

## Sporadic - E: Part 4

### VHF Properties

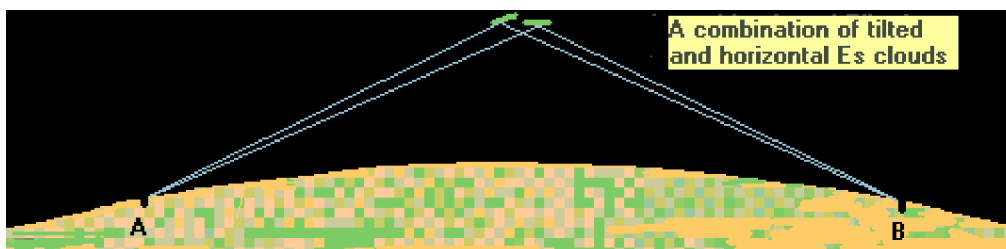
By Marcel H. De Canck, [ON5AU](#)

Es propagation modes can be very complex in structure and behavior. The last chapter displayed this already with the cloud-to-cloud characteristics. In this issue I continue to explore some more Es complex happenings.

#### Fading

Cluster clouds and close-range individual clouds randomly varying in densities, location, and tilts, result in unpredictable open directions, varying path lengths, and increasing or decreasing MUF values. Communications by them suffer also often of severe and strong fading (QSB). If the contact is accomplished by at least two clouds, we have multiple paths with different path lengths. The received signal varies between in or out phase and causes signal strength fading that can interfere and, in the worst case, totally ruin digital communications. See **Fig. 26.1**.

Communications by only one Es cloud can suffer from fading as well. Slightly changing tilt angles and/or slightly changing refracting altitudes can produce slow but extremely deep QSB, changing from hardly able to be copied to a signal strength exceeding S9. The radio waves are sweeping forward and backward over the RX locations.

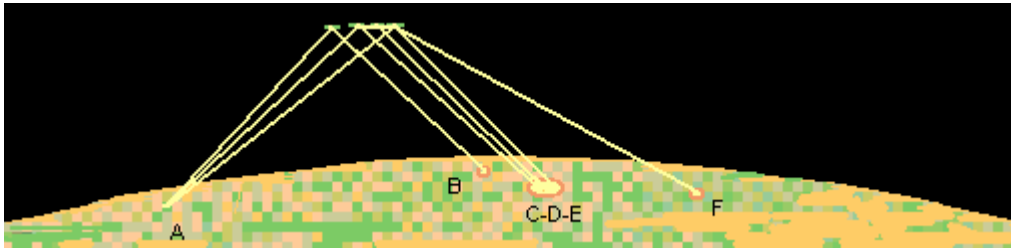


**Fig. 26.1.** An illustration of a simple dual Es cloud occurrence, resulting to multiple paths and signal fading

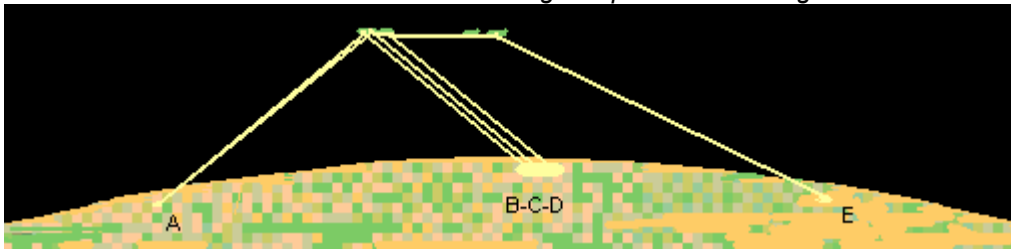
#### More Complexity

An Es cloud can be very complex in structure: ragged, patchy, tilted, a cluster of various densities, and frequently in very slow undulatory motion giving complex anisotropic behaviors. Often more than one generator is present, causing spaced groups of clouds, individual and/or cluster types. Such complex and multiple Es clouds formations are a typical summer time happening and noticed a number of days. When the lifetime and production of these clouds continue for an appreciable time, they may cover a very large geographical area, practically a day long in many directions and sometimes approaching MUF's of 200 MHz and occasionally higher to open the 220 MHz band for a short time. **Fig. 26.2a**, **26.2b**, and **26.2c** illustrate some of these mainly summertime complex Es clouds generations

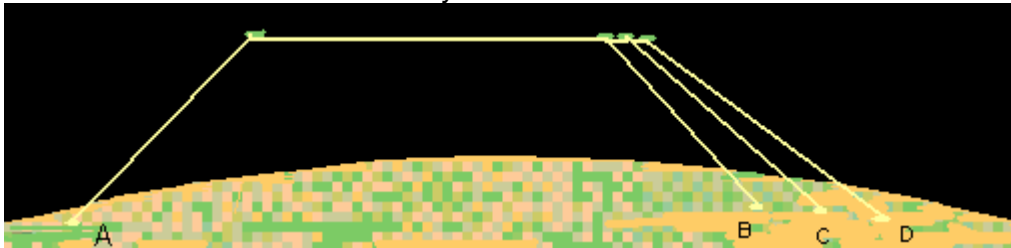
The wave path under such conditions becomes extremely complicated but gives the opportunity to the VHF enthusiast to increase his enjoyment and know-how by valuable observation. From a single observer's point of view, the VHF band may open suddenly and dramatically, with open band conditions from a few hundreds of kilometers (miles) to a few thousands kilometers (miles) away, very often with signals much stronger than those from more nearby stations. Sometimes they may be from one area only and remain in for hours, or they may appear to move in a whirling direction. Often the area first heard may reappear many times and the bearing of the skip may swing suddenly, even to an opposite direction. The whirling motions and varying tilts are the vital explanation of why certain areas may or may not be heard or contacted during such Es openings.



**Fig. 26.2a.** A cluster of several Es clouds causes signal spread and fading.



**Fig. 26.2b.** A cluster and some further away individual located Es clouds.



**Fig. 26.2c.** A single individual cloud and a further away located cluster

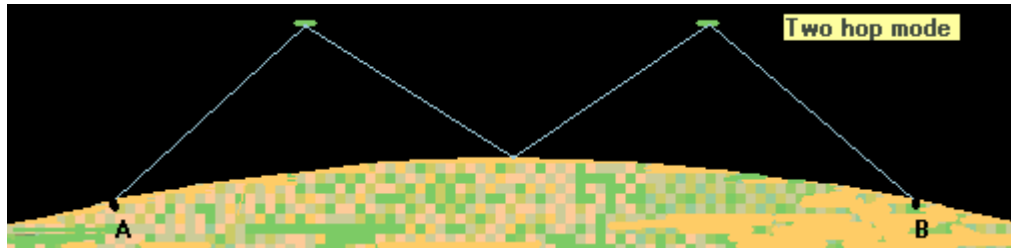
Cloud formations as in the illustrations above can bridge a much further distance than thought and often beyond the maximum classical single hop limit. The wave path's geometry can be complicated and often there is no touchdown in between, as seen in **Fig. 26.2c**.

### **2Es — Two Hop Mode**

Beyond the single Es hop limited distance, communications are not accomplished by cloud-to-cloud propagation alone. Double hop modes (earth – Es-cloud – earth – Es-cloud – earth) are another option to further long distance contacts. Communications within the one hop maximum range might be a cloud-to-cloud type too. It all depends on the structure, the critical frequencies, the critical angles, and the location of the clouds.

The classical model (assuming an Es cloud altitude of 105 km or 65 miles) may help to explain the single-hop path, but what about Es contacts further than 2,250 km (1,400 miles). This classical model requires that such a path be completed by hops via at least two Es clouds spaced at very critical and rather exact distances to complete the path. In addition, each cloud must exhibit the necessary MUF-Es. For example, a classical two-hop 2,500 km (1,550 mile) contact at 144 MHz would require at least two Es clouds with MUF-Es 170 MHz and simultaneously about 1,250 km (775 miles) apart and at 625 km (388 miles) either side of the circuit. This coincidence seems quite unlikely, as even one cloud exhibiting a MUF-Es 170 MHz is exceedingly rare. A 6-meter band contact by 2Es mode over this same distance path is more realistic; it requires only two Es clouds with MUF-Es 64 MHz at the same locations. Distances between 3,500 and 4,500 km by mean of two hop mode are in fact easier to accomplish than distances between 2,250 and 3,500 km. The needed MUF-Es for the furthest distance range is much lower than for the closer range.

To know for sure that the communication circuit is accomplished by a two-hop mode or by a cloud-to-cloud mode, you need more information about other contacts made by one or by the two clouds from other locations and bearing. When at least one of the two clouds is sideward tilted, then localizing the clouds will be trickier and the path will for sure deviate from the great circle path.



**Fig. 26.3.** A 2Es mode communication

### 3Es—Three Hop Mode

A three-hop Es mode communication is even trickier; it requires an extreme cloud arrangement, each one with sufficient ionization (MUF-Es) that additionally must be lined up very well. Pretty stiff and most unlikely, but who knows: maybe once in a year for a few lucky ones. Very likely, one or more of the clouds are tilted and causing a deviating path from the great circle, making it more difficult to analyze. But who cares about their locations and behaviors. The existence of such a complex formation will be very short in time anyway, so just enjoy this precious moment.

### Localizing Es Clouds, Determining Their MUF-Es and Path Migration

Es clouds are migrating and can be plotted by an alert operator. The plots can reveal a lot about their supporting MUF, locations, moving path, and traveling direction. This information can be used to predict when and which frequency bands could be supported, and from what area DX might be heard or contacted. By applying wave-path constraints, it is easy to approximate the location(s) of the cloud(s) and, as more data are obtained, more refinements are achieved in the tracking. All you need is a map, preferably a Maidenhead locator map with grids of 1 by 2 degrees. I am sure this worldwide grid-locator system or location identifier has no secrets to the many VHF-band DXers, but this system is perhaps not as familiar to the HF band users. Therefore a brief explanation of how the Maidenhead grid locator system works.

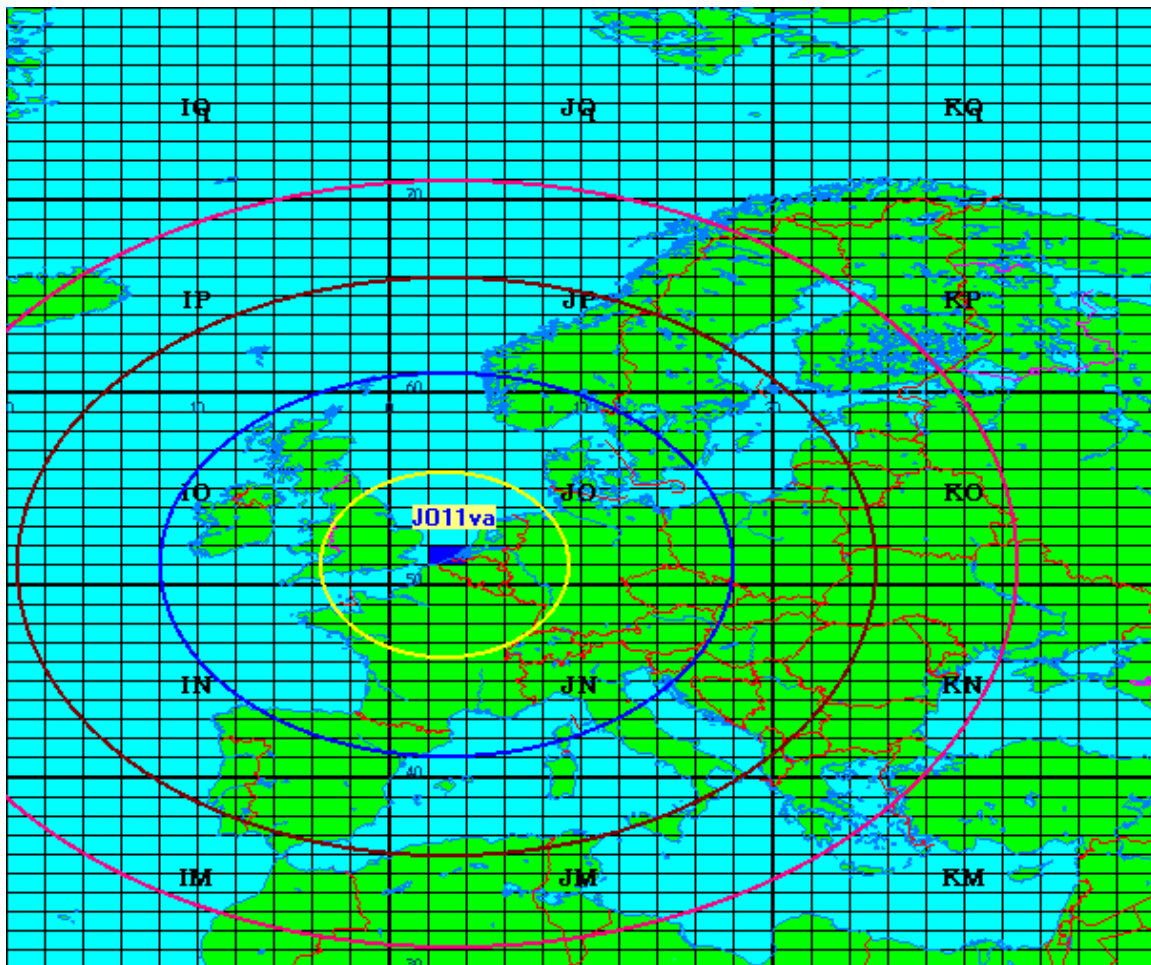
### Maidenhead Grid-Locator System

The grid squares (rectangles) allow three levels of precision (two, four, or six characters) to define a station's latitude and longitude. The world total surface is divided into a grid of rectangles that are ten degrees of latitude high by twenty degrees of longitude wide ( $18 \times 18 = 324$  rectangles). Each rectangle is identified by a different two capital case letter code, **AA** to **RR**. For example, my location is within the **JO** (Juliet Oscar) rectangle. See **Map. 26.1**.

Each of these rectangles is further divided into  $10 \times 10 = 100$  sub-rectangles, one degree of latitude high by two degrees longitude wide. Each sub-rectangle is identified by a numerical value of two figures between **00** and **99**. For my location this is **JO11** (one-one or eleven). See **Fig. 26.4a**.

For higher precision is each sub-rectangle further divided into  $24 \times 24 = 576$  sub-sub-rectangles. Each one is 2.5 minutes of latitude high by 5 minutes longitude wide and identified by a two lower case letter code from **aa** to **xx**. For my location this is **JO11av** (alpha victor). See **Fig. 26.4b**.

Take care when interpreting or calculating the distances on a grid locator map! All the meridian circles lines (North-South) are great circles off equal length. Any sub-division is also of equal length. 1 degree of a great circle = 111.11 km (69 miles) and 2.5 minutes = 4.62 km (2.87 miles). For the latitude circle lines (East-West) there is a different story. These circle are non-great circles (except the equator) and are not of equal length. For example: at the 45 degrees latitude, we have a non-great circle line (halfway the northern or southern hemisphere): 1 degree = 79 km (48.8 miles) and 2.5 minutes = 3.29 km (2.04 miles). Any rectangle on the map is in reality a trapezium. In **Table 26.1** and **26.2** you find some pre-computed distance lengths of latitude non-great circle segments, with steps of 5 degrees and 5 minutes latitude circle segments.



Oval contour lines corresponds respectively to:

555 km	345 miles
1111 km	690 miles
1666 km	1036 miles
2222 km	1381 miles

**Map 26.1.** Maidenhead locator grid map of Europe with my location **JO11va** (QTH ON5AU, Belgium, 51° 01'36"N 3° 49' 58" E) highlighted. Oval distance contour lines are added to facilitate distance determinations



At Latitude Circle E/W or W/E	Length 1 degree segment km	Length 2 degrees segment km	Length 10 degrees segment km	Length 1 degree segment miles	Length 2 degrees segment miles	Length 10 degrees segment miles
0	111	222	1111	69	138	690
5	110	220	1107	68.8	137	688
10	109	218	1094	68	136	680
15	107	214	1073	66.7	133	667
20	104	208	1044	64.9	130	649
25	101	202	1007	62.6	125	626
30	96	192	962	59.8	120	598
35	91	182	909	56.5	113	565
40	85	170	850	52.9	106	529
45	79	158	785	48.8	98	488
50	71	142	713	43.3	87	443
55	64	128	636	39.6	80	396
60	55	110	555	34.5	69	345
65	47	94	469	29.1	58	291
70	38	76	379	23.6	48	236
75	29	48	287	17.8	36	178
80	19	38	192	12	24	120
85	9.6	19.2	96	6	12	60
Longitude Meridian Circle	Length 1 degree segment km		Length 10 degrees segment km	Length 1 degree segment miles		Length 10 degrees segment miles
0	111		1111	69		690

Table 26.1. Segment length at increasing latitude and at a meridian for 1, 2 and 10 degrees

At Latitude Circle E/W or W/E	Length latitude 5 minutes segment km	Length Latitude 5 minutes segment miles
0	9.16	5.69
5	9.16	5.69
10	9.08	5.64
15	8.92	5.54
20	8.67	5.39
25	8.42	5.23
30	8.00	4.97
35	7.58	4.71
40	7.08	4.40
45	6.58	4.09
50	5.92	3.68
55	5.33	3.31
60	4.58	2.85
65	3.92	2.43
70	3.17	1.97
75	2.42	1.50
80	1.58	0.98
85	0.80	0.50
Longitude Meridian Circle	Length longitude 2.5 minutes segment km	Length longitude 2.5 minutes segment miles
0	4.62	2.87

Table 26.2. Segment length at increasing latitude and at a meridian for 2.5 and 5 minutes

## Localizing the Cloud(s)

My friend Dirk, ON4IMM, has always in close reach a folder with a bunch of grid-locator maps and some tables to lookup rapidly predictable MUF-Es values corresponding to some path distances. His method is as follows. As an observer, he draws a straight line between the two monitored station locations or between your location and the contacted or heard stations. Repeat this for most of the worked and/or spotted contacts. By means of the locator grid information of the stations, you can compute or lookup the circuit path length(s). Once the distance(s) are known with the used or monitored frequency band, you can estimate approximately the experienced MUF-Es of the Es-cloud by using **Table 26.3**, **26.4**, and **26.5**. Knowing the experienced MUF-Es allows you to estimate the possibility of making use of the Es-cloud from your location. Handy to this task is a map with some distance contour circles or ovals, **Map 26.1**. A pair of compasses to draw some various distance circles is also handy. Knowing the shortest monitored path distance allows you to estimate if a next higher in frequency band might be workable or open from your location; see **Table 26.6**.

*On the Internet you find several kinds of programs that computes the distance between two grid locator locations and often additionally the needed bearing. A real beauty and projected on various map types is found on: <http://f6kim.free.fr/construction/locator/locmap.htm>*

By making new plots at intervals of every 30 minutes or longer, the migration direction and velocity of the clouds can be determined. Unless many clouds are present or are involved, this migration will be obvious. As soon as the direction and velocity are known, the approximate location and time can be predicted, assuming the clouds do not dissipate. As an extra help, you might draw a line or an arrow on the map indicating the cloud traveling path. The travel speed can reach 300 km/hour (185 mph) or 2.7 degrees/hour.

Summertime Es conditions, when very often more than one cloud is present or rather large patchy structured clouds occur, complicate the plotting. The best technique is to plot each new cloud as it appears and indicate cloud trains on each track. A good habit is also to try estimating its MUF and using a different color to mark the cloud.

Monitoring Frequency Band 28 MHz. (10 meters)				
Cloud Distance km	Cloud Distance miles	Path Length km	Path Length miles	Experienced MUF
873.5	543	1747	1086	28
855	531	1710	1063	29
837	520	1674	1040	30
738.5	459	1477	918	35
694	431	1388	863	40
639	397	1278	794	45
591.5	368	1183	735	50
582.5	362	1165	724	51
574	357	1148	713	52
565.5	351	1131	703	53
557.5	346	1115	693	54
549.5	341	1099	683	55

**Table 26.3.** Experienced MUF-Es related to monitored path or cloud distances on the 10-meter band

Monitoring Frequency Band 50 MHz. (6 meters)				
Cloud Distance km	Cloud Distance miles	Path Length km	Path Length miles	Experienced MUF
874	543	1748	1086	50
824	512	1647	1024	55
779	484	1558	968	60
739	459	1479	918	65
704	438	1407	875	70
671	417	1342	834	75
641	398	1282	796	80
614	381	1227	763	85
588	365	1176	730	90
564	350	1128	701	95
542	337	1083	674	100
521	324	1042	648	105
501	311	1007	623	110
482	300	964	600	115
464	288	928	577	120
447	278	894	556	125
430	267	861	534	130
414	257	829	514	135
399	248	798	496	140
387	240	775	481	144
384	239	770	478	145

*Table 26.4. Experienced MUF-Es related to monitored path or cloud distances on the 6-meter band*

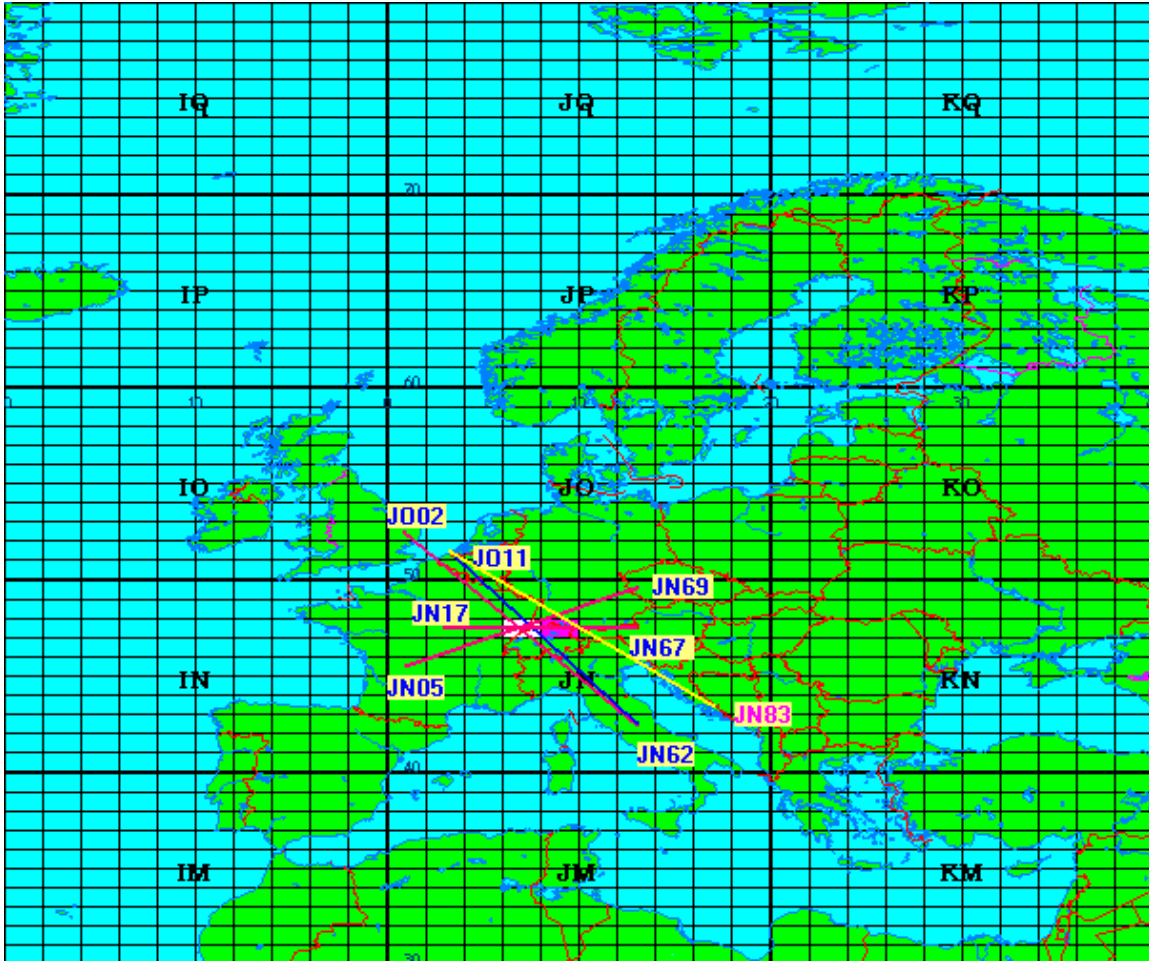
Monitoring Frequency Band 144 MHz. (2 meters)				
Cloud Distance km	Cloud Distance miles	Path Length km	Path Length miles	Experienced MUF
874	543	1748	1086	144
870	541	1740	1081	145
852	529	1704	1059	150
818	508	1636	1016	160
787	489	1574	978	170
759	472	1518	943	180
732	455	1464	910	190
720	447	1439	895	195
707	439	1414	878	200
696	432	1392	865	205
684	425	1368	850	210
673	418	1346	836	215
662	411	1325	822	220
658	409	1316	818	222

*Table 26.5. Experienced MUF-Es related to monitored path or cloud distances on the 2-meter band.*

Observed or monitoring Frequency band MHz	Observed path length km	Observed path length miles	Next open Ham-band
28	1180	733	6-meters
50	775	482	2-meters
144	1315	817	1.25-meters

**Table 26.6.** At least needed path distance on respectively the 10, 6, and 2-meter bands to predict an open next higher frequency ham-band.

**Example Plotting - 1: period 10:00 to 10:20 LT**



**Map 26.2a.**

**50 MHz 6-meter band**

**Heard:**

10:00 J002 < > JN62 [1417km (887 miles)] Estimated MUF-Es 65 to 70 MHz @JN37

**Contacted:**

10:08 J011 < > JN62 [1253 km (778 miles)] Estimated MUF-Es 80 to 85 MHz @JN37

**Heard:**

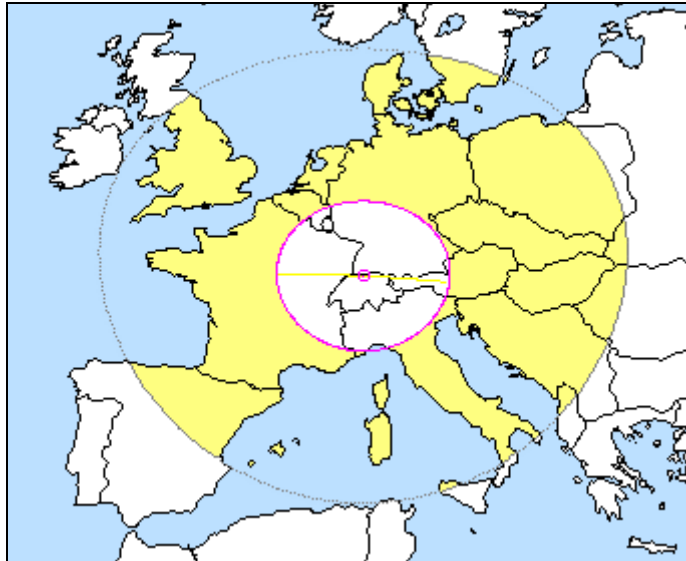
10:12 JN05 < > JN69 [1003 km (623 miles)] Estimated MUF-Es 110 to 115 MHz @JN37

10:15 JN17 < > JN67 [750 km (460 miles)] Estimated MUF-Es =< 145 MHz @JN37 & @JN47

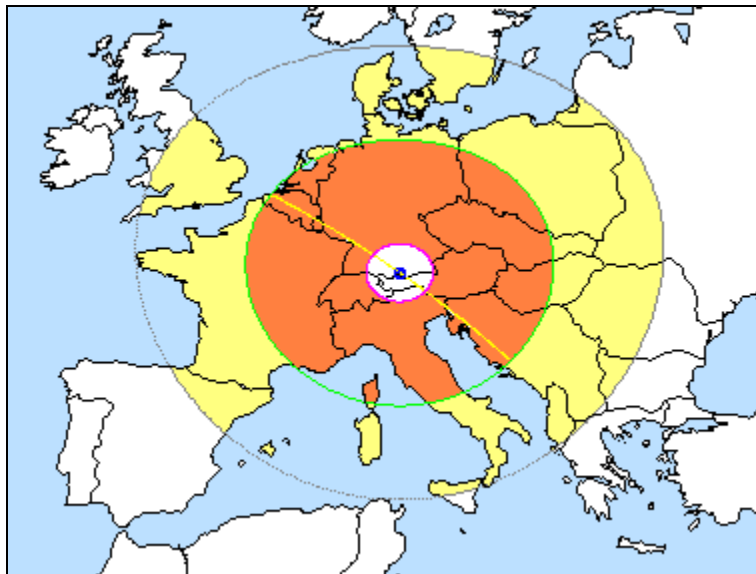
**144 MHz 2-meter band**

**Contacted:**

10:20 JO11 < > JN83 [1373 km (741 miles)] Estimated MUF- Es 210 to 215 MHz @JN47

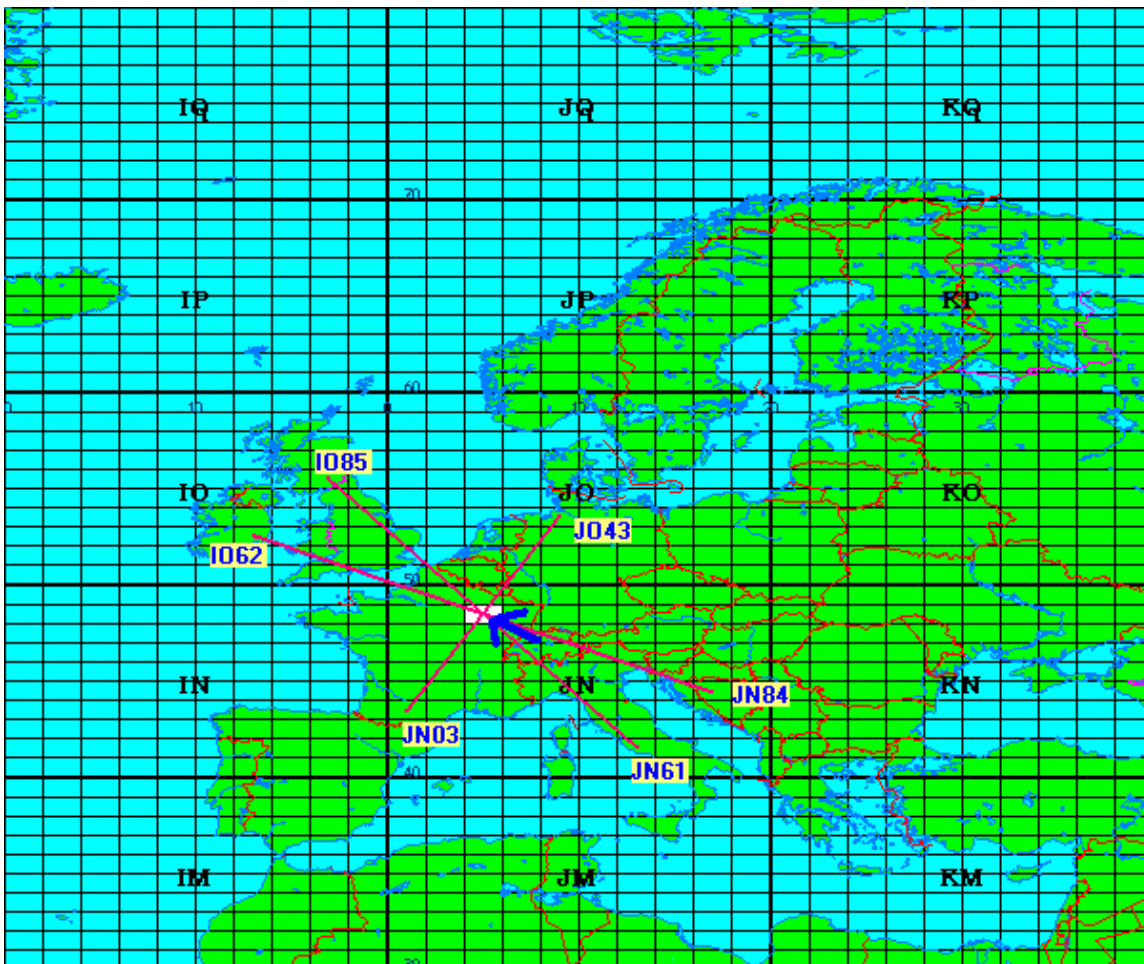


**Map 26.2b.** A QSO heard on the 6-meter band at 10:47: JN17 < > JN67 [750 km (460 miles)]. Estimated MUF-Es = < 145 MHz @JN37 & @JN47. Locations within the yellow highlighted area are able to make 50 MHz contacts by means of the Es cloud at JN37 & JN47

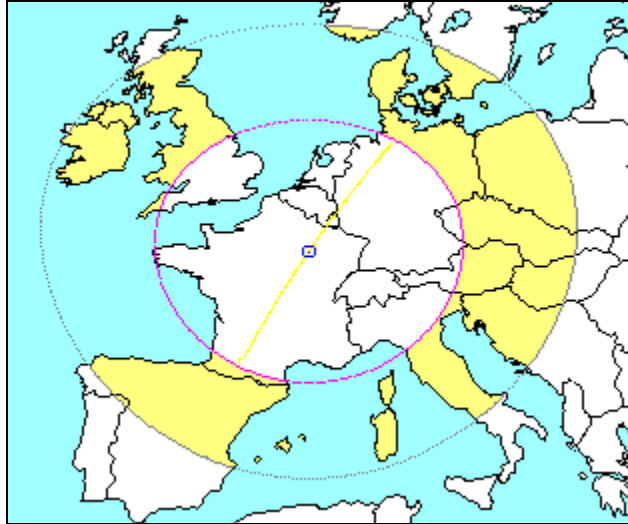


**Map 26.2c.** A QSO made on the 2 meter band at 10:50: JO11 < > JN83 [1373 km (741 miles)]. Estimated MUF- Es 210 to 215 MHz @JN47. Locations within the yellow highlighted area are able to make 144 MHz and 50 MHz contacts by means of the Es cloud at JN47. The red highlighted zone indicates where the 50 MHz contacts are still supported. Notice also the much smaller center donut hole, compared to the one on **Map 26.2b**. The 2-meter QSO results show that the prognoses of the MUF-Es by 6-meter contacts alone was underestimated.

Example Plotting - 2: period 11:00 to 11:10



**Map 26.3a.** Prolonged monitoring on the 6-meter band. The approximated cloud migration over a period of  $\pm 45$  minutes is 186 km (115 miles), with direction  $\pm 310$  degrees North-West and a speed of  $\pm 250$  km/hour (155 mph). The shortest path from JN03 to JO43, a distance of 1260 km (780 miles) predicts at least a MUF-Es of 80 MHz.



**Map 26.3b.** The monitored QSO from JN03 to JO43 let us predict the areas from where 6-meter contacts are possible (yellow colored), by making use of the Es-cloud @JN28.

As an exercise, do some plotting on a map with data from your QSO logbook. Take also time to compute the path distances and try to estimate the MUF-Es. Learn from it for the future; perhaps you may discover that you have missed the opportunity to make contacts on a higher frequency band that was also open for a while. Discover in this way which heard or contacted path distances may alert you to much higher MUF-Es. Try also to discover if that beyond the one-hop outer limit distance range contact was made via a 2Es or a cloud-to-cloud mode. Contest logs are very excellent data for study. Learn and enjoy; it will keep you pretty busy!

Next month we make a study on real sounded Es data by an ionosonde during a few years and a real Sporadic-E 2-meters band opening reaching MUF-Es 220 MHz with the Es-cloud whirling right above the Dourbes Ionosonde environment. A unique and interesting coincidence will be studied and evaluated, so stay tuned. **-30-**

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