DRN-DOC-NAVAL-ICD-RUNTIME

DRONNUR

Exported on 09/03/2025

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1 INTERFACE CONTROL DOCUMENT - RUNTIME OPERATION - NAVAL VERSION

Ver	Fw Version	Author	Description	Approv
1.0	1.0.X	OBN / AF	First issue for Naval version. ▪ Removed CAT 253 ▪ Added ESM	GA
1.1	1.0.X	SE / GA	• Misc corrections. • Added pulse length to ESM • Added navigation mode • Added drone detection mode	GA
1.2	1.0.x	SE / GA	▪ Added LongRange mode. ▪ Renamed "Normal" mode to "Surveillance".	GA

1.1 Introduction

This document is the customer interface description for Dronnur 2D Naval, which is based on the ICD for the Dronnur 2D Drone Detection Radar.

In addition to this "standard" interface document the following documents are available:

1, DRN-DOC-ICD-SERVICE which is a service extension to this protocol that allows for more in-depth tuning of the equipment.

2, DRN-DOC-ICD-MIL, which is required in order to create mission sets.

The protocol interface is based on JSON and may be used directly as JSON over network or JSON embedded in Asterix CAT-253 (TBA).

This FW version does not support any form for encryption of the communication.

1.2 Electrical Interface

Dronnur has 1 Gigabit Ethernet Interface exposed on the bottom plate for normal operation.

Internally there is a SFP interface capable of running at 10Gb, which may be used if external processing using the IF data is required. Currently not generally available.

1.3 Default Interface IP Address

The default IP address is: 192.168.1.248.

Default username and password is user/user.

1.4 Optional External Computer

The Naval version has some functionality that may require an external computer. Regardless, this ICD is the same, as the same code will be utilized. It will mere act as a gateway in-between the radar and the system.

1.5 The dspnor Standard Discovery Protocol

Network connected devices sends out a 40 bytes packet every second to multicast address 227.228.229.230:59368 informing other network connected devices of its existence, and where they can connect to get more information on the device. The content of the packet is the following string; ("dspnor: v.%04x\n%u.%u.%u.%u:%u\n", DISCOVERY_VERSION, IP[0], IP[1], IP[2], IP[3], INFO_PORT).

For example: "dspnor: v.0000\n192.168.1.248:59623\n\x0\x0\x0\x0\x0" for discovery protocol 0x0000, default IP 192.168.1.248 and information service on default port 59623.

Connected devices listen for incoming TCP connection on a port (default 59623) and send a response containing information on the device to the connecting client. When the information is sent it closes the connection. The number of simultaneous connection is limited to one. To limit the potential for abuse the maximum rate of responses is limited to 1 response every second. The content of the information string is determined by the protocol version and the type of device, and are described below.

1.5.1 Dronnur2D Discovery Protocol Response

The response contains description of all of the services and versions available on the unit.

All version numbers are using 3 fields. The numbers are hexadecimal.

XX.YY.ZZ : XX: Major , YY: Minor, ZZ: Build nr or correction.

JSON Field	Description	Type	Values	Default	Comments
type	The type of the device.	String	"D2D"	"D2D"	Note that that other devices may be on the same network, like ScanStreamer, RSCC, ScanView or DeStreamer
serial	Serial number of System	Number	0 – 99999999		Zero padded
missionset	Current mission set	String		"Default"	Currently not implemented for Naval Version.
modules:		Array			Array of Modules. See services below.
services		Array			Array of services. See services below.

1.5.2 Control of Discovery Protocol Announcement

The user may only turn this off after startup. This command is non-sticky.

```
{
"DiscoveryEnable": false
}
```

1.6 Modules

The modules reports hardware version, FPGA version (if it exists), MCU version (if it exists), CPU version (if it exists), runtime (If it exists) and module serial number(if it exists).

If a module is not present only the name is reported.

If any data is not available the field will be empty, represented with "".

1.6.1 Processing Board

```
{"name": "ProcHW": "xx.yy.zz", "ProcCarHW": "xx.yy.zz", "ProcFpFW": "xx.yy.zz", "ProcCpuFW": "xx.yy.zz",
"ProcRuntime": "xxxxx"}
```

1.6.2 RF Converter

```
{"name": "RfConverter", "RfConHW": "xx.yy.zz", "RfConFpFW": "xx.yy.zz", "RfConMcFW": "xx.yy.zz",
"RfConRuntime": "xxxxx"}
```

1.6.3 Power Amplifier

```
{"name": "PowerAmp", "PAPow": "xxx", "PAHW": "xx.yy.zz", "PAFWMcuFW": "xx.yy.zz", "PARunTime": "xxxxx"}
```

1.6.4 Clock Generator

```
{"name": "ClkGenerator", "ClkGHW": "xx.yy.zz", "ClkGMcuFW": "xx.yy.zz", "ClkGRunTime": "xxxxx"}
```

1.6.5 Motor Controller Horizontal Operation

```
{"name": "MotConHor", "MotConHorHW": "xx.yy.zz", "MotConHorFW": "xx.yy.zz", "MotConHorRunTime": "xxxxx"}
```

1.6.6 Motor Controller Vertical Operation

```
{"name": "MotConVer", "MotConVerHW": "xx.yy.zz", "MotConVerFW": "xx.yy.zz", "MotConVerRunTime": "xxxxx"}
```

1.7 Services

The reporting of services are a bit more complex as the services also contains ports and IP addresses.

These elements are part of all services.

All the services follow the same command format

```
{
    "ServiceName":
    {
        "Enabled": true,
        "IP": 225.0.0.5,
        "Port": 4445,
        "Protocol": "UDP",
        "Options": {
            "Key": "Value",
            ....
        }
    }
}
```

The json command and response is wrapped around a small text-based header

```
PROTOCOL=D2D\n
VERSION=1.0\n
TYPE=TEXT\n
LENGTH=BYTE_LENGTH_OF_CONTENT\n
\n
CONTENT
```

Example

```
PROTOCOL=D2D
VERSION=1.0
TYPE=TEXT
LENGTH=20

{"TxMode": "normal"}
```

For all requests the system will respond with its current state. All requests are ordered, so if two requests are being sent the responses will also arrive in the same order.

JSON Field	Description	Type	Values	Default	Metric	Comments
ServiceName	Name of service.	String				
IP	IP address for service.	String				
Port	Port for service	Integer	0 – 65535			
Protocol	Protocol for service	String	"TCP", "UDP"			

1.7.1 List of available services

ServiceName	Description	
ExternalGNS	If ExternalGNS is enabled then the internal sensor is not used.	
ExternalINS	If ExternalINS is enabled the the internal sensor is not used.	Typically used for high frequency gyro, but can also be used for position through GGA or GLL The system will select ExternalINS position if it stops receiving GGA or GLL from ExternalGNS or if ExternalGNS is disabled
AISInternal	Internal AIS to network. Transmits the AIS strings received via the internal AIS receiver. Will not be shown the AIS module is not installed/active. Normally embedded in CAT-010.	

ServiceName	Description	
NMEATTM	Output from the internal tracker. Absolutely no amplifying information, and the position is relative. It will simply output a NMEA xxTTM string.	
ADSBInternal	Internal ADS-B to network raw data. Transmits the ADS-B string received from the internal ADS-B receiver. Normally embedded in CAT-010.	
AsterixCat010	Output from the internal tracker, fused or unfused.	
EsmDetected	Outputs a proprietary NMEA formatted DNESM string. Only active when the unit is in "esm" mode.	
AsterixCat240	Outputs AsterixCat240 video	
AsterixCat253	Asterix CAT-253 control and status.	
Syslog		

1.7.2 Service - ExternalGNS

If ExternalGNS is enabled then the internal sensor is not used.

1.7.2.1 Additional Options

Key	Value	Description

1.7.3 Service - ExternalINS

If ExternalINS is enabled the the internal sensor is not used.

1.7.3.1 Additional Options

Key	Value	Description

1.7.4 Service - AISInternal

Internal AIS to network. Transmits the AIS strings received via the internal AIS receiver. Will not be shown the AIS module is not installed/active. Normally embedded in CAT-010.

This service will not be available if the AIS module is not installed.

If the service/server is not available then no response will be given apart from the missing service in the discovery response.

Update rate is once per second.

1.7.4.1 Additional Options

Key	Value	Description

1.7.5 Service - NMEATTM

Output from the internal tracker. Absolutely no amplifying information, and the position is relative. It will simply output a NMEA xxTTM string.

Update rate is once per second.

1.7.5.1 Additional Options

Key	Value	Description

1.7.6 Service - ADSBInternal

Internal ADS-B to network raw data. Transmits the ADS-B string received from the internal ADS-B receiver. Normally embedded in CAT-010.

This service will not be available if the ADSB module is not installed.

If the service/server is not available then no response will be given apart from the missing service in the discovery response.

Update rate is once per second.

1.7.6.1 Additional Options

Key	Value	Description

1.7.7 Service - AsterixCat010

Output from the internal tracker, fused or unfused.

Update rate is once per second.

1.7.7.1 Additional Options

Key	Value	Description

1.7.8 Service - AsterixCat240

The video setup also includes the number of bins the unit shall transmit. Each bin is of equal length and resolution.

The Doppler bin merge and setup is decided by the Mission Set.

Due to the amount of data it is not recommended to enable the CAT240 video with it's current implementation.

1.7.8.1 Additional Options

Key	Description	Type	Default
`CFARZeroVal`		Float	0.5
`CFARSpeedVal`		Float	0.2

1.7.9 Service - AsterixCat253

Status is TBA

Asterix CAT-253 control and status

1.7.9.1 Additional Options

Key	Description	Type	Default
SAC	System Area Code	Integer (0-255)	125
`SIC`	System Identification Code	Integer (0-255)	233
LocalID	Local Identifier	Integer (0-255)	24

1.7.10 Service - Syslog

The debug protocol is based on Syslog. The user may enable or disable this protocol. It is advised to store these data in a local Syslog server for later analysis. Dspnor will supply a Syslog analysis tool at a later stage.

1.7.10.1 Additional Options

Key	Description	Type	Default
Debug	Send debug messages	boolean	false
Info	Send info messages	boolean	true
Warning	Send warning messages	boolean	true

1.7.11 INTERNAL GNS Source

Internal GNS to network. The following strings will be transmitted:

Will no be shown if the GNS module is not installed/activated.

Type	Content
RMC	Recommended Minimum Navigation Information
GGA	Fix Data, Time, Position and fix related data for a GPS receiver
GLL	Geographic Position - Latitude/Longitude
GSA	GLONASS DOP and active satellites
VTG	Course and Speed Information relative to the Ground
GSV	Satellites in view

System	Identifier
GPS (Default)	GPxxx
GPS+GLONASS	GLxxx
GPS+GLONASS+GALILEO	GAxxx

1.8 SETTING UP

1.8.1 System IP Addresses and Functionality

1.8.1.1 Own Interface IP

```
{
"Network":
        {
            "InterfaceIP":    [192, 168, 1, 253],
            "Mask":           [255, 255, 255, 0],
            "Gateway":        [192, 168, 1, 1]
        },
}
```

1.9 Magnetometer

Field	Type	Values	Default	Comments
`CalibrateMagnetometer`	Boolean	`true/false`	"false"	Start the calibration of the magnetometer (This will start rotating the antenna and also turn off TX)

1.10 Antenna Commands

Dronnur supports 3 relative oriented blanking sectors. Within the sector transmission will stop.

Field	Type	Values	Default	Comments
`AntennaOperation`	String	`cw/ccw/sector/ss/off`	"off"	ss: Stop & Stare: Tracker controls the antenna if active.
`AntennaRPM`	Number	1.0 - 30.0	10.0	Rounds per minute. Limited to 12.0 if sector mode.
AntennaSBn	Array	See below		Currently 3 blanking sectors are supported.
`AntennaSecScan`	Array	See below		Max 3 sectors supported

Field	Type	Values	Default	Comments
AntennaTilt	Number	-(10.0) - 20.0	0	Vertical tilt in degrees
AntennaChannel	Number	0-16	8	Antenna Channel

1.10.1 Antenna Sector Scan Array

Typically used relative to the heading marker, the "front" position of the radar.

Note: The system will always start at the given start angle and move clockwise to the stop angle.

Field	Type	Values	Default	Comments
Start	Number	-359.9 - 360.0	-25.0	The angle where the sector will start
Stop	Number	-359.9 - 360.0	25.0	The angle where the sector will stop, the system will move clockwise from start to stop.
TrueRelative	String	"true"/"relative"	"relative"	
Scans	Number	0-10	0	0 = Infinite, determines how many scans to perform in the given sector before going to the next sector Note: When specifying 0 and more than 1 sector, it will move to the next sector after 1 scan

1.10.2 Antenna Sector Blanking Array

The sector blanking is only accepted when in CW or CCW mode or if AntennaStopStare is active.

Field	Type	Values	Default	Comments
Active	String	"on"/"off"	"off"	
Start	Number	0.0 - 360.0	0.0	
Stop	Number	0.0 - 360.0	0.0	

Field	Type	Values	Default	Comments
TrueRelative	String	"true"/"relative"	"relative"	If gyro is unavailable the the antenna will always revert to relative.

Example:

```
{
"AntennaMode": "sector",
"AntennaRPM": 10.0,
"AntennaTilt":  0,
"AntennaSecScan":[ {"Start": -20.0, "Stop": 20.0, "TrueRelative": "relative", "Scans": 0 } ],
"AntennaSB1":{"Active":"on", "Start": 0.0, "Stop": 20.0, "TrueRelative": "relative"},
"AntennaSB2":{"Active":"on", "Start": 135.0, "Stop": 225.0, "TrueRelative": "relative"}
}
```

1.10.3 Antenna Azimuth Offset

Although the antenna alignment should be performed during commissioning it is useful to have the possibility. Should be performed while the antenna is rotating and Asterix CAT-240 is enabled.

Field	Type	Values	Default	Comments
AntennaAziOffset	Number	0.0 - 360.0	0.0	Must only be sent when required
AntennaAziOffsetStore	String	"true/false"	"false"	Non-sticky command. Set to "true" if storage is required.

Example

```
{
"AntennaAziOffset": 310.1,
"AntennaAziOffsetStore": true
}
```

1.11 Startup / RunTime Command

Field	Type	Values	Default	Comments
Initsystem	String	"skip"/"position"/"full"	"skip"	Skip: Continue last operation. Position: Rotate antenna in order to adjust north. (Not relevant for Naval) Full: The antenna will rotate and the system will try to map any obstacles by measuring the returned energy. This array will be used to adjust automatically sensitivity when operating (Not relevant for Naval)
TxPower	Number	1.0 - 20.0	10	Output power. Value limited by installed power. Not normally used.
TxMode	String	"Surveillance"/"lpi"/"esm"/"drone"/"off"	"off"	Mission set / Operating mode (When issued the system will start to transmit once the initialization has completed. If the skip command has been issued the the system will start immediately.) • Surveillance: Reports every detected AND tracked object within 19 km. • LongRange: Reports every detected AND tracked object within 38 km. • lpi: Reduces peak power and rotating speed. Reports every detected AND tracked object within 19 km. • esm: When issued the processor will still run and report emissions in the X-band. • nav: For navigation use. CFAR is not applied to static bin. Range 10 km. • drone: For detection of smaller drones out to 5 km. • off: The processor is stopped.
TxRange	Number	12.0 / 18.0 / 24.0 Currently controlled by mode	18	The default instrumented range is 19 km. Consider this a placeholder for the command.

Example

```
{
"InitSystem": "skip",
"TxMode": "normal"
}
```

1.12 External INS Via JSON

External INS can be provided using JSON, the server will not respond with anything and you have to check the status message for "ExternalINS": true if you want to know if the messages was accepted.

Preferred update frequency for input data is 20-50hz,

When sending the message partial updates are allowed, so you can send any combination of the fields for each message.

```
{
    "INS": {
        "TrueBearing": 360.0,
        "Lat": 60.5,
        "Lon": 5.0,
        "COG": 360.0,
        "SOG": 36.0
    }
}
```

1.12.1 Field Description

Key	Description	Type
`TrueBearing`	Degrees	Float (0.0 - 360.0)
`Lat`	WGS84 Latitude	Float
Lon	WGS84 Longitude	Float
COG	Course Over Ground, Degrees	Float (0.0 - 360.0)
SOG	Speed Over Ground, Meters Per Second	Float

1.13 RunTime Status

This message is transmitted once every 5 seconds or when a setting has been received.

All the fields has not be determined yet.

Example:

```
{
"InternalGPS": true,
"InternalAIS": false,
"InternalADSB":false,
"InternalGyro": true,
"AntennaTilt": true,
"ExternalGps": true,
"ExternalGyro": true,
"Sensors": {
    "GPS":
    {
        "Source": "ExternalGNS",
        "LastUpdate": ms_since_epoch,
        "Lat": 60.5,
        "Lon": 5.1,
        "Alt": 2.0
    },
    "Gyro":
    {
        "Source": "Internal",
        "LastUpdate": ms_since_epoch,
        "Heading": 132.5
    },
    "SOG":
    {
        "Source": "ExternalINS":
        "LastUpdate": ms_since_epoch,
        "Speed": 13.2
    }
},
"TxMode": "normal",
"TxPower": 10,
"SystemHw":  {"Temp": 32, TBD},
"ProcHW": {"Temp": 32, TBD},
"RfConverter": {"Temp": 32, TBD},
"PowerAmp": {"Temp": 32, TBD},
"ClkGenerator": {"Temp": 32, TBD},
"MotConHor": {"Temp": 32, TBD},
"MotConVer": {"Temp": 32, TBD},
"Magnetometer": { "Calibrating": false, "Calibrated": false }
}
```

Field description

Field	Description	Comments
InternalGPS	Whether the internal GPS is present or not	
InternalAIS	Whether internal AIS is present or not	
InternalGyro	Whether internal Gyro is present or not	

Field	Description	Comments
AntennaTilt	Whether antenna has tilt support or not	
ExternalGNS	Whether external GNS is present or not	
ExternalINS	Whether external INS is present or not	
TxMode	Which tx mode is currently active	
TxPower	The output power level of the antenna	
Sensors	See the table below	

GPS

Field	Description	Comments
Source	The source used for the data	
LastUpdate	Timestamp milliseconds since epoch	
Lat	wgs84	
Lon	wgs84	
Alt	wgs84	

Gyro

Field	Description	Comments
Source	The source used for the data	
LastUpdate	Timestamp milliseconds since epoch	
Heading	current heading in degrees	

SOG

Field	Description	Comments
Source	The source used for the data	
LastUpdate	Timestamp milliseconds since epoch	
Speed	Speed over ground in meters per second	

1.14 Additional Commands

1.14.1 Reset / Reboot Unit

> This feature MUST be implemented with care, with several safeguards.

To reset the unit you will have to send a special command to the multicast address 227.228.229.230 and port 59369 as shown below.

This will reset the unit to factory settings.

The same procedure can be used in order to reboot the unit.

```
{
    "ResetUnit": "SerialNumber",
    "RebootUnit": "SerialNumber"
}
```

2 ASTERIX UAP & PROTOCOL DESCRIPTIONS

2.1 DNESM Event Message V1

The DNESM message is transmitted once every time energy has been detected which is above the noise floor. Currently no further processing has been developed but the data fields have been setup with further features in mind. Please refer to the user manual for more information about

Example:

$DNESM, 115.1,143.4,9300,3000,,134322.100*xx<CR><LF>

Field	Description	Comments
DNESM	Sentence ID	
aaa.a	Bearing, relative	
bbb.b	Bearing, true	
ccccc	Frequency in MHZ	Between 9000 and 9500 MHz. Reported as 9300.
ddddd	Signal level, relative	Raw ADC data.
eeeee	Signal level, dBm	TBA, currently not used.
hhmmss.sss	UTC timestamp	
*xx	Checksum	May or may not be used
<CR><LF>	End of sentence	

2.2 Asterix CAT-010 User Application Profile (UAP)

Data Item Reference Number	Description	Resolution	Encoding Rules	2D Tracker Use
I010/000	Message Type	N.A.	M	Yes
I010/010	Data Source Identifier	N.A.	M	Yes

Data Item Reference Number	Description	Resolution	Encoding Rules	2D Tracker Use
I010/020	Target Report Descriptor	N.A.	M	Yes
I010/040	Measured Position in Slant Polar Coordinates	RHO: 1 m THETA: 360°/(2^16)	O	Option *1
I010/041	Position in WGS-84	180°/(2^31)	O	Option*1
I010/042	Position in Cartesian Co-ordinates	1 m	O	Option*1
I010/060	Mode-3/A Code in Octal Representation	N.A.	O	No
I010/090	Flight Level in Binary Representation	1/4 FL	O	No
I010/091	Measured Height	6.25 ft	O	Option
I010/131	Amplitude of Primary Plot	1 dBm	O	No
I010/140	Time-of-Day	1/128 s	M	Yes
I010/161	Track Number	N.A.	O	Option*2
I010/170	Track Status	N.A.	O	Yes
I010/200	Calculated Track Velocity in Polar Co-ordinates	Speed: 2^-14 NM/s Angle : 360°/(2^16)	O	Option
I010/202	Calculated Track Velocity in Cartesian Coord.	0.25 m/s	O	Option
I010/210	Calculated Acceleration	0.25 m/s^2	O	Option
I010/220	Target Address	N.A.	O	Option *2
I010/245	Target Identification	N.A.	O	Option
I010/250	Mode S MB Data	N.A.	O	No
I010/270	Target Size & Orientation	Size: 1 m Orient.: 360°/128	O	No

Data Item Reference Number	Description	Resolution	Encoding Rules	2D Tracker Use
I010/280	Presence	D_Rho: 1m D_Theta: 0.15°	O	No
I010/300	Vehicle Fleet Identification	N.A.	O	No
I010/310	Pre-programmed Message	N.A.	O	No
I010/500	Standard Deviation of Position	0.25 m^2	O	No
I010/550	System Status	N.A.	O	No

2.2.1 NOTE A:

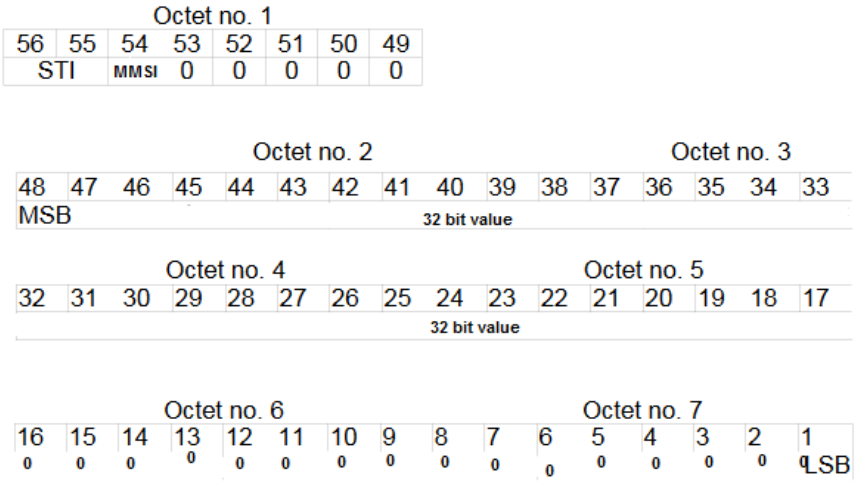
Regarding fields marked with Option. These fields will only be filled out if the tracker source used supplies this information. See additional information below:

Option *1: One of the 3 will always be supplied. Most likely I010/041, least likely I010/042. I010/040 will be supplied if own position is valid.

Option *2: One of the 2 will always be supplied. Most likely I010/220. Otherwise I010/161. I010/161 is based on a least recently used cycling of a fixed number of values (1-4095)

2.2.2 NOTE B:

Target Identification is handled specially for tracks with MMSI, in Data Item I010/245
Tracks with MMSI information has bit 54 set, according to specification. Bit 54 is set to 0 by standard, but we use it to signal that the value is indeed a MMSI value.
The MMSI is stored as a 4 byte BigEndian 32 bit value. in Octet no.2 to Octet No.5. Octet no.6 and no.7 is left at 0.
This 32 bit value equals the 9 digit MMSI ID. (Stored BigEndian)



2.3 Asterix CAT-240 User Application Profile (UAP)

Version 0x0004.

FRN	Data Item Reference Number	Description	Length	Message 001	Message 002
2	I240/000	Message Type	1	M	M
1	I240/010	Data Source Identifier	2	M	M
3	I240/020	Video Record Header	4	X	M
4	I240/030	Video Summary	1+n	M	X
5	I240/040	Video Header Nano	12	X	Either one is mandatory
6	I240/041	Video Header Femto	12	X	
7	I240/048	Video Cells Resolution & Data Compression Indicator	2	X	M

FRN	Data Item Reference Number	Description	Length	Message 001	Message 002
FX	-	Field Extension Indicator		Not used	M
8	I240/049	Video Octets & Video Cells Counters	5	X	M
9	I240/050	Video Block Low Data Volume	1+4*n	X	Either one is mandatory
10	I240/051	Video Block Medium Data Volume	1+64*n	X	
11	I240/052	Video Block High Data Volume	1+256*n	X	
12	I240/140	Time of Day	3	Not used	Not used
13	RE	Reserved Expansion Field	1+	X	X
14	SP	Special Purpose Field	1+	X	M
FX	-	Field Extension Indicator	-	Not used	Not used

2.3.1 Data Item I240/030, Video Summary

```
uint8 hdr[2] = "dn";  // D2D Asterix CAT240
uint16 version = 0x0004; // D2D Asterix CAT240 protocol version.
uint16 range_cells; // Total number of range cells.
uint16 subbins; // Total numer of doppler bins before combining.
uint16 bins; // Total numer of doppler bins after combining.
float doppler_res_mps; // Doppler resolution in m/s.
uint32 pos_x; // X position
uint32 pos_y; // Y position
uint32 pos_z; // Z position
```

2.3.2 Data Item SP, D2D

```
uint8 Rep; // repetition field, including self.
uint16 elevation_start; //Elevation Start
uint16 elevation_end; //Elevation end
uint48 meas_start; //System time at start of measurement.
uint48 meas_end; //System time at end of measurement.
uint16 doppler_bin; //current doppler bin.
int16 start_cms; //Doppler start cm/s
int16 end_cms; //Doppler end cm/s
```

System time is a 48-bit timer running on the sampling clock (125MHz) in the FPGA.

2.3.3 Video Format

Processed data as float32