Compliance Checks against Ofcom / ICNIRP EMF limits

for Microwaves

Peter Zollman G4DSE Ian White GM3SEK

Click through the slides – but for the complete presentation, watch the video.

The licence requirement

In short:

“Ensure that your transmissions do not breach the ICNIRP limits for EMF exposures of the General Public.”

See *RadCom* and www.rsgb.org/emf for background.

We now have to make assessments to ensure this.

Basic principles

To meet this requirement:

- **Define** an EMF Exclusion Zone.
  This is the zone within which the exposure limits **could** be exceeded.
- **Control** the Exclusion Zone:
  - If someone **is actually present** in the EZ, then **don't transmit**.
  - If someone enters the EZ, **stop transmitting**
    (it's OK if you do this promptly).

Basic principles

To meet this requirement:

- **Define** an EMF Exclusion Zone.
- **Control** the Exclusion Zone.
- **Record** your assessment.

Basic principles

For compliance:

- You need to **know the boundaries** of the EZ.
- **Preferably make the EZ inaccessible.**
- **Or always know if people are inside the EZ.**

Active supervision – a big advantage for Amateur Radio

- **No action needed for persons outside the EZ.**

Basic principles

Another way to comply:

- **Low power:** your equipment never exceeds 10W EIRP averaged over 6 minutes (and never >100W EIRP peak).

Basic principles

Another way to comply:

- **Low power:** your equipment never exceeds 10W EIRP **averaged over 6 minutes** (and never >100W EIRP peak).
- **IMPORTANT: always average your actual power.**
- **50% TX time is a realistic default**, almost always conservative.
- **Mode factor** if relevant (full-carrier 100%, SSB 20-50%,

All the power levels we will quote here are averaged.

Basic principles

Ofcom, not ICNIRP

Another way to comply:

- **Low power:** your equipment never exceeds 10W EIRP averaged over 6 minutes.
- **But what if**

  EIRP = {very low power} x {high antenna gain} **?**

  - 10W EIRP = 100 mW and 20 dBi
  - 10W EIRP = 10 mW and 30 dBi
  - 10W EIRP = 1 mW and 40 dBi

Tiny RF power… so we looked into that.

Basic principles

Application to Microwaves

This Is Not HF!

Shorter wavelengths, smaller antennas make a big practical difference.

- **We aren't totally surrounded by the EM field**
- **Much narrower main beams**, easier to avoid or exclude.
- **Much sharper boundaries for all parts of the Exclusion Zone** – "either in or out".

Application to Microwaves

Also “Not HF”

- **Microwaves are not entry-level amateur radio.**
  We assume some technical understanding and engagement.
- **Some microwave EMF advice can be very simple and practical:**

“Don’t do anything that you already know you shouldn’t be doing.”

For example…

Application to Microwaves

Things you already know you shouldn't be doing:

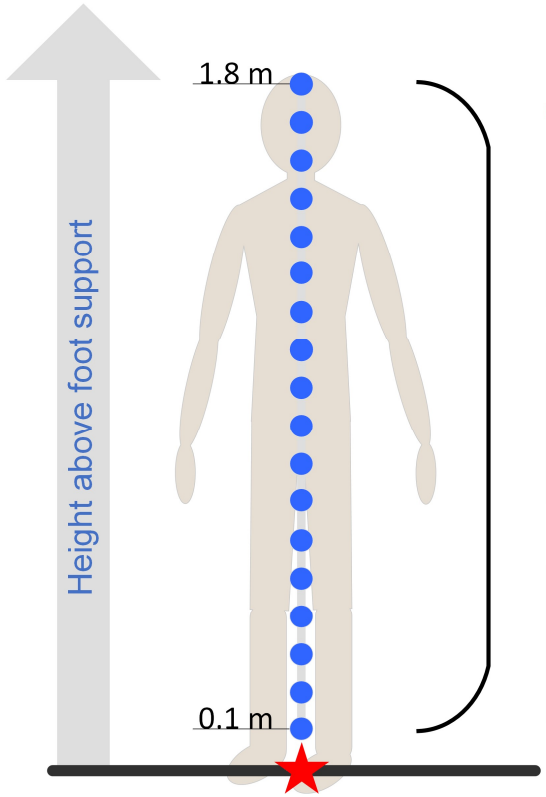
- **Don't look into the waveguide** = avoid localized high concentrations of EMF
- **Don't allow** any body part (your own or anyone else's) in areas of high EMF while you transmit.
- **Or don't transmit.**

Carry on not doing those things.

Application to Microwaves

Estimating Human Exposure

– Strong spatial variations of EMF mean that a ‘Whole Body Average’ **must** be correctly evaluated using several different points.



Power density (S) sample point

Compute power density at 18 sample points over height of body

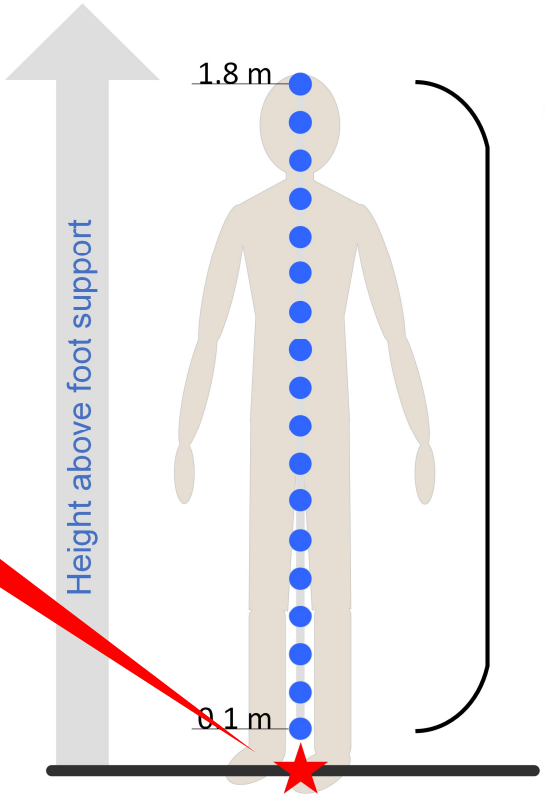
Determine:
- Ave[S] for all sample points
- Max[S] for all sample points

Assign Average and Maximum S values to ★ location representing foot position

Application to Microwaves

Estimating Human Exposure

Is it OK for someone to be standing at this point?



- Power density (S) sample point

Compute power density at 18 sample points over height of body

↓

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- Ave[S] for all sample points
- Max[S] for all sample points

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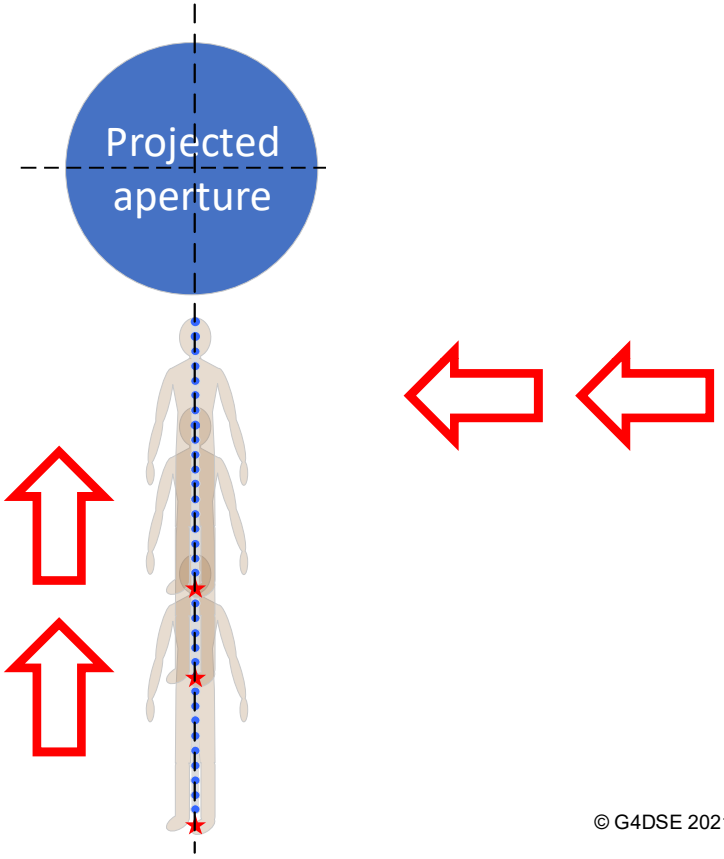
Application to Microwaves

Estimating Human Exposure



Application to Microwaves

Estimating Human Exposure

- Strong spatial variations of EMF mean that ‘Whole Body Average’ must be calculated correctly.
- New limits for Local exposure in ICNIRP 2020 (higher than for WBA but could apply to **any** 2x2cm area).
- Either WBA or Local could be the limiting quantity (depending on location) so **both need to be determined, everywhere**.

We’re handling these details so that you won’t need to.

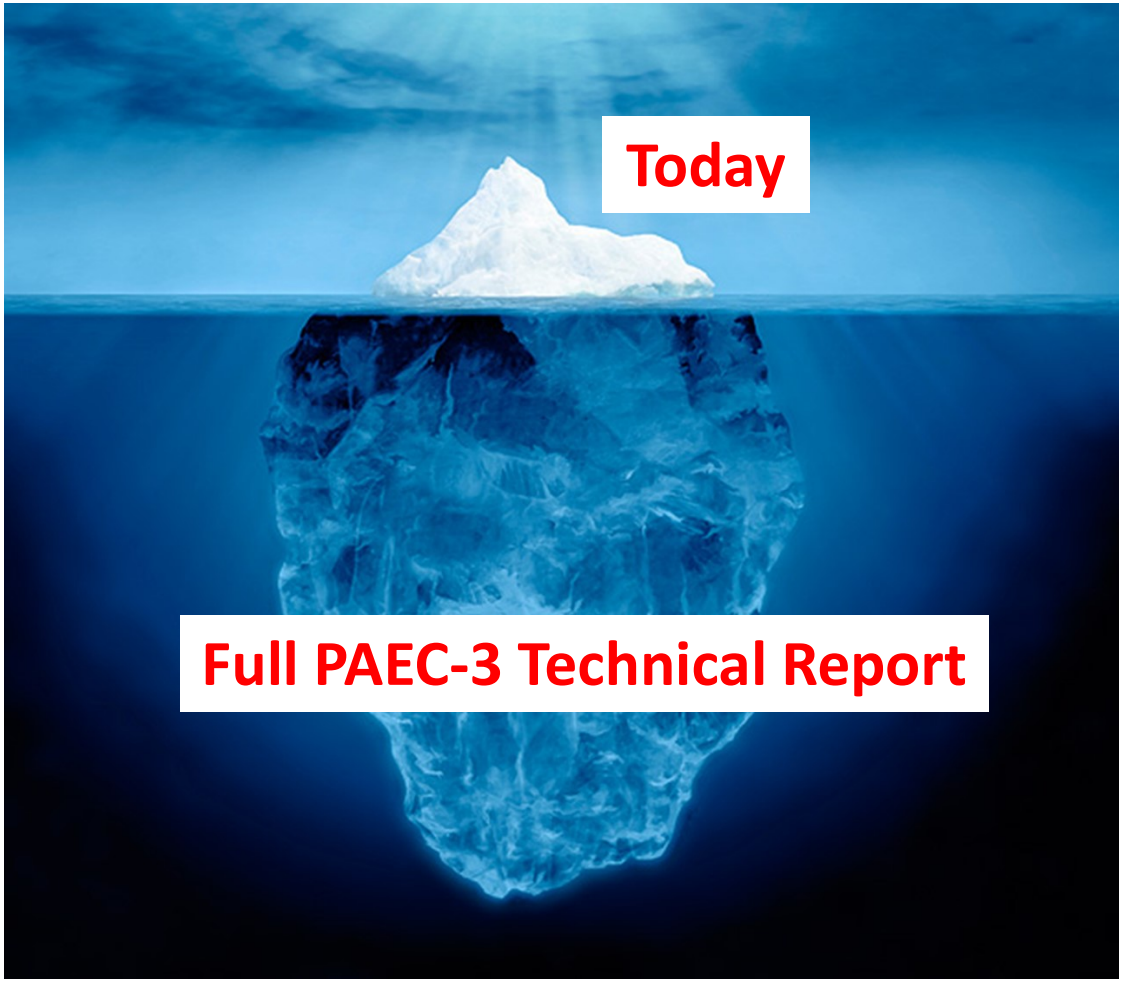
Application to Microwaves

Back to the basic questions

1. Where exactly are the EMF Exclusion Zones?

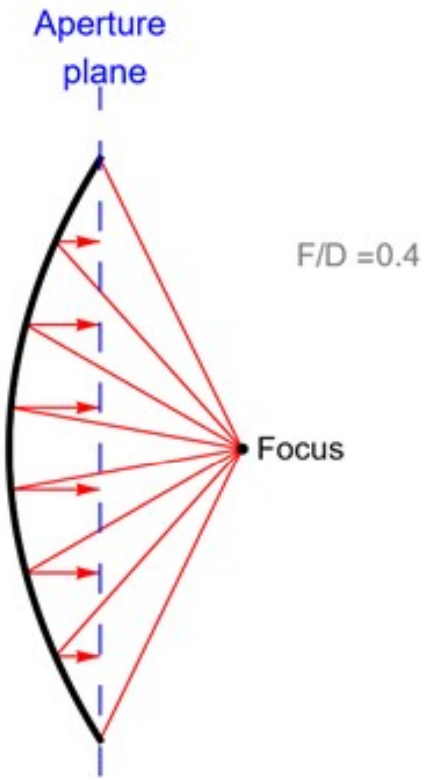
Application to Microwaves

Application to Microwaves



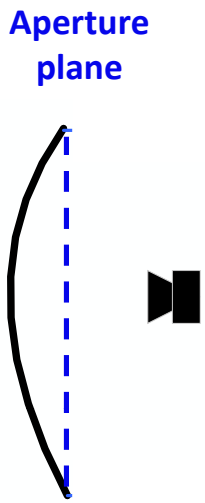
EM fields from dishes

Parabolic reflector



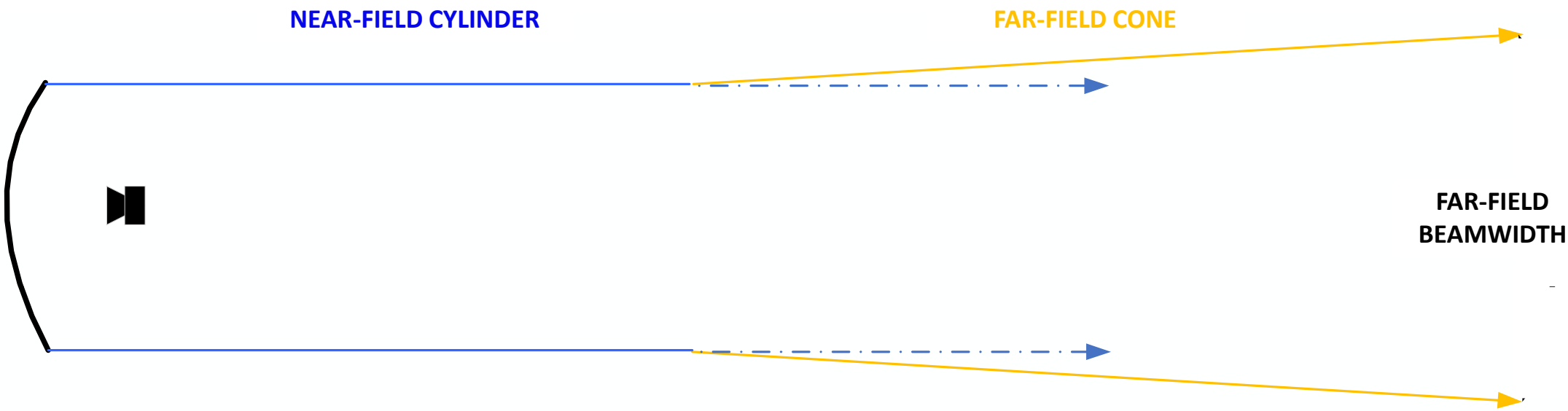
Ideally,
uniform phase
across the aperture

EM fields from dishes



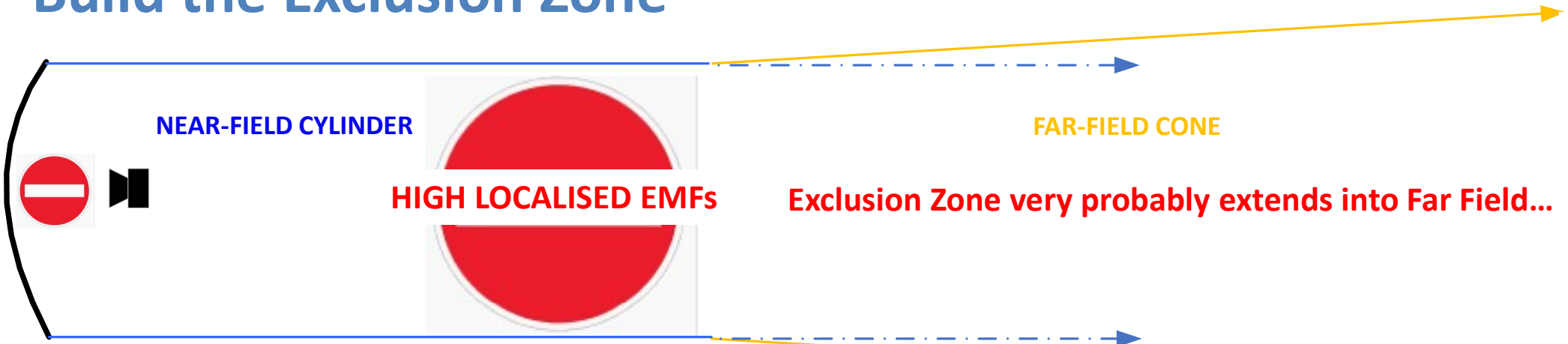
NEAR-FIELD CYLINDER

EM fields from dishes



EM fields from dishes

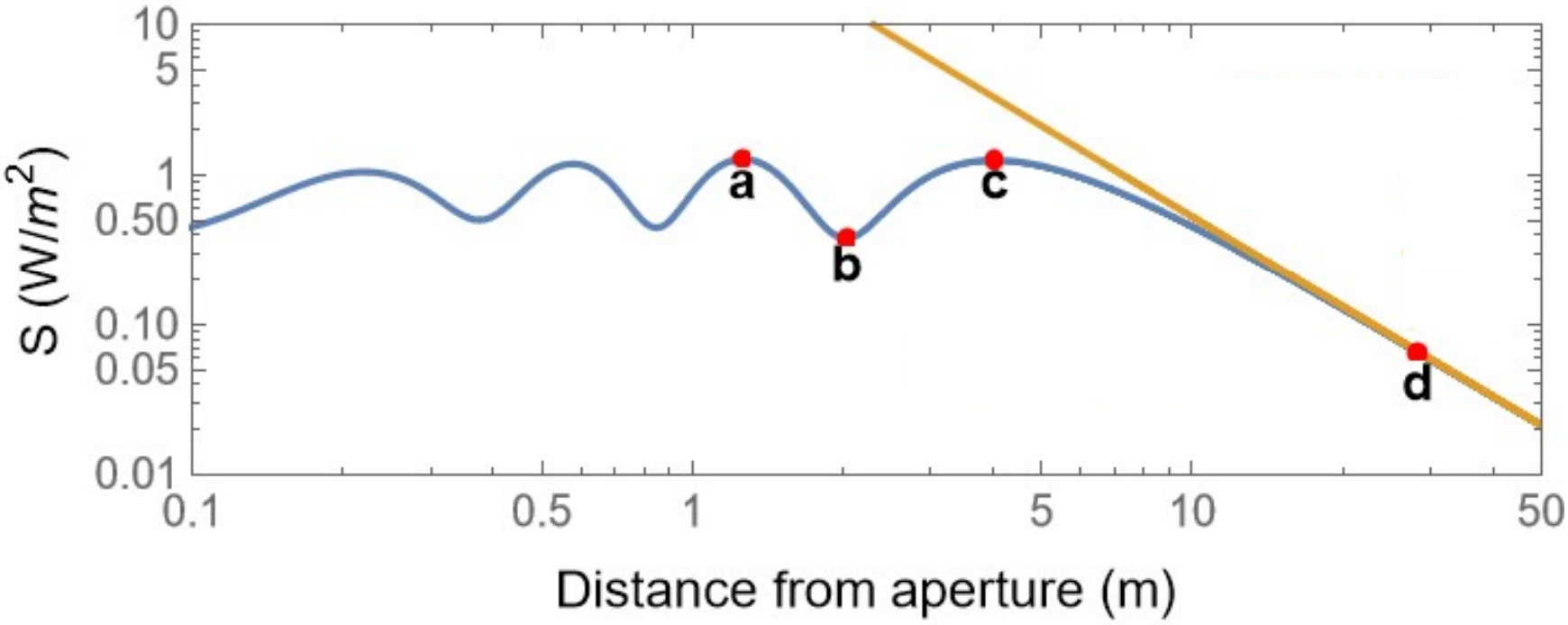
Build the Exclusion Zone



EM fields from dishes

What's happening here?

Power density (*S*) along main beam axis



EM fields from dishes

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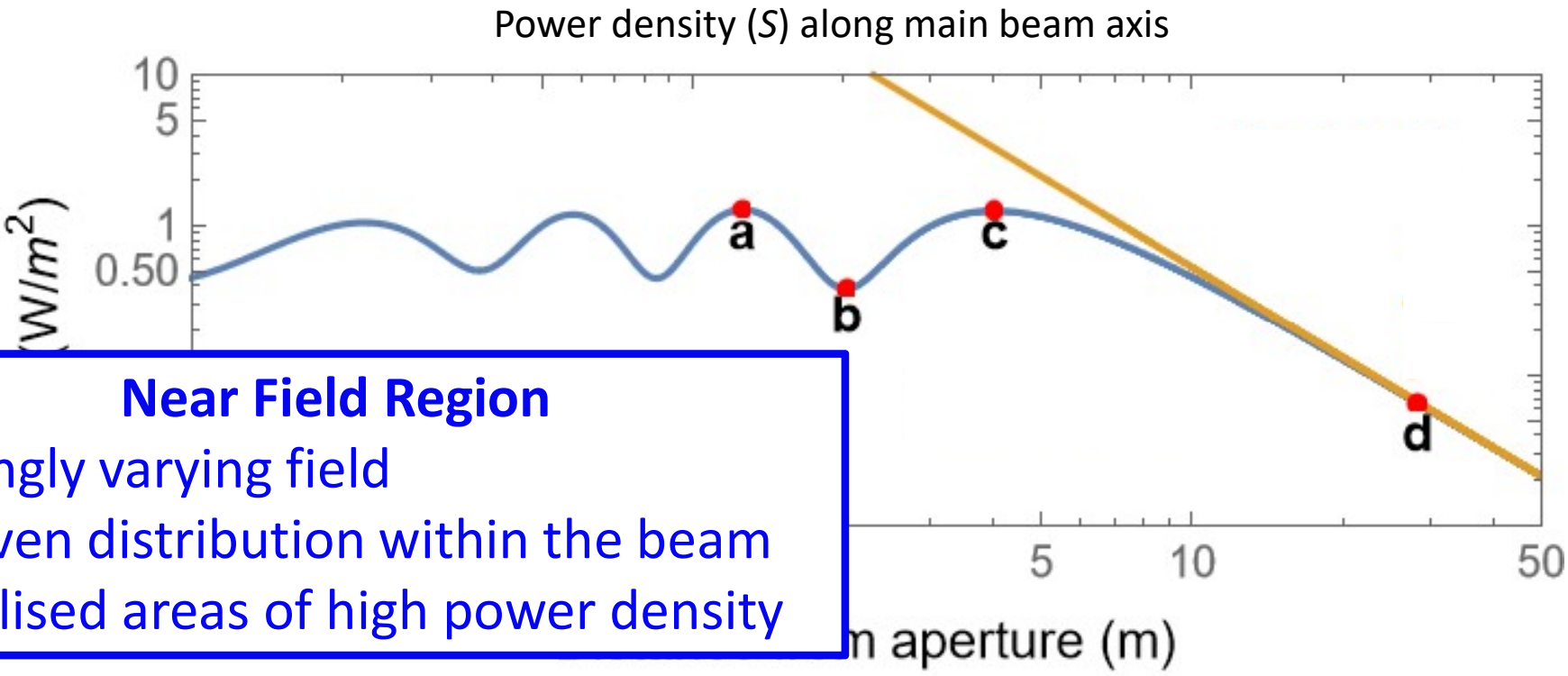


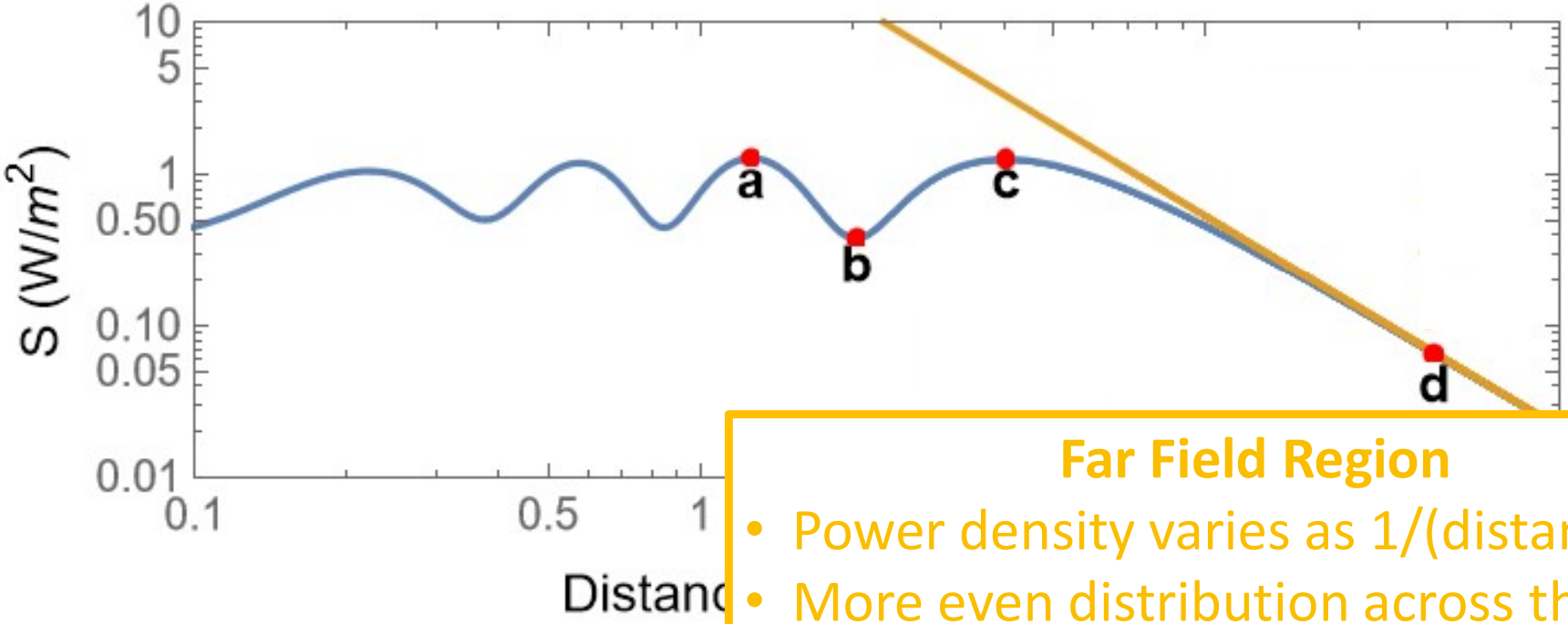
Near Field Region

- Strongly varying field
- Uneven distribution within the beam
- Localised areas of high power density

EM fields from dishes

What's happening here?

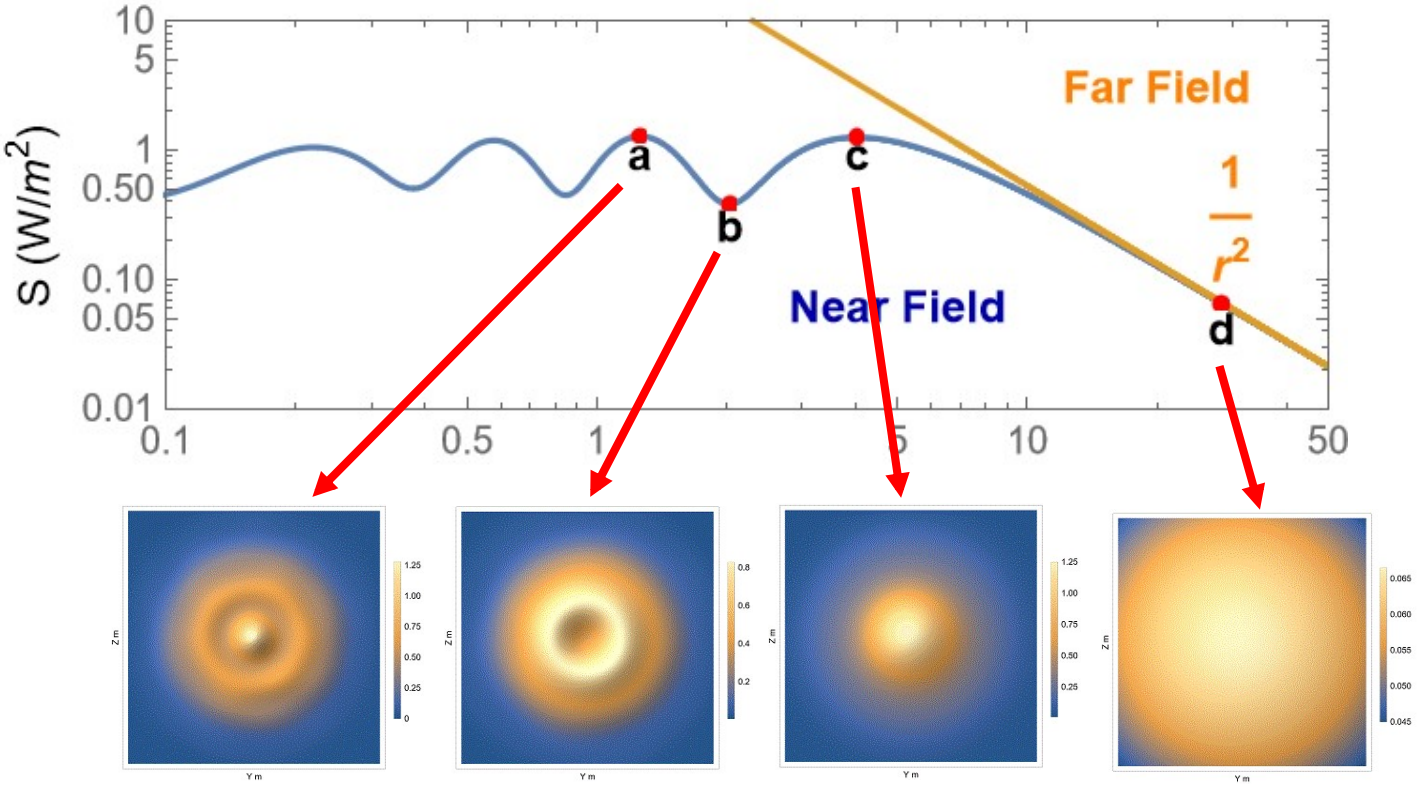
Power density (*S*) along main beam axis



Far Field Region

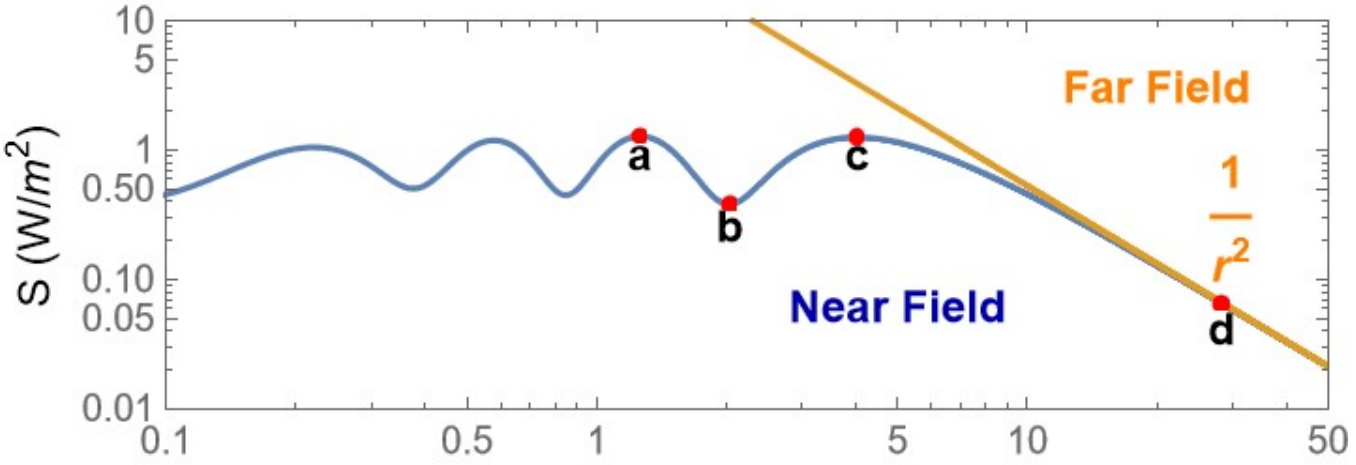
- Power density varies as 1/(distance)^2
- More even distribution across the beam

EM fields from dishes



Looking directly towards the dish along the main beam axis

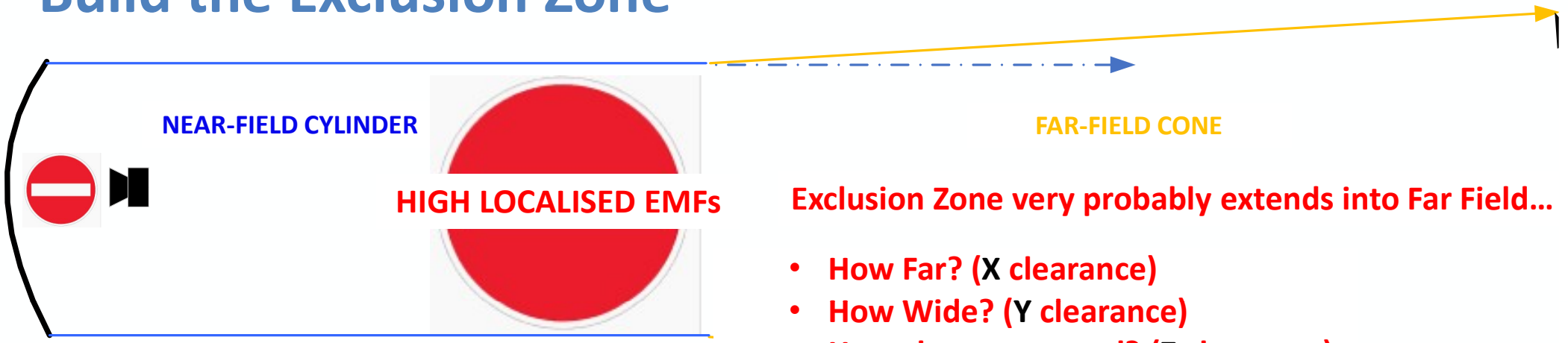
EM fields from dishes



- Too much near-field detail – go back to simple formulae.
- A separate formula for each region.

EM fields from dishes

Build the Exclusion Zone



Exclusion Zone very probably extends into Far Field…

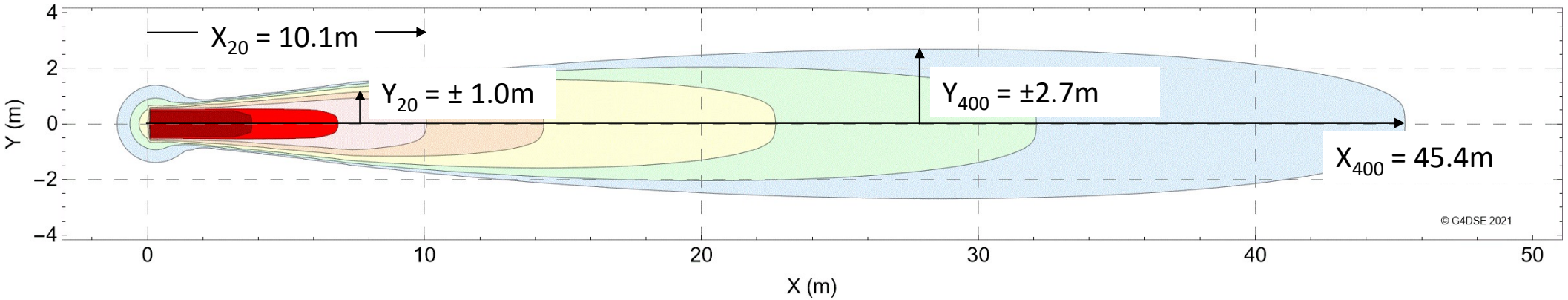
- **How Far? (X clearance)**
- **How Wide? (Y clearance)**
- **How close to ground? (Z clearance)**
- **Tilt angle for satellite and EME**

EM fields from dishes

Create maps of Exclusion Zones vs RF power

For example…

Looking down from above

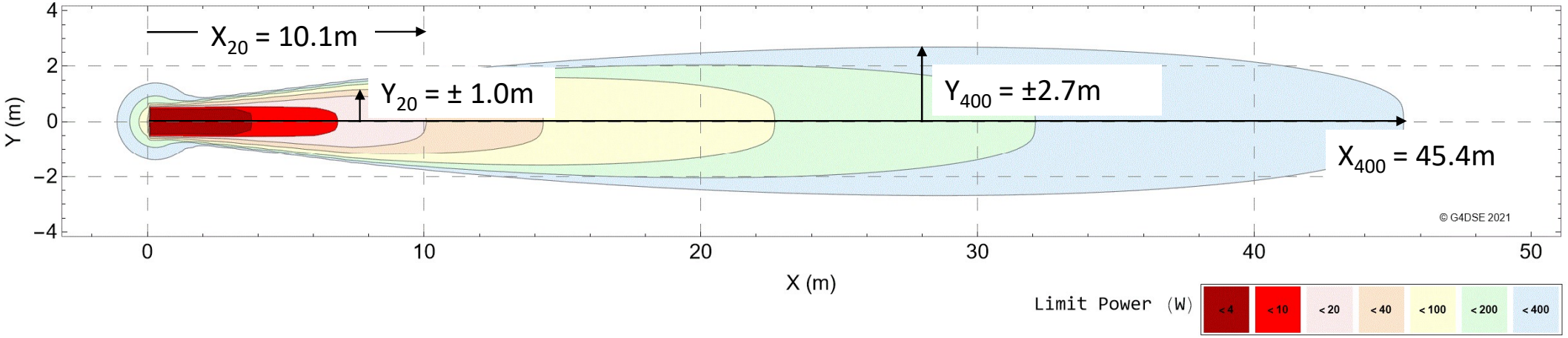


Contours show Exclusion Zones for various average power levels.

EM fields from dishes

Prime focus dish, this example F/D = 0.4, Illumination -11dB at rim, Efficiency 0.7

fMHz	Diameter	Gain FF dBi	HPBW (deg)	Power	X Compliant	Y Compliant	Z Compliant
2350	1.20	27.9	7.28	4	3.8	0.5	-2.0
2350	1.20	27.9	7.28	10	6.9	0.6	-2.4
2350	1.20	27.9	7.28	20	10.1	1.0	-2.4
2350	1.20	27.9	7.28	40	14.4	1.2	-2.5
2350	1.20	27.9	7.28	100	22.7	1.6	-3.0
2350	1.20	27.9	7.28	200	32.1	2.1	-3.2
2350	1.20	27.9	7.28	400	45.4	2.7	-3.8



EM fields from dishes

Prime focus dish, this example F/D = 0.4, Illumination -11dB at rim, Efficiency 0.7

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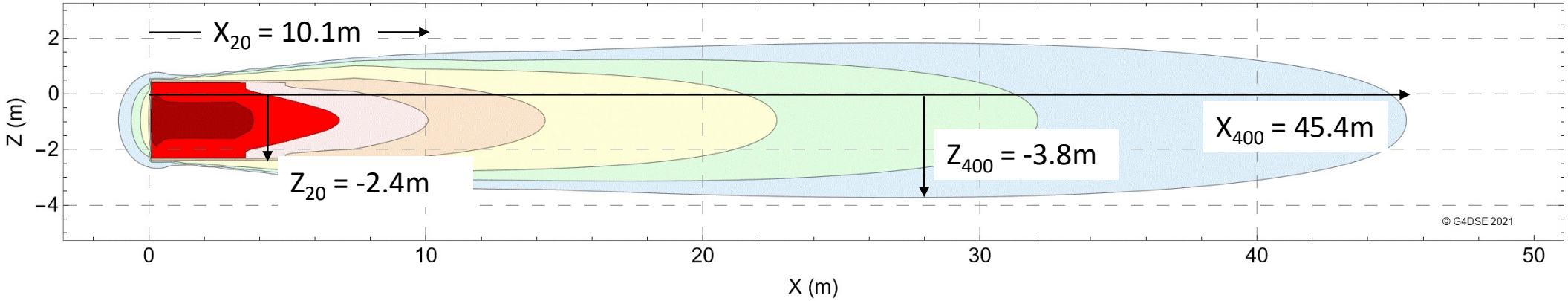
Looking from the side



EM fields from dishes

Ofcom EMF calculator?

e F/D = 0.4, Illumination -11dB at rim, Efficiency 0.7

			(deg)	Power	X Compliant	Y Compliant	Z Compliant
2350	1.20	27.9	7.28	4	3.8	0.5	-2.0
2350	1.20	27.9	7.28	10	6.9	0.6	-2.4
2350	1.20	27.9	7.28	20	10.1	1.0	-2.4
2350	1.20	27.9	7.28	40			
2350	1.20	27.9	7.28	100			
2350	1.20	27.9	7.28	200	32.1	2.1	-3.2
2350	1.20	27.9	7.28	400	45.4	2.7	-3.8

Ofcom calc = 15.9m clearance in EVERY direction!

Low power exemption – good news

What we're looking for

- **Power levels below which compliance will be guaranteed**
- by proving that it's **physically impossible** to exceed any ICNIRP Basic Restrictions with the power available.
- **Widest achievable range of applicability**
  e.g. across most of the microwave spectrum.

Low power exemption – good news

Analyse three inputs:

- **ICNIRP**
  - Fundamentally about temperature rise of body tissue (W/kg)
  - Whole-body exposure – total power absorbed by the body
  - Local exposure – power absorbed in a defined small mass or area.
- **IEC 62232** guidance on body weight to use for assessments.
- **RF Engineering**
  - Relationships between dish size, efficiency, peak power density in the near field

Low power exemption – good news

Develop a provable rationale

- **One example**

  "Average powers up to 1W can be guaranteed compliant

  - on any band up to 10GHz
  - and provided that energy is distributed over at least 0.5m diameter "

- **More in PAEC-3 report, including higher bands**

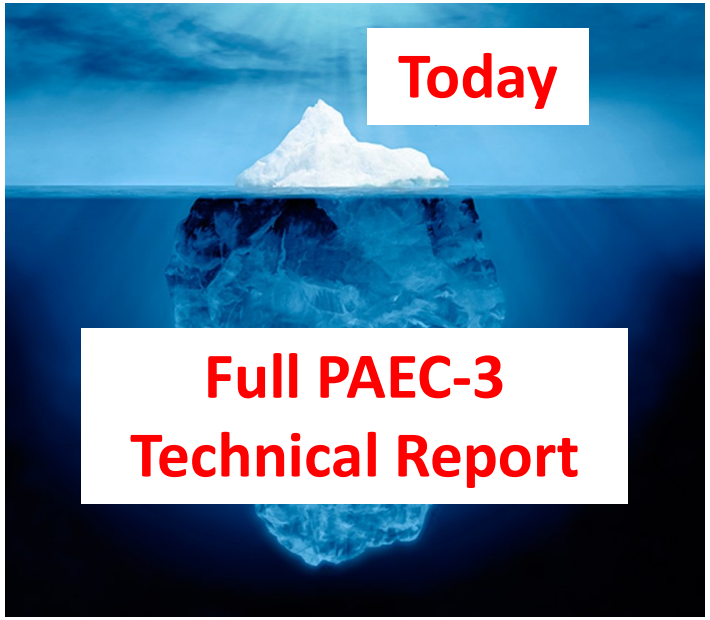
The To-Do List

Working with UKuG and BATC…

- **Practical values for tables and spreadsheets**
- **Smaller dishes** (< 8λ dia, important for lower bands)
- **Offset feeds**
- **Spillover**
- **Ground reflection?**
- **Tilt angles for satellite and EME**
- **13cm Yagis** (PAEC-2 already contains 23cm)
- **Publish PAEC-3** and inform Ofcom.

- **Role of measurements?** (more practical at microwaves)
- **Help with rollout**
- **Help with feedback.**

Thank You



Thank You

A very short version…

Keep avoiding the Exclusion Zones we already know about.

Learn about actual boundaries of Exclusion Zones.

This is new – we all have more to learn.

Please give us your experience and feedback.

Questions, please?