Boom Distance Influence on Yagi Antenna

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Introduction

In a previous article **[1]** we investigated boom radius influence on six Yagi antennas very similar in all characteristics except in Q factor values **[3]**.
Now, using computer simulations, we will investigate how fixed radius boom on various distances from antenna elements influences Yagi antenna parameters.
For this task antenna simulation software based on FIT method has been used, instead of usual MoM based software which has been found inadequate due to a few unacceptable program limitations **[2].**
Boom influence has been monitored on following antenna parameters:

1. Antenna input return loss (S11) given in dB
2. Broadband directivity given in dB over isotropic radiator
3. Antenna directivity pattern in E and H planes

Yagi antennas were simulated without boom and later with a **50 mm diameter** conductive round tube boom added. The boom was placed below the elements so that the **distance** (**x**) **between the boom axis and elements axis** has been varied from **30** to **300 mm**. Elements height above the boom, i.e. insulation gap between the boom's top-most surface and element's bottom-most surface was

$$h = x - br - r$$

where **br=25 mm** is boom radius and **r** is corresponding antenna element radius (Fig.1). It represented a simulation of a Yagi antenna with elements insulated from a boom and mounted on boom using plastic insulators with very low dielectric permittivity and different height of elements above the boom.

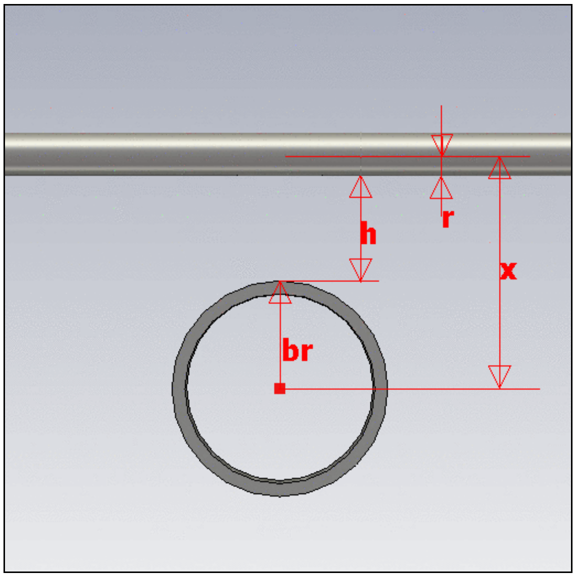


Fig.1

Simulation results

On the presented diagrams on Fig. 2 it can be seen that curves of antenna input return loss shift toward higher frequency simultaneously with the decrease of the distance between boom and antenna elements. This is a result of the well known effect predicted by theoretical calculations and verified by practical measurements. The presence of a thick conductive boom close to the elements tends to shorten the effective length of the elements and thus shifts performances of the antenna to a higher frequency. Maximum of antenna input return loss (minimum SWR), maximum antenna directivity and other characteristics also shift to a higher frequency. Antenna radiation diagram also changes, in a way that side lobes and back lobe change their magnitude and angular position related to main lobe.

It is very interesting that for some antennas, at large distances of 200 – 300 mm between boom and elements, frequency shift of maximum input return loss becomes very small compared to input return loss of the same antenna without boom, but directivity and radiation pattern still considerable differ.

This fact shows that it is not always possible to estimate whether antenna suffers from some destructive influence from its surrounding by simple measuring antenna input return loss or SWR.

It would be very interesting to investigate how far from antenna elements the boom should be in order to have influence small enough that it could be neglected. In one of the next articles we will try to answer this question.

Input Return Loss

From the presented diagrams on Fig. 2 of input return loss, considerable shift toward higher frequencies when boom distance decreases can be seen. Frequency shift of maximum input return loss is 1.3 – 2.2 MHz for antennas with a very close boom compared to antennas with no boom. Considering 2 m amateur band width of 2 MHz in Europe it is very high value!

Variation of input return loss and maximum difference within frequency for DX band 144-145 and whole European band 144-146 MHz are given in Table 1.

From results in Table 1 it is obvious that antennas with lower average Q factors have less variation and difference of input return loss due to variation of boom distance in chosen frequency bands.

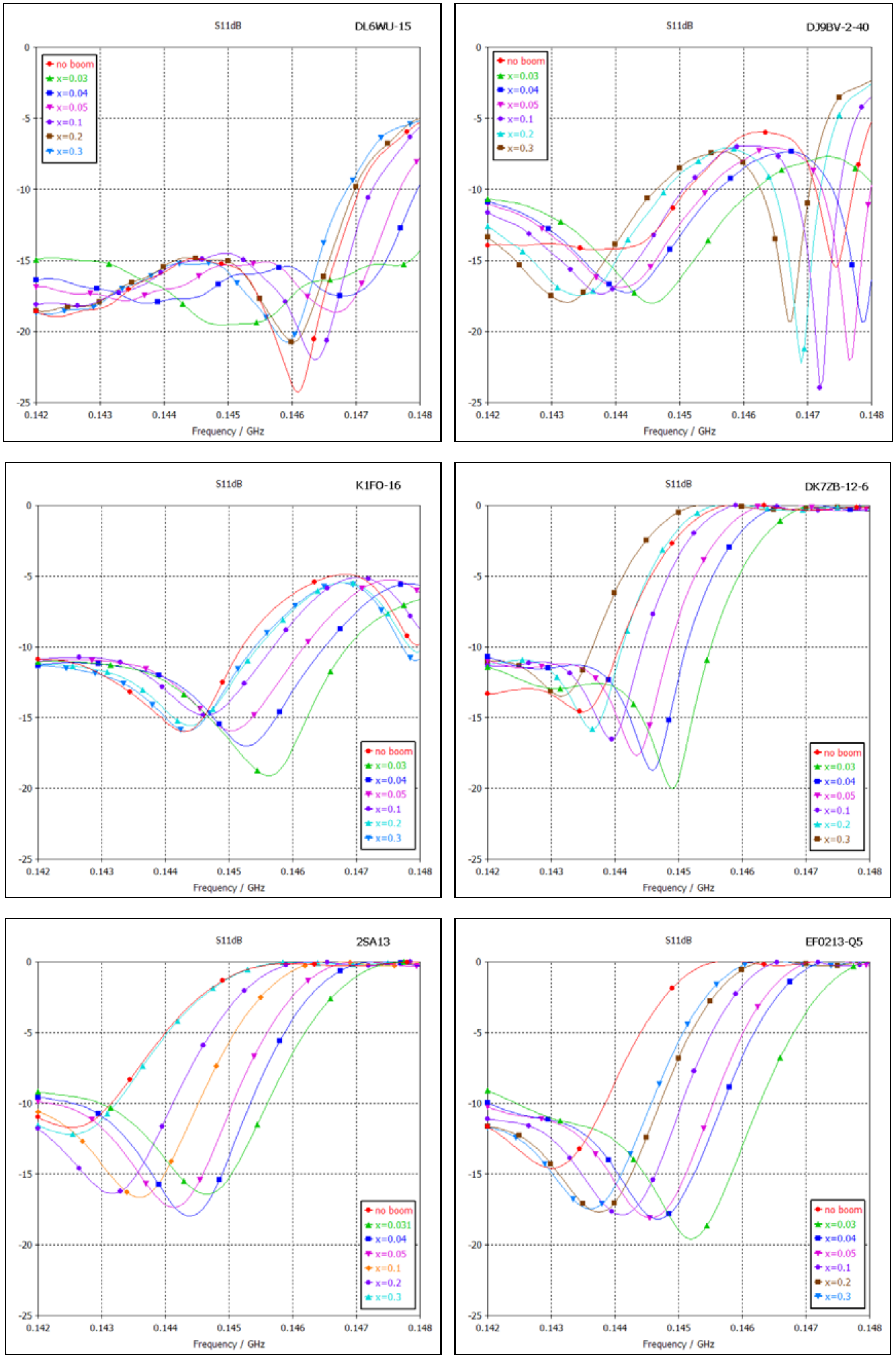

S11dB
DL6WU-15
DJ9BV-2-40
K1FO-16
DK7ZB-12-6
2SA13
EF0213-Q5
0
-5
-10
-15
-20
-25
0.142
0.143
0.144
0.145
0.146
0.147
0.148
Frequency / GHz
no boom
x=0.03
x=0.031
x=0.04
x=0.05
x=0.1
x=0.2
x=0.3

Fig.2

Table 1

Antenna type	Dry/Wet antenna average Q factor	Return Loss variation 144-145 MHz [dB]	Return Loss difference 144-145 MHz [dB]	Return Loss variation 144-146 MHz [dB]	Return Loss difference 144-146 MHz [dB]
DL6WU-15	13.8 / 16.3	-14.5 − -19.6	5.1	-14.5 − -23.6	9.2
DJ9BV-2-40	16.9 / 20.2	-8.5 − -18.0	9.5	-6. 2 − -18.0	11.8
K1FO-16	8.3 /12.7	-11.7 − -16.0	4.3	-6.4 − -19.2	12.8
DK7ZB-12-6	91.7 / 252.6	-0.5 – -20.0	19.5	0.0 − -20.0	20.0
2SA13	75.1 /224.7	-1.1 − -18.0	16.9	-0.1 − -18.0	17.9
EF0213-Q5	70.4 / 291.3	-1.4 − -18.2	16.8	0.0 − -19.6	19.6

Broadband directivity

As expected, antenna broadband directivity curves given on Fig. 3 also shift toward higher frequencies due to a conductive boom influence. This effect produces significant variation of antenna directivity within the amateur band width. This directivity variation is given in Table 2 for whole (European) band 144-146 MHz and for DX part 144-145 MHz.

Antenna directivity variation due to the impact of variable conductive boom proximity within these two frequency bands is given together with maximum directivity differences that can be expected within bands.

Antennas with high average Q factor show higher value of directivity variation as a result of higher sensibility to boom influence and narrower working bandwidth.

Table 2

Antenna type	Dry/Wet antenna average Q factor	Directivity variation 144-145 MHz [dB]	Directivity difference 144-145 MHz [dB]	Directivity variation 144-146 MHz [dB]	Directivity difference 144-146 MHz [dB]
DL6WU-15	13.8 / 16.3	15.8 − 16.2	0.5	15.8 − 16.2	0.5
DJ9BV-2-40	16.9 / 20.2	15.8 − 16.2	0.4	15.5 − 16.2	0.7
K1FO-16	8.3 /12.7	16.1 − 16.3	0.2	16.0 − 16.3	0.3
DK7ZB-12-6	91.7 / 252.6	16.0 − 16.4	0.4	7.8 − 16.4	8.6
2SA13	75.1 /224.7	14.8 − 16.5	1.7	1.1 − 16.5	15.4
EF0213-Q5	70.4 / 291.3	15.1 − 16.3	1.2	4.6 − 16.3	11.7

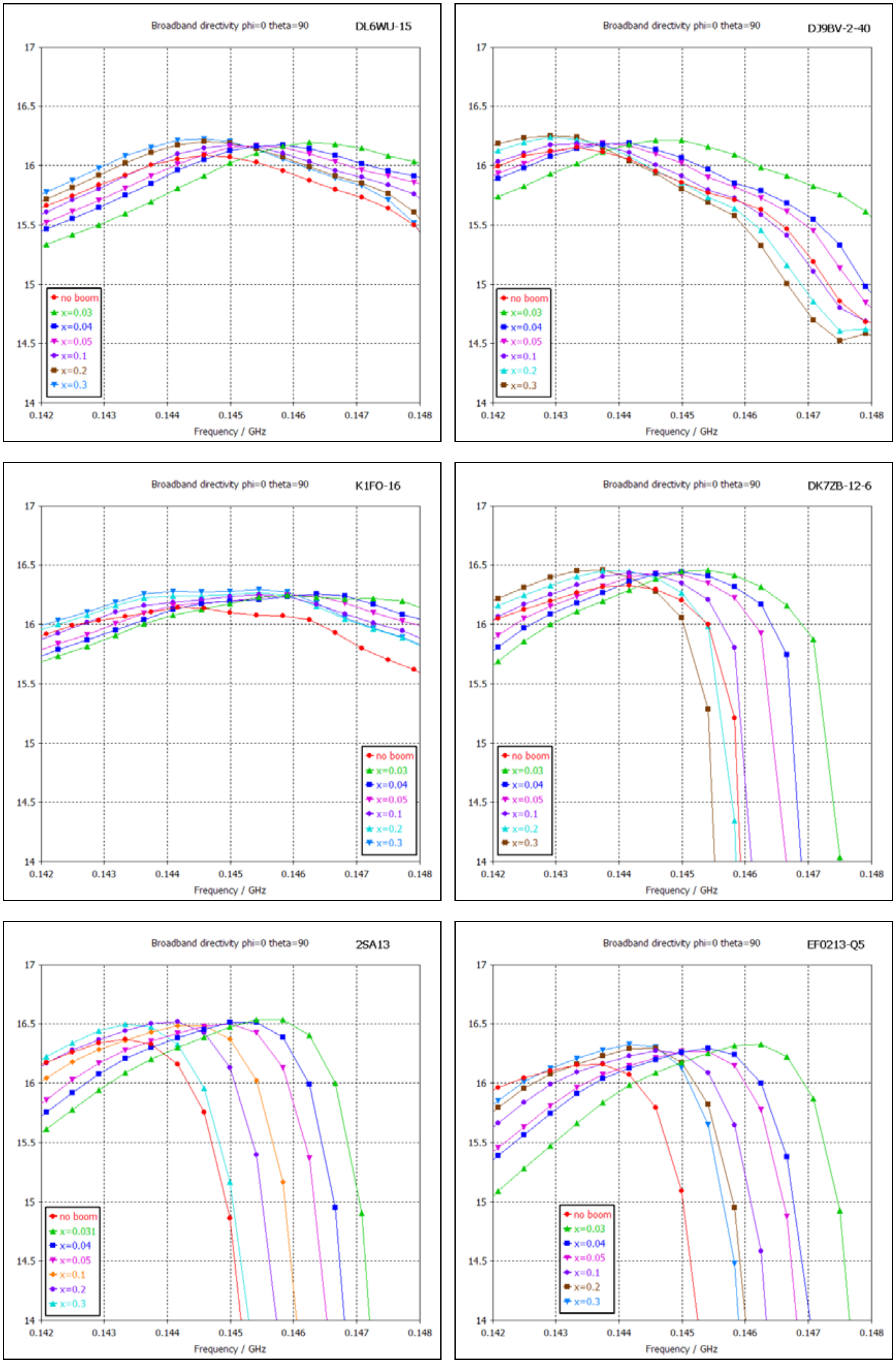
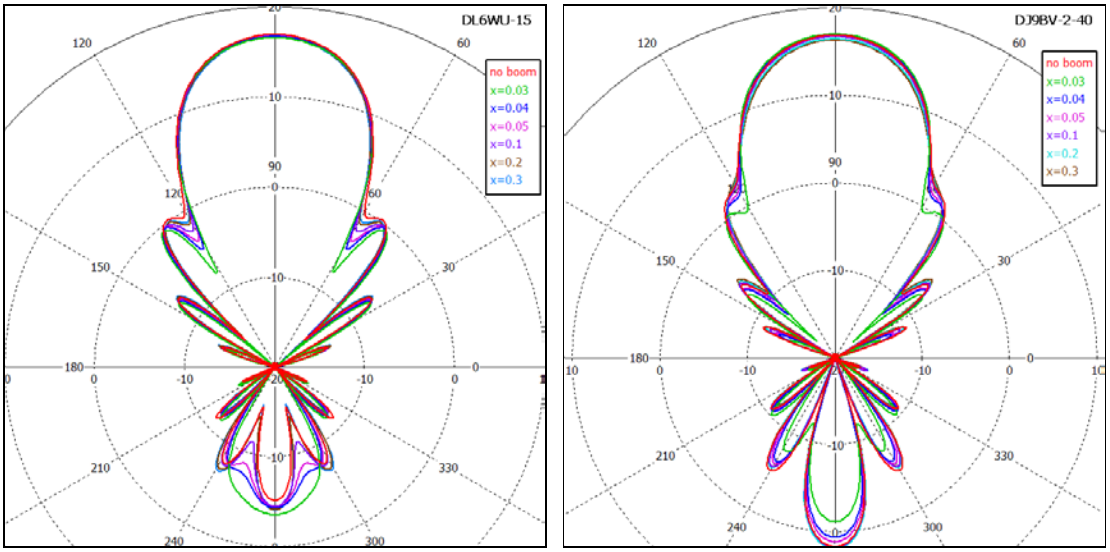
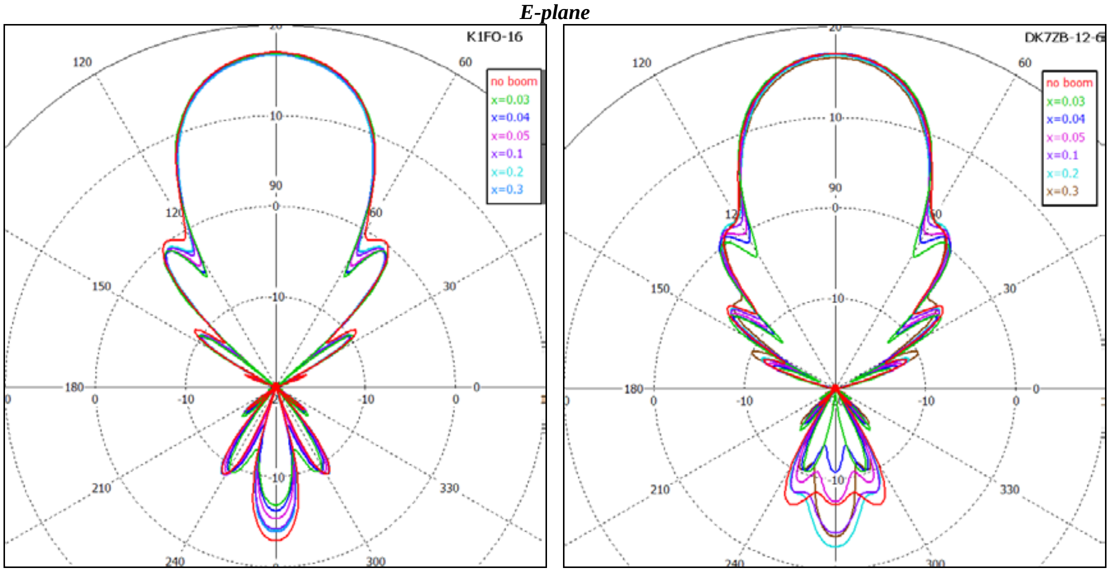

Broadband directivity phi=0 theta=90
DL6WU-15
17
16.5
16
15.5
15
14.5
14
0.142
0.143
0.144
0.145
0.146
0.147
0.148
Frequency / GHz
no boom
x=0.03
x=0.04
x=0.05
x=0.1
x=0.2
x=0.3
Broadband directivity phi=0 theta=90
DJ9BV-2-40
no boom
x=0.03
x=0.04
x=0.05
x=0.1
x=0.2
x=0.3
Frequency / GHz
Broadband directivity phi=0 theta=90
K1FO-16
no boom
x=0.03
x=0.04
x=0.05
x=0.1
x=0.2
x=0.3
Frequency / GHz
Broadband directivity phi=0 theta=90
DK7ZB-12-6
no boom
x=0.03
x=0.04
x=0.05
x=0.1
x=0.2
x=0.3
Frequency / GHz
Broadband directivity phi=0 theta=90
2SA13
no boom
x=0.031
x=0.04
x=0.05
x=0.1
x=0.2
x=0.3
Frequency / GHz
Broadband directivity phi=0 theta=90
EF0213-Q5
no boom
x=0.03
x=0.04
x=0.05
x=0.1
x=0.2
x=0.3
Frequency / GHz

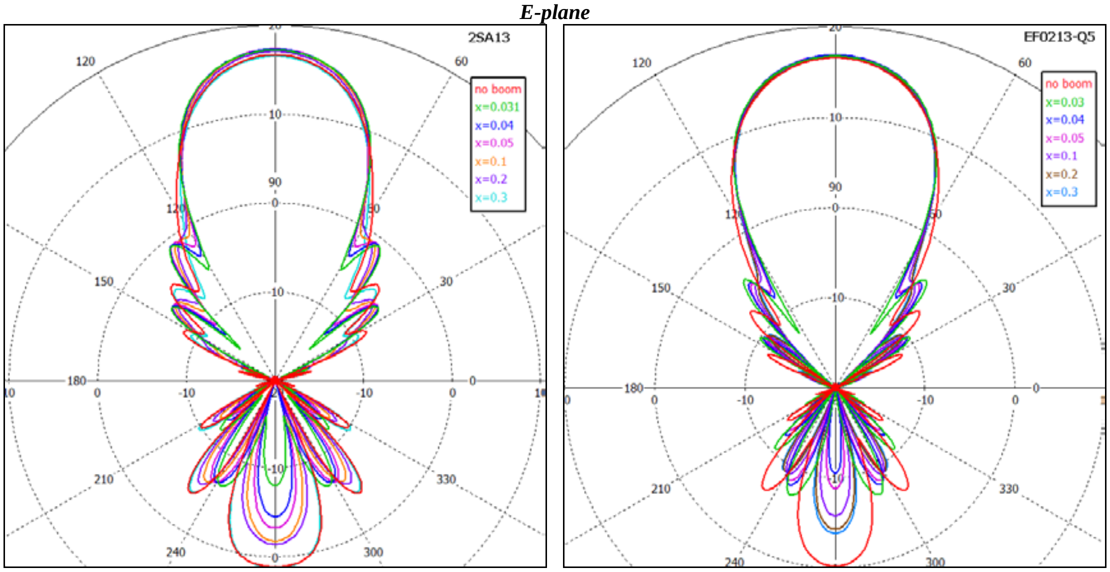
Fig.3



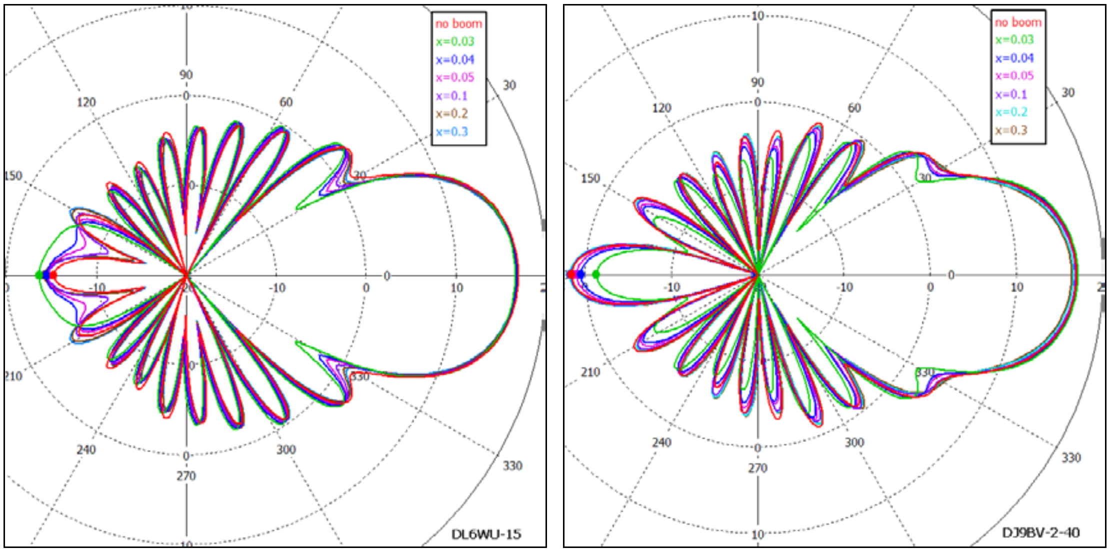
E-plane



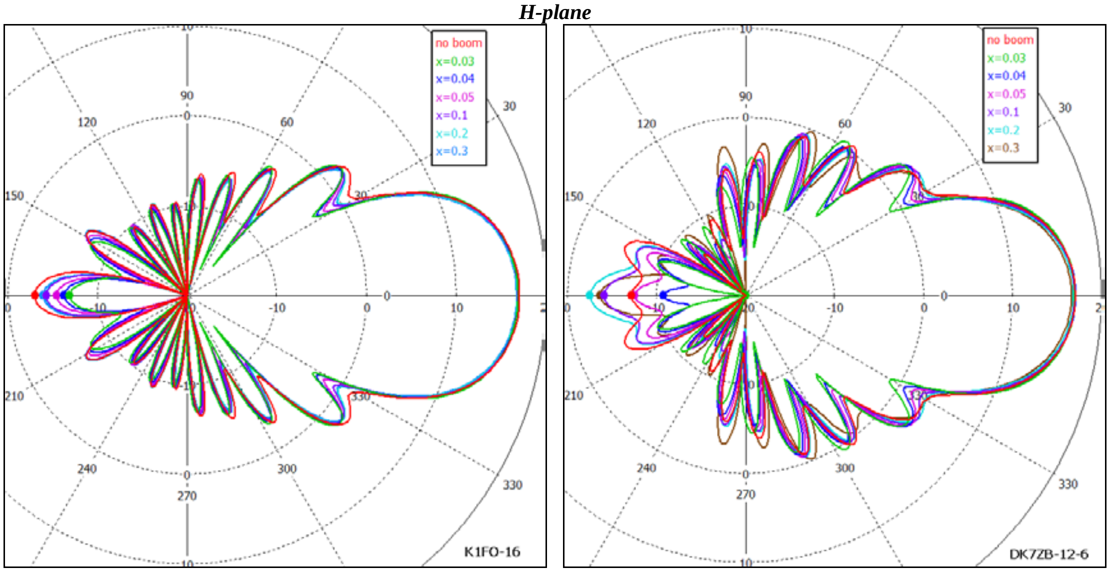
E-plane



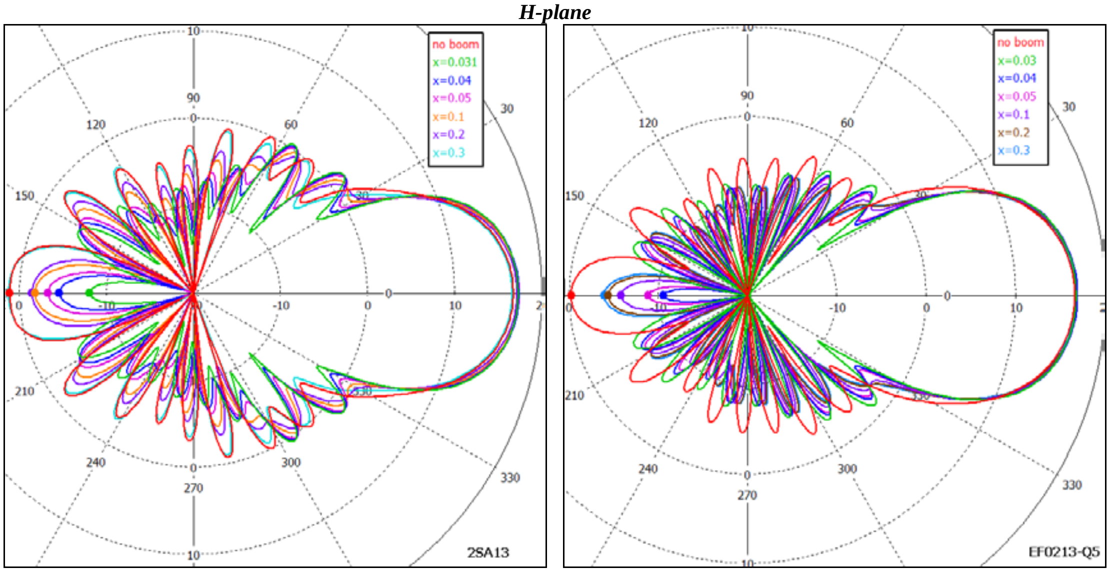
E-plane



H-plane



H-plane



H-plane

Antenna pattern

All antenna patterns were taken on frequency 144.5 MHz. This frequency is chosen because the antennas with high average Q factors usually have considerably distorted radiation patterns on higher frequencies. They are usually computer optimized only for work at the lower portion of the 2 m band and thus they are conditioned for this choice of frequency.

On the presented polar plots of antenna directivity in E and H plane it can be seen that largest impact of a conductive boom is on angular position and magnitude of the first side lobes and the back lobe.

Antennas with low average Q factors show a more stable angular position and less magnitude variation of side lobes in both E and H planes. Variation of back lobe magnitude with a change of boom distance is also lower for antennas with lower average Q factors.

First side lobe magnitude and angular position differences for all six antennas are given in Table 3. Back lobe variation and thus antenna F/B ratio variation due to conductive boom influence is also given in Table 3.

Table 3

Antenna type	Dry/Wet antenna average Q factor	E plane first side lobe magnitude difference [dB]	H plane first side lobe magnitude difference [dB]	E plane first side lobe angular difference [Deg.]	H plane first side lobe angular difference [Deg.]	Back lobe magnitude difference [dB]
DL6WU-15	13.8 / 16.3	0.7	0.5	2	3	1.6
DJ9BV-2-40	16.9 / 20.2	2	1.5	4	5	3
K1FO-16	8.3 /12.7	1	0.7	2.5	2.5	3.8
DK7ZB-12-6	91.7 / 252.6	1.5	1	5	6	8.5
2SA13	75.1 /224.7	3.6	3	9	9	9.5
EF0213-Q5	70.4 / 291.3	3	2	12	12	20

Frequency shift

The built antenna behavior depends on the various mechanical solutions that are used for antenna elements mounting. Also there is very strong parameter dependence on whether antenna is built with conductive or non-conductive boom. Different antenna designs behave differently under the same conditions depending on its Q factor, i.e. sensitivity to environmental influences.

Behavior and frequency shift of two important parameters, frequency of maximum directivity and maximum input return loss for all 6 antennas are summarized in Table 4.

Table 4

Antenna type	Dry/Wet antenna average Q factor	Maximum Return Loss Frequency Shift [MHz]	Maximum Directivity Frequency Shift [MHz]
DL6WU-15	13.8 / 16.3	1.7	1.7
DJ9BV-2-40	16.9 / 20.2	1.4	1.8
K1FO-16	8.3 /12.7	1.3	1.6
DK7ZB-12-6	91.7 / 252.6	1.8	1.7
2SA13	75.1 /224.7	2.1	2.3
EF0213-Q5	70.4 / 291.3	2.2	2.5

Conclusion

In this paper we presented simulations and analyses of conductive boom influence on Yagi antenna performances depending on its distance from antenna elements.

Various boom distances from antenna elements and its effects on antenna input return loss, broadband directivity and radiation pattern for different antenna designs were compared. Good correlation between antenna average Q factor and these boom effects are found. It is confirmed that antenna Q factor is an important parameter which defines antenna susceptibility to boom effects.

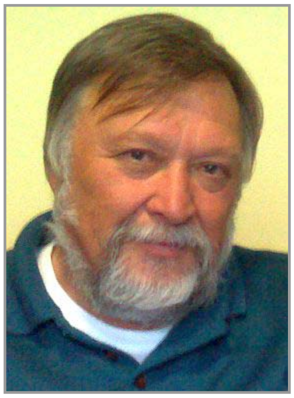
It is also found that the maximum distance of 300 mm between boom axis and elements axis, that is about 0.15 wavelengths at 2m band, is not wide enough to produce irrelevant effects on antenna directivity and radiation pattern. It would be necessary to enlarge maximum distance and to investigate its effects, not only because of boom, which can never be on such a large distance from elements, but because of other possible mechanical structures in antenna proximity. **-30-**

References:

1. Dragoslav Dobričić, YU1AW, **Boom Radius Influence on Yagi Antenna**, *antenneX*, June 2009, Issue No. 146.
2. Dragoslav Dobričić, YU1AW, **Boom Influence on Yagi Antenna**, *antenneX*, May 2009, Issue No. 145.
3. Dragoslav Dobričić, YU1AW, **Yagi Antenna Design Sensitivity in Practice**, *antenneX*, November 2008, Issue No. 139.

BRIEF BIOGRAPHY OF THE AUTHOR

Dragoslav Dobričić, YU1AW, is a retired electronic Engineer and worked for 40 years in Radio Television Belgrade on installing, maintaining and servicing radio and television transmitters, microwave links, TV and FM repeaters and antennas. At the end of his



professional career, he mostly worked on various projects for power amplifiers, RF filters and multiplexers, communications systems and VHF and UHF antennas.

For over 40 years, Dragan has published articles with different original constructions of power amplifiers, low noise preamplifiers, antennas for HF, VHF, UHF and SHF bands. He has been a licensed Ham radio since 1964. He is married with two grown up children, a son and a daughter.

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