



SAR Evaluation Considerations for Handsets with Multiple Transmitters & Antennas

**FCC / OET
Laboratory Division
February 2008**

TCB Workshop



Issues

- current TCB requirements:
 - non-dominant transmitters in handsets that transmit simultaneously cannot be approved by TCB when output is > 5 mW
 - these have to be submitted to the FCC for approval
- SAR procedures for simultaneous transmission have not been standardized among SAR systems
 - the high level recommendations in draft standards are insufficient and testing is very time consuming at multiple frequencies
 - procedures on how to determine 1-g SAR for simultaneous transmission are unclear
 - simultaneous SAR tests are often problematic and done incorrectly
- measurement issues in tight regions of the SAM phantom



Procedures Overview

- the procedures in KDB 648474 will allow:
 - manufacturers to minimize or avoid complex tests when satisfying certain SAR and antenna separation requirements while products are developed
- TCB can approve these when simultaneous SAR tests are not required
 - consumer cellphones with multiple transmitters & antennas
 - Part 22H, 24E, 27L (AWS) & 90 SMR
 - with 802.11 a/b/g and Bluetooth
- stand-alone SAR tests
 - routine evaluation applies to licensed transmitters
 - test reduction applies to unlicensed devices
- simultaneous transmission test exclusion applies when
 - the sum of stand-alone 1-g SAR is within SAR limit
 - SAR to antenna separation ratio of antenna pair is low
- when simultaneous transmission test is required
 - test only highest SAR configuration in stand-alone evaluation



Stand-alone Test Requirements

- **licensed transmitters:** IEEE-1528, Supplement C, 3G procedures
 - routine SAR required
- **unlicensed transmitters:** Supp. C, 802.11 & 3-6 GHz procedures
 - output $< 60/f_{(\text{GHz})}$ mW – SAR evaluation is generally not required (see flowchart)
 - output $\geq 60/f_{(\text{GHz})}$ mW – test according to multiples of P_{Ref}
 - SAR not required for certain antenna separation & power
 - test highest output channel only if SAR is ≤ 0.8 W/kg
 - test all required channels if SAR is > 0.8 W/kg (50% of limit)

	2.45	5.15 – 5.35	5.47 – 5.85	GHz
P_{Ref}	12	6	5	mW

Values for P_{Ref} are derived from $\frac{1}{2} \cdot 60/f_{(\text{GHz})}$
Device output power should be rounded to the nearest mW
to compare with values specified in this table.

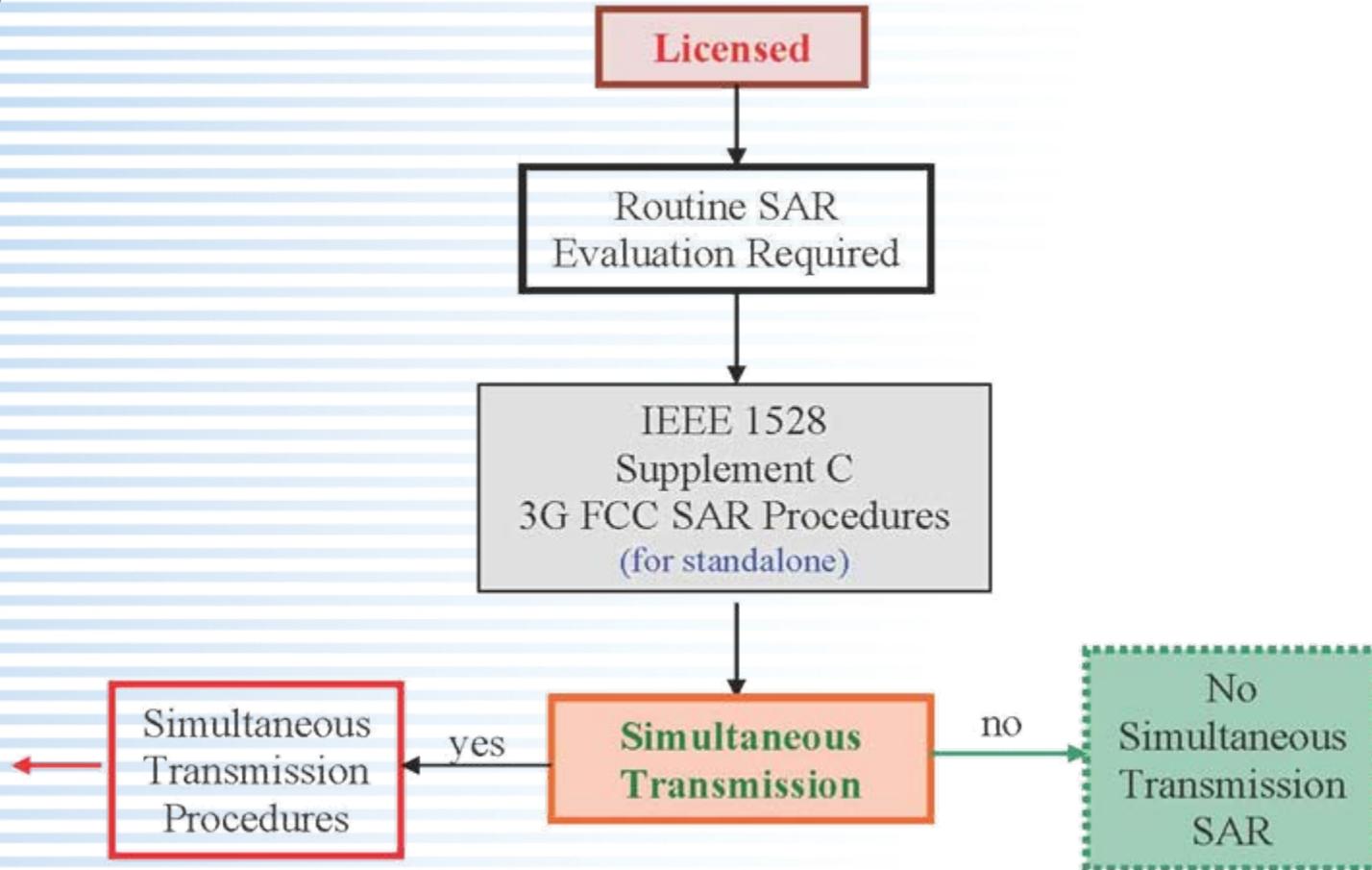


Simultaneous Transmission SAR - General

- **simultaneous transmission:** overlapping transmissions
 - except when maximum network handoff time is $< 30\text{s}$
- **unlicensed transmitters:** SAR is not required when
 - antenna is $> 5\text{ cm}$ from other antennas and stand-alone SAR is not required (i.e. $\leq 2 \cdot P_{\text{Ref}}$, see flow charts)
- **all transmitters in a cellphone:**
 - SAR is not required when
 - sum of 1-g SAR is $< 1.6\text{ W/kg}$ (SAR limit) or
 - SAR to antenna separation ratio for antenna pair is < 0.3
 - SAR is required when
 - SAR to antenna separation ratio for antenna pair is ≥ 0.3
 - test only highest SAR configuration in stand-alone mode
- simultaneous transmission SAR requirements for head and body can be different; especially for clam-shell phones

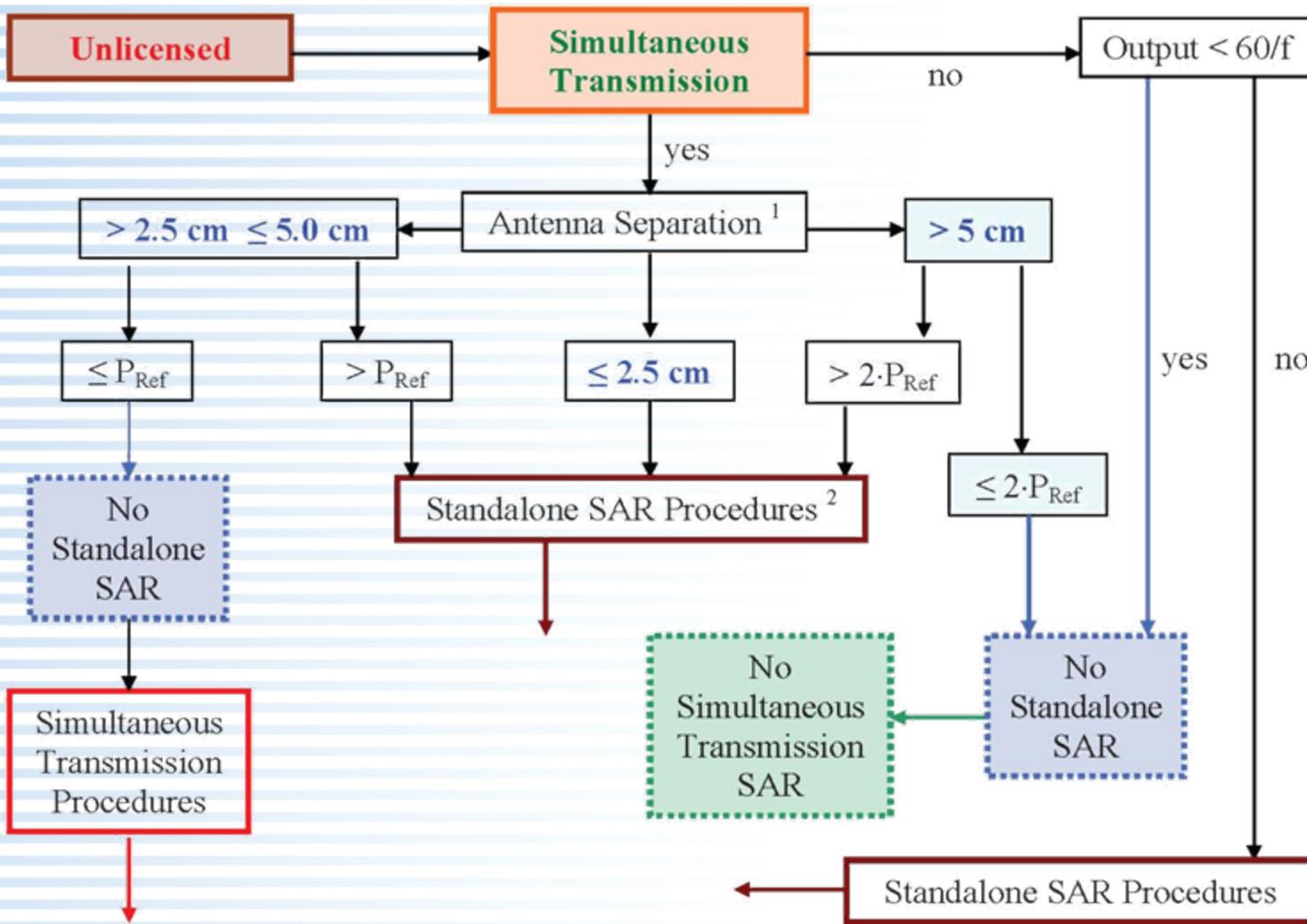


Licensed Transmitters





Unlicensed Transmitters

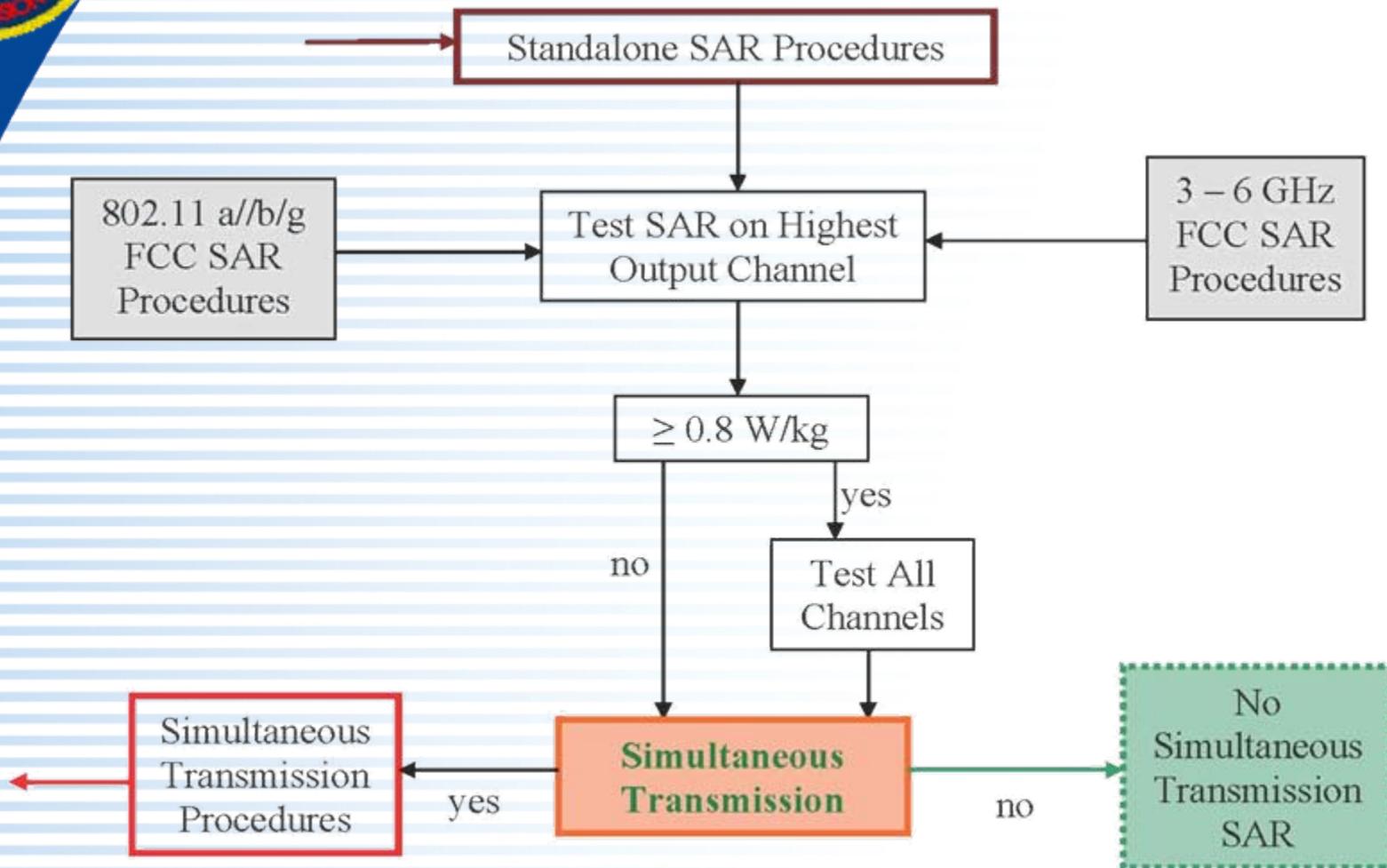


¹ Antenna separation is determined by the closest distance between antennas

² When simultaneous transmission applies, reduced antenna separations may require SAR at $< 60/f$

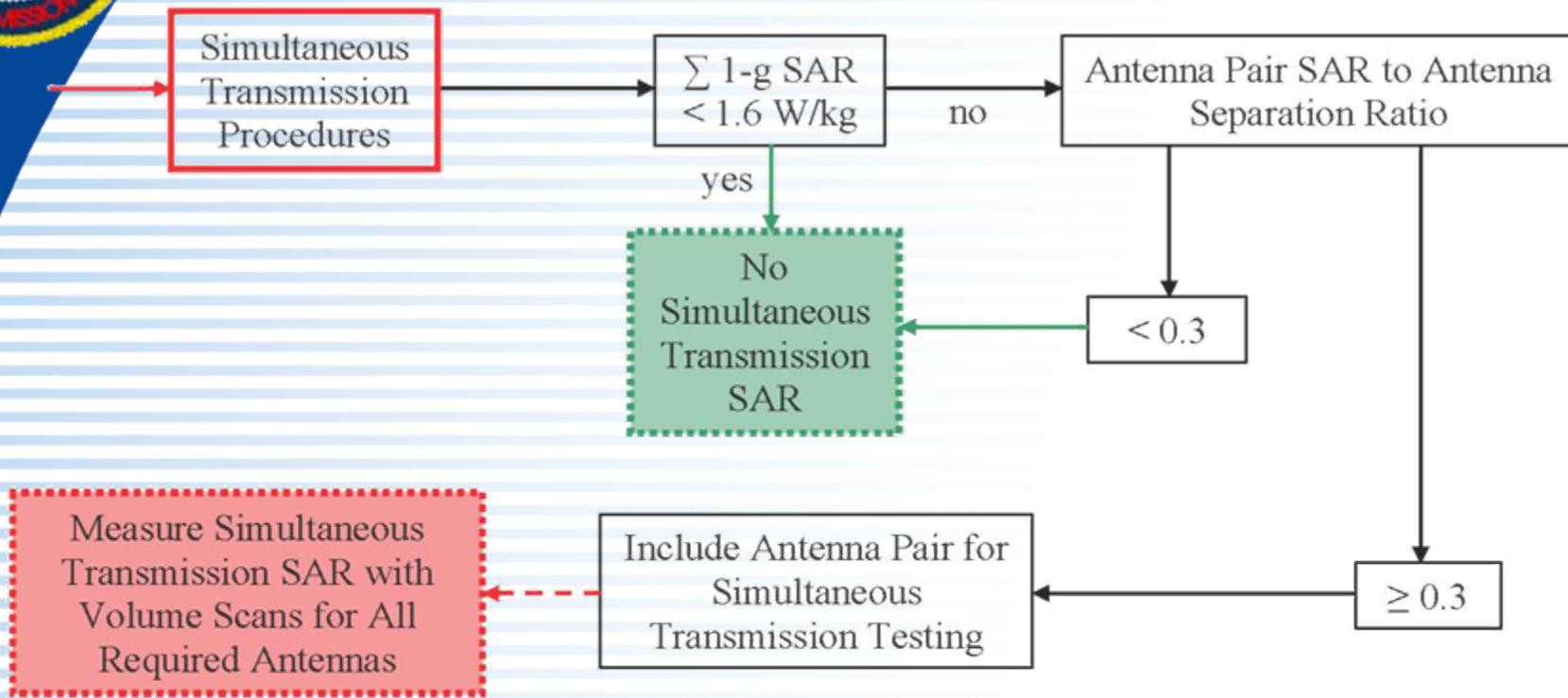


Unlicensed Stand-alone Procedures





Simultaneous Procedures



Note: Simultaneous transmission exposure conditions for head and body can be different for certain style phones; therefore, different test requirements may apply. For example, clam-shell phones in open and folded operating configurations.



Examples: rectangular phones

- upper center (patch antenna) - 250 mW PCS
 - routine stand-alone SAR
 - simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg or SAR to antenna ratio ≥ 0.3
- bottom edge – 50 mW 802.11 b/g, simultaneous with PCS only
 - > 5 cm (PCS only) and $> 2 \cdot P_{\text{Ref}}$ - test stand-alone SAR
 - on highest output channel and test all channels if SAR ≥ 0.8 W/kg
 - simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg or SAR to antenna ratio ≥ 0.3
- lower left edge – 5 mW Bluetooth, simultaneous with PCS only
 - > 5 cm (PCS only) and $\leq 2 \cdot P_{\text{Ref}}$
 - no stand-alone SAR and no simultaneous SAR

	2.45	5.15 – 5.35	5.47 – 5.85	GHz
P_{Ref}	12	6	5	mW



Examples: clam-shell phones

- right hinge (stub antenna) – 300 mW PCS
 - routine stand-alone SAR
 - simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg or SAR to antenna ratio ≥ 0.3
- bottom edge – 20 mW 802.11 a/b/g
 - > 5 cm (PCS & Bluetooth)
 - 802.11 b/g $\leq 2 \cdot P_{\text{Ref}}$ – no stand-alone SAR and no simultaneous SAR
 - 802.11 a $> 2 \cdot P_{\text{Ref}}$ – test stand-alone SAR
 - on highest output channel and test all channels if SAR ≥ 0.8 W/kg
 - simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg or SAR to antenna ratio ≥ 0.3
- top edge – 25 mW Bluetooth
 - > 5 cm (PCS & 802.11 a/b/g) and $> 2 \cdot P_{\text{Ref}}$ – test stand-alone SAR
 - on highest output channel and test all channels if SAR ≥ 0.8 W/kg
 - simultaneous SAR if $\sum 1-g \geq 1.6$ W/kg or SAR to antenna ratio ≥ 0.3
- when body-worn exposure conditions apply
 - simultaneous transmission exposure conditions for head and body are different for 802.11 and Bluetooth



Simultaneous Measurements

- simultaneous transmission at different frequencies
 - require different tissue liquids and probe calibrations
 - separate measurements are necessary
- require measured raw data to be summed
 - on identically registered measurement grids
 - with all simultaneous transmitting antennas enclosed in identical measurement volumes for each measurement
 - to enable the extrapolation and interpolation procedures to determine the aggregate 1-g SAR in post-processing
- volume scans are quite time-consuming
 - difficulties and constrains should be expected



SAR in Mouth Region of SAM

- measurement difficulties in tight regions of SAM
 - mouth, jaw, nose and similar partially enclosed regions
 - measurement accuracy & probe accessibility issues
 - SAM configuration issues – horizontal vs. up-right
- measure SAR with flat phantom
 - when measurement is not feasible with SAM or results can be questionable due to probe calibration and orientation issues
 - position phone with lower edge at a fixed distance determined by smallest separation in cheek touching position using SAM
 - rectangular phones with ERP at $\frac{1}{2}$ cm from flat phantom
 - clam-shell phones with hinge against smooth edge of flat phantom and upper half unfolded beyond side wall
- contact FCC for interim guidance on
 - other clam-shell phone positioning issues (variable gap with SAM)
 - simultaneous transmission SAR measurement requirements