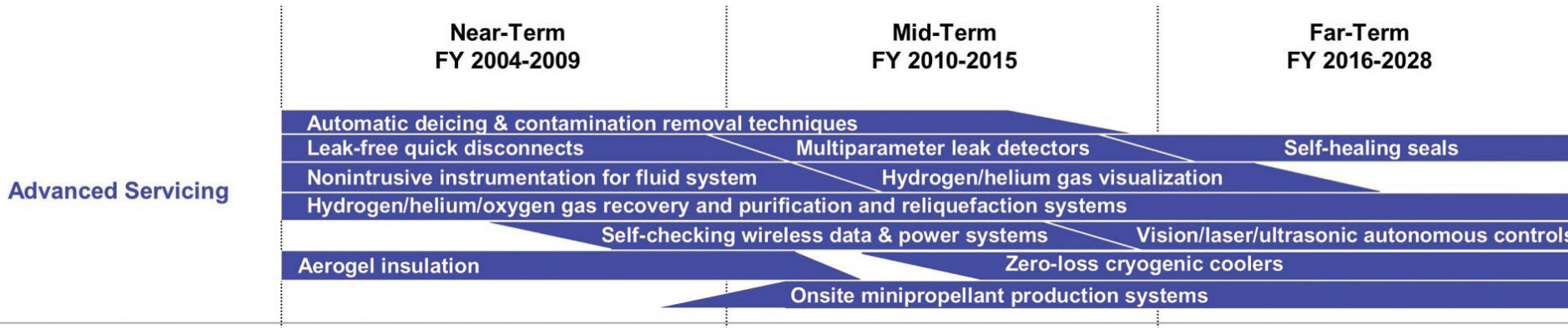
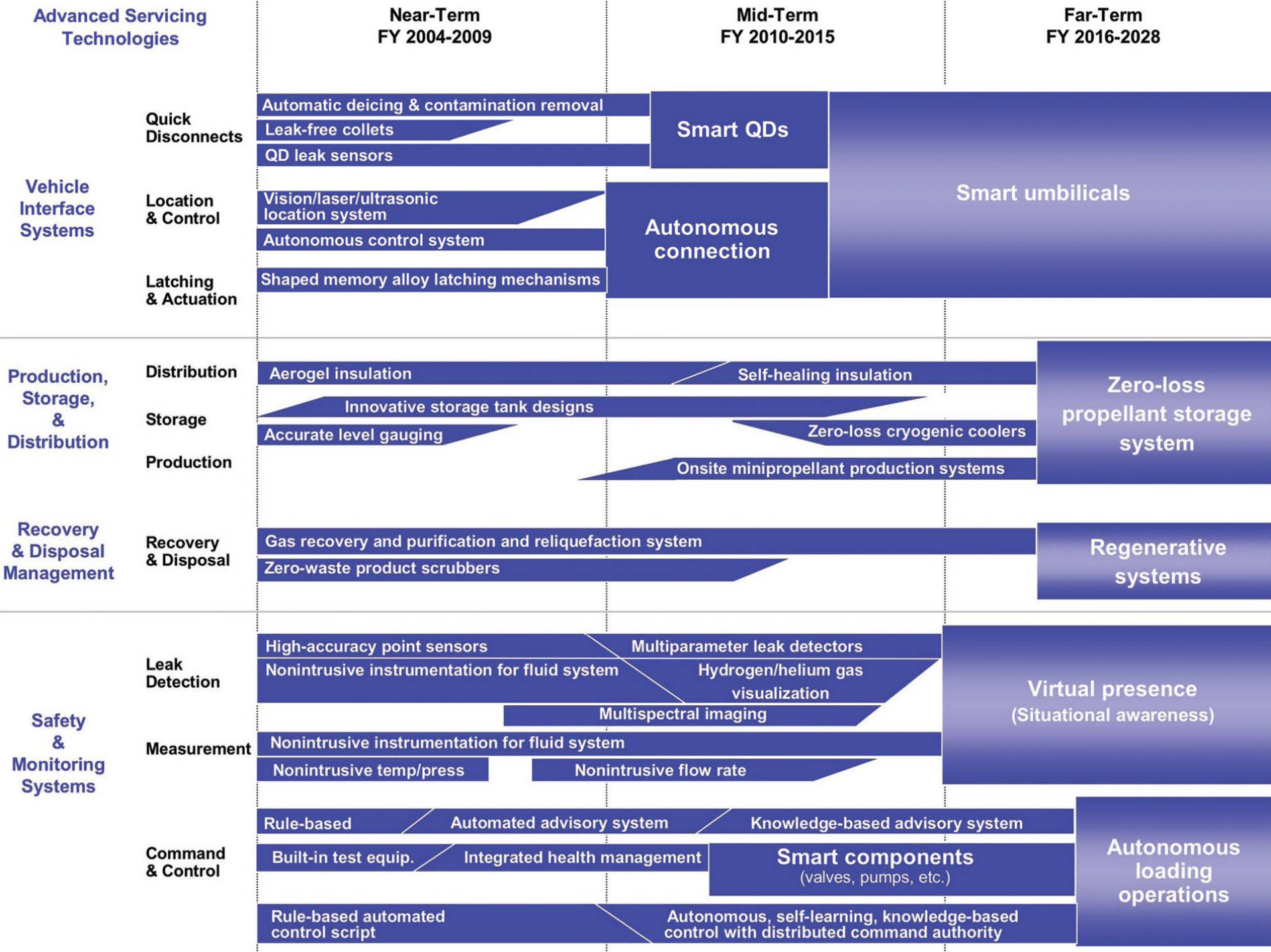

Near-Term
FY 2004-2009
Mid-Term
FY 2010-2015
Far-Term
FY 2016-2028
Advanced Servicing
Automatic deicing & contamination removal techniques
Leak-free quick disconnects
Multiparameter leak detectors
Self-healing seals
Nonintrusive instrumentation for fluid system
Hydrogen/helium gas visualization
Hydrogen/helium/oxygen gas recovery and purification and reliquefaction systems
Self-checking wireless data & power systems
Vision/laser/ultrasonic autonomous controls
Aerogel insulation
Zero-loss cryogenic coolers
Onsite minipropellant production systems

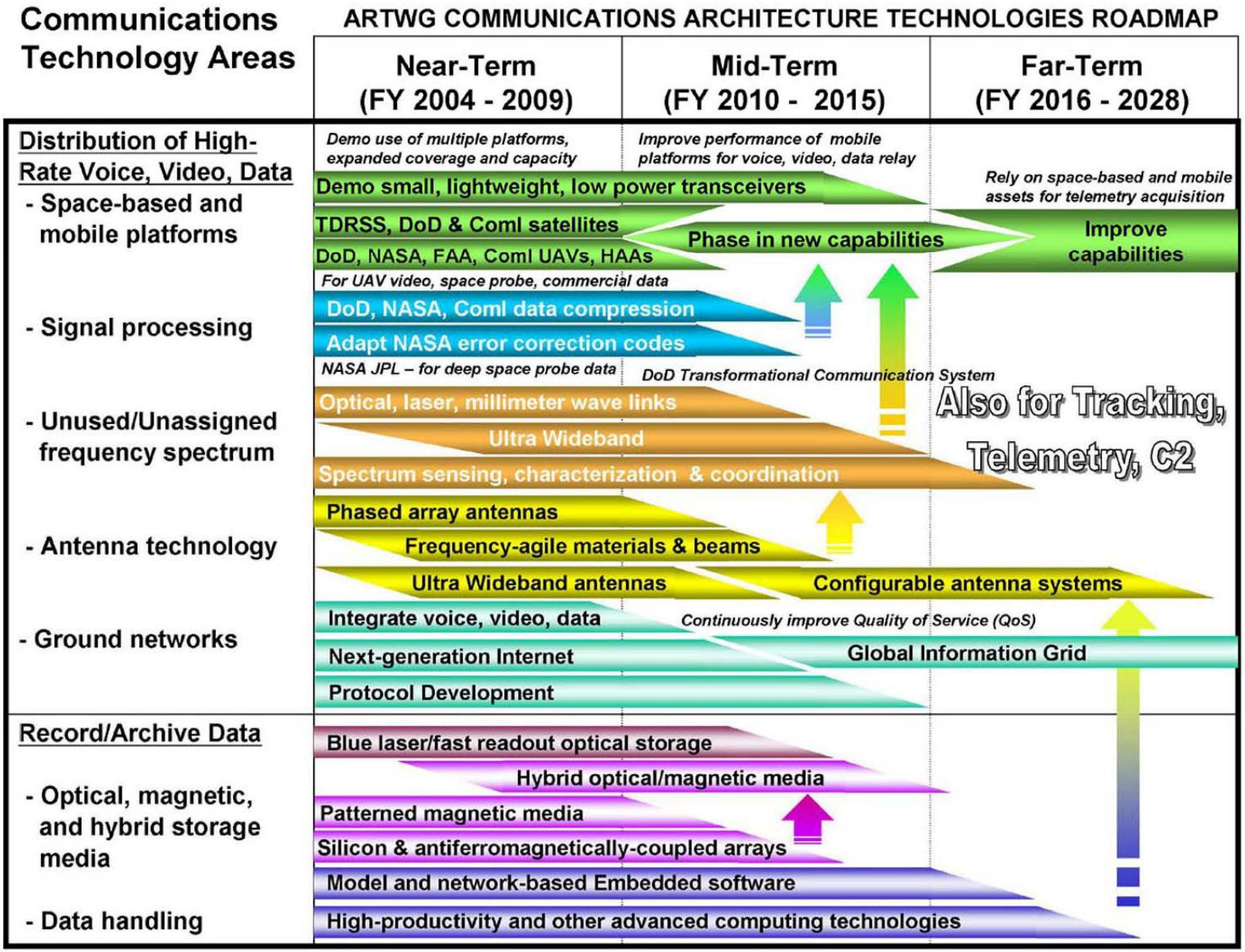

Advanced Servicing Technologies
Near-Term FY 2004-2009
Mid-Term FY 2010-2015
Far-Term FY 2016-2028
Vehicle Interface Systems
Quick Disconnects
Automatic deicing & contamination removal
Leak-free collets
QD leak sensors
Smart QDs
Smart umbilicals
Location & Control
Vision/laser/ultrasonic location system
Autonomous control system
Autonomous connection
Latching & Actuation
Shaped memory alloy latching mechanisms
Production, Storage, & Distribution
Distribution
Aerogel insulation
Self-healing insulation
Storage
Innovative storage tank designs
Accurate level gauging
Zero-loss cryogenic coolers
Production
Onsite minipropellant production systems
Zero-loss propellant storage system
Recovery & Disposal Management
Recovery & Disposal
Gas recovery and purification and reliquefaction system
Zero-waste product scrubbers
Regenerative systems
Safety & Monitoring Systems
Leak Detection
High-accuracy point sensors
Multiparameter leak detectors
Nonintrusive instrumentation for fluid system
Hydrogen/helium gas visualization
Multispectral imaging
Measurement
Nonintrusive instrumentation for fluid system
Nonintrusive temp/press
Nonintrusive flow rate
Virtual presence
(Situational awareness)
Command & Control
Rule-based
Automated advisory system
Knowledge-based advisory system
Built-in test equip.
Integrated health management
Smart components
(valves, pumps, etc.)
Rule-based automated control script
Autonomous, self-learning, knowledge-based control with distributed command authority
Autonomous loading operations

ARTWG envisions global network interconnectivity with voice, video, and data distribution through high speed ground networks, satellites, and mobile range assets.

ADVANCED RANGE TECHNOLOGIES WORKING GROUP (ARTWG) CAPABILITY ROADMAP
Communication Architecture: Functions and Capabilities

Near-Term (FY 2004 - 2009)	Mid-Term (FY 2010 - 2015)	Far-Term (FY 2016 - 2028)
Develop Global Range Comm Network (e.g., Next-Generation Internet) Maintain reverse compatibility, Update Infrastructure, Std Protocol dev	Standard system administration and network management, dynamic security	Global, interoperable system with seamless integration of range comm systems for continuous operation, high-data rate capacity, to support multiple simultaneous missions
Integrate local range system network Prototype of integrated range using mobile and space-based assets	Integrate national range comm system making operational use of ground-based, mobile, and space-based comm assets	
Identify and allocate frequency and bandwidth for point to point and network communications	Quality of service (QoS) network capacity, elastic bandwidth	High QoS in support of any frequency in use

Space-based and mobile platforms, ground networks, signal processing, alternative use of frequency spectrum, antenna technologies, storage media, and advanced data handling.

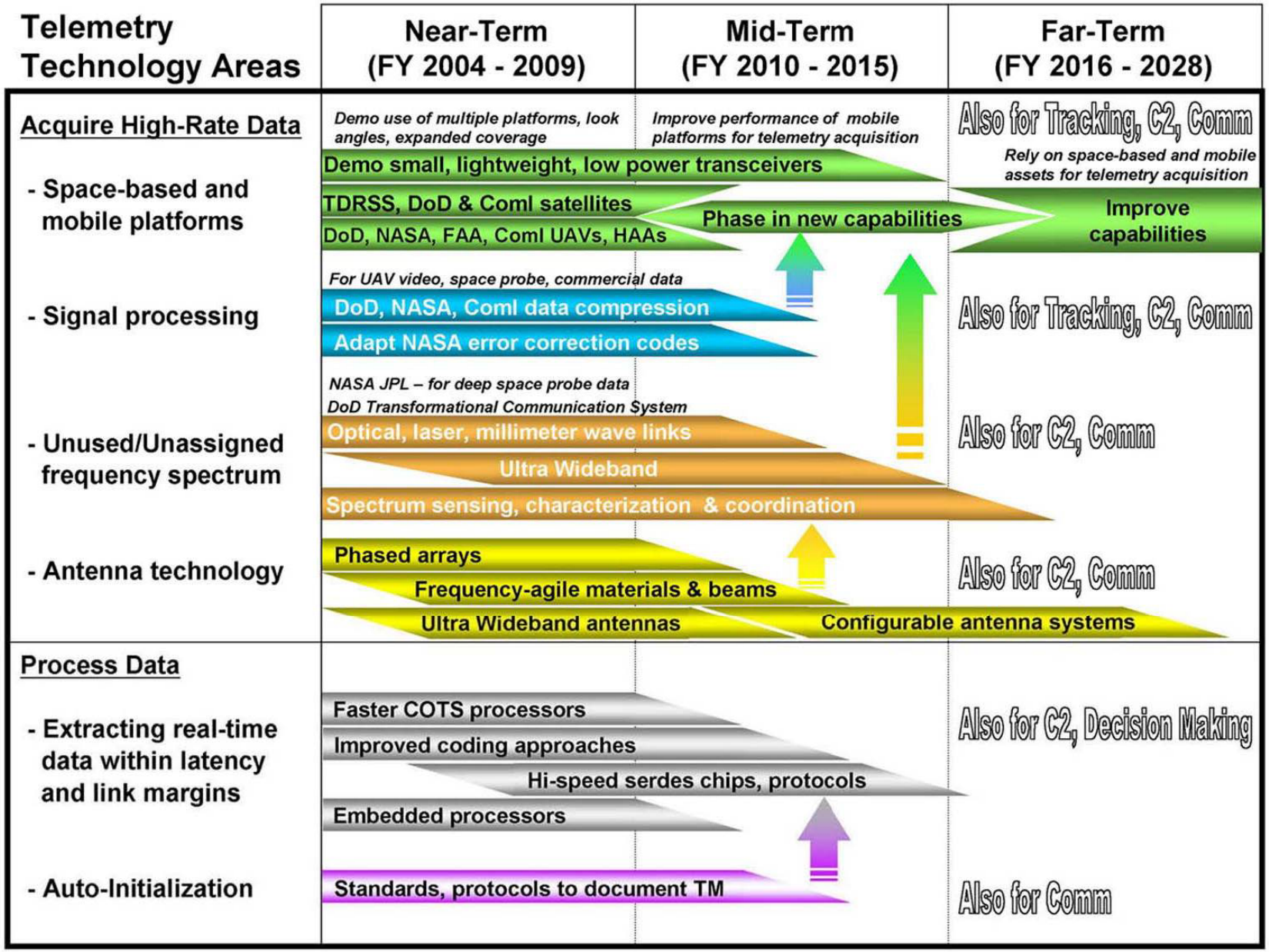


ARTWG envisions satellites and deployable mobile platforms for acquiring and relaying telemetry, eventually combining telemetry and command into one robust two-way link.

ADVANCED RANGE TECHNOLOGIES WORKING GROUP (ARTWG) CAPABILITY ROADMAP
Telemetry: Functions and Capabilities

Near-Term (FY 2004 - 2009)	Mid-Term (FY 2010 - 2015)	Far-Term (FY 2016 - 2028)
Demo improved onboard TM systems (lighter, higher power) and integrate with launch vehicles	Phase in new satellite relays and integrate with ranges	Global coverage provided by space centric assets supplemented by mobile/deployable assets. •Minimal handoff •Adaptable service
Leverage existing satellites (TDRS, ComSat relays), test, and phase in new aerial TM relays	Integrate aerial relays and ranges	
Define and promote TM stream specification for autoinitialization	Modify TM stream, to autoinitialize	
Study existing command capabilities	Integrate command and TM into generalized communications link	Implement command-based TM D/L packet-based TM
Study suitable coding for D/L and causes of TM dropouts	Implement coding for improved efficiency and test solutions for early ascent dropouts	Error-free and channel-efficient TM D/L and acquisition
Transition delay <0.25 second over CONUS (flight safety criteria)		

Space-based and mobile platforms, signal processing, alternate uses of frequency spectrum, antenna technologies, optical and magnetic storage media, and advanced data handling.



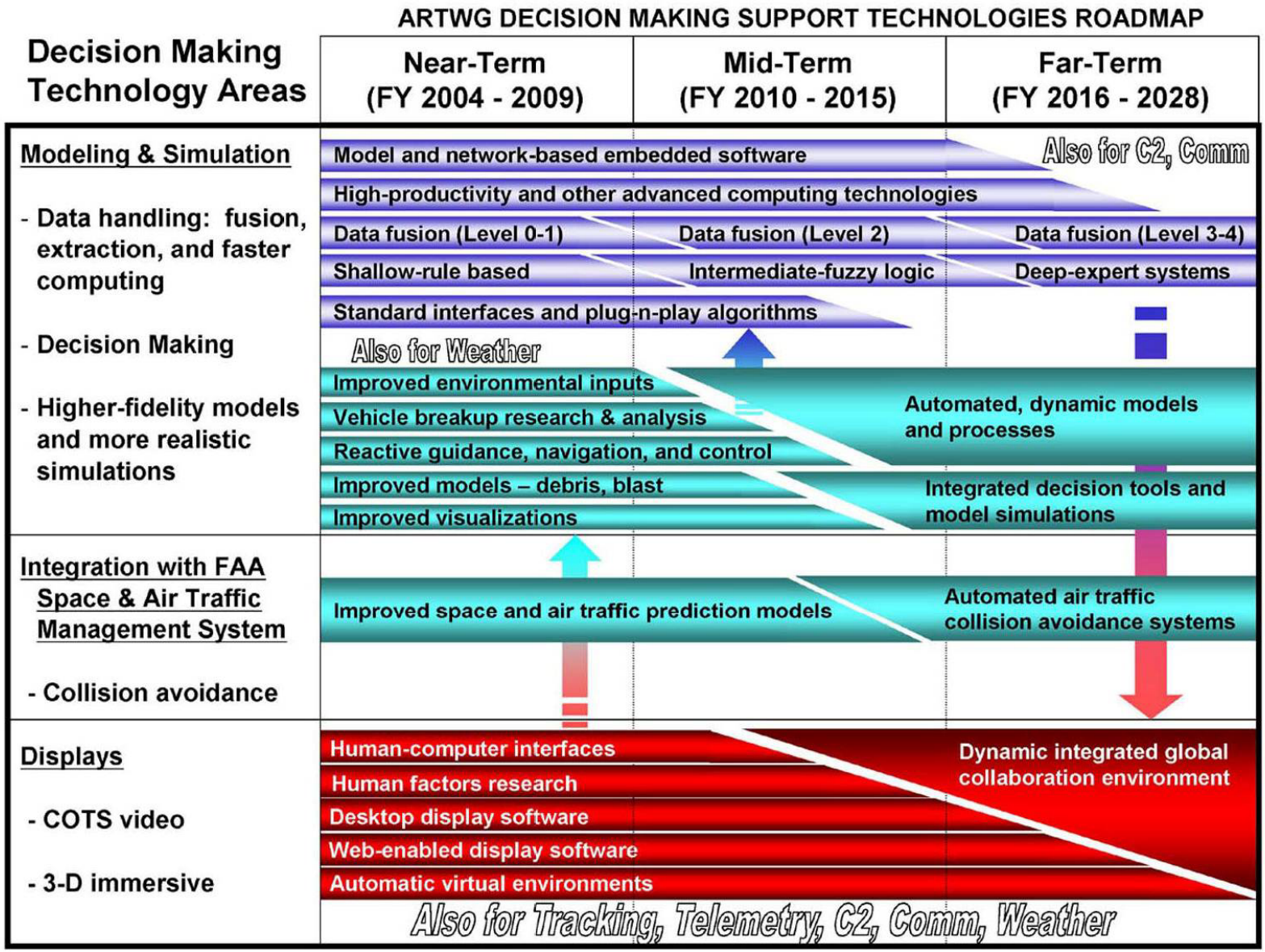
ARTWG envisions increased standardization in modeling and simulation, collision avoidance, and sophistication of 2-D and 3-D immersion-type displays.

ADVANCED RANGE TECHNOLOGIES WORKING GROUP (ARTWG) CAPABILITY ROADMAP
Decision Making Support: Functions and Capabilities

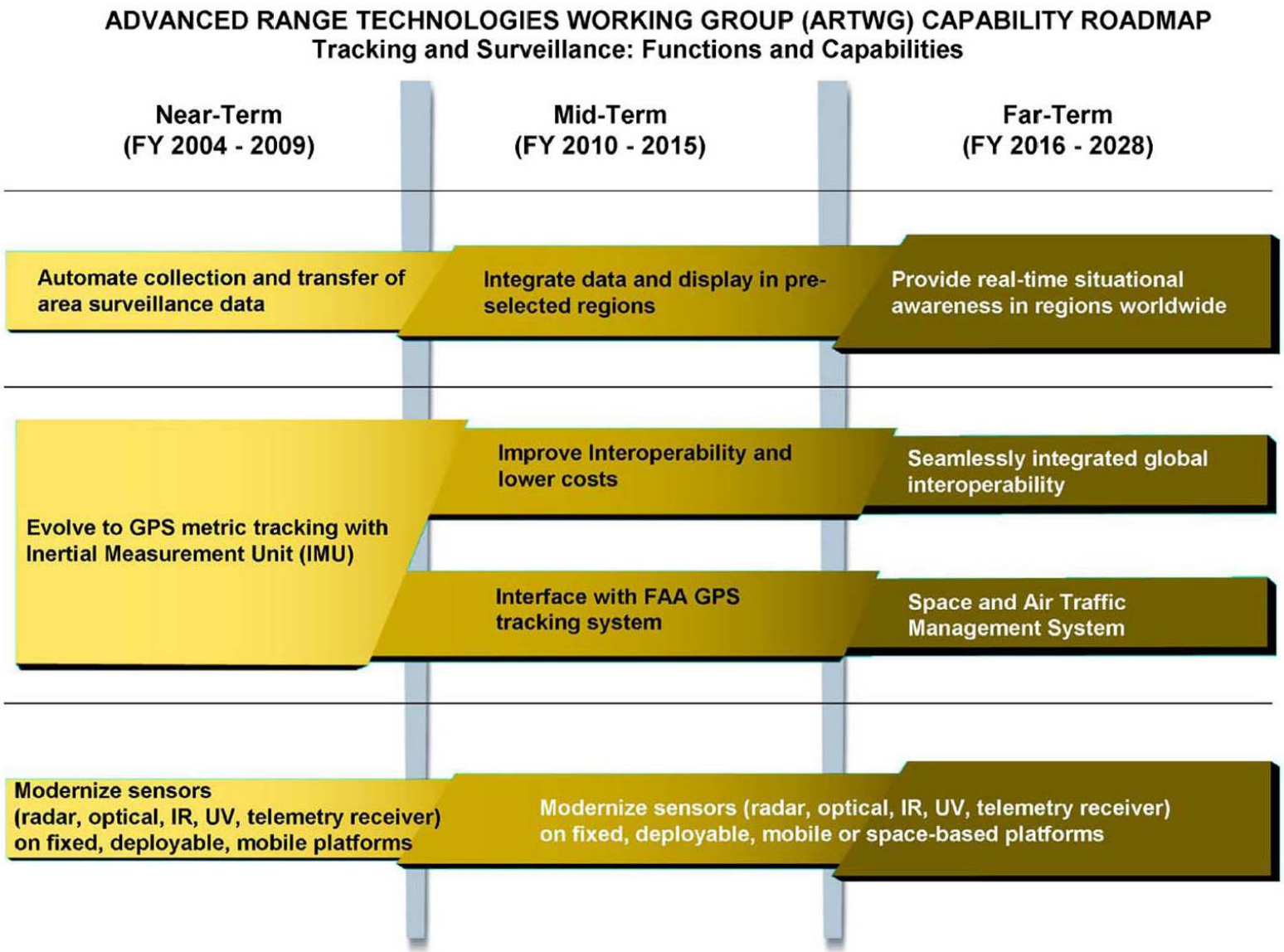
Near-Term (FY 2004 - 2009)	Mid-Term (FY 2010 - 2015)	Far-Term (FY 2016 - 2028)
Improve risk assessment for mission planning/flight operations	Improve risk assessment for mission planning/flight operations	Improve risk assessment for mission planning/flight operations
Enhanced real-time decision situational awareness locally	Enhanced real-time decision situational awareness regionally	Semi-automated real-time decision situational awareness nationally
Semi-automate decision making tools and analysis at a single range	Automate decision making tools across ranges within a region	Automated decision making tools nationally with a centralized "range authority"
Enhanced human-computer display interfaces	Flexible/collaborative display systems regionally	Flexible/collaborative display systems nationally

Centralized "range authority" utilizing automated near real-time hazards (COLA, Toxic Plume, etc.) situational awareness tools which are seamlessly integrated and interoperable with internal range systems/ functions and external agencies (i.e., FAA ATC)

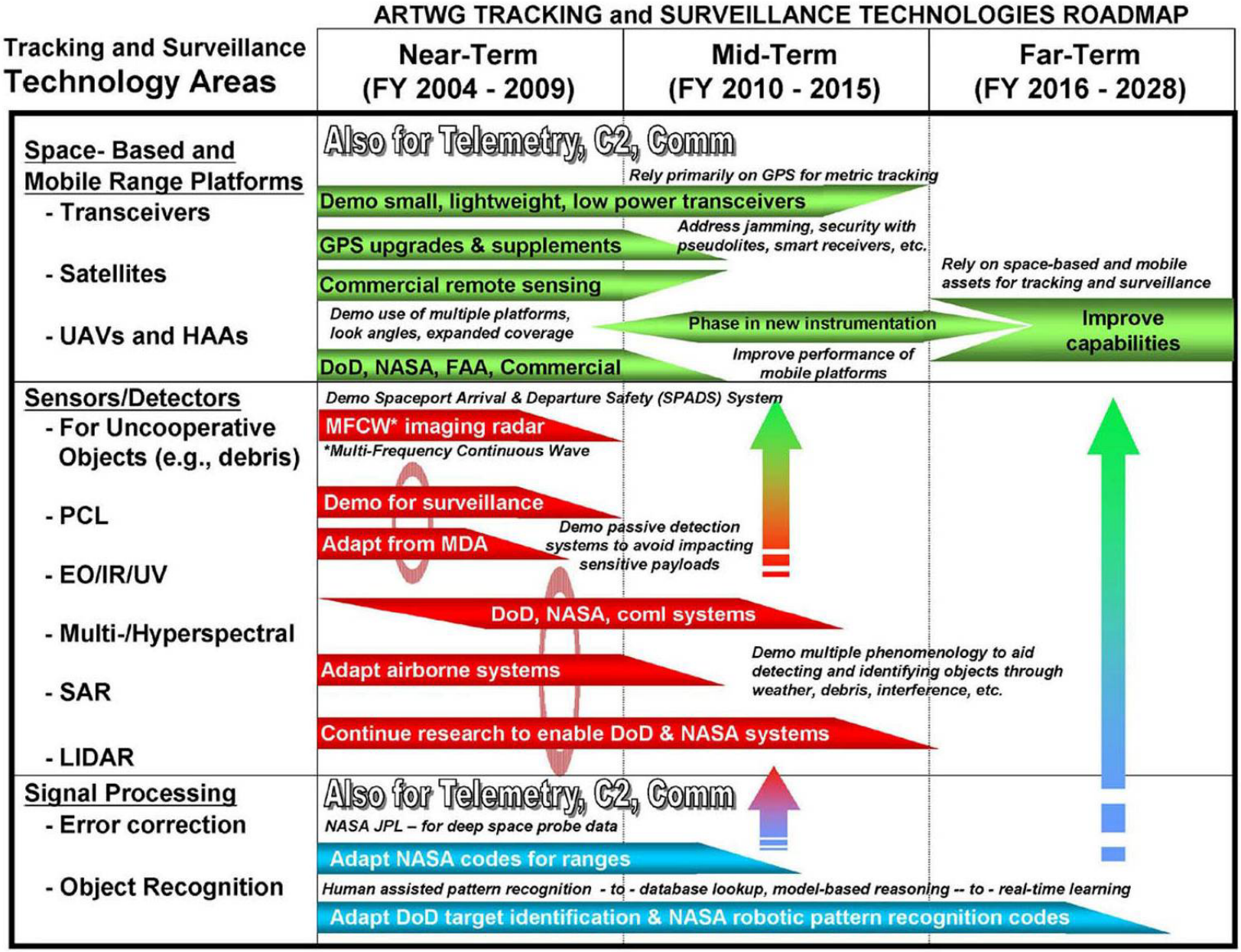
Higher fidelity modeling and simulation based on enhanced data fusion and extraction capabilities, better integration with FAA space and air traffic management systems, and improved display capabilities.

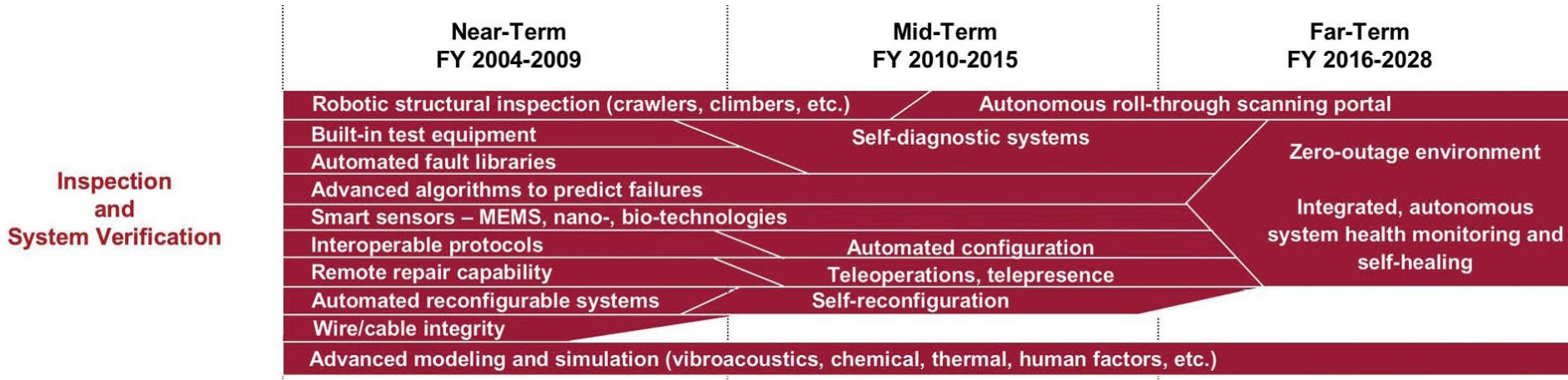


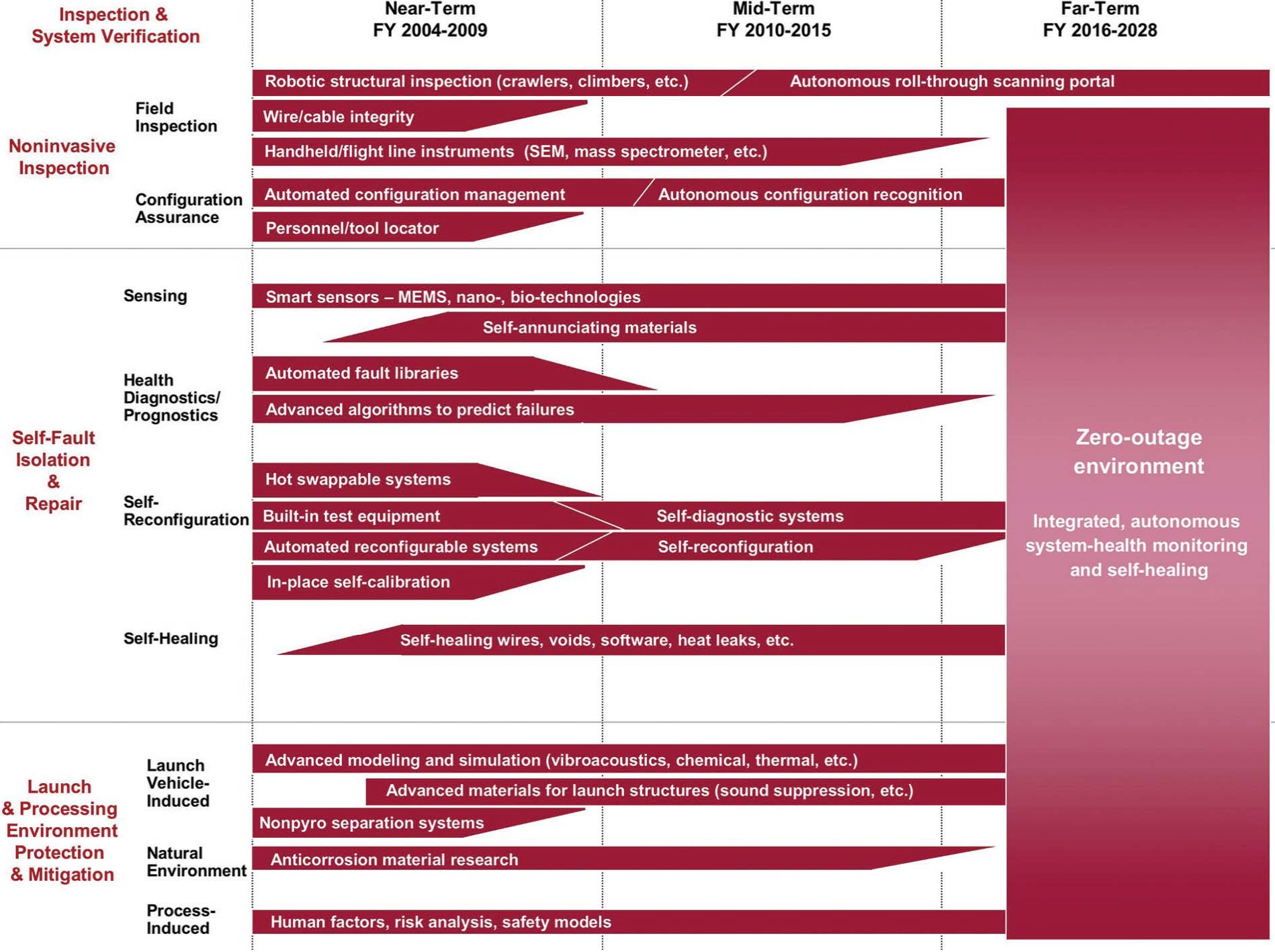
ARTWG envisions automated surveillance capabilities, GPS for metric tracking, and modernized sensors for fixed, deployable, and space-based platforms.

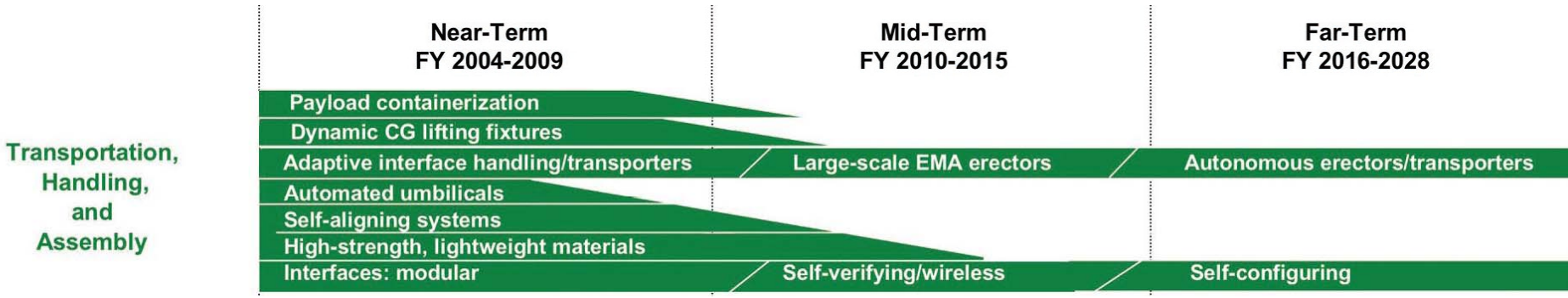


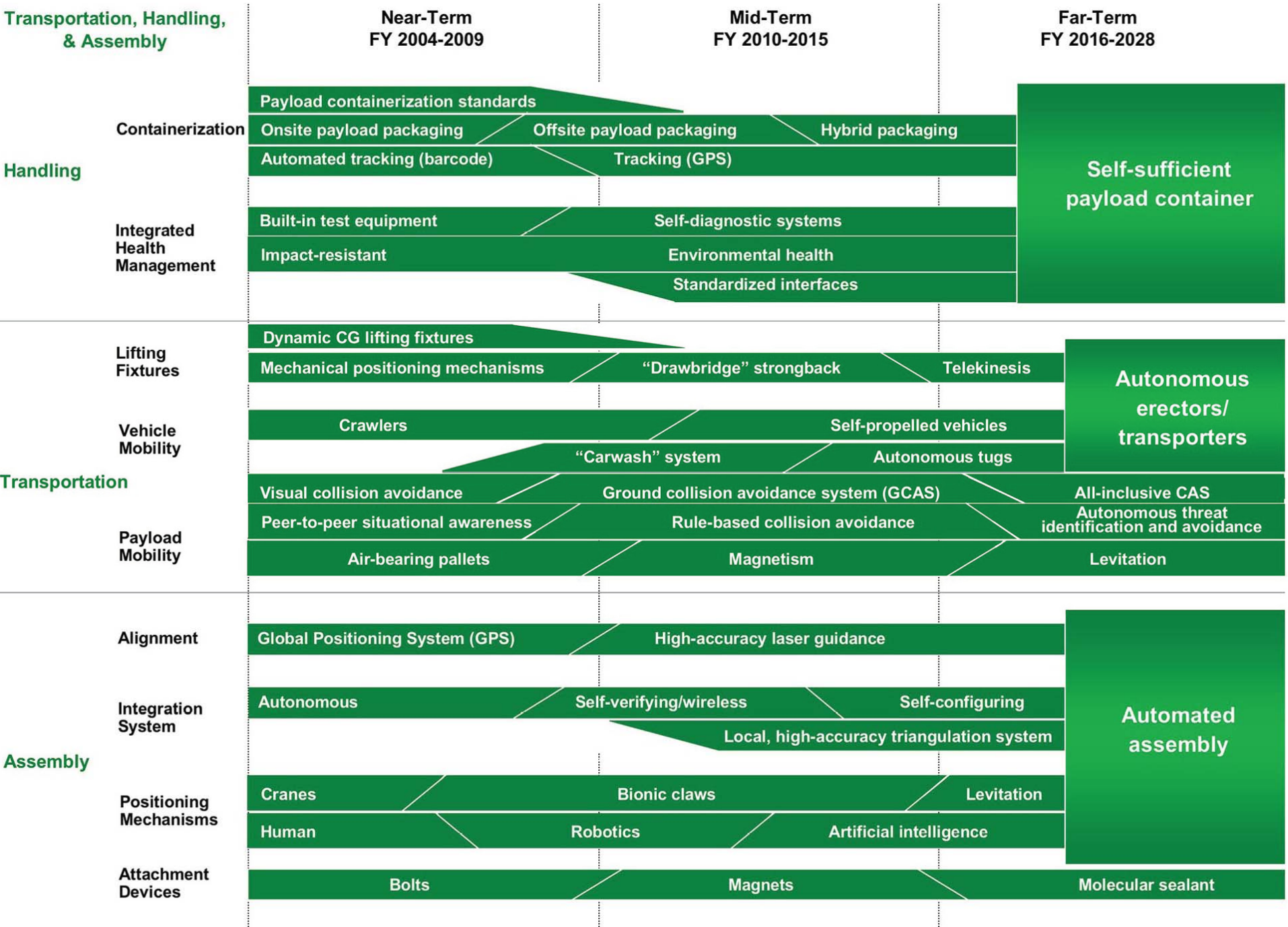
Space-based and mobile platforms, GPS systems, instruments for passive detection in multiple spectral bands, and improved signal processing for error correction and object recognition.

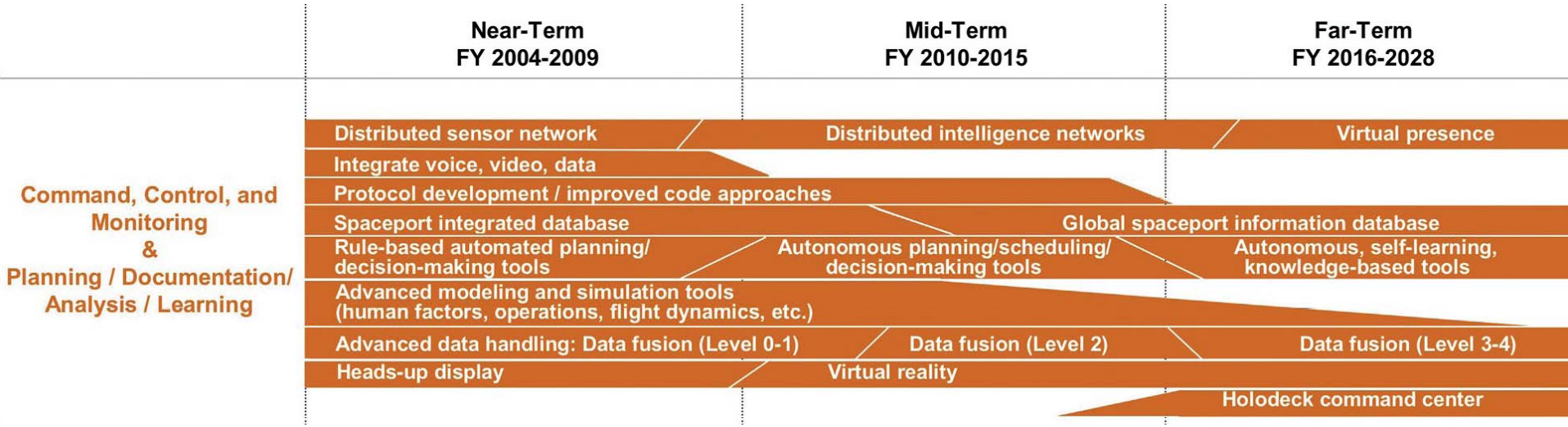


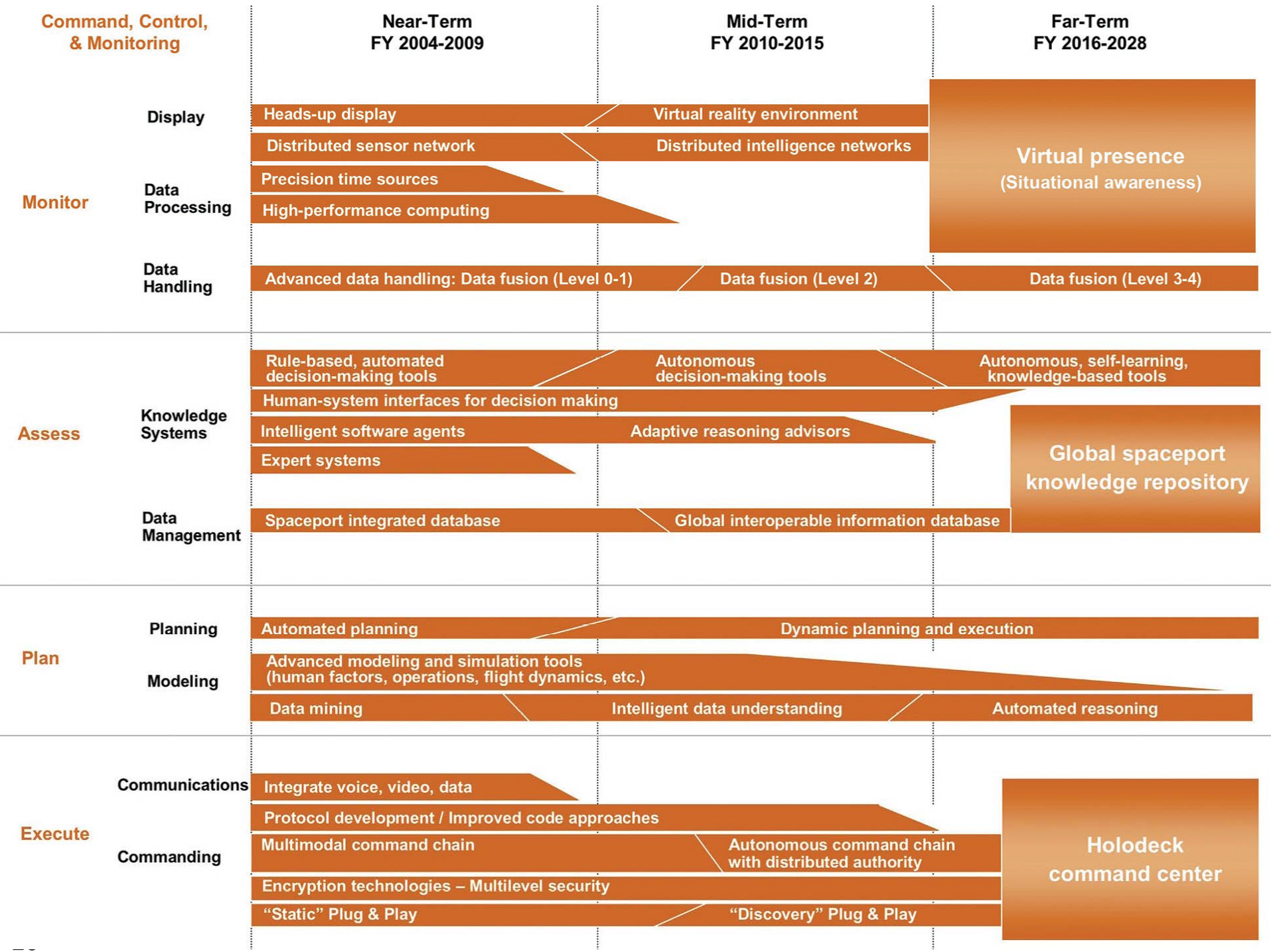

Near-Term
FY 2004-2009
Mid-Term
FY 2010-2015
Far-Term
FY 2016-2028
Inspection
and
System Verification
Robotic structural inspection (crawlers, climbers, etc.)
Autonomous roll-through scanning portal
Built-in test equipment
Automated fault libraries
Self-diagnostic systems
Zero-outage environment
Advanced algorithms to predict failures
Smart sensors – MEMS, nano-, bio-technologies
Integrated, autonomous system health monitoring and self-healing
Interoperable protocols
Automated configuration
Remote repair capability
Teleoperations, telepresence
Automated reconfigurable systems
Self-reconfiguration
Wire/cable integrity
Advanced modeling and simulation (vibroacoustics, chemical, thermal, human factors, etc.)


Inspection & System Verification
Near-Term FY 2004-2009
Mid-Term FY 2010-2015
Far-Term FY 2016-2028
Noninvasive Inspection
Field Inspection
Robotic structural inspection (crawlers, climbers, etc.)
Autonomous roll-through scanning portal
Wire/cable integrity
Handheld/flight line instruments (SEM, mass spectrometer, etc.)
Configuration Assurance
Automated configuration management
Autonomous configuration recognition
Personnel/tool locator
Self-Fault Isolation & Repair
Sensing
Smart sensors – MEMS, nano-, bio-technologies
Self-annunciating materials
Health Diagnostics/ Prognostics
Automated fault libraries
Advanced algorithms to predict failures
Self-Reconfiguration
Hot swappable systems
Built-in test equipment
Self-diagnostic systems
Automated reconfigurable systems
Self-reconfiguration
In-place self-calibration
Self-Healing
Self-healing wires, voids, software, heat leaks, etc.
Zero-outage environment
Integrated, autonomous system-health monitoring and self-healing
Launch & Processing Environment Protection & Mitigation
Launch Vehicle-Induced
Advanced modeling and simulation (vibroacoustics, chemical, thermal, etc.)
Advanced materials for launch structures (sound suppression, etc.)
Nonpyro separation systems
Natural Environment
Anticorrosion material research
Process-Induced
Human factors, risk analysis, safety models


Near-Term
FY 2004-2009
Mid-Term
FY 2010-2015
Far-Term
FY 2016-2028
Transportation, Handling, and Assembly
Payload containerization
Dynamic CG lifting fixtures
Adaptive interface handling/transporters
Large-scale EMA erectors
Autonomous erectors/transporters
Automated umbilicals
Self-aligning systems
High-strength, lightweight materials
Interfaces: modular
Self-verifying/wireless
Self-configuring

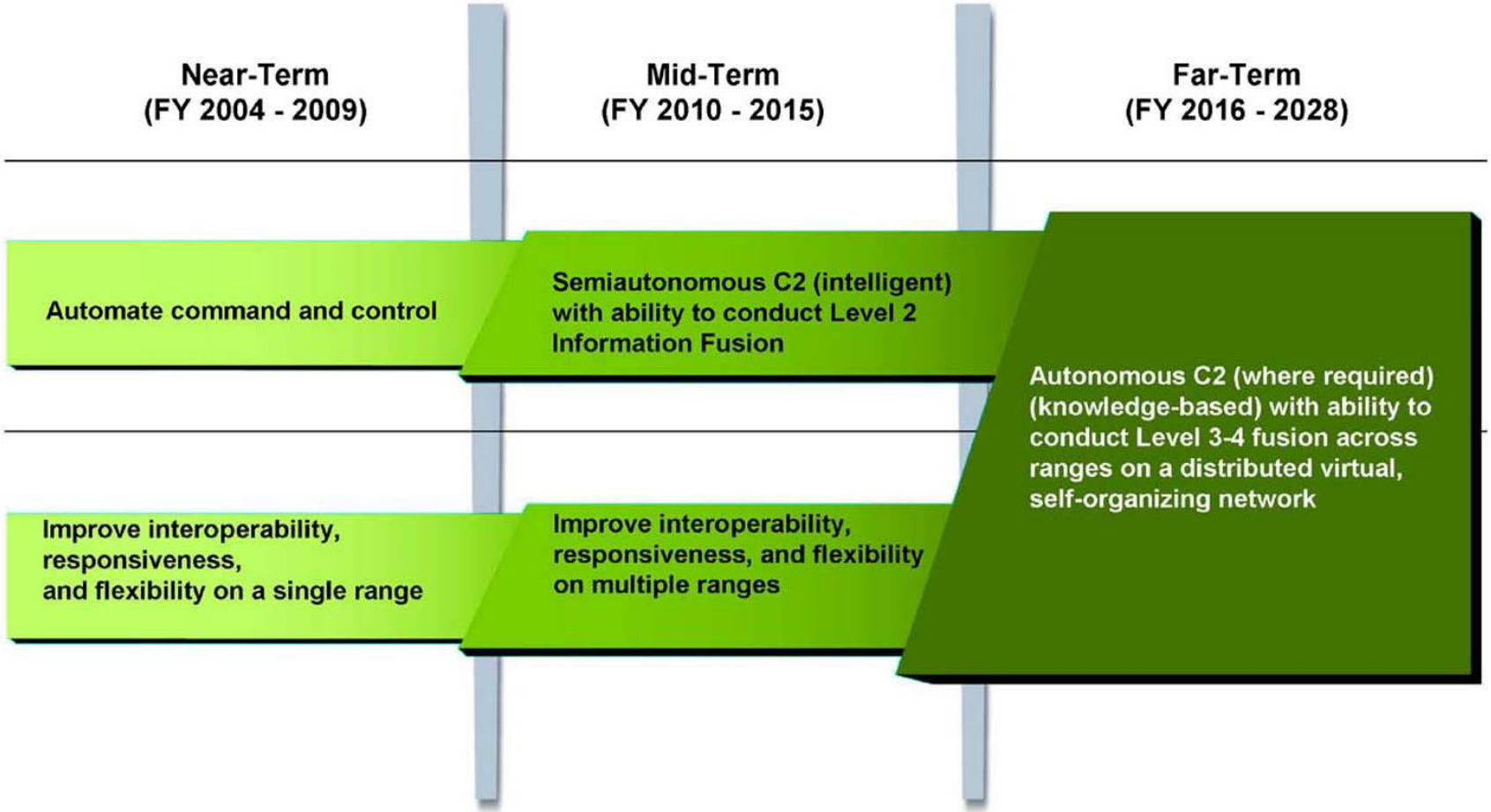

Transportation, Handling, & Assembly
Near-Term FY 2004-2009
Mid-Term FY 2010-2015
Far-Term FY 2016-2028
Handling
Containerization
Payload containerization standards
Onsite payload packaging
Offsite payload packaging
Hybrid packaging
Automated tracking (barcode)
Tracking (GPS)
Integrated Health Management
Built-in test equipment
Self-diagnostic systems
Impact-resistant
Environmental health
Standardized interfaces
Self-sufficient payload container
Transportation
Lifting Fixtures
Dynamic CG lifting fixtures
Mechanical positioning mechanisms
"Drawbridge" strongback
Telekinesis
Vehicle Mobility
Crawlers
Self-propelled vehicles
"Carwash" system
Autonomous tugs
Autonomous erectors/ transporters
Payload Mobility
Visual collision avoidance
Ground collision avoidance system (GCAS)
All-inclusive CAS
Peer-to-peer situational awareness
Rule-based collision avoidance
Autonomous threat identification and avoidance
Air-bearing pallets
Magnetism
Levitation
Assembly
Alignment
Global Positioning System (GPS)
High-accuracy laser guidance
Integration System
Autonomous
Self-verifying/wireless
Self-configuring
Local, high-accuracy triangulation system
Positioning Mechanisms
Cranes
Bionic claws
Levitation
Human
Robotics
Artificial intelligence
Attachment Devices
Bolts
Magnets
Molecular sealant
Automated assembly


Near-Term
FY 2004-2009
Mid-Term
FY 2010-2015
Far-Term
FY 2016-2028
Command, Control, and Monitoring
&
Planning / Documentation/ Analysis / Learning
Distributed sensor network
Distributed intelligence networks
Virtual presence
Integrate voice, video, data
Protocol development / improved code approaches
Spaceport integrated database
Global spaceport information database
Rule-based automated planning/ decision-making tools
Autonomous planning/scheduling/ decision-making tools
Autonomous, self-learning, knowledge-based tools
Advanced modeling and simulation tools (human factors, operations, flight dynamics, etc.)
Advanced data handling: Data fusion (Level 0-1)
Data fusion (Level 2)
Data fusion (Level 3-4)
Heads-up display
Virtual reality
Holodeck command center

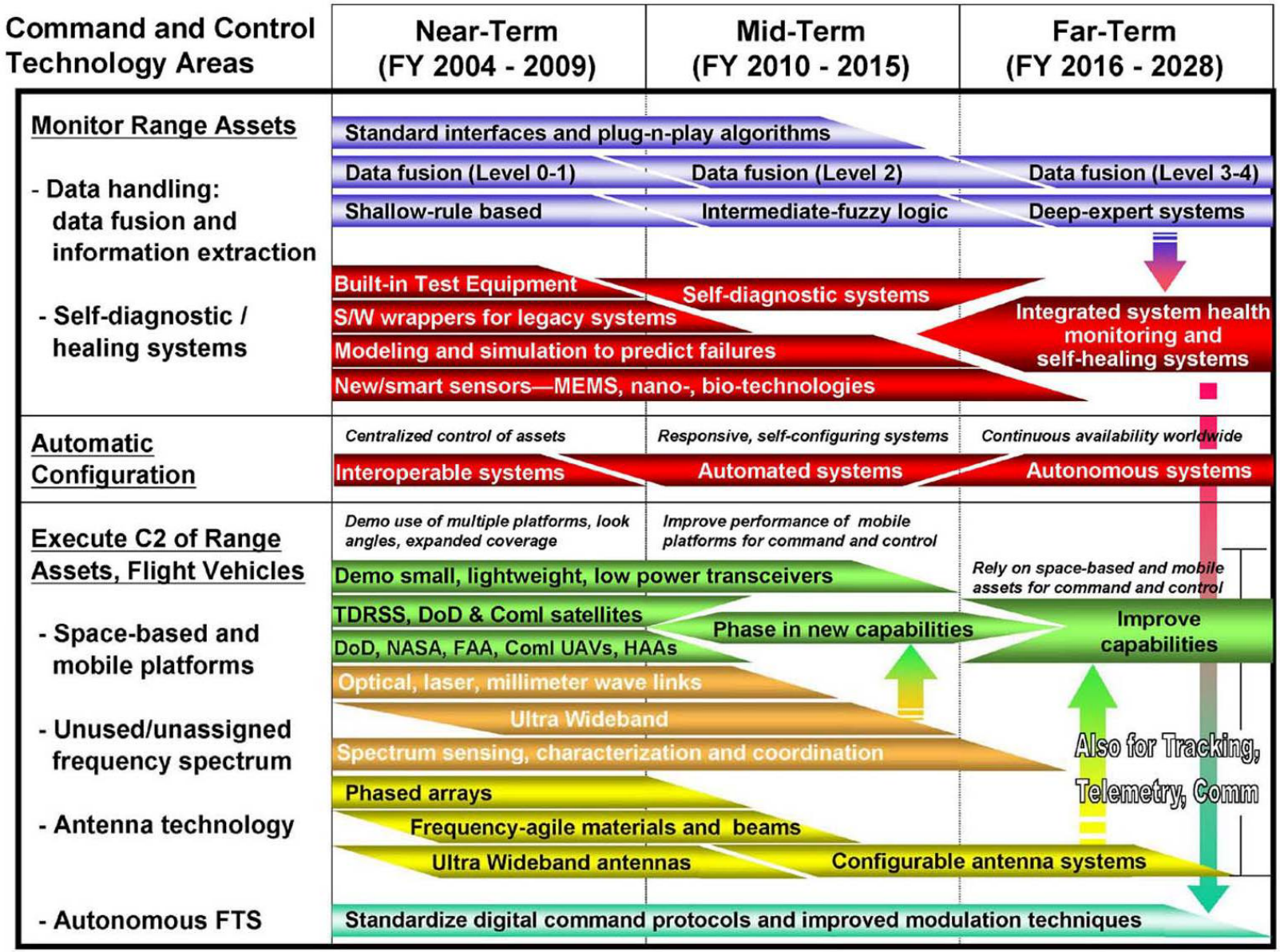

Command, Control, & Monitoring
Near-Term FY 2004-2009
Mid-Term FY 2010-2015
Far-Term FY 2016-2028
Monitor
Display
Heads-up display
Virtual reality environment
Distributed sensor network
Distributed intelligence networks
Data Processing
Precision time sources
High-performance computing
Virtual presence (Situational awareness)
Data Handling
Advanced data handling: Data fusion (Level 0-1)
Data fusion (Level 2)
Data fusion (Level 3-4)
Assess
Knowledge Systems
Rule-based, automated decision-making tools
Autonomous decision-making tools
Autonomous, self-learning, knowledge-based tools
Human-system interfaces for decision making
Intelligent software agents
Adaptive reasoning advisors
Expert systems
Global spaceport knowledge repository
Data Management
Spaceport integrated database
Global interoperable information database
Plan
Planning
Automated planning
Dynamic planning and execution
Modeling
Advanced modeling and simulation tools (human factors, operations, flight dynamics, etc.)
Data mining
Intelligent data understanding
Automated reasoning
Execute
Communications
Integrate voice, video, data
Protocol development / Improved code approaches
Commanding
Multimodal command chain
Autonomous command chain with distributed authority
Encryption technologies – Multilevel security
"Static" Plug & Play
"Discovery" Plug & Play
Holodeck command center

ARTWG envisions autonomous knowledge-based data fusion, a robust self-organizing network, providing increasingly interoperable, responsive, and flexible range and flight safety support for global operations.

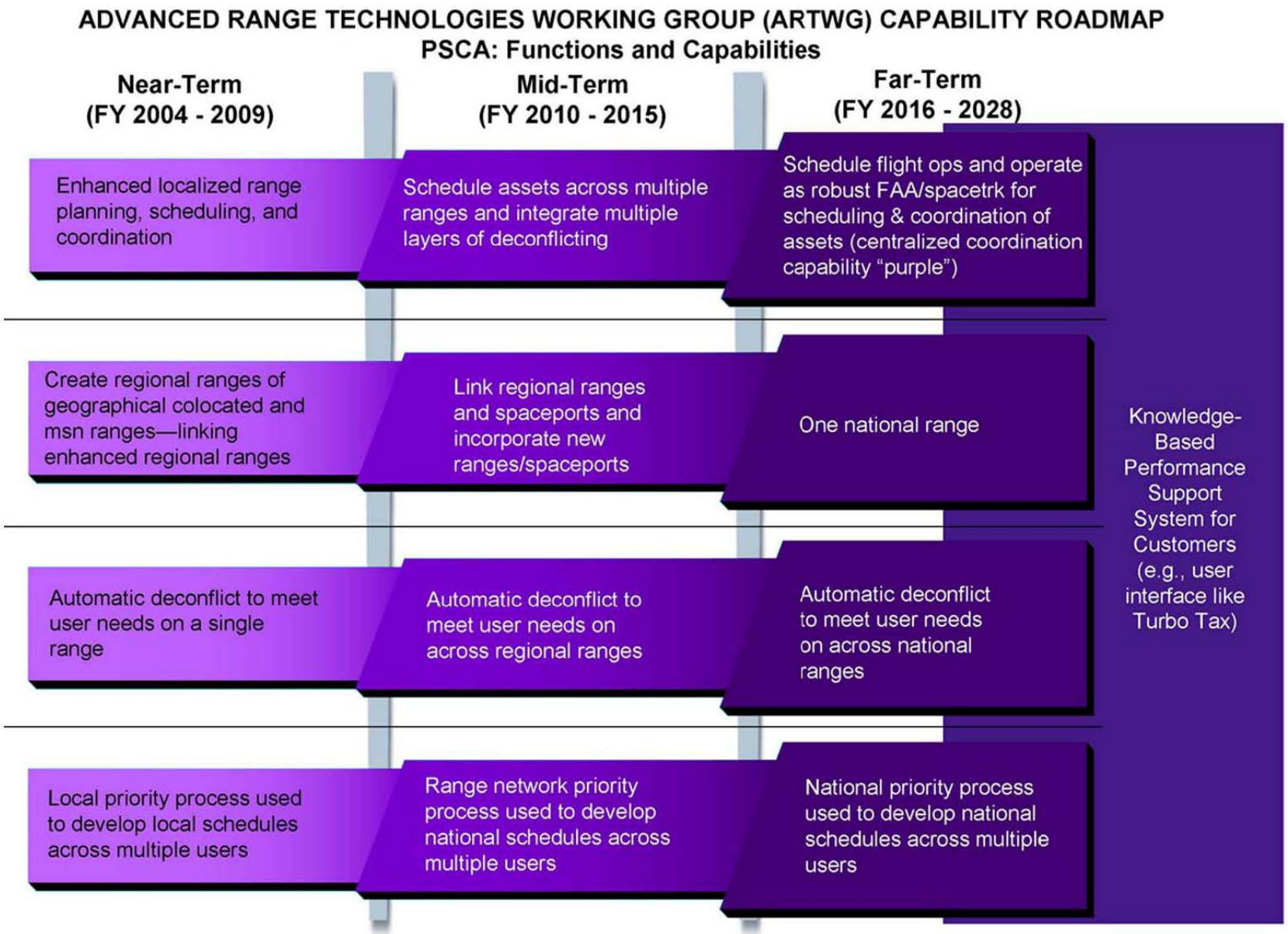
ADVANCED RANGE TECHNOLOGIES WORKING GROUP (ARTWG) CAPABILITY ROADMAP
Range Command and Control Systems: Functions and Capabilities



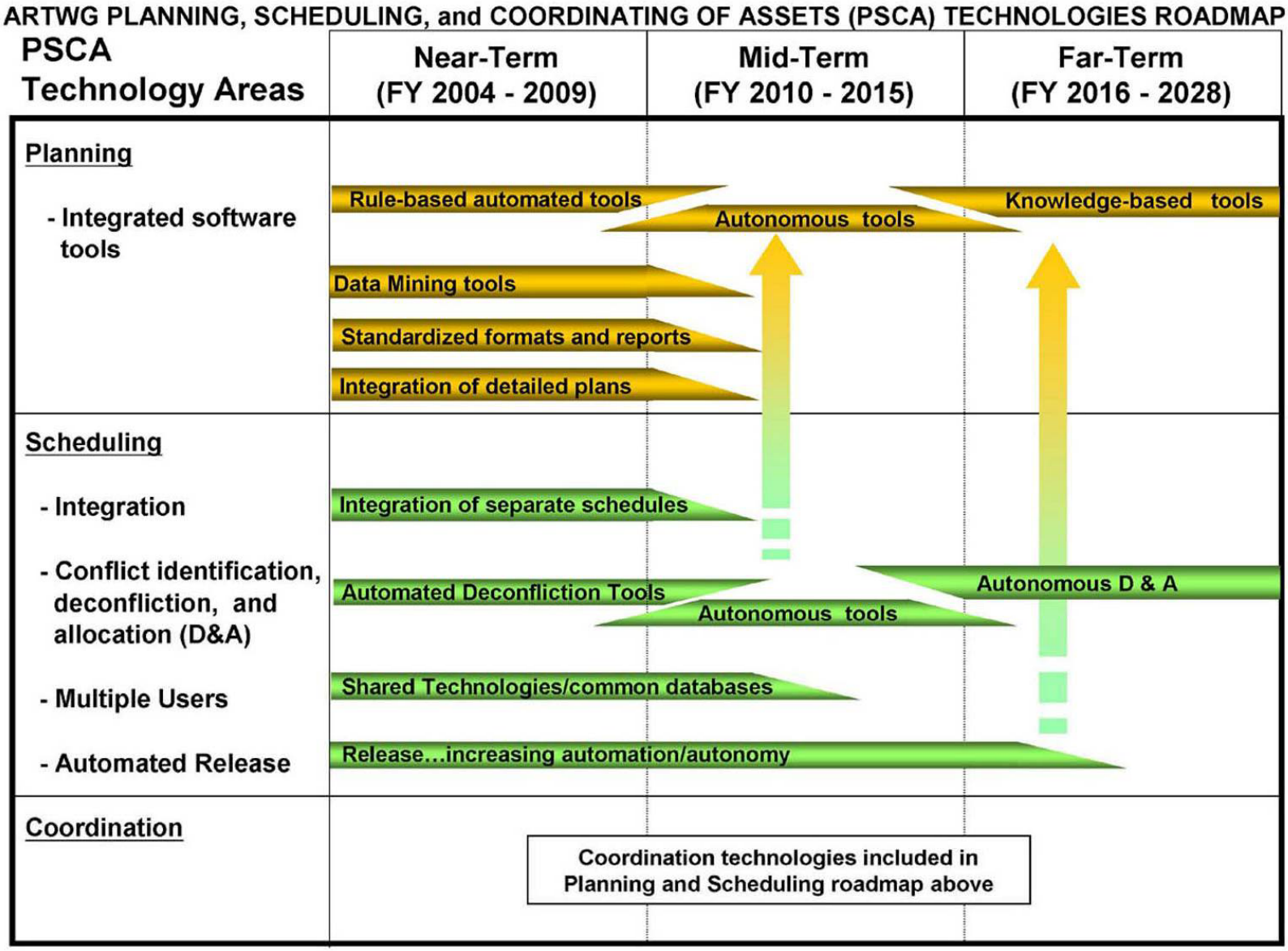
Monitoring range assets, automating reconfiguration capabilities, and executing commands through a robust two-way data link shared with the vehicle telemetry link.

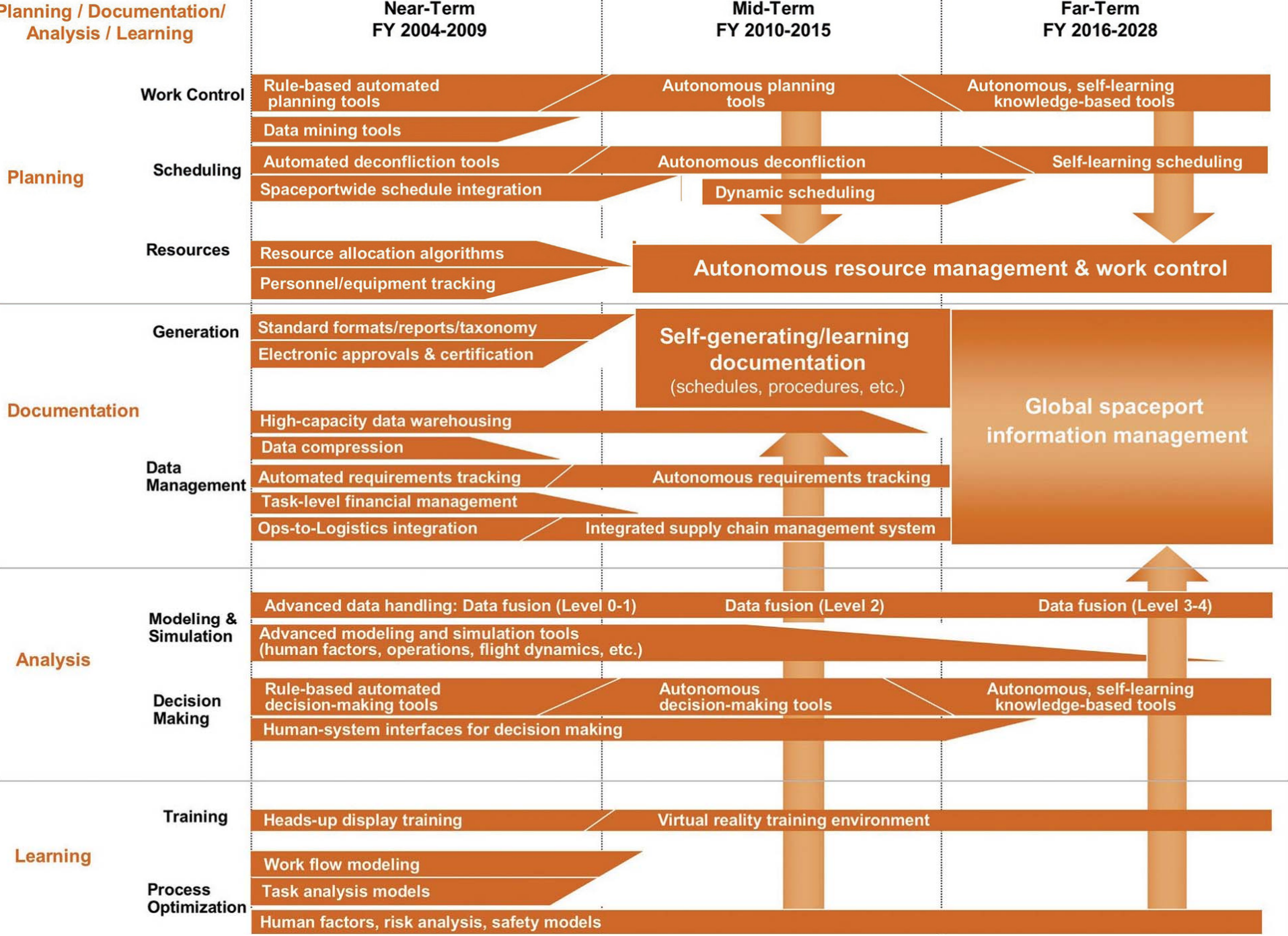


ARTWG envisions increased automation and centrally addressing range planning, scheduling, and coordination of assets activities on a broader scale.



Integrated software tools to evolve from rule-based to knowledge-based expert systems and database systems to enable autonomous scheduling and deconfliction.




Planning / Documentation/ Analysis / Learning
Near-Term FY 2004-2009
Mid-Term FY 2010-2015
Far-Term FY 2016-2028
Planning
Work Control
Rule-based automated planning tools
Autonomous planning tools
Autonomous, self-learning knowledge-based tools
Data mining tools
Scheduling
Automated deconfliction tools
Autonomous deconfliction
Self-learning scheduling
Spaceportwide schedule integration
Dynamic scheduling
Resources
Resource allocation algorithms
Personnel/equipment tracking
Autonomous resource management & work control
Documentation
Generation
Standard formats/reports/taxonomy
Electronic approvals & certification
Self-generating/learning documentation
(schedules, procedures, etc.)
Global spaceport information management
Data Management
High-capacity data warehousing
Data compression
Automated requirements tracking
Autonomous requirements tracking
Task-level financial management
Ops-to-Logistics integration
Integrated supply chain management system
Analysis
Modeling & Simulation
Advanced data handling: Data fusion (Level 0-1)
Data fusion (Level 2)
Data fusion (Level 3-4)
Advanced modeling and simulation tools
(human factors, operations, flight dynamics, etc.)
Decision Making
Rule-based automated decision-making tools
Autonomous decision-making tools
Autonomous, self-learning knowledge-based tools
Human-system interfaces for decision making
Learning
Training
Heads-up display training
Virtual reality training environment
Process Optimization
Work flow modeling
Task analysis models
Human factors, risk analysis, safety models

ARTWG envisions commonality among the various subgroups, self-healing networks enhancing the delivery of services within the subgroups, autonomous control and interactive simulation and testing for all operators.

ADVANCED RANGE TECHNOLOGIES WORKING GROUP (ARTWG) CAPABILITY ROADMAP
Cross-Cutting Architecture: Functions and Capabilities

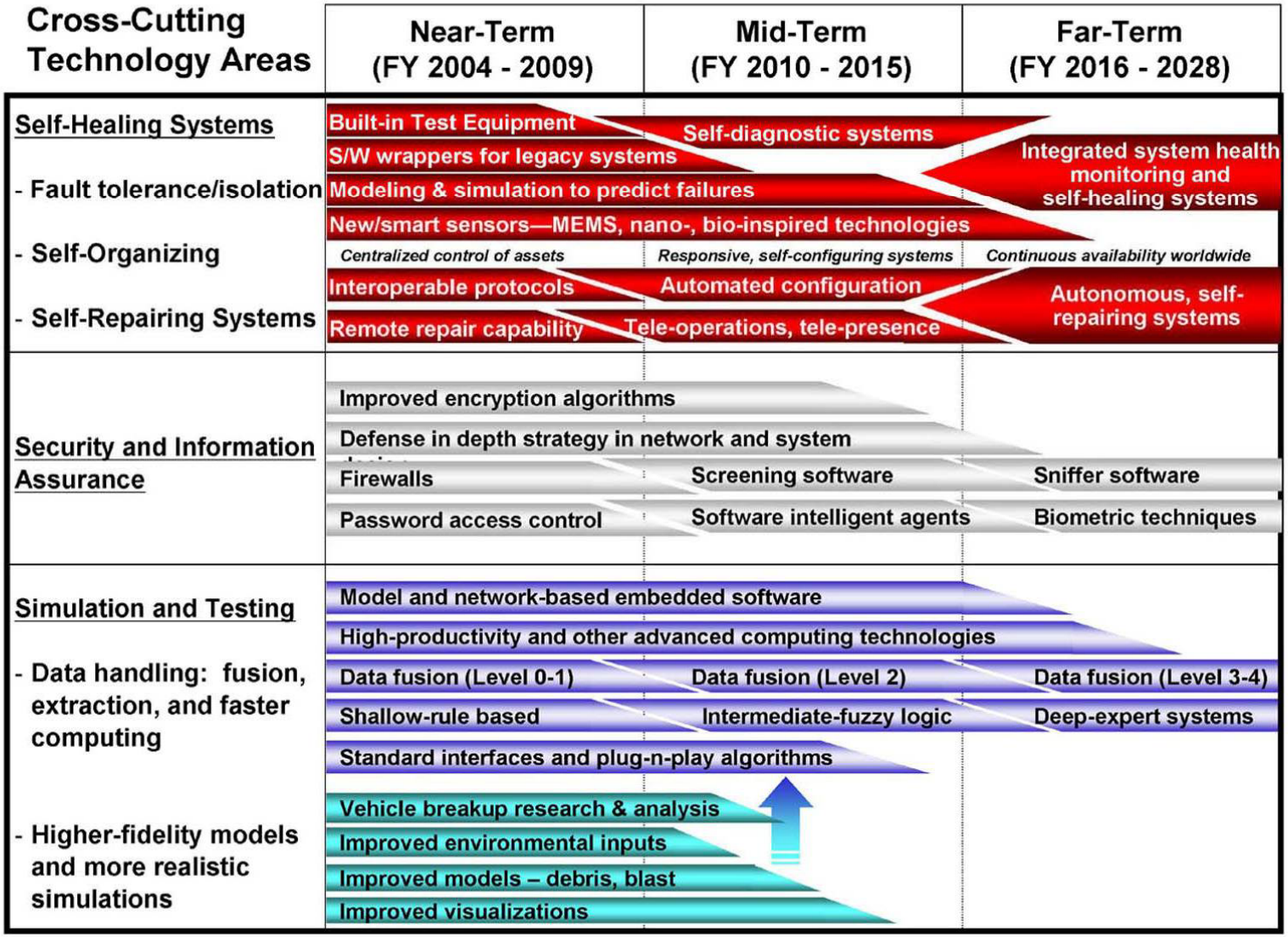
Near-Term (FY 2004 - 2009)	Mid-Term (FY 2010 - 2015)	Far-Term (FY 2016 - 2028)
Remote monitoring and dynamic reconfiguration of range systems	Enhanced dynamic reconfiguration	Self-healing and self-organizing nationwide networks
Enhanced data encryption and intrusion detection	Multiple levels of encryption and automated access control	All data encrypted and autonomous access control
Semiautomated training	Automated training	Interactive simulation
Component-level simulation and semiautomated testing within a single range	System-level simulation and automated testing for regional ranges	Testing and simulation of global range system

ARTWG envisions cross-cuttng performance measures evolving over time to result in commonality among the various subgroups, self-healing networks enhancing delivery of services, autonomous control, and interactive simulation and testing for all operators.

ADVANCED RANGE TECHNOLOGIES WORKING GROUP (ARTWG) CAPABILITY ROADMAP
Cross-Cutting Performance Measures

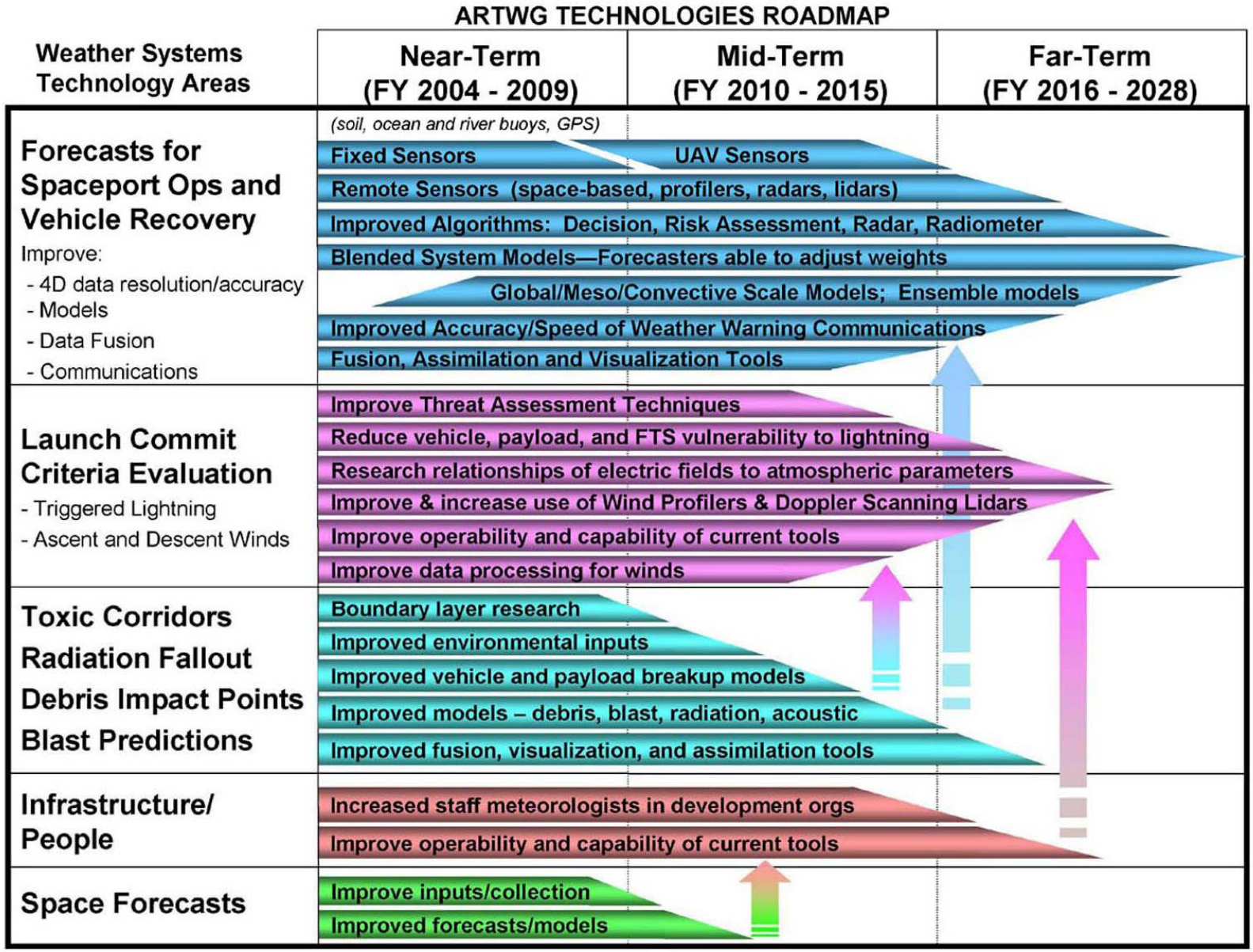
Near-Term (FY 2004 - 2009)	Mid-Term (FY 2010 - 2015)	Far-Term (FY 2016 - 2028)
Automated self-test (GO/NO GO) and redundant range assets with semi-automated reconfiguration within 1-2 hours for 98% availability on a single range	Automated fault-isolation and reconfiguration within 30 minutes for regional ranges for 99% availability of ranges in a region	Self-diagnostic and self-healing global range with continuous availability
Standardized cost models for itemized accounting for services at a single range	Optimized labor and asset costs for itemized accounting for services across ranges in a region	Cost optimization for range users and owners (e.g., scalable fees) with itemized accounting for services on the global range
Provide standardized connectivity across a single range with regional interfaces to FAA's national air traffic management system	Provide standardized connectivity across multiple ranges in a region with automated interfaces to the FAA's GPS-based air traffic management system	Provide standardized global connectivity with automated interfaces to the FAA's Space and Air Traffic Management System (SATMS)

Key technologies for cross-cutting architecture include automated systems, autonomous self-repairing systems, integrated system health monitoring and self-healing, software intelligent agents, data fusion, model and network-based embedded software for testing.



ARTWG envisions capabilities in Weather Systems evolving over time toward centralized hubs for forecasting and technology transition, based on improvement of sensors and models.

ADVANCED RANGE TECHNOLOGIES WORKING GROUP (ARTWG) CAPABILITY ROADMAP
Weather Measurement and Forecasting: Functions and Capabilities

Near-Term (FY 2004 - 2009)	Mid-Term (FY 2010 - 2015)	Far-Term (FY 2016 - 2028)
•Significant reduction in weather impacts on ground processing productivity, launch scrubs, and EOM diverts while marinating safe operations • Reduce weather support costs: forecast hubs, space-based sensors, focused technology transition, atmospheric scientists participate in design		
• Enhanced local prediction	• Regional Weather hubs for forecasting and technology transition	• Centralized hub facilities for forecasting and technology transition
Improved spatial and temporal resolution and accuracy of forecasts and warnings		
Improved 4D analysis forecast of temperatures and winds to improve toxic, radiation, debris, and acoustic forecasts		
Improved ability to assess electric field aloft		Improved ability to assess each specific vehicle's impact on electric field
• Reduced spatial and temporal errors in measuring upper winds along flight path • Reduced vulnerability of vehicles, payload, GSE, concepts of operations, etc., to atmosphere due to increased input of meteorologists during design		
• Improved forecasts of solar storm and their impact on space operations		
• Modernize local sensors • Initiate development of space-based sensors		Transition / optimize space-based weather sensors

Better sensors, models, and data fusion, communications, flexible lightning and upper-level wind launch commit criteria, better use of tools and expertise to develop safer vehicles, better mesosphere and space models.