Fletcher, Heald & Hildreth

The Law of Communications

Squeezing New Technologies into the Spectrum

National Spectrum Management Association

Mitchell Lazarus

703-812-0440 | lazarus@fhhlaw.com

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Need for Spectrum Sharing

- Growing recognition that spectrum sharing is necessary

- New spectrum-sharing schemes in the works
  - PCAST process, FCC initiatives, others.

Techniques for Spectrum Sharing

- Some present approaches–
  - geographical – low power applications
    - *e.g.*, Wi-Fi, Bluetooth spectrum very densely shared
  - antenna pointing (FS/FSS;14-14.5 GHz air-ground NPRM)
  - hierarchical – low-priority yields to higher priority
    - *e.g.*, FCC rulemakings for 3.6 GHz, 5 GHz U-NII
  - interstitial: white space; guard bands; fitting communications around radar signals
  - exclusive spectrum to carriers for sharing by users
  - receiver standards (allows closer packing in frequency domain).

Problems for New Radio Technologies

- Entrepreneurs continually develop new radio-based systems
  - by definition, do not comply with pre-existing standards
- **No room in above sharing plans for novel technologies**
- All useful spectrum (for most applications) is occupied
  - wholly vacant spectrum is rare and expensive
  - last auction (700 MHz): avg. $370 million per MHz (!)
- Most new technologies must share existing spectrum
  - entrepreneurs must account for spectrum realities
- Spectrum incumbents are not friendly about accommodating newcomers
  - opposition is almost inevitable.

Tasks for Newcomers

1. Prevent interference to incumbent receivers (which may have overbroad passbands)
   - *e.g.*, LightSquared signal, although removed from GPS frequencies, threatened interference to GPS receivers
   - newcomer must take the spectrum as is
2. Accept interference from incumbent transmitters
3. Satisfy conservative regulators at FCC, NTIA.

Incumbent Opposition

- Incumbents often oppose regardless of actual interference risk
  - few evaluate solely on technical grounds
    - *e.g.*, Radio Astronomy Service, point-to-point Fixed Service
- Typical arguments –
  - interference predictions based on highly implausible scenarios:
    - "Jurassic assumption" (zero noise floor)
    - unlikely geometries of transmitter and receiver
  - concern that interfering with newcomer will harm incumbent
    - esp. if newcomer provides health or safety services
- Possible reasons for exaggerated opposition:
  - may hope to extract payment (esp. auction licensees)
  - "adolescent love of hierarchy."

Regulatory Concerns

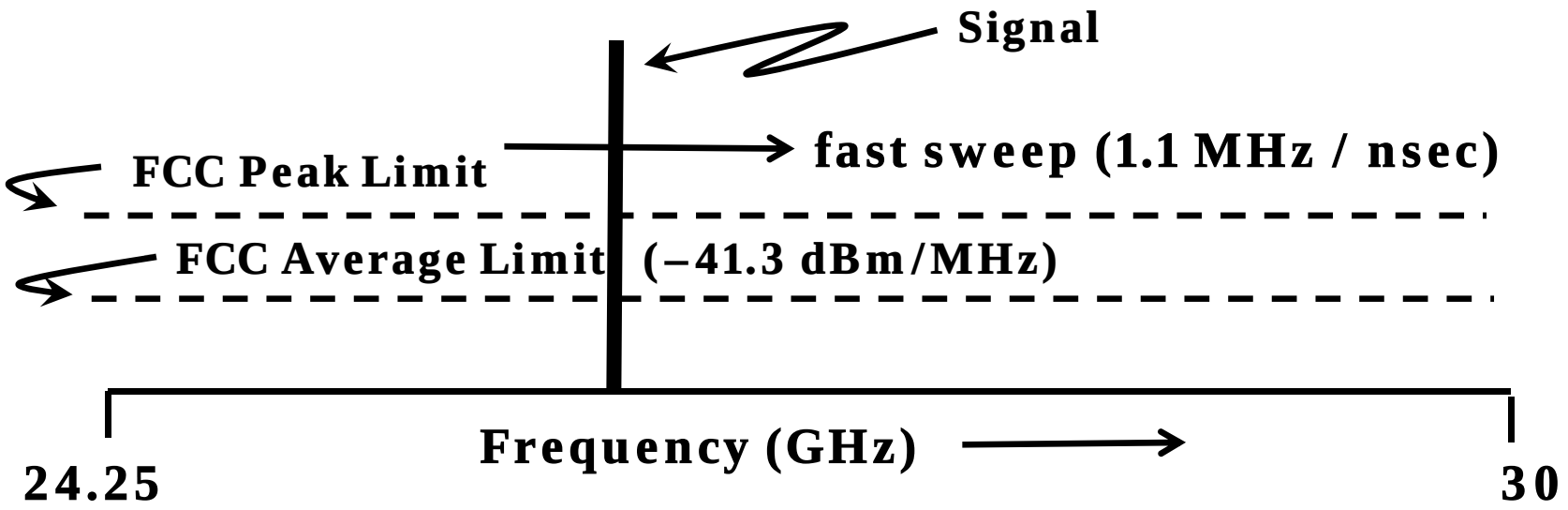
- Regulators seek to:
  - protect existing health, public safety, defense, homeland security, aero, GPS, search &rescue, time signals, radio astronomy, etc.
  - protect existing licensed commercial services
  - respond to political pressures
  - foster innovation / new technologies
  - avoid setting overly broad precedents
  - avoid foreclosing future actions
- Advantages of innovating in unlicensed spectrum:
  - more tolerant regulatory environment
  - no spectrum cost; no delay for auction; flexible technical rules
  - but unlicensed incumbents may oppose.

Case Study 1: Airport Body Scanner

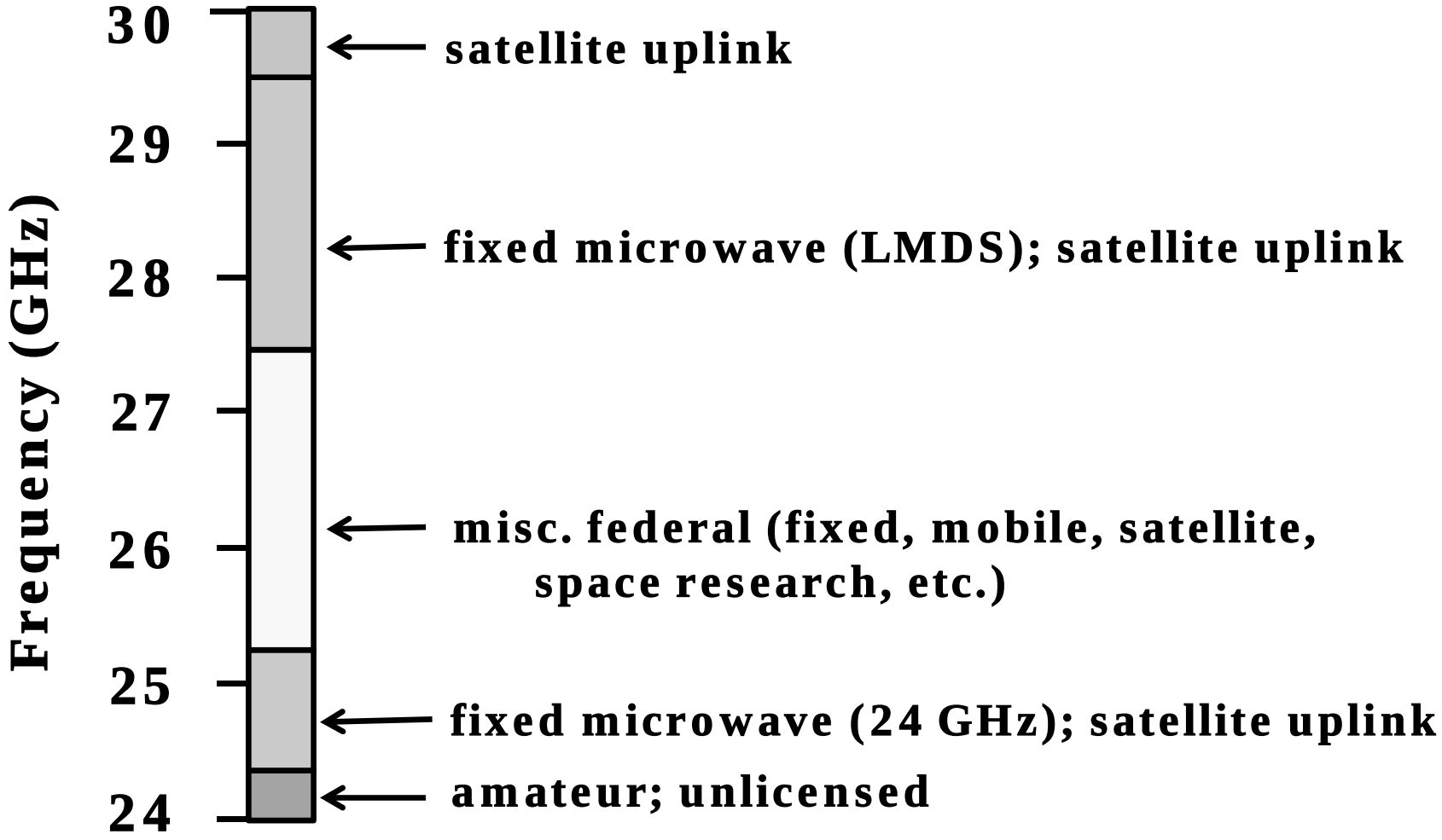
- Developed by SafeView, Inc., now L-3 Security & Detection Systems
- Operates under FCC unlicensed rules
- Uses fast sweep from 24.25–30 GHz
  - sweeps at 1.1 MHz / nsec
  - sweep repeats twice for each of 192 antennas on vertical mast
  - 2 x 192 sweep sequence repeats for each of 210 rotating mast positions
  - complete scan takes < 2 sec., entails 80,640 sweeps
  - device processes multiple reflections into image.

FCC Waiver Required

- Two elements of waiver:
  1. measure average emissions with sweep running
  2. allow peak/average ratio of 41 dB (up from 20 dB)
- Manufacturer not flexible as to spectrum.



Spectrum Incumbents (greatly simplified)



Opposition to Waiver

- Applicant avoided the 24-24.25 GHz amateur band
- Federal spectrum users did not oppose
- Opposition came only from fixed microwave licensees at 24.25-25.25, 27.5-29.5 GHz:
  - presented highly improbable predictions of interference into microwave receivers
  - expressed concerns about causing interference to scanner
- Applicant argued:
  - average emissions (with sweep running) meet limit for consumer digital devices (75 nanowatts / MHz)
  - sweep goes by too fast to register in microwave receiver
  - indoor-only scanners will not affect outdoor microwave systems.

Outcomes

- FCC granted waiver
  - filed August 18, 2004; granted August 4, 2006 (23 months)
- Original grant had time limits and numerical limits on sales
- Subsequent changes:
  - Sept. 2009: extended waiver time duration
  - (Dec. 2009: Detroit “underwear bomber”)
  - Jan. 2010: denied reconsideration of waiver
  - Feb. 2010: increased numerical limits
  - July 2011: removed time and numerical limits.

Case Study 2: Surveillance Robot

- Manufactured by ReconRobotics , Inc.
- Robot relays video and audio over three 6 MHz channels
  - can also be fitted with infrared, temperature sensors, radiation detectors, etc.
  - control unit transmits on 75 MHz R/C frequencies
- Radio technology not new, but needed to support innovative robotics.

About the Device

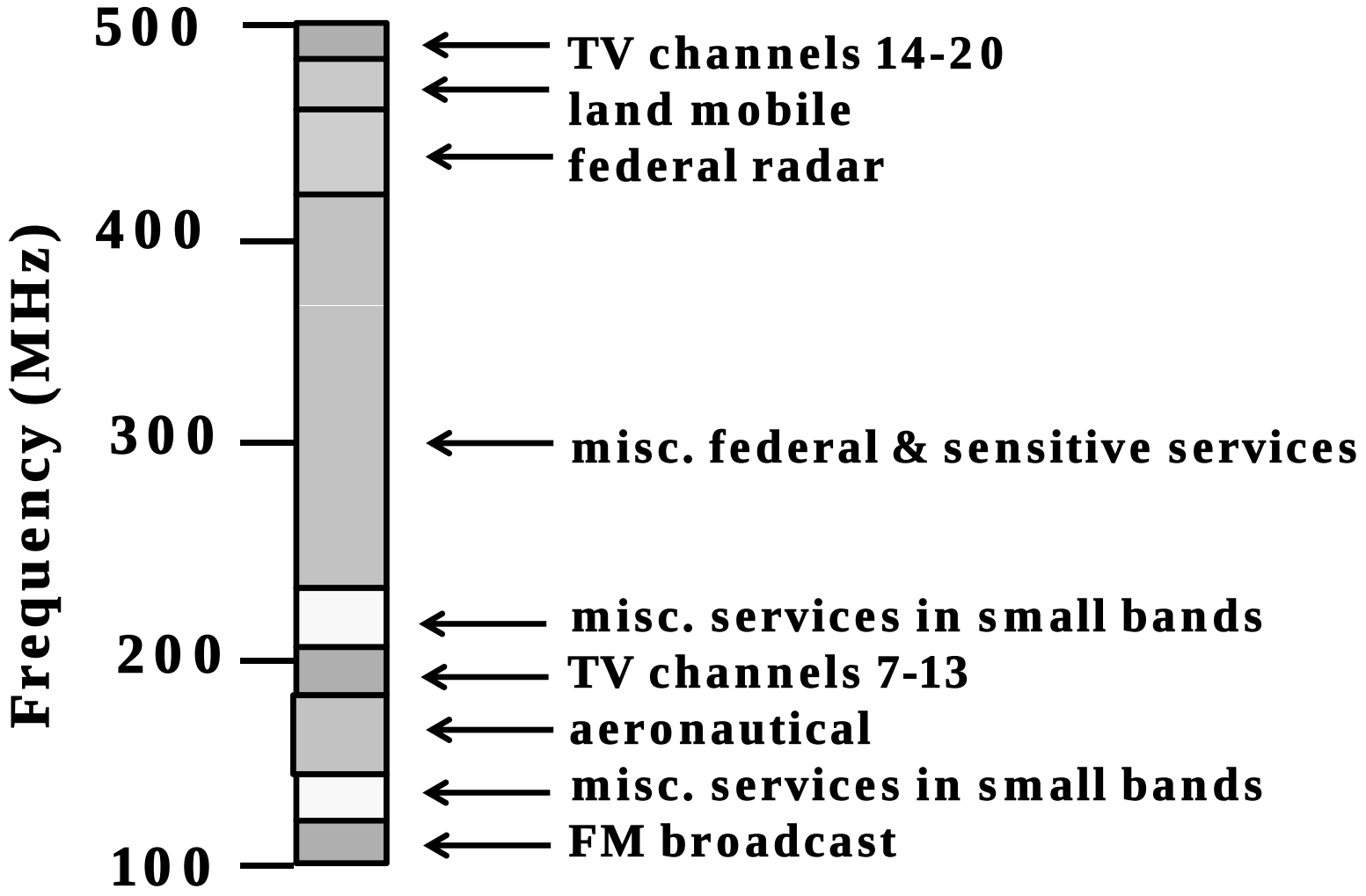
- Dimensions:
  - 7 inches long by 3 inches high
  - weight 1.2 pounds
- Easily thrown into third-story window
- Takes repeated 30 ft. drops onto concrete
- Battery life 1 hour
- Typical civilian applications:
  - locating hostages, hostiles, bystanders before rescue attempt
  - searching for survivors in burning building
  - checking building prior to forced entry
  - inspecting site of chemical or nuclear release.

Technical Constraints

- Analog video (to avoid out-of-range cutoff)
  - requires 6 MHz channels
  - three channels for multiple units at a site
- Above about 100 MHz
  - for manageable antenna length
- Below about 500 MHz
  - for adequate wall penetration
- Power 0.25 W average, 1 W peak

- No suitable existing allocation over 100-500 MHz
  - waiver required for FCC certification and licensing.

Allocations 100-500 MHz (greatly simplified)



Allocations (420-450 MHz)

Federal	Non-Federal
RADIOLOCATION (primary)	Amateur (secondary)

- Footnotes:
  - federal radar restricted to military
  - various sub-bands specified for wind profilers, land mobile, amateur satellite, space operation services, space research services, space telecommand, Earth exploration-satellite, certain non-federal radiolocation, low power federal radio control.

Waiver Process

- Company applied to use 430-436, 436-442, 442-448 MHz
  - offered to accept all interference (including amateur)
- NTIA signed off
- Amateurs (with secondary allocation) opposed
  - cited concerns of interference to amateur receivers
    - one filing: device will "preclude reception" at 401 km, and on the International Space Station (330 km min. altitude)
  - argued against propriety of waiver process, accuracy of occupied bandwidth
  - feared reprisals if amateurs interfere with device in emergency
- Amateurs challenged waiver, certification, end users' license applications.

Outcomes

Jan. 11, 2008	waiver request filed
Feb. 23, 2010	waiver granted (25 months)
April 22, 2010	equipment certification granted
Aug.-Sept. 2010	end-user license applications filed
Apr. 15, 2011	reconsideration of waiver denied
Feb. 6, 2012	first end-user licenses granted (18 months after applications)
Nov. 23, 2012	subsequent end-user licenses granted (26 months after applications)

Conclusion

- New spectrum technologies are unlikely to comply with any given sharing paradigm
- Typically must fit around incumbents
  - opposition is likely (even if not well founded)
  - working around existing users is increasingly difficult
  - newcomer must pick bands carefully, pay close attention to properties of incumbent operations
- Outcome typically depends on both technical and political considerations

- Plans for sharing should allow for unanticipated new technologies.

Thank you!

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