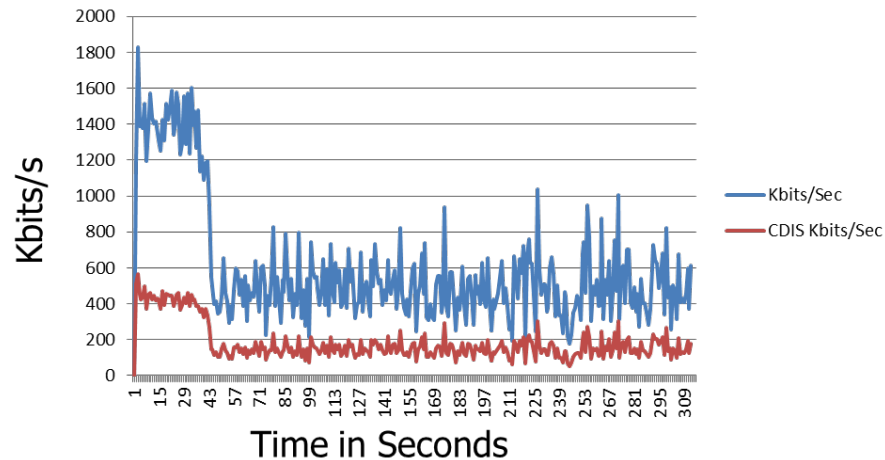


In the following slides “LVC PDUs” are everything except Voice and Link16 (SLATE doesn’t pass voice or Link16 over 5G-ATW)



C-DIS LVC PDU Results (2015)

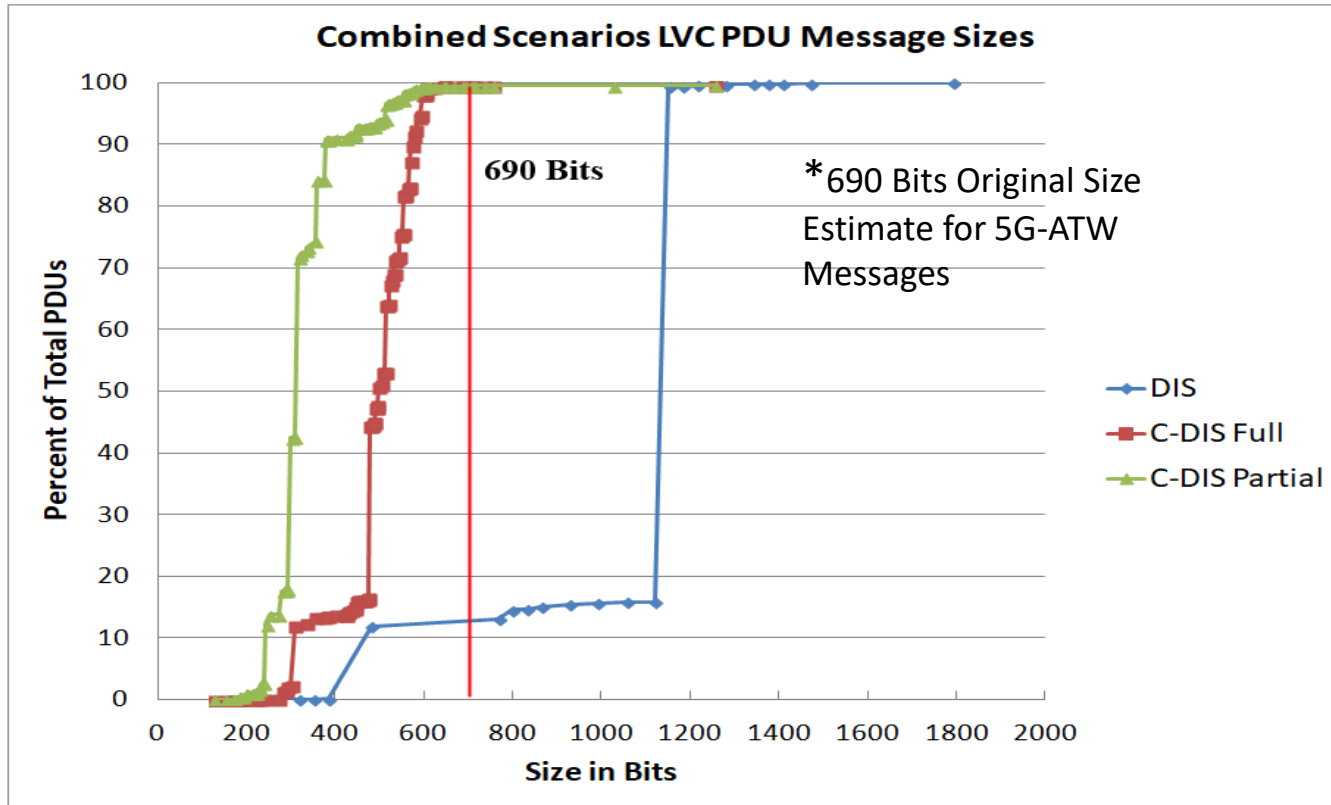
Large Exercise Scenario Test Results



Test Case	Compression % size vs Full DIS PDU Size
3000+ constructive entities	30.8 %
AFA 8 Virtual cockpits + 65 CGF Entities	37.3 %
Sweden CAS 4 Virtual cockpits + 28 CGF Entities	29.0 %



Combined Scenario LVC PDU Results (2015)

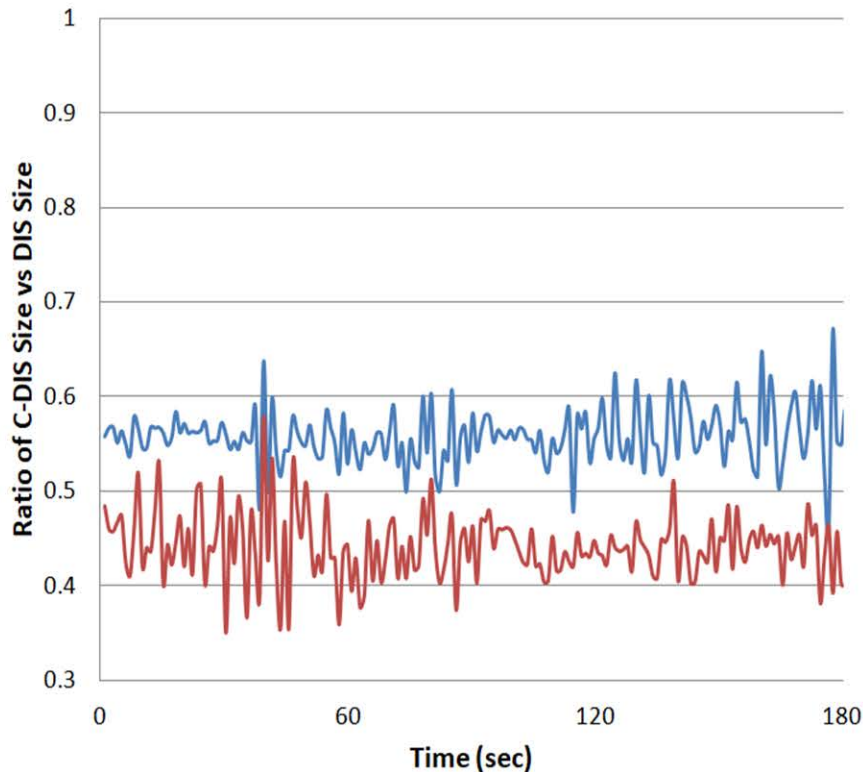




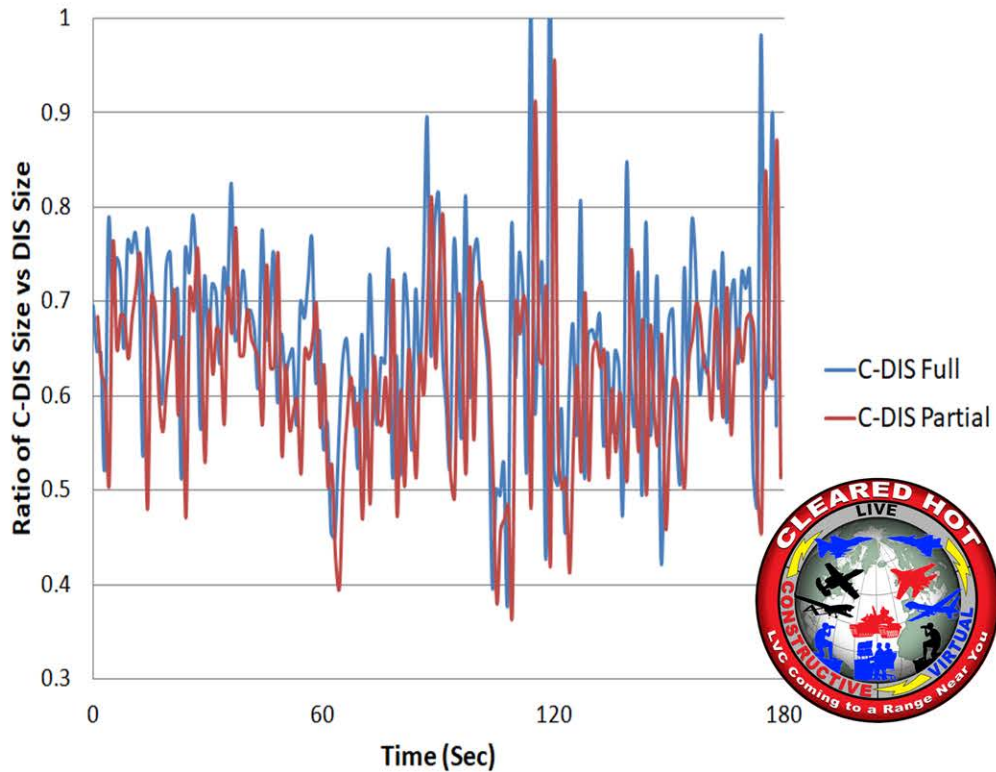
Second by Second Compression Ratios

LVC PDUs & All PDUs Cleared Hot Event (2016)

IITSEC 2016 LVC PDU C-DIS Size compared to DIS



IITSEC 2016 ALL PDU C-DIS Size compared to DIS





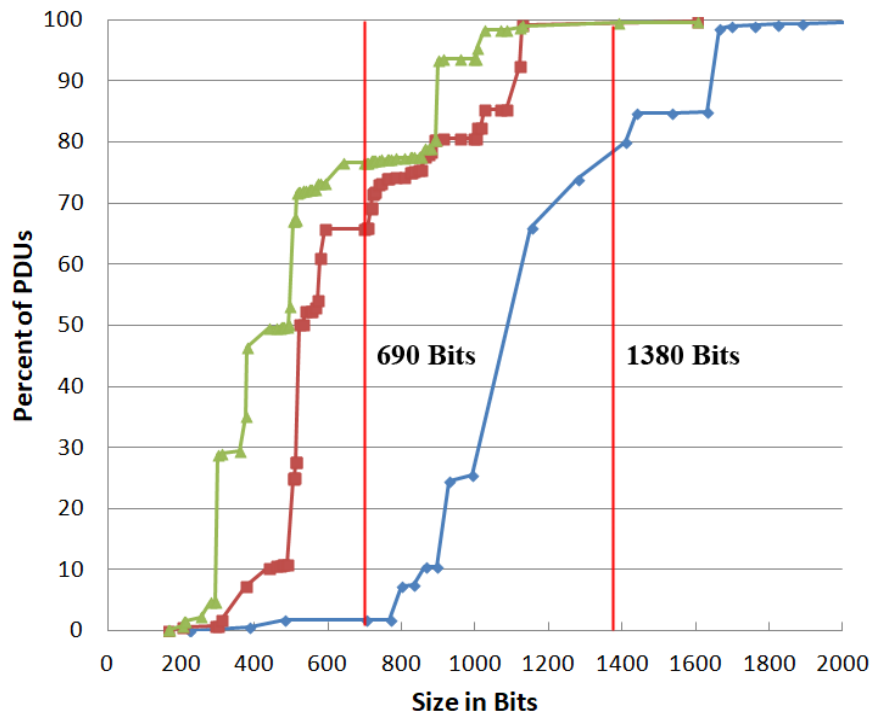
Variable Records & Datums

- I/ITSEC 2016 Entity States had 2-9 variable records (Average = 3) which can significantly increase the size of the Entity State and possibly exceed 768 bits
- SLATE ATD did not use many variable records so this was not an immediate issue for SLATE
 - *C-DIS V1.3 Proposal for a method to compress Variable Records by 40-60 percent has been identified but not implemented or tested*

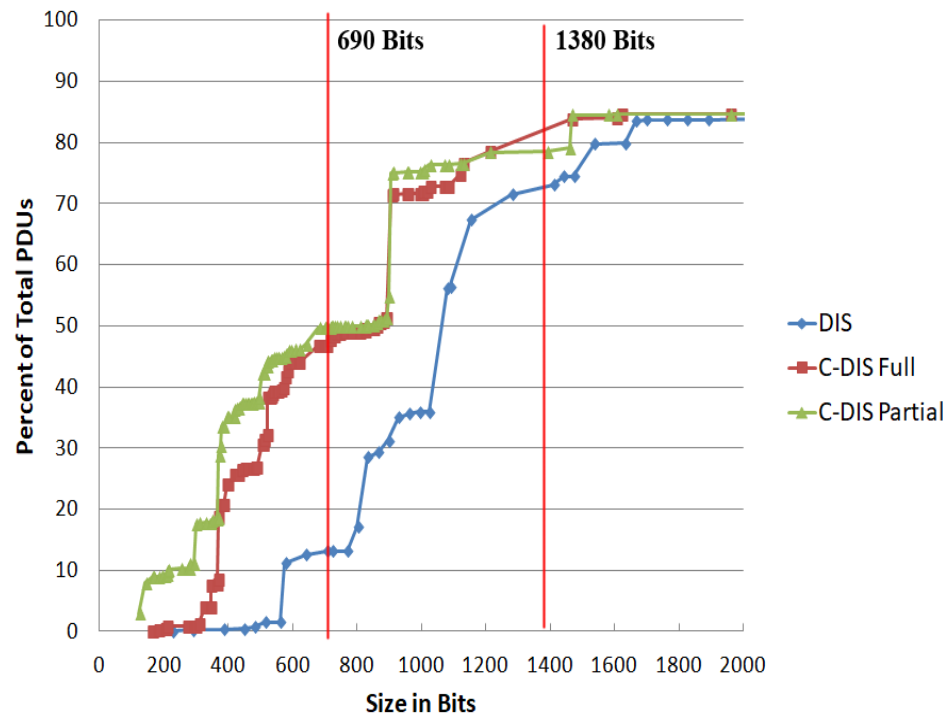


I/ITSEC 2016 PDU Results

ITSEC 2016 LVC PDU Message Sizes



I/ITSEC 2016 All DIS PDU Sizes



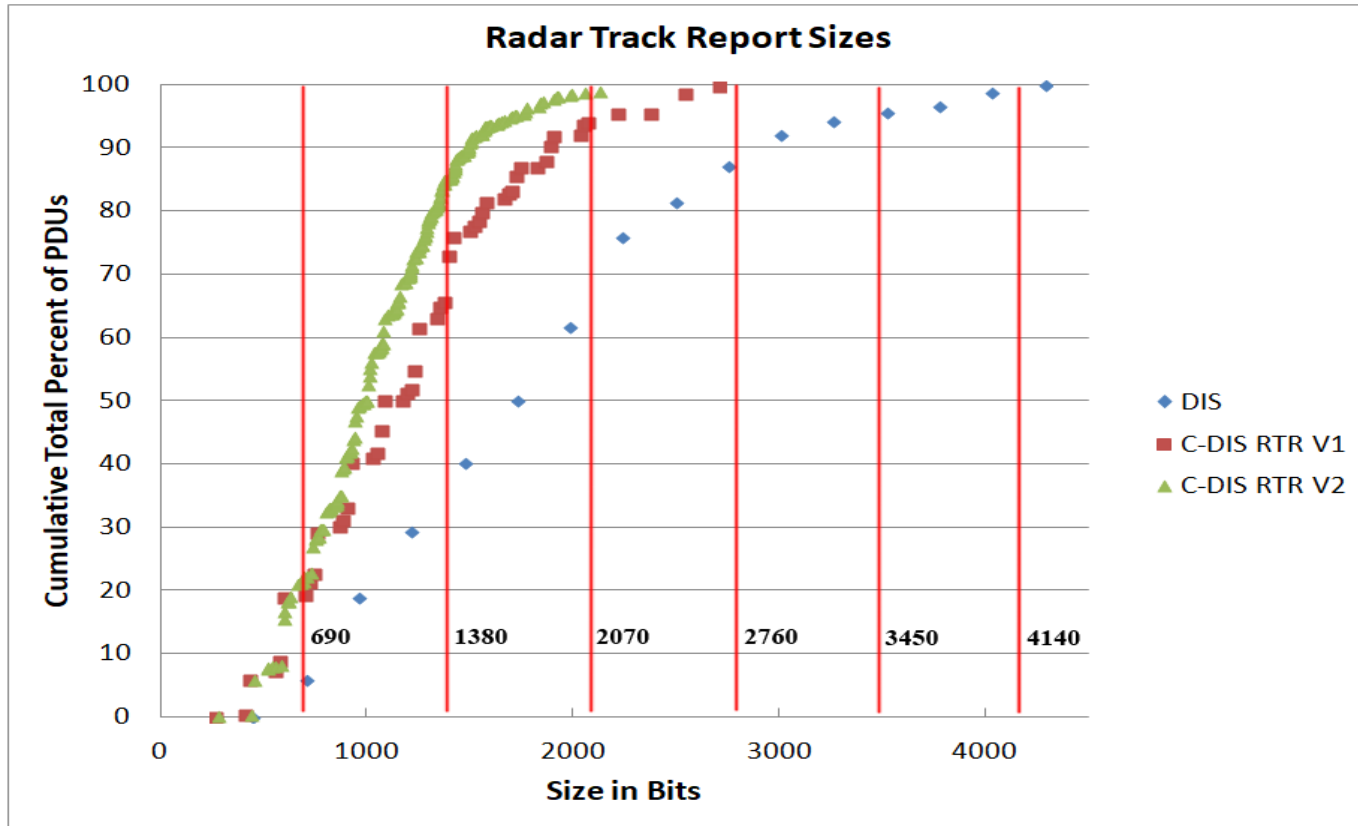


Siman/DATA PDUs

- **Some CAF DMO Datums that contribute significantly to bandwidth have been compressed**
 - Radar Track Report
 - Jammer Report
 - Jammer False Targets Report
 - Data is in an Annex of C-DIS due to releasability
- **Other user Datums that contribute significantly to bandwidth could apply C-DIS techniques and be added to the C-DIS standard**

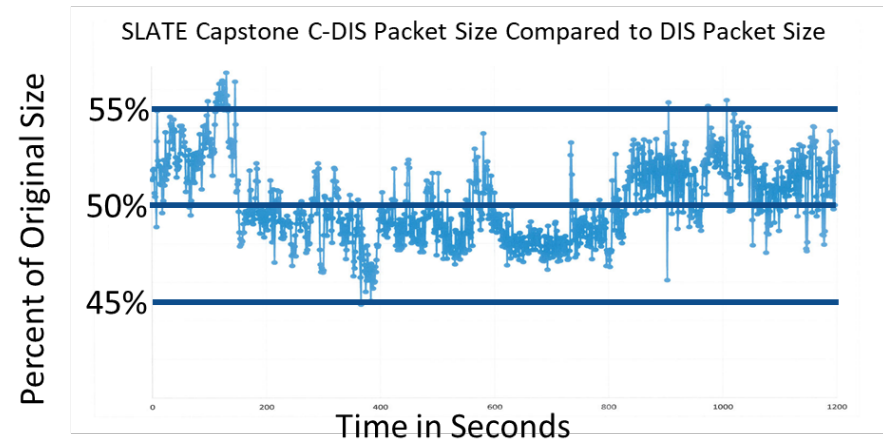
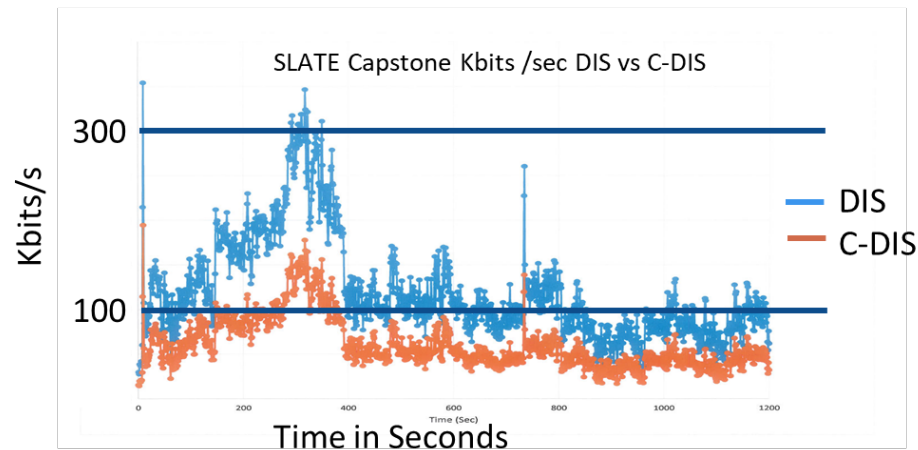


Radar Track Report (2015)





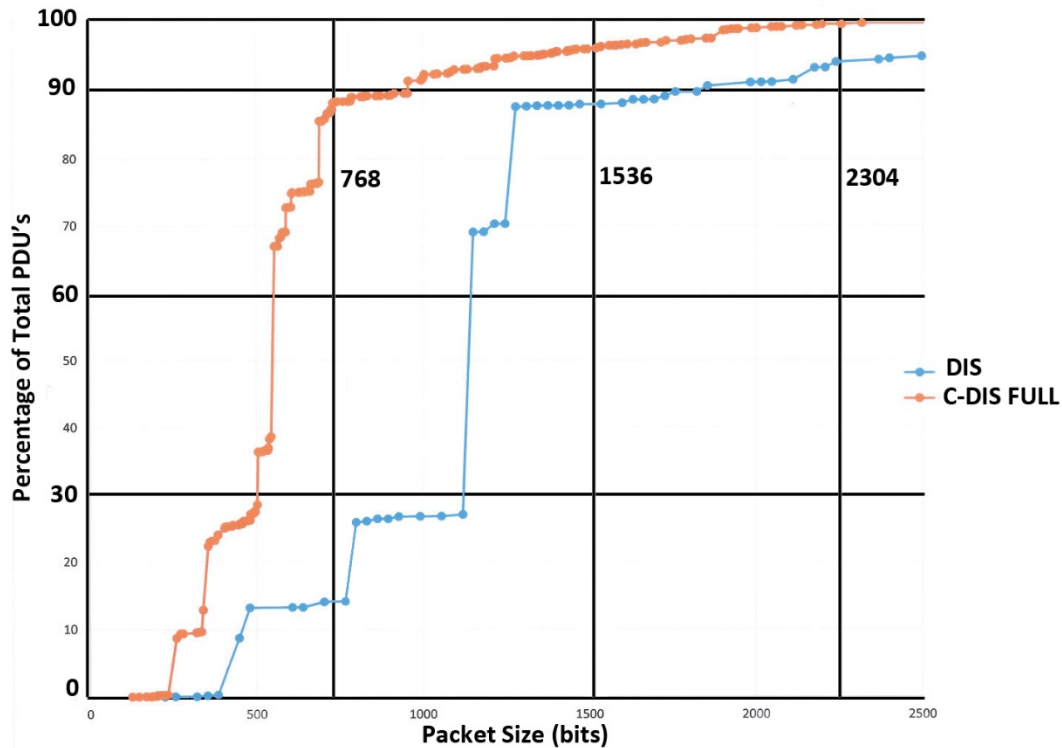
C-DIS SLATE Demonstration Results (Sept 2018)



Test Case	Compression % size vs Full DIS PDU Size
JFCOM >3000 constructive entities	30.8 %
AFA 8 Virtual cockpits + 65 CGF Entities	37.3 %
Sweden CAS 4 Virtual cockpits + 28 CGF Entities	29.0 %
SLATE Capstone Demo 16 Live, 4 Virtual, 20CGF	50.0 %



C-DIS SLATE Demonstration Results (Sept 2018)





C-DIS Packet Difference Output – Yellow Highlights

Airplane PDU Sent

Force ID	1
Num Artic Params	0
Entity Type	1:2:225:1:5:5:0 (F-15)
ALT Entity Type	1:2:225:1:5:5:0 (F-15)
Vel X (North ft/s) (Knots)	-197.02847 (208.2499) (123.3)
Vel Y (East ft/s) (Knots)	125.18078 (-759.6250) (-450.0)
Vel Z (Up ft/s) (Knots)	57.23061 (37.2500) (22.0)
Geocentric X (Lat Deg)	-2150701.46 (37.5751)
Geocentric Y (Lon Deg)	-4587541.02 (-115.1178)
Geocentric Z (Alt Ft)	3872289.00 (22104.1595)
Heading (Geod Hdg Deg)	2.594213 (-73.4381)
Pitch (Geod Pitch Deg)	-0.2816197 (4.9713)
Roll (Geod Roll Deg)	-2.9774709 (61.6662)
Appearance	0x00000004 (NVG Mode(AFRL_FLASH_LIGHTS))
DR Alogorithm	4
Other Params	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Acceleration X (North ft/s) (Knots)	6.6425505 (42.2890) (25.0)
Acceleration Y (East ft/s) (Knots)	7.797231 (8.8734) (5.2)
Acceleration Z (Up ft/s) (Knots)	8.662039 (-8.3593) (-4.9)
Rot Vel Heading (Clockwise deg/s)	-0.0073631075 (-0.4218)
Rot Vel Pitch (Up deg/s)	0.043360524 (2.4843)
Rot Vel Roll (Clockwise deg/s)	0.03449752 (1.9765)
Charcter Set	1
Marking	SR02
Capabilities	0x00000000

Ground PDU Received

Force ID	1
Num Artic Params	0
Entity Type	1:2:225:1:5:5:0 (F-15)
ALT Entity Type	1:2:225:1:5:5:0 (F-15)
Vel X (North ft/s) (Knots)	-197.0 (208.0482) (123.2)
Vel Y (East ft/s) (Knots)	125.1 (-759.4279) (-449.9)
Vel Z (Up ft/s) (Knots)	57.2 (37.3475) (22.1)
Geocentric X (Lat Deg)	-2150701.45 (37.5751)
Geocentric Y (Lon Deg)	-4587541.01 (-115.1178)
Geocentric Z (Alt Ft)	3872288.99 (22104.1338)
Heading (Geod Hdg Deg)	2.5938277 (-73.4280)
Pitch (Geod Pitch Deg)	-0.28155422 (4.9522)
Roll (Geod Roll Deg)	-2.9774165 (61.6641)
Appearance	0x00000004 (NVG Mode(AFRL_FLASH_LIGHTS))
DR Alogorithm	4
Other Params	0 0 0 0 0 0 0 0 0 0 0 0 0 0 0 0
Acceleration X (North ft/s) (Knots)	6.6 (41.9154) (24.8)
Acceleration Y (East ft/s) (Knots)	7.7 (8.8824) (5.2)
Acceleration Z (Up ft/s) (Knots)	8.6 (-8.2076) (-4.8)
Rot Vel Heading (Clockwise deg/s)	-0.006138921 (-0.3517)
Rot Vel Pitch (Up deg/s)	0.042972445 (2.4621)
Rot Vel Roll (Clockwise deg/s)	0.030694604 (1.7586)
Charcter Set	1
Marking	SR02
Capabilities	0x00000000



Limitations

- Service Request, Resupply, and Reliable PDUs not required for SLATE are not yet supported, but could be if there is a need.
- Voice and Large custom Data PDU's only compress common Siman/Signal PDU header bytes and therefore compression is limited
- C-DIS V1.2 Variable Records/Articulated Parts are not compressed
- C-DIS V1.3 Proposal for a method to compress Variable Records by 40-60 percent has been defined but not implemented or tested



Summary

- C-DIS requires additional computations (Encoder/Decoder)
- C-DIS relies on data originators to use thresholds and timeouts to change the number of messages per second
- C-DIS reduces the size of each message (Effectively doubles the available network bandwidth for SLATE)
- C-DIS compression rates depend on the mix of DIS PDU types and use of variable records, voice/signal PDUs and custom Datums



Conclusions

- C-DIS allows significantly more entities, sensors, and complex interactions to be modeled over a given bandwidth, which improves training
- C-DIS could be used over any data link or bus where bandwidth is limited



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Simulation Interoperability Standards Organization

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QUESTIONS