JTRS ORD Waveforms R/Evolution

(With New JROC Approved Version 3.2 of 9 April 03)

Special Presentation to ICNS Conference

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Philosophy

- The JTRS Program is a *military tactical radio* program, period! *(At least initially)*
- And JTRS (& SDR) present a dramatic potential for *military, civil, and world-wide* aviation applications & r/evolution
- *Waveforms* are the "*Heart*" of the ORD
- Thus JTRS (& SDR) provide
  - An *unprecedented & flexible* capability

-And an outstanding technical & operational opportunity to "think outside the box!"

JTRS ORD Revision History

- 1998 ver 1.0 was first “real” ORD
  - Just notional waveform (WF) *placeholders*
- 2001 ver 2.2 WFs better, but *still vague*
  - Table organization improved, but not WFs
  - *Numerous technical & operational errors*
  - *Unlikely interoperability & performance*
- 2002 ver 2.3 (no WF changes)
- 2003 ver 3.2 *dramatic WF improvement*
  - Clear, concise, correct, comprehensive…
  - Product of two-year crusade to “fix it right”
  - OSD, JS, JPO, Services, Feds, MITRE…

JTRS ORDs & Waveform Counts

- Three Waveform Categories in ORDs
  - **"Key Performance Parameters (KPPs)"="K"**
  - **"Threshold" Waveforms = "T"**
  - **"Objective" Waveforms = "O"**
- Ver 1.0 - 23 Mar 1998
  - 6-K + 32-T + 4-O = ***42*** waveforms
- Ver 2.2 - 31 Jan 2001
  - 5-K + 24-T + 4-O = ***33*** waveforms
- Ver 2.3 - 13 Mar 2002 (no WF changes)
- Ver 3.2 - 9 Apr 2003 *(newly approved)*
  - 6-K + 25-T + 2-O = "***32***" waveform/*families*

JTRS ORD Ver 2.3 - 2002 - Table 4-2

***Entire* Set of Waveforms in a *Single* Page Table...**

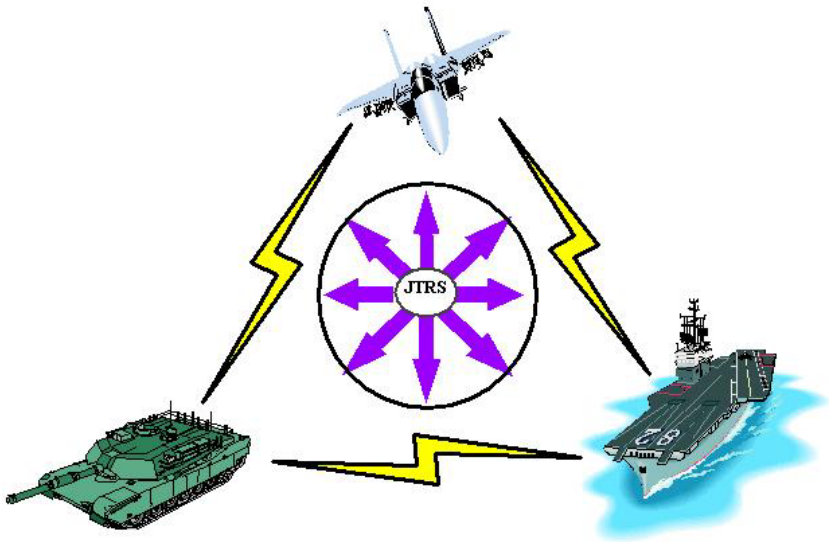
WAVEFORM	FREQ. BAND	BANDWIDTH	DATA RATES	K/T/O
***SINCGARS ESIP w/MIL-STD 188-220**	30-88 MHz	25 KHz	16 Kbps	K-T
***HAVE QUICK II**	225-400 MHz	25 KHz	16 Kbps	K-T
***UHF DAMA SATCOM (MIL-STD-188-181/182/183 Compliant)**	225-400 MHz	5 and 25 KHz	75, 300, 600 bps; 1.2, 2.4, 4.8, 9.6, 16, 19.2, 28.8, 32, 38.4, 48, 56, 64Kbps	K-T
***Enhanced Position Location Reporting System (EPLRS)**	420-450 MHz	3 MHz	57 Kbps VHSIC SIP 114 Kbps VECP	K-T
***Wideband Networking Waveform (WNW) (new, modified or existing waveform)**	Government or Vendor Developed	Government or Vendor Developed	Government or Vendor Developed	K-T
UHF DAMA SATCOM (MIL-STD-188-184 Compliant	225-400 MHz	5 and 25 KHz	TBD	T
HF Independent Side Band (ISB) w/ Automatic Link Establishment (ALE)	2-30 MHz	3 -12 KHz	4.8/9.6 Kbps	T
HF Single Side Band (SSB) w/Automatic Link Establishment (ALE)	2-30 MHz	3 KHz	2.4/9.6 Kbps	T
Link 11	2-30 MHz and 225-400 MHz	3 KHz and 25 KHz	2.25 Kbps	T
STANAG 5066 (HF)	2-30 MHz	3 KHz	9.6 Kbps	T
STANAG 4529	2-30 MHz	1.24 KHz	1.8 Kbps	T
ATC HF Data Link	2-30 MHz	3 KHz	300,600,1200,1800 Bps	T
VHF FM	30-88 MHz	25 KHz	16 Kbps	T
VHF for ATC (replaces 25 KHz spacing)	112-137 MHz	8.33 KHz	TBD	T
VHF AM	118-156 MHz	25 KHz	16 Kbps	T
VHF FM Public Service (APCO 25) (Land Mobile Radio)	138-150.8 MHz and 162-174 MHz	6.5, 12.5,25 KHz	16 Kbps	T
ATC VHF Data Link	112-137 MHz	25 KHz	31.5 Kbps	T
UHF AM/FM PSK LOS	225-400 MHz	25 KHz	16 Kbps	T
STANAG 4231 (UHF SATCOM)	225-400 MHz	TBD	TBD	T
Link 4A	225-400 MHz	25 KHz	5 Kbps	T
Link 11B	225-400 MHz	25 KHz	0.6, 1.2, 2.4 Kbps	T
Integrated Broadcast Service Module (IBS-M)	225-400 MHz	5 and 25 KHz	19.2 Kbps (tunable 2.4, 4.8, 9.6, 19.2)	T
SATURN	225-400 MHz	25 KHz	TBD	T
UHF FM Public Service APCO 25(Land Mobile Radio)	380-420 MHz	5 and 12.5 KHz	25 KHz: 16 Kbps	T
Link 16	960-1215 MHz	3 MHz	118/236 Kbps w/FEC	T
STANAG 4193 Mode S Level 4/5	1030/1090 MHz	3.5 MHz/3 MHz	TBD	T
Digital Wideband Transmission System (DWTS)	1350-1850 MHz	125 KHz	144,256,288,512,1024, 1544,2048 Kbps	T
Soldier Radio	1.75 - 1.85 GHz	25 KHz	16 Kbps	T
COBRA	340-400 MHz	TBP	TBP	T
MUOS	240-320 MHz	5 MHz, 25 MHz	2.4, 9.6, 16, 32 Kbps	O
Cellular Radio	TBD	TBD	TBD	O
Link 22	3-30 MHz and 225-400 MHz	TBD	TBD	O
Mobile Satellite Service (MSS)	1.61- 2 GHz	TBD	2.4 - 9.6 Kbps	O

TABLE 4-2

***K = KPP T = Threshold O = Objective**

JROC APPROVED
UNCLASSIFIED
9 April 2003

Joint Tactical Radio System



JOINT TACTICAL RADIO SYSTEM
(JTRS)

OPERATIONAL REQUIREMENTS DOCUMENT
(ORD)

Version 3.2
JROC Approved, JROCM 087-03, 9 April 2003

(Supersedes previous version 2.3 dated 24 April 2002)
ACAT: 1D

3rd ORD

JROC Approved – 9 April 03!

JTRS ORD Ver 3.2 - 2003 - Table 4-2

9 April 2003

JTRS WAVEFORMS (By Priority: KPP / Threshold / Objective)

ID	KPP (K)	ID	THRESHOLD (T)	ID	OBJECTIVE (O)
W1	***SINCGARS ESIP** (VHF-FM Military Tactical AJ)	W7	UHF SATCOM Military Protocol (184)	W30	MSS [Waveform Family]
W2	***HAVE QUICK II** (UHF-AM/FM/PSK Military Tactical AJ)	W8	HF-ISB ALE	W32	BOWMAN (UK HF/UHF Military Tactical) [Waveform and Equipment Family]
W3	***UHF SATCOM Military** (181-182-183 "DAMA")	W9	HF-SSB ALE AJ		
W4	***EPLRS**	W10	Link-11 / TADIL-A		
W5	***WNW**	W11	STANAG 5066 (HF Message Protocol)		
W6	***Link 16** / TADIL-J	W12	STANAG 4529 (HF NB Modem)		
		W13	VHF-FM – Military Tactical		
		W14	HF ATC Data Link		
		W15	VHF-AM ATC		
		W16	VHF-AM ATC Extended		
		W17	VHF/UHF-FM LMR: (Land Mobile Radio & Public Safety w/ Project-25 and TETRA) [Waveform Family]		
		W18	VHF ATC Data Link (NEXCOM)		
		W19	UHF-AM/FM/PSK Military Tactical		
		W20	Link-4A / TADIL-C		
		W21	Link-11B / TADIL-B		
		W22	SATURN (UHF PSK AJ NATO)		
		W23	STANAG 4193 Mode S Level 4/5		
		W24	DWTS (UHF PSK WB LOS)		
		W25	Soldier Radio & WLAN & Advanced Capability [Waveform Family]		
		W26	COBRA		
		W27	MUOS-CAI (UHF SATCOM Military Obj.)		
		W28	Cellular Radio & PCS [Waveform Family]		
		W29	Link 22 / NILE		
		W31	IBS-M		
		W32	BOWMAN (VHF)		

TABLE 4-2

Note: Individual waveform characteristics are shown in Annex E.

"Key Performance Parameters" Waveforms (KPPs) or "(K)" in BOLD with STAR

"Objective" Waveforms or "(O)"

"Threshold" Waveforms or "(T)"

JTRS ORD Ver 3.2 - 2003 - Table 4-2

JTRS WAVEFORMS (By Priority: KPP / Threshold / Objective)

ID	KPP (K)	ID	THRESHOLD (T)	ID	OBJECTIVE (O)
W1	*SINCGARS ESIP (VHF-FM Military Tactical AJ)	W7	UHF SATCOM Military Protocol (184)	W30	MSS [Waveform Family]
W2	*HAVE QUICK II (UHF-AM/FM/PSK Military Tactical AJ)	W8	HF-ISB ALE	W32	BOWMAN (UK HF/UHF Military Tactical) [Waveform and Equipment Family]
W3	*UHF SATCOM Military (181-182-183 "DAMA")	W9	HF-SSB ALE AJ		
W4	*EPLRS	W10	Link-11 / TADIL-A		
W5	*WNW	W11	STANAG 5066 (HF Message Protocol)		
W6	*Link 16 / TADIL-J	W12	STANAG 4529 (HF NB Modem)		
		W13	VHF-FM – Military Tactical		
		W14	HF ATC Data Link		
		W15	VHF-AM ATC		
		W16	VHF-AM ATC Extended		
		W17	VHF/UHF-FM LMR: (Land Mobile Radio & Public Safety w/ Project-25 and TETRA) [Waveform Family]		
		W18	VHF ATC Data Link (NEXCOM)		
		W19	UHF-AM/FM/PSK Military Tactical		
		W20	Link-4A / TADIL-C		
		W21	Link-11B / TADIL-B		
		W22	SATURN (UHF PSK AJ NATO)		
		W23	STANAG 4193 Mode S Level 4/5		
		W24	DWTS (UHF PSK WB LOS)		
		W25	Soldier Radio & WLAN & Advanced Capability [Waveform Family]		
		W26	COBRA		
		W27	MUOS-CAI (UHF SATCOM Military Obj.)		
		W28	Cellular Radio & PCS [Waveform Family]		
		W29	Link 22 / NILE		
		W31	IBS-M		
		W32	BOWMAN (VHF)		

TABLE 4-2

Aviation Waveforms Extract
– 9 May 2003
– Version C1

Military Specific in BLUE (including many Air-Ground and BLOS) and Civil Applications in YELLOW

JTRS ORD Ver 3.2 - 2003 - Table 4-2

JTRS WAVEFORMS (By Priority: KPP / Threshold / Objective)

ID	KPP (K)	ID	THRESHOLD (T)	ID	OBJECTIVE (O)
W1	***SINCGARS ESIP** (VHF-FM Military Tactical AJ)	W7	UHF SATCOM Military Protocol (184)	W30	MSS [Waveform Family]
W2	***HAVE QUICK II** (UHF-AM/FM/PSK Military Tactical AJ)	W8	HF-ISB ALE	W32	BOWMAN (UK HF/UHF Military Tactical) [Waveform and Equipment Family]
W3	***UHF SATCOM Military** (181-182-183 "DAMA")	W9	HF-SSB ALE AJ		
W4	***EPLRS**	W10	Link-11 / TADIL-A		
W5	***WNW**	W11	STANAG 5066 (HF Message Protocol)		
W6	***Link 16** / TADIL-J	W12	STANAG 4529 (HF NB Modem)		
		W13	VHF-FM – Military Tactical		
		W14	HF ATC Data Link		
		W15	VHF-AM ATC		
		W16	VHF-AM ATC Extended		
		W17	VHF/UHF-FM LMR: (Land Mobile Radio & Public Safety w/ Project-25 and TETRA) [Waveform Family]		
		W18	VHF ATC Data Link (NEXCOM)		
		W19	UHF-AM/FM/PSK Military Tactical		
		W20	Link-4A / TADIL-C		
		W21	Link-11B / TADIL-B		
		W22	SATURN (UHF PSK AJ NATO)		
		W23	STANAG 4193 Mode S Level 4/5		
		W24	DWTS (UHF PSK WB LOS)		
		W25	Soldier Radio & WLAN & Advanced Capability [Waveform Family]		
		W26	COBRA		
		W27	MUOS-CAI (UHF SATCOM Military Obj.)		
		W28	Cellular Radio & PCS [Waveform Family]		
		W29	Link 22 / NILE		
		W31	IBS-M		
		W32	BOWMAN (VHF)		

TABLE 4-2

C-SAR & GPRS Waveforms Extract
– 9 May 2003
– Version C1

SAR, CSAR, Distress & Calling, Guards, and Emergency Operations Applications in YELLOW

ORD Functional Waveform Families

- Military Line-of-Sight (LOS)
- Military Beyond-Line-of-Sight (BLOS)
- ***Military Aviation & Navigation***
- Military Tactical Data Links
- Non-Military LOS
- Non-Military BLOS
- ***Non-Military Aviation & Navigation***

Note - The ***primary*** Aviation Waveforms are shown in ***BOLD Italics*** in the following slides.

Military Line-of-Sight (LOS) Family

- W1 -*SINCGARS ESIP (VHF-FM Mil Tac AJ)
- W13 - VHF-FM Military Tactical
- ***W2 -*HAVE QUICK II (UHF-AM/FM/PSK AJ)***
- ***W19 - UHF-AM/FM/PSK Military Tactical***
- W22 - SATURN (UHF PSK AJ NATO)
- W26 - COBRA
- W32 - BOWMAN (UK VHF/UHF Mil Tactical)
- W4 -*EPLRS
- W25 - Soldier Radio & WLAN *(& Civil)*
- W24 - DWTS (UHF PSK WB LOS) *(non-Air?)*
- W5 -*WNW (WB Networking WF)

Military Beyond-LOS (BLOS) Family

- W3 -*UHF SATCOM Military (181-182-183 "DAMA")
- W7 - UHF SATCOM Military Protocol (184)
- W27 - MUOS-CAI (UHF SATCOM Mil Obj)
- W31 - IBS-M
- ***W8 - HF-ISB ALE (& Civil)***
- ***W9 - HF-SSB ALE AJ (& Civil)***
- W11 - STANAG 5066 (HF Msg Proto)*(& Civil)*
- W12 - STANAG 4529 (HF NB Modm) *(& Civil)*
- W32 - BOWMAN (UK HF Mil Tactical Family)

Military AV-NAV-TADIL Families

- Military Aviation & Navigation Family
  - ***W23 - STANAG 4193 Mode S Level 4/5 (& Civil)***
- Military Tactical Data Link Family
  - ***W20 - Link-4A / TADIL-C***
  - W10 - Link-11 / TADIL-A *(non-Air?)*
  - W21 - Link-11B / TADIL-B *(non-Air?)*
  - ***W6 -*Link-16 / TADIL-J***
  - W29 - Link 22 / NILE *(non-Air?)*

Non-Military B/LOS Families

- Non-Military LOS Family
  - ***W17 - VHF/UHF-FM LMR (P-25 & TETRA)***
  - W28 - Cellular Radio & PCS
  - W25 - Soldier Radio & WLAN *(& MIL)*
- Non-Military BLOS Family
  - ***W30 - MSS (Mobile Satellite Services)***
  - ***W8 - HF-ISB ALE (& MIL)***
  - ***W9 - HF-SSB ALE AJ (& MIL)***
  - W11 - STANAG 5066 (HF Msg Prot)*(&MIL)*
  - W12 - STANAG 4529 (HF NB Mod) *(&MIL)*

Non-Military Aviation & Nav Family

- ***W15 - VHF-AM ATC***
- ***W16 - VHF-AM ATC Extended***
- ***W18 - VHF ATC Data Link (NEXCOM)***
- ***W14 - HF ATC Data Link***
- ***W23 - STANAG 4193 Mode S Level 4/5 (& MIL)***

New "Criteria [& Comments]" Fields

- Provide information *essential to success*
  - Ensure *interoperability & performance*
  - Ensure *operational mission effectiveness*
- *"Criteria"* includes *mandatory* elements
  - Standards, specifications, regulations…
    - ARINC, FAA, FCC/NTIS, Federal & Military...
  - Missions, applications, *safety, guards*…
  - *Specifies* "Thresholds" & "Objectives"
- *"[Comments]"* includes *clarifications*
  - Operational procedures, needs, uses…
  - Associated systems, beneficial *"Options"…*

JTRS ORD Ver 3.2 - 2003 - Annex E

WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied]
STANAG 5066 (HF Message Protocol)	W11	N/A	N/A	N/A	Protocol only, transported over supporting HF waveforms HF-ISB/SSB (W8 & W9) and employing MIL-STD-188-141 & -110. OBJECTIVE to 1.5 MHz in compliance with STANAG-4203, QST...
STANAG 4529 (HF NB Modem)	W12	(T) 2-30 MHz (O) 1.5-30	1.24 KHz	DATA 7...	...ported over MIL-STD-...11 ... 4203... Requires Forward Error Correction (FEC) coding fully compliant with STANAG 4285 Annex E. OBJECTIVE to 1.5 MHz in compliance with STANAG-4203, QSTAG-733, et al.
VHF-FM – Military Tactical	W13	30-88 MHz	25 KHz and 50 KHz	VOICE (A & D 16 Kbps)	MIL-STD-188-242 compliant. Includes guard (40.50 MHz et al) & inband signals ("new squelch" 150 Hz tone et al). Includes legacy non-AJ for Allied and Coalition interoperability.
HF ATC Data Link	W14	(O) 2-30 MHz (O) 1.5-30 MHz	3 KHz	VOICE (A) & DATA 300, 600, 1200, 1800 Bps	Air Traffic Control (ATC). RTCA DO-265, ARINC 635-3 & -735-3, and FAA TSO-C31d & -C32d compliant TDMA and FDMA. OBJECTIVE to 1.5 MHz in compliance with STANAG-4203, QSTAG-733, et al. [Packet data.]
VHF-AM ATC	W15	(T) 118-137 MHz (O) 108-137 MHz	8.33 KHz [Includes 25 KHz]	VOICE (A) 16 Kbps	Air Traffic Control (ATC). RTCA DO-186a & ARINC 716 compliant and NAS Architecture with future 108-118 MHz (presently VOR/ILS and emergency ATC voice). Navigation uses may require increased reliability and availability. Includes legacy 25 KHz plus European 8.33 KHz. Includes VHF guards (121.5 & 123.1 MHz et al) & inband signals (ELT & SELCAL et al).
VHF-AM ATC Extended	W16	108-156 MHz	25 KHz	(T) VOICE (A) (O) VOR/ILS Nav (A)	Air Traffic Control (ATC), VHF Omni-Range (VOR), and Instrument Landing System (ILS). QSTAG-706 & RTCA DO-186a & -195 & -196 & ARINC 716 compliant, and NAS Architecture with future 108-118 MHz (presently VOR/ILS and emergency ATC voice). Navigation uses may require increased reliability and availability. Includes extended legacy 25 KHz. Includes VHF guards (121.5 & 123.1 MHz et al) & inband signals (ELT & SELCAL et al).

Entire Waveform Tables Attached!

Significant Aviation Waveform Cases

- UHF-AM/FM/PSK Military Tactical
- Public Safety Interoperability & VHF/UHF-FM LMR
- Mobile Satellite Services (MSS)
- STANAG 4193 Mode S Level 4/5

Ex: "UHF-AM/FM/PSK Military Tactical"

[Waveform Family]

Old ORDs…

"UHF AM/FM PSK LOS"

(T) 225-400 MHz

New Improved ORD…

"UHF-AM/FM/PSK Military Tactical"
(New Name)

(T) 225-400 MHz
(O) 225-450 MHz

Ex: "UHF-AM/FM/PSK Military Tactical"

All NEW in ORD! MIL-STD-188-181B & -243 compliant. Includes FAA CONUS and overseas & military ATC operations. Includes UHF guards (243.0 / 282.8 / (O) 406.025 MHz et al) & inband signals (ELT & SELCAL, CTCSS & DTMF et al). OBJECTIVE includes ability to exploit (both transmit and receive) 406 beacon position location systems, including interface to GPS, IAW TSO C-126. [Data up to 16 Kbps w/ optional IDM.] [Optional implementation of VDL 2 & 3 NEXCOM FUW FAA CONUS up to 31.5 Kbps]

Ex: Public Safety Interoperability

- *Almost all* "public safety" in *FCC LMR*
  - JTRS is *military* & focused on *NTIA* bands
  - 1998 *Poor* - Just *2 of many* needed bands
    - Had VHF-High & UHF-450 basic LMR bands
  - 2001 *Worse!*
    - 150-162 MHz FCC segment *removed!*
    - But added military-only 380-420 MHz UHF
  - 2002 *No WF improvements...*
  - 2003 OK! Includes *full LMR family*
    - Military, NTIA, FCC, Allied, Euro & OCONUS
    - VHF-Low/Mid/High/220, UHF/T/700-800-900
    - Conventional, analog/digital, Proj-25 & TETRA

Ex: "VHF/UHF-FM LMR…"

"Land Mobile Radio & Public Safety w/ Project-25 and TETRA"

[Waveform Family]

Old ORDs…

"VHF or UHF FM Public Safety LMR APCO 25"

(T) "High"= 136-174 MHz

(T) "UHF"= 380-420 MHz

["Missing Link" 150-162]

New Improved ORD…

(New & Better Name)

(T) "Low"= 25-54 MHz

(T) "Mid" = 72-76 MHz

(T) "High"= 136-174 MHz

(T) "220" = 216-225 MHz

(T) "UHF/T"= 380-512 MHz

(T) "800" = 764-869 MHz

(O) "TV" = 686-960 MHz

Ex: "VHF/UHF-FM LMR..."

All NEW in ORD! Includes Homeland Security (HLS) & Defense (HLD) legacy interoperability with both NTIA and FCC, digital & analog, "wideband," "narrowband," & future "very narrowband" systems, plus International Maritime VHF. Project-25 compliant includes Common Air Interface (CAI) for subscriber units (not infrastructure) for JTRS unit-unit and unit-infrastructure use. Includes capability for NSA/NIST Type 1 through 4 COMSEC. Includes VHF/UHF guards (47.42, 156.8 / 156.525 and 866.0125 MHz et al) & inband signals (ELT & DSC, CTCSS & DTMF et al). Shall include future upgrade to Terrestrial Trunked Radio (TETRA) and frequency flexibility for overseas LMR bands, including 380-400 MHz NATO Emergency Services and 400-430 MHz European Civil bands, et al. "220" Band utilizes Single Side Band (SSB) and/or Narrow Band FM (NBFM) in 5 KHz. OBJECTIVE includes emerging "TV" bands (channels 70-83 806-in 890 MHz and 50-69 in 686-806 MHz.).

Ex: "Mobile Satellite Services (MSS)"

[Waveform Family]

Old ORDs…

"MSS"

(O) "61."-2.5 GHz
in 1998

or

(O) 1.61-2 GHz
in 2001-2002

New Improved ORD…

(New Name)

(O) 137-150 MHz

and

(O) 1.61-2 [2.5] GHz
and per system

Ex: "Mobile Satellite Services (MSS)"

All NEW in ORD! Mobile Satellite Service (MSS). Includes both VHF and UHF MSS bands and both fielded and emerging LEOSAT & MEOSAT systems and standards, such as IRIDIUM, Globalstar, et al. Includes capability for NSA/NIST Type 1 through 4 COMSEC. OBJECTIVE includes capability to utilize GEOSAT systems such as Motient (formerly AMSC) and INMARSAT, et al. Addition of appropriate antenna systems may be required. OBJECTIVE also includes future expansion bands to 2.5 GHz. [OBJECTIVE includes transoceanic aviation use of INMARSAT AERO-I and AERO-H FUW GANS and GATM.]

Ex: "STANAG 4193 Mode S Level 4/5"

(Civil air "transponders" from WW-II "IFF")
[Waveform Family]

Old ORDs…
"Mode S Level 4"

(T) 1030-1090 MHz

New Improved ORD…
(New Name)

(T) 1030-1090 MHz

Ex: "STANAG 4193 Mode S Level 4/5"

All NEW in ORD! Fully compliant with STANAG 4193 including Mode Select (Mode S), Levels 5 & 4 lower. THRESHOLD includes both transponders and interrogators on platforms and at low transmit powers. OBJECTIVE includes upgrade to high power (ground-based and airborne warning et al) interrogators. Includes Mark X & XII/A with all Identification Friend or Foe (IFF) and Selective Identification Feature (SIF) Modes 1 through 5 and A & C, and ACP-160 and ICAO Annex 10 compliance. Includes civil secondary Air Traffic Control Radar Beacon System (ATCRBS), Airborne Collision Avoidance System (ACAS) and Traffic Alert & Collision Avoidance System (TCAS), and Automatic Dependent Surveillance – Addressable (ADS-A) and Broadcast (ADS-B) functionality. Includes supporting interface to GPS and other systems for flight, navigation and timing data. ADS requires interface to SATCOM, VHF Data Link, and other alternate channels IAW platform capabilities and mission needs. Includes generation of, and detection and alarm on, emergency messages, including ATCRBS (7700 emergency, 7600 communications failure, et al) and special military (4X et al) codes.

Waveform Issues Still in Process

- Other Aviation Possibilities
  - INMARSAT
  - Multiple Global Navigation Satellite Systems (GNSS)
- Potential Future JTRS Roles
  - SATCOM Ground Terminals
  - Extension above 2 GHz

Significant *Proposed* Aviation WFs

- *Withheld* Pending Further Consideration
  - Aviation POS/NAV & Landing Sys. [Family]
  - GNSS & JPALS [Family]
    - GPS itself is NOT enumerated as a JTRS "waveform" but is required in all JTR Sets
  - LAAS & JPALS DGPS [Family]
  - INMARSAT [Family] (with MSS)
  - VHF/UHF Emergency & Distress [Family]
    - NOT enumerated as "waveform," and cited and/or embedded elsewhere in Table

Ex:“Aviation POS/NAV & Landing Sys”

Proposed! Position and Navigation (POS/NAV) Systems. Includes Civil VHF OmniRange (VOR), Military TACtical Air Navigation (TACAN) and VORTAC, and shared Distance Measuring Equipment (DME), plus glideslope component required for Instrument Landing System (ILS).. Includes Joint Precision Aircraft Landing System (JPALS). Shall include necessary signal and system integrity assurance functions. Should permit optional reuse of legacy or external flight systems, such as Flight Management Systems (FMS) and Heads-Up Displays (HUD) and autopilots, plus human-machine interfaces, including Horizontal Situation Indicators (HSI) and Course Deviation Indicators (CDI).

Ex: “GNSS & JPALS [Family]”- 1

Proposed! (Part 1) Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) Family. GPS itself is NOT enumerated as a JTRS “waveform” but is required in every JTR Set (K). GPS shall include civil “C/A code” Standard Positioning Service (SPS), plus military “P-code” Precise Positioning Service (PPS) that shall require incorporation of Selective Availability Anti-Spoofing Module (SAASM) or approved equivalent for security per National Policy. GPS shall also receive and provide Precise Time and Time Interval (PTTI) data. THRESHOLD also includes implementation of Differential GPS (DGPS) functionality, including Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) interoperable with FAA systems, and ICAO Ground Based Augmentation System (GBAS), in accordance with RTCA DO-246B and DO-253 et al. (T) Military aviation implementation THRESHOLD specifically includes Joint Precision Approach and Landing System (JPALS) Local Area Differential Global Positioning System (LDGPS) and Shipboard-Relative GPS (SRGPS) variant. Compliant with JPALS-STD-002 and –003.

Ex: “GNSS & JPALS [Family]”- 2

Proposed! (Part 2) GPS implementations on aircraft, or in Safety-of-Life (SOL) or precision navigation applications, shall incorporate reliability assurance supervision and alerting per FAA TSO-C129 and TSO-C146. This specifically includes Receiver Autonomous Integrity Monitoring (RAIM) and Fault Detection and Exclusion (FDE) in compliance with RTCA DO-236 and DO-229 or approved equivalent. This may mandate that JTR Set and channel Operational Availability A(o) in excess of that specified by ORD KPP criteria. This is also required to support Sole Means Primary Navigation use during all phases of flight or maneuver, including Instrument Flight Rules (IFR) and Category IIIC Instrument Landing Systems (ILS) (T). OBJECTIVE includes capability to implement and exploit synergistically alternative GNSS, specifically including GLObal Navigation Satellite System (GLONASS) and European GALILEO for reliability through redundancy and for increased precision.

Ex: “LAAS & JPALS DGPS [Family]”

Proposed! Military Joint Precision Approach and Landing System (JPALS) and Civil Local Area Augmentation System (LAAS). Compliant with JPALS-STD-002 and –003. Transports Differential GPS (DGPS) correction data for augmentation of associated GPS and navigation systems. LAAS serves as interim JPALS. Employment for navigation and Safety-of-Flight operations may mandate JTR Set and channel Operational Availability A(o) in excess of that specified by ORD KPP criteria. This is also required to support Sole Means Primary Navigation use during all phases of flight or maneuver, including Instrument Flight Rules (IFR) and Category IIIC Instrument Landing Systems (ILS) (T). [JPALS & LAAS VHF DGPS signals have similarities to VDB waveform, are one-way (ground to air et al), and JPALS is encrypted for military uses. Navy UHF SRDGPS utilizes a secure DSSS two-way interactive signal protocol.].

Ex: “INMARSAT [in MSS Family]”

Proposed! Mobile Satellite Service (MSS). Includes both VHF and UHF MSS bands and both fielded and emerging LEOSAT & MEOSAT systems and standards, such as IRIDIUM, Globalstar, et al. *THRESHOLD requires GANS-GATM aviation implementations with INMARSAT, specifically including AERO-I and AERO-H that are required for transoceanic aviation et al.* Includes capability for NSA/NIST Type 1 through 4 COMSEC. OBJECTIVE includes capability to utilize GEOSAT systems such as Motient (formerly AMSC). Addition of appropriate antenna systems may be required. OBJECTIVE also includes future expansion bands to 2.5 GHz.

NOTE - New ORD is similar but includes as “objective”: [OBJECTIVE includes transoceanic aviation use of INMARSAT AERO-I and AERO-H FUW GANS and GATM.]

Ex: “VHF/UHF Emergency & Distress”

Proposed! (Part 1) [Waveform Family] [NOT enumerated as “waveform,” and cited and/or embedded elsewhere in Table] Combat Search and Rescue (CSAR), Combat Survivor Evader Locator (CSEL) and emerging Global Personnel Recovery System (GPRS) and compliance with International Civil Aviation Organization (ICAO) and International Safety of Life at Sea (SOLAS) agreements, TSO-C91a & C-126, et al. GPRS Family includes multiple waveforms and/or capabilities embedded in JTRS Waveforms listed elsewhere above. Waveforms include Demand Assigned Multiple Access Mode C (DAMA-C) transmissions, plus COBRA. THRESHOLD includes Downed Aircrew Location System (DALS) 225-299 MHz. Also includes transmit and parallel guard receiver capabilities.

Ex: “VHF/UHF Emergency & Distress”

Proposed! (Part 2) THRESHOLD requires at least one single frequency guard receiver function per operational channel, set to standard or organizationally determined guard frequency. OBJECTIVE adds a second guard receiver function on designated channels, set to organizational or user selected tactical frequency. Guard frequencies 121.5 / 123.1 & 156.8 / 156.525 & 243.0 / 282.8 & 406.025 MHz et al civil and military Emergency Locator Transmitters (ELTs) FUW SARSAT/COSPAS satellites and Direction Finding (DF). OBJECTIVE includes capability to perform Automatic Direction Finding (ADF) and Ranging (ADFR) by utilization of appropriate antenna systems.

JTRS Aviation Safety & Certification

- ATC & *Safety of Flight* Impacts JTRS
- Safety & Certification
  - Process guarantees ATC functions meet Civil safety, performance, interoperability...
  - ATC functions vary in Safety of Flight considerations and certification difficulty
  - GATM-ATC architectures over decades
  - JTRS reprogramability breaks new ground in certification concepts
  - New JTRS (& SDR) paradigms radically different, with unknown implications

JTRS Aviation System Issues

- *Safety of Flight* applications & mandates
  - Very high availability, reliability, RAIM…
  - ATC requirements may limit sharing radio resources among channels & processes
  - ATC waveforms, messages & protocols changing as ATC moves from voice to data
- Significant JTRS *software* concerns
  - Software Controlled Architecture (SCA) is combination: COTS, near-COTS & CORBA
  - Not yet to ATC certification requirements…
- RF & SDR *hardware* has similar issues..

JTRS Aviation Alternative Approaches

- Strict JTRS ATC-Qualified Paradigm
  - Develop *all* JTRS *S/W & H/W* to meet ATC!
- JTRS MIL-Spec or "GOTS" Equivalency
  - MIL- to ATC-Qual negotiation & resolution?
- Special JTRS ATC-Qual Configurations
  - Limited production builds to DO-178B, et al
    - Remaining "other" JTRS systems "non-ATC"
  - Potential stand-alone JTRS LRUs for ATC
    - Dedicated to necessary "ATC" channel subsets
    - Specialized, ATC-qualified S/W & H/W modules
    - Reuse S/W in "non-ATC" (or limited "non-SCA")

Summary

- JTRS & it's Waveforms are *evolving*
  - JTRS ORD is the *"Driver,"* with many versions and drafts over five years
  - JTRS Waveforms are the *"Heart"* of ORD
- *New* JTRS ORD (ver 3.2 - 9 Apr 03)
  - Achieves *dramatic WF improvements*
  - Clear, concise, correct, comprehensive…
  - Product of two-year crusade to "fix it right"
  - OSD, JS, JPO, Services, Feds, MITRE…
- Additional waveforms in process…
  - ***ATC & Safety of Flight issues***

Useful JTRS ORD Documents

- *New* JTRS ORD (ver 3.2 - 9 Apr 03)
- Mission or Program Oriented Extracts
  - Annotated Waveform Table 4-2 & Annex E
    - Aviation & Airborne
    - CSAR & GPRS
    - Homeland Security
  - Others...
- JTRS ORD R/Evolution Briefing
- JTRS ORD Critical Issues Briefing
- Gateway and Message Format Translation (GW & MFT) Briefings

Special Appreciation! ☺

- U.S. Army SIGCEN - Ft. Gordon
- OASD(C3I) - C3 Programs
- U.S. Military Service Reps & Joint Staff
- U.S. Coast Guard
- Federal Agencies & Associates
  - FEMA, FBI, DoJ, USCS, FAA, HHS, ARC...
- JTRS JPO
- MITRE Staff
  - Thanks for Aviation JTRS Concerns - Ms. Mary Girard - mgirard@mitre.org

Discussions

Thank You!

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BACKUPS

JTRS ORD Ver 3.2 - 2003 - Table 4-2

JTRS WAVEFORMS (By Priority: KPP / Threshold / Objective)

ID	KPP (K)	ID	THRESHOLD (T)	ID	OBJECTIVE (O)
W1	*SINCGARS ESIP (VHF-FM Military Tactical AJ)	W7	UHF SATCOM Military Protocol (184)	W30	MSS [Waveform Family]
W2	*HAVE QUICK II (UHF-AM/FM/PSK Military Tactical AJ)	W8	HF-ISB ALE	W32	BOWMAN (UK HF/UHF Military Tactical) [Waveform and Equipment Family]
W3	*UHF SATCOM Military (181-182-183 "DAMA")	W9	HF-SSB ALE AJ		
W4	*EPLRS	W10	Link-11 / TADIL-A		
W5	*WNW	W11	STANAG 5066 (HF Message Protocol)		
W6	*Link 16 / TADIL-J	W12	STANAG 4529 (HF NB Modem)		
		W13	VHF-FM – Military Tactical		
		W14	HF ATC Data Link		
		W15	VHF-AM ATC		
		W16	VHF-AM ATC Extended		
		W17	VHF/UHF-FM LMR: (Land Mobile Radio & Public Safety w/ Project-25 and TETRA) [Waveform Family]		
		W18	VHF ATC Data Link (NEXCOM)		
		W19	UHF-AM/FM/PSK Military Tactical		
		W20	Link-4A / TADIL-C		
		W21	Link-11B / TADIL-B		
		W22	SATURN (UHF PSK AJ NATO)		
		W23	STANAG 4193 Mode S Level 4/5		
		W24	DWTS (UHF PSK WB LOS)		
		W25	Soldier Radio & WLAN & Advanced Capability [Waveform Family]		
		W26	COBRA		
		W27	MUOS-CAI (UHF SATCOM Military Obj.)		
		W28	Cellular Radio & PCS [Waveform Family]		
		W29	Link 22 / NILE		
		W31	IBS-M		
		W32	BOWMAN (VHF)		

TABLE 4-2

Homeland Security, Counter Terrorism, and Public Safety Interoperability Waveforms Extract
– 9 May 2003
– Version C1

Civil HLS, CT, & PS Interoperability Applications in YELLOW and Military Specific & Support in BLUE

JTRS ORD Ver 3.2 - 2003 - Annex E

ANNEX E

SUPPORTED JTRS WAVEFORMS CHARACTERISTICS

WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied]
***SINCGARS ESIP** (VHF-FM Military Tactical AJ)	W1	30-88 MHz	25 KHz	VOICE (A & D 16 Kbps) & DATA 75 Bps to 16 Kbps	Single Channel Ground Air Radio System (SINCGARS) with Enhanced SINCGARS Improvement Program (ESIP). MIL-STD-188-220 & -241-1/-2 compliant. Includes guard (non-hop 40.50 MHz et al) & inband signals ("SINCGARS squelch" 150 Hz tone, et al). Includes AJ.
***HAVE QUICK II** (UHF-AM/FM/PSK Military Tactical AJ)	W2	225-400 MHz	25 KHz	(T) VOICE (A & D 16 Kbps) plus (O) DATA 75 to 16 Kbps (see)	MIL-STD-188-220 & -243 and JIEO-9120A compliant. Includes guard (non-hop 243.0 & 282.8 MHz et al) (but inband signals TBD.) Data 75, 150, 300, 600 Bps; 1.2, 2.4, 4.8, 9.6, 16 Kbps with required IDM.
***UHF SATCOM Military** (181-182-183 "DAMA")	W3	225-400 MHz	5 and 25 KHz	(T) VOICE (A & D) & DATA 75 Bps to 56 Kbps (see) / (O) 64 Kbps	MIL-STD-188-181 & -182 DAMA & -183 DAMA/TDMA compliant. Includes STANAG 4321 version 4. Includes DAMA-C FUW GPRS. Includes DAMA guard lists (but inband signals TBD.) THRESHOLD Data 75, 300, 600 Bps; 1.2, 2.4, 4.8, 9.6, 16, 19.2, 28.8, 32, 38.4, 48, 56 Kbps; and OBJECTIVE up to 64 Kbps (already demonstrated).
***EPLRS**	W4	420-450 MHz	3 MHz [For each of 4 hop bands]	DATA 57 Kbps VHSIC SIP, plus 228 Kbps VECP	Enhanced Position Location Reporting System (EPLRS) with version 11 or higher (in lieu of Situational Awareness Data Link (SADL) functionality). TDMA /CDMA /FDMA. CDRL-4002W-001A compliant.
***WNW**	W5	[Government or Vendor Developed]	[Government or Vendor Developed]	[Government or Vendor Developed]	Wideband Networking Waveform (WNW). Compliant with WNW Functional Description Document (FDD) version 2.31 or later. [New, modified or existing waveform, expected over 2 MHz to 2 GHz at up to 5 Mbps network throughput.] [Guards & inband signals TBD.]
***Link-16** / TADIL-J	W6	960-1215 MHz	3 MHz [51 to 37 freqs]	VOICE (D 2.4 & 16 Kbps) & DATA w/ FEC 28.8 Kbps to 1.137 Mbps	MIL-STD-6016 & STANAG 5516 compliant. Data with FEC 28.8, 57.6, 115.2, 119.0, 238.1 Kbps, up to 1.137 Mbps [FDMA /TDMA /CDMA ECCM-AJ TADIL, with emerging IP bearer services.]

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WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied]
UHF SATCOM Military Protocol (184)	W7	N/A	N/A	N/A	MIL-STD-188-184 Data Control Waveform. Robust link protocol only, required for reliable data transport over UHF SATCOM, normally employing MIL-STD-188-181, -182, & -183 single access, 5 & 25 KHz channels.
HF-ISB ALE	W8	(T) 2-30 MHz (O) 1.5-30 MHz	3 / 6 / 12 KHz	VOICE (A & D) & DATA 75, 150, 300, 600, 1200, 2400, 3200, 4800, 6400, 8000, 9600 Bps, per ISB channel	High Frequency (HF) - Independent Side Band (ISB) with Automatic Link Establishment (ALE). Fully compliant with MIL-STD-188-141B including as mandatory Appendices A- (ALE) & B- Linking Protection (LP) & C- Third Generation (3G) and -MIL-STD-188-110B including as mandatory Appendices C- Data Above 2400 bps & F- Multiple Channel Systems. OBJECTIVE to 1.5 MHz in compliance with STANAG-4203, QSTAG-733, et al. Includes HF guards (non-hop 2182 & 5680 KHz et al) & inband signals (SELCAL et al). [Optional MD-1295/A DATA modem.]
HF-SSB ALE AJ	W9	(T) 2-30 MHz (O) 1.5-30 MHz	3 KHz	VOICE (A & D) & DATA 75, 150, 300, 600, 1200, 2400, 3200, 4800, 6400, 8000, 9600 Bps per SSB channel	High Frequency (HF) - Single Side Band (SSB) with Automatic Link Establishment (ALE) and Anti-Jam (AJ). Fully compliant with MIL-STD-188-141B including as mandatory Appendices A- (ALE) & B- Linking Protection (LP) & C- Third Generation (3G) and -MIL-STD-188-110B including as mandatory Appendices C- Data Above 2400 bps & F- Multiple Channel Systems and MIL-STD-188-148 HF AJ ECCM. OBJECTIVE to 1.5 MHz in compliance with STANAG-4203, QSTAG-733, et al. Includes HF guards (non-hop 2182 & 5680 MHz et al) & inband signals (SELCAL et al). [Optional MD-1295/A data modem.]
Link-11 / TADIL-A	W10	2-30 MHz and 225-400 MHz	3 and 25 KHz	DATA 1364 & 2250 Bps	MIL-STD-188-203-1A & STANAG 5511 compliant.

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WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied]
STANAG 5066 (HF Message Protocol)	W11	N/A	N/A	N/A	Protocol only, transported over supporting HF waveforms HF-ISB/SSB (W8 & W9) and employing MIL-STD-188-141 & -110. OBJECTIVE to 1.5 MHz in compliance with STANAG-4203, QSTAG-733, et al.
STANAG 4529 (HF NB Modem)	W12	(T) 2-30 MHz (O) 1.5-30 MHz	1.24 KHz	DATA 75, 150, 300, 600, 1200 Bps FEC, up to 1.8 Kbps	Narrowband HF modem standard, transported over MIL-STD-188-141 or STANAG 4203... Requires Forward Error Correction (FEC) coding fully compliant with STANAG 4285 Annex E. OBJECTIVE to 1.5 MHz in compliance with STANAG-4203, QSTAG-733, et al.
VHF-FM – Military Tactical	W13	30-88 MHz	25 KHz and 50 KHz	VOICE (A & D 16 Kbps)	MIL-STD-188-242 compliant. Includes guard (40.50 MHz et al) & inband signals ("new squelch" 150 Hz tone et al). Includes legacy non-AJ for Allied and Coalition interoperability.
HF ATC Data Link	W14	(O) 2-30 MHz (O) 1.5-30 MHz	3 KHz	VOICE (A) & DATA 300, 600, 1200, 1800 Bps	Air Traffic Control (ATC). RTCA DO-265, ARINC 635-3 & -735-3, and FAA TSO-C31d & -C32d compliant TDMA and FDMA. OBJECTIVE to 1.5 MHz in compliance with STANAG-4203, QSTAG-733, et al. [Packet data.]
VHF-AM ATC	W15	(T) 118-137 MHz (O) 108-137 MHz	8.33 KHz [Includes 25 KHz]	VOICE (A) 16 Kbps	Air Traffic Control (ATC). RTCA DO-186a & ARINC 716 compliant and NAS Architecture with future 108-118 MHz (presently VOR/ILS and emergency ATC voice). Navigation uses may require increased reliability and availability. Includes legacy 25 KHz plus European 8.33 KHz. Includes VHF guards (121.5 & 123.1 MHz et al) & inband signals (ELT & SELCAL et al).
VHF-AM ATC Extended	W16	108-156 MHz	25 KHz	(T) VOICE (A) (O) VOR/ILS Nav (A)	Air Traffic Control (ATC), VHF Omni-Range (VOR), and Instrument Landing System (ILS). QSTAG-706 & RTCA DO-186a & -195 & -196 & ARINC 716 compliant, and NAS Architecture with future 108-118 MHz (presently VOR/ILS and emergency ATC voice). Navigation uses may require increased reliability and availability. Includes extended legacy 25 KHz. Includes VHF guards (121.5 & 123.1 MHz et al) & inband signals (ELT & SELCAL et al).

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WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied]
VHF/UHF-FM LMR: (Land Mobile Radio & Public Safety w/ Project-25 and TETRA) [Waveform Family]	W17	(T) "Low"= 25-54 MHz (T) "Mid"= 72-76 MHz (T) "High"= 136-174 MHz (T) "220"= 216-225 MHz (T) "UHF/T"= 380-512 MHz (T) "800"= 764-869 MHz (O) "TV"= 686-960 MHz	"Low" NTIA & FCC (T) 20 KHz "Mid" & "High" FCC (T) 30 & 15 KHz / (O) 7.5 KHz "High" thru "TV" NTIA & FCC (T) 25 & 12.5 KHz / (O) 6.25 KHz "220" FCC (T) 5 KHz FM & SSB	VOICE (A & D 16 Kbps) & DATA up to 16 Kbps	Includes Homeland Security (HLS) & Defense (HLD) legacy interoperability with both NTIA and FCC, digital & analog, "wideband," "narrowband," & future "very narrowband" systems, plus International Maritime VHF. Project-25 compliant includes Common Air Interface (CAI) for subscriber units (not infrastructure) for JTRS unit-unit and unit-infrastructure use. Includes capability for NSA/NIST Type 1 through 4 COMSEC. Includes VHF/UHF guards (47.42, 156.8 / 156.525 and 866.0125 MHz et al) & inband signals (ELT & DSC, CTCSS & DTMF et al). Shall include future upgrade to Terrestrial Trunked Radio (TETRA) and frequency flexibility for overseas LMR bands, including 380-400 MHz NATO Emergency Services and 400-430 MHz European Civil bands, et al. "220" Band utilizes Single Side Band (SSB) and/or Narrow Band FM (NBFM) in 5 KHz. OBJECTIVE includes emerging "TV" bands (channels 70-83 806-in 890 MHz and 50-69 in 686-806 MHz.).
VHF ATC Data Link (NEXCOM)	W18	118-137 MHz	25 KHz	VOICE (D 4.8 Kbps) & DATA 31.5 Kbps	RTCA DO-186a & -224a compliant, a.k.a. VDL 2 & 3 Next Generation Communications (NEXCOM) FUW FAA CONUS and overseas & military ATC.
UHF-AM/FM/PSK Military Tactical	W19	(T) 225-400 MHz (O) 225-450 MHz	5 and 25 KHz	(T) VOICE (A & D 16 Kbps) & (O) DATA up to 16 Kbps (w/ IDM)	MIL-STD-188-181B & -243 compliant. Includes FAA CONUS and overseas & military ATC operations. Includes UHF guards (243.0 / 282.8 / (O) 406.025 MHz et al) & inband signals (ELT & SELCAL, CTCSS & DTMF et al). OBJECTIVE includes ability to exploit (both transmit and receive) 406 beacon position location systems, including interface to GPS, IAW TSO C-126. [Data up to 16 Kbps w/ optional IDM.] [Optional implementation of VDL 2 & 3 NEXCOM FUW FAA CONUS up to 31.5 Kbps]

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WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied]
Link-4A / TADIL-C	W20	225-400 MHz	25 KHz	DATA 5 Kbps	MIL-STD-188-203-3 compliant.
Link-11B / TADIL-B	W21	225-400 MHz	25 KHz	DATA 600, 1200, 2400 Bps	MIL-STD-188-212 & STANAG 5511 compliant
SATURN (UHF PSK AJ NATO)	W22	225-400 MHz	25 KHz	VOICE (D) & DATA [Rates TBP]	Second generation Anti-jam Tactical UHF Radio for NATO (SATURN). STANAG-4372 & JIEO-9120A compliant. [See also W2 AJ, and W19 non-AJ.]
STANAG 4193 Mode S Level 4/5	W23	1030 & 1090 MHz	3.5 MHz / 3 MHz	DATA 689.7 Bps (1.45 uS PCM) IFF Family, and 9.6 to 128 Kbps Mode S, plus others per Standards.	Fully compliant with STANAG 4193 including Mode Select (Mode S), Levels 5 & 4 lower. THRESHOLD includes both transponders and interrogators on platforms and at low transmit powers. OBJECTIVE includes upgrade to high power (ground-based and airborne warning et al) interrogators. Includes Mark X & XII/A with all Identification Friend or Foe (IFF) and Selective Identification Feature (SIF) Modes 1 through 5 and A & C, and ACP-160 and ICAO Annex 10 compliance. Includes civil secondary Air Traffic Control Radar Beacon System (ATCRBS), Airborne Collision Avoidance System (ACAS) and Traffic Alert & Collision Avoidance System (TCAS), and Automatic Dependent Surveillance – Addressable (ADS-A) and Broadcast (ADS-B) functionality. Includes supporting interface to GPS and other systems for flight, navigation and timing data. ADS requires interface to SATCOM, VHF Data Link, and other alternate channels IAW platform capabilities and mission needs. Includes generation of, and detection and alarm on, emergency messages, including ATCRBS (7700 emergency, 7600 communications failure, et al) and special military (4X et al) codes.

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WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied]
DWTS (UHF PSK WB LOS)	W24	1350-1850 MHz (NATO Band 3)	125 KHz	VOICE Order Wire (A & D) and DATA 144, 256, 288, 512, 576, 1024, 1152, 1544, 2048, 2304 Kbps	Digital Wideband Transmission System (DWTS). Shipboard system for high capacity secure & nonsecure, line-of-sight (LOS), ship-to-ship, and ship-to-shore, digital voice/data/imagery communications in the UHF range and interface into Marines ashore and Army Mobile Subscriber Element (MSE) et al.
Soldier Radio & WLAN [Waveform Family]	W25	(T) 1.755-1.850 GHz Army LW 2.450-2.483.5 GHz COTS	13 MHz (COTS provides 11 overlapping channels)	(T) VOICE (D 16 Kbps) & DATA 1 Mbps DATA 1, 2, 5.5, 11 Mbps	Wireless Local Area Network (WLAN). Army Land Warrior (LW) Program includes basic Direct Sequence Spread Spectrum (DSSS) IEEE 802.11 wireless Ethernet LAN standard at 1 Mbps. Includes security capability up to NSA Type 1. Includes COTS multiple channels in 2.4 GHz band and upgrade to 802.11b 11 Mbps. 802.11e FEC & 802.11g 54 Mbps et al, plus use of dual diversity antennas. Advanced Capability: 350 MHz – 2.5 GHz; 350 MHz – 1GHz (Band 2); & 1 GHz – 2.5 GHz (Band 3) [Guards & inband signals not known to be applicable.]
COBRA	W26	340-400 MHz	TBP	TBP	Includes interoperability with CSEL et al and support for GPRS and CSAR. [Characteristics to be provided to authorized users.]
MUOS-CAI	W27	240-320 MHz	5 & 25 KHz	DATA 2.4, 9.6, 16, 32, 64 Kbps	Mobile User Objective System (MUOS) – Common Air Interface (CAI). [Guards & inband signals TBD.]

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WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied]
Cellular Radio & PCS [Waveform Family]	W28	(T) 824-894 MHz (T) 890-960 MHz (T) 1850-1990 MHz (O) 1850-2200 MHz IAW standard & Host Nation	30 KHz to 1.6 MHz 3G to 5xN MHz IAW standard & Host Nation	VOICE a/o DATA – 10 Kbps nominal 3G DATA up to 144/384 Kbps & 2 Mbps IAW standard & Host Nation	Includes multiple US and overseas standards – TR-45.1 AMPS & IS-54 TDMA & -IS-95b CDMA & IS-136 HS TDMA & GSM & 3GSM & 2.5G & 3G & WCDMA & CDMA-2000 et al compliant. Includes both cellular telephone and Personal Communications Services (PCS), providing voice, data, short message services (SMS), et al... Includes Enhanced Specialized Mobile Radio (ESMR), interoperable with 900 MHz band and iDEN (NEXTEL, Southern-Link, et al) protocols, et al. Includes capability for NSA/NIST Type 1 through 4 COMSEC. Shall include ability to use any available Wireless Priority Access Service (WPAS) or equivalent for assured access and capacity. Shall include ability to exploit cell phone position location systems, including interface to GPS. Includes inband signals (DTMF et al). [Note – 1994 FCC PCS plan 1850-2200 MHz.]
Link 22 / NILE	W29	3-30 MHz and 225-400 MHz	TBD	DATA (rate TBD)	NATO Improved Link Eleven (NILE). STANAG 5522 compliant. Requires modem waveforms in STANAG 4539 Annex D.
MSS [Waveform Family]	W30	137-150 MHz 1.61-2 [2.5] GHz and per system	TBD per system	VOICE (D 2.4 to 9.6 Kbps et al) & DATA 2.4, 9.6 Kbps up to 2.048 Mbps per system	Mobile Satellite Service (MSS). Includes both VHF and UHF MSS bands and both fielded and emerging LEOSAT & MEOSAT systems and standards, such as IRIDIUM, Globalstar, et al. Includes capability for NSA/NIST Type 1 through 4 COMSEC. OBJECTIVE includes capability to utilize GEOSAT systems such as Motient (formerly AMSC) and INMARSAT, et al. Addition of appropriate antenna systems may be required. OBJECTIVE also includes future expansion bands to 2.5 GHz. [OBJECTIVE includes transoceanic aviation use of INMARSAT AERO-I and AERO-H FUW GANS and GATM.]

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WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied]
IBS-M	W31	225-400 MHz	5 and 25 KHz	DATA 2.4, 4.8, 9.6 & 19.2 Kbps	Integrated Broadcast Service Module (IBS-M). As a "Single JTRS Channel" and multiples as follows – THRESHOLD is parallel receive 4X & transmit 0X data streams, implemented in a single "JTRS channel" and OBJECTIVE is up to receive 12X & transmit 4X; potentially implemented as several "JTRS channels" with all cases including necessary multiple cryptographic streams. Integrated Broadcast Service (IBS) - Currently consists of three legacies UHF broadcasts (TIBS, TDDS, and TRIXS) which will be replaced in the future with a Common Interactive Broadcast (CIB). The CIB will be a DAMA compliant broadcast using a developing Integrated Waveform, MIL-STD-188-181C/-182B/-183B. Data carried over IBS will be an IBS Common Message Format (CMF), which will be a member of the J-Series family of message formats."
BOWMAN (UK HF/VHF/UHF Military Tactical) [Equipment Family]	W32	HF-1.6 60 MHz VHF- 30-80 MHz UHF-225-450 MHz	3 KHz 25 KHz 600 KHz & 4MHz	75-2400 bps 156 Kbps 500 Kbps	"BOWMAN" is the designator for the UK Tri-Service Tactical communications System. [Guards & inband signals TBD.] Includes BOWMAN-HF (per Harris RF-5800), BOWMAN-VHF (per ITT ADR+ variant of SINCGARS) and BOWMAN-UHF (per ITT High Capacity Data Radio (HCDR) variant of Naval Tactical Data Radio (NTDR)). [NOTE - US-UK interoperability criteria under negotiation by OSD and JS.]

TABLE E-1 SUPPORTED JTRS WAVEFORMS CHARACTERISTICS

Note: *= KPP (also shown in **BOLD**)

(Note – In this Extract, VHF-AM aviation SAR channel editorially corrected from "123.0" to "123.1."

Waveform Issues Still in Process

- Navigation Waveforms - GANS...
  - "GPS" in *every* JTRS, but *not counted* WF
    - Required for timing, plus injection elsewhere
  - WAAS, LAAS, GLONASS, GALILEO...
- Aviation Waveforms - GATM...
  - Civil: VOR, LOC, DME, ILS...
  - Military: TACAN, JPALS, SRGPS, DALS…
  - *Safety of Flight* applications mandate very high availability & reliability, RAIM…
  - Smart use of UHF "Military NEXCOM"?
  - Pending determination of impacts to JTRS

JTRS ORD Annex E - *Proposed* WFs

WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied] *NOTE – FOR REFERENCE & COMMENT ONLY - PROPOSED BUT NOT YET ENDORSED OR APPROVED*
					MILITARY AVIATION & NAVIGATION
Aviation POS/NAV & Landing Systems [Waveform Family]	Wxx	ILS= 40 channels Localizer-108-112 MHz Glideslope 329-335 MHz VOR= 120 channels 112-118 MHz VORTAC= TACAN 126 paired channels & DME 962-1213 MHz	(per signal standards)	(per signal standards)	Position and Navigation (POS/NAV) Systems. Includes Civil VHF OmniRange (VOR), Military TACtical Air Navigation (TACAN) and VORTAC, and shared Distance Measuring Equipment (DME), plus glideslope component required for Instrument Landing System (ILS).. Includes Joint Precision Aircraft Landing System (JPALS). Shall include necessary signal and system integrity assurance functions. Should permit optional reuse of legacy or external flight systems, such as Flight Management Systems (FMS) and Heads-Up Displays (HUD) and autopilots, plus human-machine interfaces, including Horizontal Situation Indicators (HSI) and Course Deviation Indicators (CDI)

JTRS ORD Annex E - *Proposed* WFs

WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOM. CHAN BAND-WIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied] *NOTE – FOR REFERENCE & COMMENT ONLY - PROPOSED BUT NOT YET ENDORSED OR APPROVED*
					MILITARY AVIATION & NAVIGATION
GNSS & JPALS [Waveform Family] [GPS itself is NOT enumerated as a JTRS "waveform" but is required in all JTR Sets]	Wxx	(T) GPS= L1-1575.42 MHz L2-1227.6 MHz L5-1176.45 MHz (O) GLONASS= L1-1602 +Nx0.5625 MHz L2-1246.0 +Nx0.4375 MHz (avoiding radio astronomy) (O) GALILEO= E1-1589 MHz E2-1511 MHz E3-N/A E4-1256 MHz E5-1189 MHz E6-1280 MHz	20 MHz	GPS DATA 1.023 Mcps and 10.23 Mcps chip rates. (Others per Standards TBP)	Global Positioning System (GPS) and Global Navigation Satellite System (GNSS) Family. GPS itself is NOT enumerated as a JTRS "waveform" but is required in every JTR Set (K). GPS shall include civil "C/A code" Standard Positioning Service (SPS), plus military "P-code" Precise Positioning Service (PPS) that shall require incorporation of Selective Availability Anti-Spoofing Module (SAASM) or approved equivalent for security per National Policy. GPS shall also receive and provide Precise Time and Time Interval (PTTI) data. THRESHOLD also includes implementation of Differential GPS (DGPS) functionality, including Wide Area Augmentation System (WAAS) and Local Area Augmentation System (LAAS) interoperable with FAA systems, and ICAO Ground Based Augmentation System (GBAS), in accordance with RTCA DO-246B and DO-253 et al. (T) Military aviation implementation THRESHOLD specifically includes Joint Precision Approach and Landing System (JPALS) Local Area Differential Global Positioning System (LDGPS) and Shipboard-Relative GPS (SRGPS) variant. Compliant with JPALS-STD-002 and –003. GPS implementations on aircraft, or in Safety-of-Life (SOL) or precision navigation applications, shall incorporate reliability assurance supervision and alerting per FAA TSO-C129 and TSO-C146. This specifically includes Receiver Autonomous Integrity Monitoring (RAIM) and Fault Detection and Exclusion (FDE) in compliance with RTCA DO-236 and DO-229 or approved equivalent. This may mandate that JTR Set and channel Operational Availability A(o) in excess of that specified by ORD KPP criteria. This is also required to support Sole Means Primary Navigation use during all phases of flight or maneuver, including Instrument Flight Rules (IFR) and Category IIIC Instrument Landing Systems (ILS) (T). OBJECTIVE includes capability to implement and exploit synergistically alternative GNSS, specifically including GLObal Navigation Satellite System (GLONASS) and European GALILEO for reliability through redundancy and for increased precision.

JTRS ORD Annex E - *Proposed* WFs

WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied] *NOTE – FOR REFERENCE & COMMENT ONLY - PROPOSED BUT NOT YET ENDORSED OR APPROVED*
					MILITARY AVIATION & NAVIGATION
LAAS & JPALS DGPS [Waveform Family]	Wxx	VHF Civil LAAS & Military JPALS= 108-118 MHz UHF Navy SRGPS= 225-400 MHz (potential sub-bands TBP)	VHF 25 kHz UHF SRGPS TBP	VHF 31.5 kbps UHF TBP	Military Joint Precision Approach and Landing System (JPALS) and Civil Local Area Augmentation System (LAAS). Compliant with JPALS-STD-002 and –003. Transports Differential GPS (DGPS) correction data for augmentation of associated GPS and navigation systems. LAAS serves as interim JPALS. Employment for navigation and Safety-of-Flight operations may mandate JTR Set and channel Operational Availability A(o) in excess of that specified by ORD KPP criteria. This is also required to support Sole Means Primary Navigation use during all phases of flight or maneuver, including Instrument Flight Rules (IFR) and Category IIIC Instrument Landing Systems (ILS) (T). [JPALS & LAAS VHF DGPS signals have similarities to VDB waveform, are one-way (ground to air et al), and JPALS is encrypted for military uses. Navy UHF SRDGPS utilizes a secure DSSS two-way interactive signal protocol.].
DALS	Wxx	225-299 MHz	TBP	TBP	Downed Aircrew Location System (DALS). Includes interoperability with CSEL et al and support for GPRS and CSAR. [Parameters to be provided.]

JTRS ORD Annex E - *Proposed* WFs

WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied] *NOTE – FOR REFERENCE & COMMENT ONLY - PROPOSED BUT NOT YET ENDORSED OR APPROVED*
					NON-MILITARY BEYOND LOS
MSS (W30) & INMARSAT (Wxx) [Waveform Family]	W30 & Wxx	137-150 MHz 1.525-1.661 GHz 1.61-2 [2.5] GHz and per system	TBD per system	VOICE (D 2.4 to 9.6 Kbps et al) & DATA 2.4, 9.6 Kbps up to 2.048 Mbps per system	Mobile Satellite Service (MSS). Includes both VHF and UHF MSS bands and both fielded and emerging LEOSAT & MEOSAT systems and standards, such as IRIDIUM, Globalstar, et al. THRESHOLD requires GANS-GATM aviation implementations with INMARSAT, specifically including AERO-I and AERO-H that are required for transoceanic aviation et al. Includes capability for NSA/NIST Type 1 through 4 COMSEC. OBJECTIVE includes capability to utilize GEOSAT systems such as Motient (formerly AMSC). Addition of appropriate antenna systems may be required. OBJECTIVE also includes future expansion bands to 2.5 GHz.

JTRS ORD Annex E - *Proposed* WFs

WAVEFORM (Short ORD Name & Description)	ORD ID	FREQUENCY BAND	NOMINAL CHANNEL BANDWIDTH	INFORMATION VOICE and/or DATA RATES	CRITERIA [and COMMENTS in brackets] [Latest Versions of Documents Shall be Applied] ***NOTE – FOR REFERENCE & COMMENT ONLY - PROPOSED BUT NOT YET ENDORSED OR APPROVED***
					EMERGENCY & DISTRESS – MULTIPLE BANDS & MODES
VHF/UHF Emergency & Distress [Waveform Family] [NOT enumerated as waveform, and cited and/or embedded elsewhere in Table]	Wee	2182/5680 KHz 40.50/47.42 MHz 121.5/123.1 MHz 156.8/156.525 MHz 243.0/282.8 MHz 406.025 MHz 225-400 MHz and others per Standards	3 KHz,, 5 KHz,, per Standards	Alert Tone (A) & VOICE (A) & DATA 400 Bps (to DAMA-C rate) per Standards	Combat Search and Rescue (CSAR), Combat Survivor Evader Locator (CSEL) and emerging Global Personnel Recovery System (GPRS) and compliance with International Civil Aviation Organization (ICAO) and International Safety of Life at Sea (SOLAS) agreements, TSO-C91a & C-126, et al. GPRS Family includes multiple waveforms and/or capabilities embedded in JTRS Waveforms listed elsewhere above. Waveforms include Demand Assigned Multiple Access Mode C (DAMA-C) transmissions, plus COBRA. THRESHOLD includes Downed Aircrew Location System (DALS) 225-299 MHz. Also includes transmit and parallel guard receiver capabilities. THRESHOLD requires at least one single frequency guard receiver function per operational channel, set to standard or organizationally determined guard frequency. OBJECTIVE adds a second guard receiver function on designated channels, set to organizational or user selected tactical frequency. Guard frequencies 121.5 / 123.1 & 156.8 / 156.525 & 243.0 / 282.8 & 406.025 MHz et al civil and military Emergency Locator Transmitters (ELTs) FUW SARSAT/COSPAS satellites and Direction Finding (DF). OBJECTIVE includes capability to perform Automatic Direction Finding (ADF) and Ranging (ADFR) by utilization of appropriate antenna systems.