Agile Space Radio (ASR)

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AFSPC/CC Direction

DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE SPACE COMMAND

DEC 2 3 2008

MEMORANDUM FOR 14 AF/CC SMC/CC HQ AFSPC DIRECTORS

FROM: AFSPC/CC
150 Vandenberg Street, Suite 1105
Colorado Springs CO 80914-4020

SUBJECT: Commander's Intent for Air Force Satellite Operations (SATOPS) Enterprise Architecture Transformation

2. The focus of the effort is to develop more efficient SATOPS architectures and identify requirement commonalities, enabling consolidation of functions and capabilities, reducing duplication and improving interoperability at all levels, to include the 614th Air and Space Operations Center. Any future AFSPC SATOPS enterprise architectures must not only address an open architecture, but also legacy system requirements and infrastructures ensuring we provide improved space situational awareness, defensive space control and operationally responsive space capabilities, enabling AFSPC to meet National Security Space objectives and Joint warfighter operational needs.

4. I've asked Brig Gen Hyten to provide me a progress report on this effort within 90 days. My lead for this effort is Col André Shappell, Command Lead for Launch, Ranges and Networks, HQ AFSPC/A3R, DSN 692-9879, andre.shappell@peterson.af.mil.

C. ROBERT KEHLER
General, USAF
Commander

cc:
ORS Office
AFRL/CC
ESC/CC
SIDC/CC

GUARDIANS OF THE HIGH FRONTIER

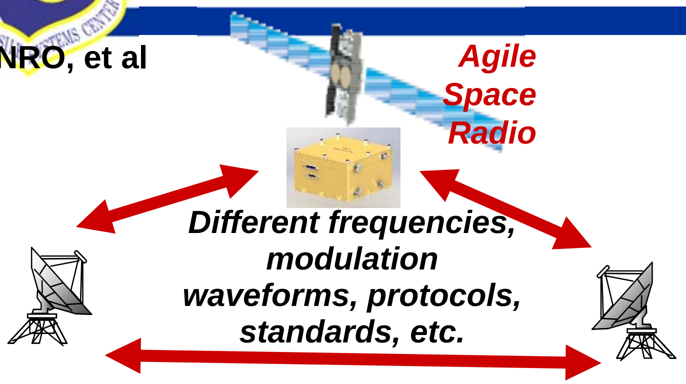
The Need

- Long lead times of satellite acquisitions require early definition of communication interfaces
- Spectrum allocations are changing due to national and international pressures
- Space-to-ground interface standards are evolving
- Different satellites use different freq, modulation, protocols, formats, etc. to communicate with other space and ground systems
- Requirement for backward and forward compatibility prevents standardization of interfaces

Inability to achieve interoperability/netcentricity as mandated by policy

Agile Space Radio (ASR)

DoD, NRO, et al



Enables seamless & interoperable communications

Technology and CONOPS Goals and Resulting Payoff

- Agile multiband radios/transceivers that can automatically find and use the most efficient frequencies, modulation waveforms, protocols, etc. for satellite communications
- Achieves interoperability; enables dynamic synchronization of interfaces
- Reduces program cost and schedule
- Addresses hostile jamming and environmental interference
- Increases spectrum resiliency and efficiency

Program Requirements and Sponsorship:

- Addresses CJCSI 6212.01E, "Interoperability and Supportability" and OSD/AF Directives in dual band spectrum use for satellite operations
- Sponsorship: Space PEO, SMC/CC, AFRL, OSD, NRO
  - Included in SMC Technology Roadmap and NRO Roadmap
- Provides a robust and resilient architecture to meet natural and man-made threats
  - Reduces acquisition risks and costs
  - Enables SATOPS Transformation as per AFSPC/CC directive in addressing capability gaps

Program Status and Requested Funding:

Funding Needs:
- SBIR Phase IIE: $400K
- Program ??

- ASR Project Status
- Phase II Contractor (Space Micro) has demonstrated autonomous characterization of USB/SGLS waveforms
- Phase II RF Hardware Demonstrated
- Flight Like Digital Module Design Complete
- Fabrication and Testing of Digital Module – March 2014
- Additional System Level Testing Required with Ground Station Simulators

Current Spectrum Issues Addressed by Agile Space Radio

- **Pre-/Post-launch (small) frequency allocation change and format/protocol change**
  - **Launch vehicle frequencies may conflict with payload frequencies (Pre-launch)**
  - **SMC may be forced to move command uplinks from L-band to S-band**
  - **S-band could utilize either SGLS format, USB formats, or Spectrum Efficient Waveform formats**
  - **May be accomplished by existing software defined radios, but not in real time**

- **Post-launch (large) frequency allocation change such as L- to C- to Ku-band**
  - **Assumes a multi-band cognitive radio such as ASR could be pre-certified**
    - **Quick concept-to-launch missions could be enabled**
  - **Antenna and ASR Radio Frequency front end would need to be examined for wideband capability**
  - **May be accomplished by existing software defined radios, but not in real time**

Future Spectrum Issues Addressed by Agile Space Radio

- **Opportunistic spectrum usage – operating in white spaces**
  - **ASR would dynamically identify unused spectrum and use it**
  - **Awaits future spectrum regulation that mandates or encourages this type of spectrum usage**
  - **Some relatively simple cognitive features would have to be added to ASR**
  - **Reliability of this type of operations would have to be field tested (problem is correctly identifying unused spectrum)**
  - **Cannot be accomplished using existing software defined radio**

- **Using transceiver position and location database to share spectrum**
  - **Awaits future spectrum regulation that mandates or encourages this type of spectrum usage**
    - **Appropriate database must be created**
  - **Some relatively simple cognitive features would have to be added to ASR**
  - **Reliability of this type of operations would have to be field tested (problem is correctly identifying unused spectrum)**
  - **Cannot be accomplished using existing software defined radio**

SATOPS Interoperability and Interfacing Issues Addressed by Agile Space Radio

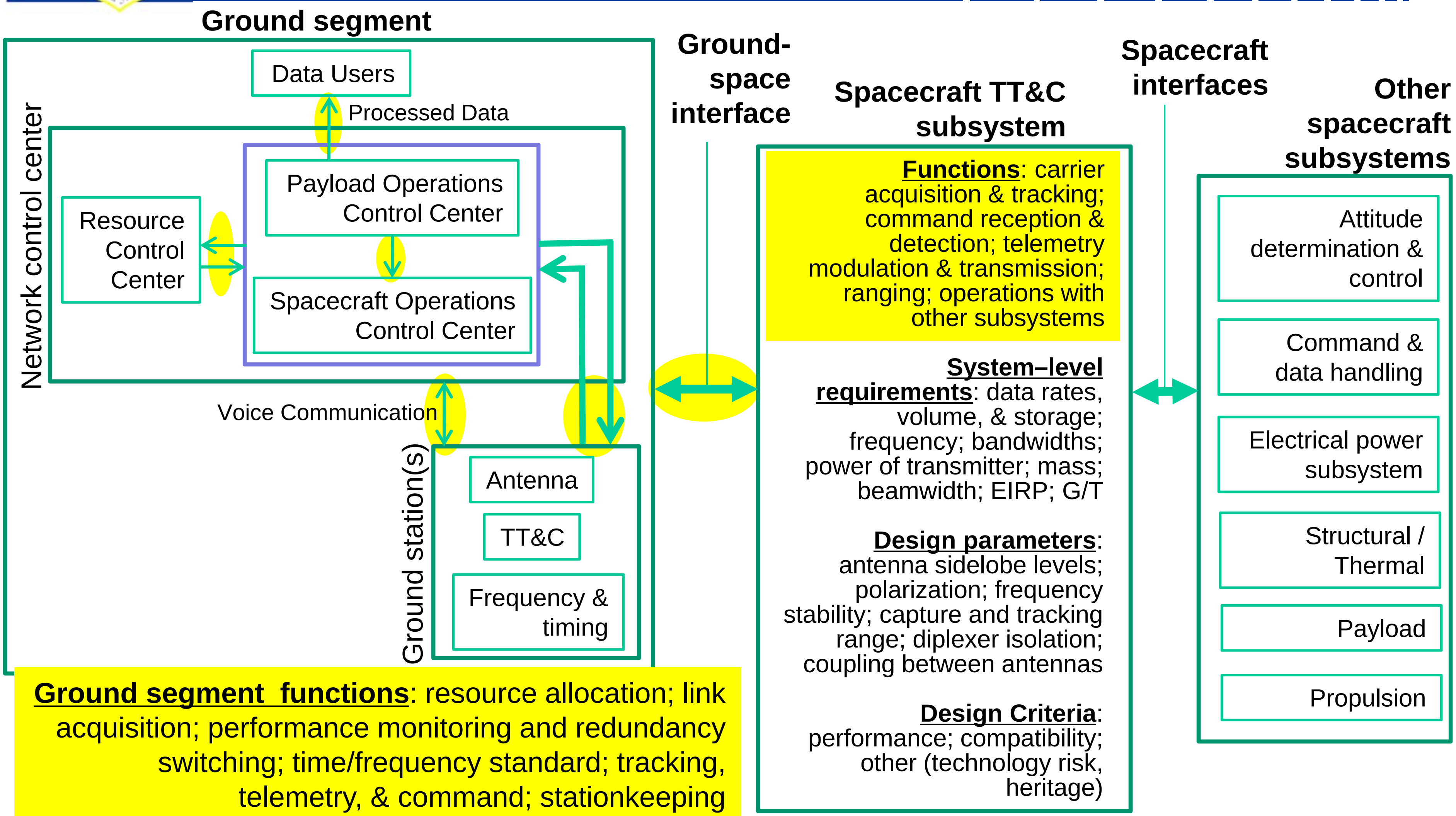
- **SATOPS interoperability**
  - NASA and NOAA earth stations could give additional coverage (planned or unplanned) to DoD missions
  - Coordination (technical and operational) with NASA and NOAA is required
  - Possible, but difficult, to accomplish using existing software defined radios
    - Difficult because of lack of a single NASA or NOAA Tracking, Telemetry & Command uplink standard

- **Automatic compatibility with other SATOPS component HW/SW/protocols**
  - Use cases, i.e. to what components ASR would interface needs to be defined
  - Cannot be accomplished using existing software defined radio

TT&C System Is Difficult to Maintain, Upgrade, and Modify

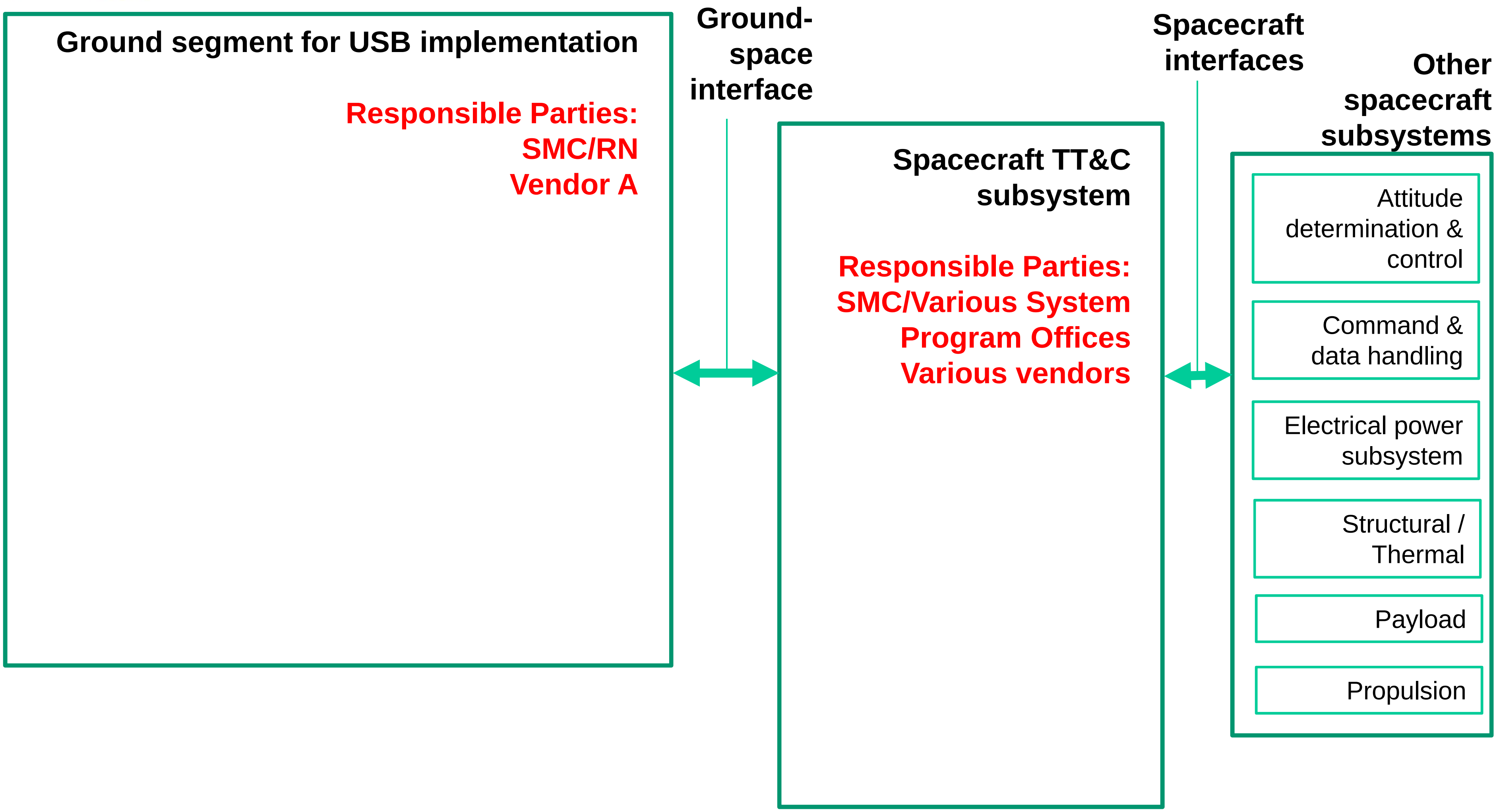
- Development of TT&C system is dominated by the most difficult subsystem to maintain and develop: Ground Segment
- Ground Segment is not rebid for every new mission as the spacecraft segment is
  - This leads to difficulty in maintaining multiple vendors who can maintain and upgrade or modify the ground segment
  - Less competition tends to lead to increased difficulty in performing maintenance, upgrades and modifications

Tracking, Telemetry & Command (TT&C) System Is Complex



Multiple functions and interfaces must be specified for TT&C to work correctly. Yellow highlighted areas must be specified.

Responsible Parties for Ground Segment and Spacecraft Differ



Compatibility of Agile Space Radio Can Facilitate TT&C System Implementation

- Several interfaces and subsystems must interface correctly to implement TT&C
- Certain subsystems are more competitively developed than others (more quickly available, at a more competitive cost)
- Goal is to use more of these competitively developed subsystems
  - Requires competitively developed subsystems to interface correctly
  - Agile Space Radio is a major subsystem that is intended to integrate automatically with the other TT&C subsystems to which it is connected
  - Agile Space Radio is intended to work with all combinations

Draft Enabling Concept for SATOPS Enterprise

SATOPS Capability Characteristics/Attributes

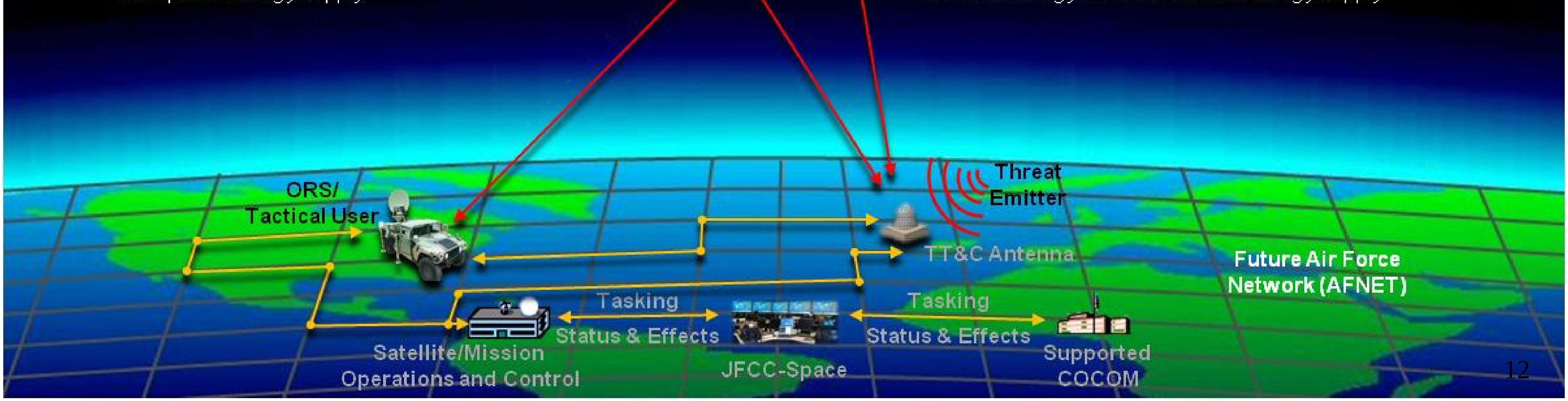
Transformation to On-Demand, Protected, Agile SATOPS

Current

- **Agility (adaptability, flexibility, test fidelity)** - *Current*
  - Site-specific/-dependent reconstitution; slow response
  - Mission unique implementation
  - Lack of pre-launch test realism – much emulation
- **Responsiveness (coverage, timeliness)** - *Current*
  - Coverage gaps
  - Task-based, stove-piped architecture
  - Limited ability to fuse data/share information for SSA, C2
  - Unable to rapidly integrate new users – proprietary I/F
  - Resource intensive monitor and control/scheduling
- **Protection (capacity, spectrum resiliency)** - *Current*
  - Priority-dependent resource allocation; limited surge
  - Static, openly-documented ground-to-space link
  - Antiquated energy supply

Future

- **Agility** - *Future*
  - Geographic flexibility
  - Broader consolidation and re-use (enterprise management)
  - Replication of ops assets for pre-launch testing
- **Responsiveness** - *Future*
  - 24/7/365 all-orbit coverage
  - Net-centric/services-based operations
  - Enterprise business processes and management tools
  - Commodity IP-based edge devices
  - Machine-to-machine I/F; user-defined operating picture
- **Protection** - *Future*
  - Priority-independent resource allocation; surge margin
  - Adaptive/compatible links; operations in and through RFI
  - Reduced energy demand/secured energy supply

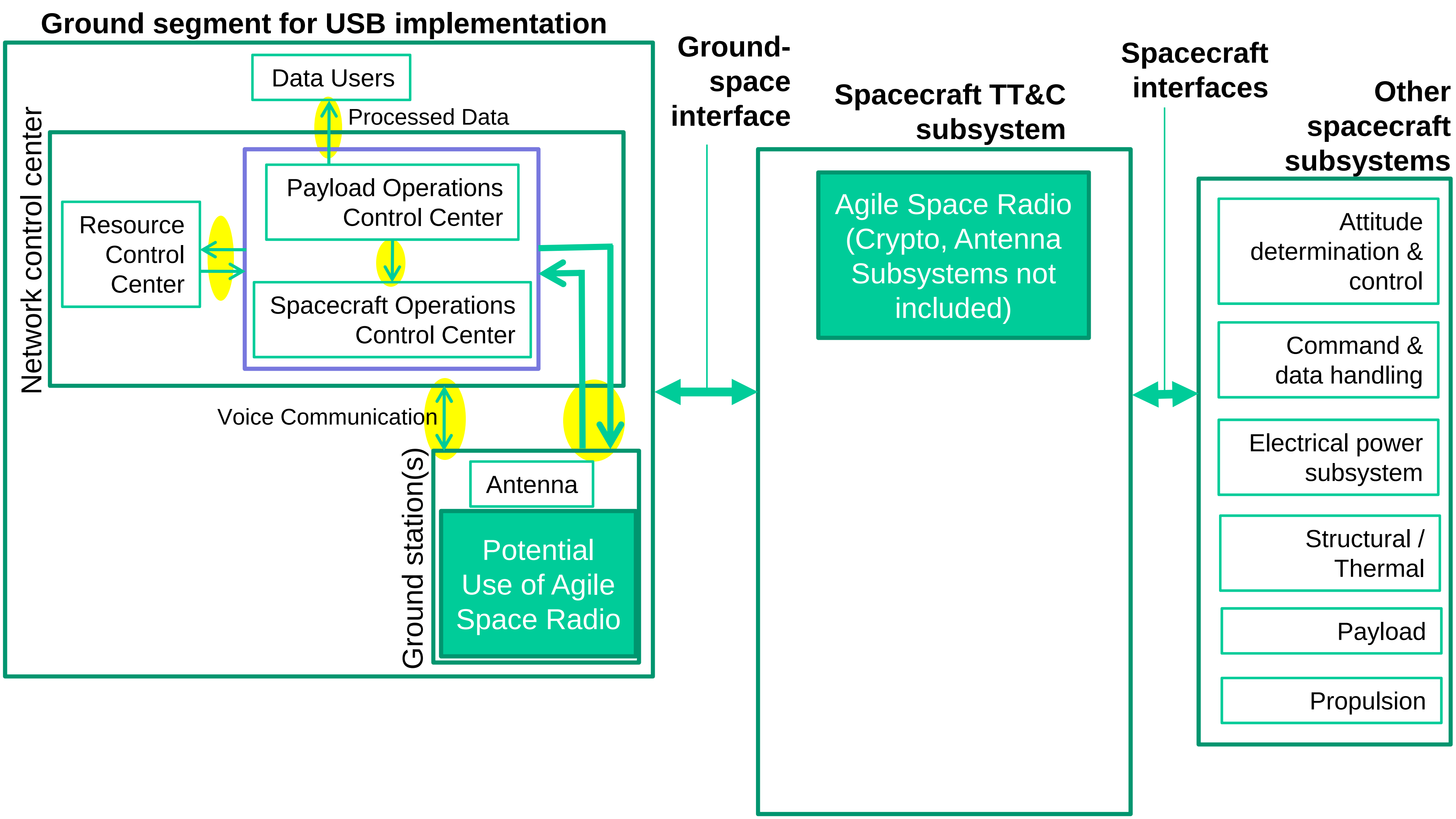


Summary/Conclusion

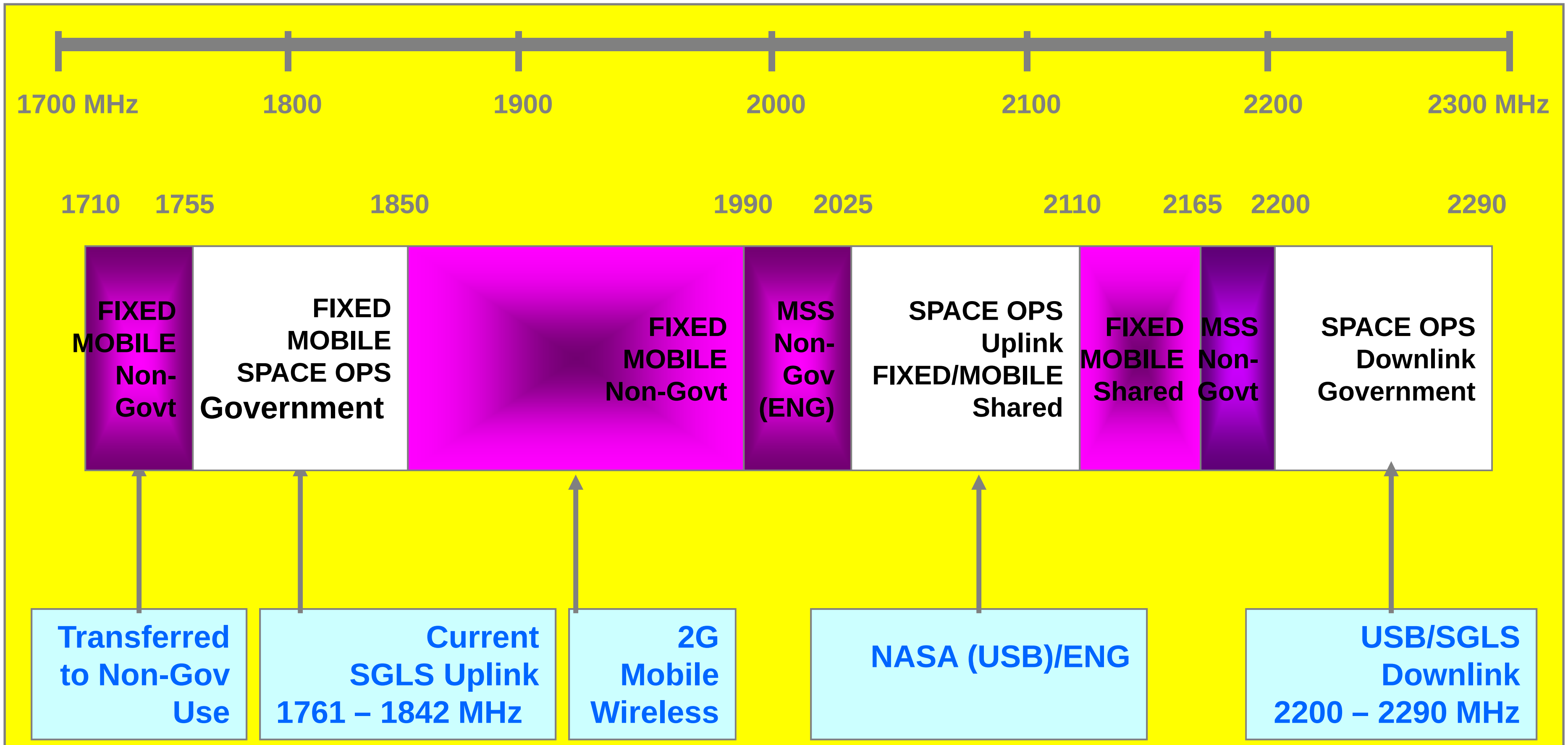
- Must address the inability to achieve interoperability/netcentricity as mandated by policy
- Current TT&C System Is Difficult to Maintain, Upgrade, and Modify
- Obsolescent infrastructure technology is costly
- ASR addresses these issues and allows for technology injection and innovation

BACKUP

Agile Space Radio Is a Major Component of the Spacecraft TT&C Subsystem



Sharing of SATOPS Spectrum



Sharing of USB with civil & commercial users will have operational impacts