REVISED WORK BREAKDOWN STRUCTURE
(Levels 2-3)

Level 1

HTCI Summary Strategic R&T Road Map

Level 2: Theme
Strategic R&T Theme

2.3
Bioastronautics

Level 3: Elements
Capability-Focused Technology Projects

- **Habitation** 2.3.1
- **Life Support Systems** 2.3.2
- **Environmental Monitoring & Control** 2.3.3
- **Human Factors & Habitability** 2.3.4
- **Adaptation & Countermeasures** 2.3.5
- **Space Medicine & Health Care Systems** 2.3.6
- **Biological Risk Prediction & Mitigation** 2.3.7
- **Biological Systems** 2.3.8
- **Extra-Vehicular Activity** TO BE COMPLETED BY XA 2.3.9

STRATEGIC TECHNOLOGY APPROACHES

2.3.1 HABITATION

Recycle plastic waste from consumables

- Reduce current rates of plastic waste (0.75 kg plastic trash/crew/day or 225 kg/3 crew/100 days)
- L:imit accumulation of tons of plastic waste over a multi-year mission

Use soft stowage (plastic) instead of metal racks, trays, etc.

Reduce current stowage overhead for crew (25-33% of supply mass)

- Change chemical properties via catalysts etc.
- Form, mold, machine, extrude, to make hermetically sealed sample/trash containers, tables, chairs, support structures, air filters, cloth, replacement parts, "Erector-set ™" components
- Make items that can be used later or used and returned to Earth for biggest savings

Reduce plastics mass by "family style" dining and preparation

New galley techniques for zero or reduced gravity dining and cooking

Wash clothes and cleaning towels

Reduce current use: 3 kg of clothes and towels/ crew/ day

Zero and reduced gravity clothes washing and drying equipment which recycles solvents (water, organic solvents, etc.)

Strategic Goal:
Reduce launch cost from savings in crew supplies

See detailed conclusions in:

D. Stillwell, R. Boutros, and J. Connolly. "Chapter 18: Crew Accommodations," pp.. 575-606 in W. Larson and L. Pranke *Human Spaceflight: Mission Analysis and Design*, McGraw Hill, 1999

2.3.1 HABITATION

DESCRIPTION

- Strategic technology research and development designed to improve recycling techniques, stowage solutions, repair and maintenance, and food preservation/preparation for long-duration missions.

APPROACH

- A diverse portfolio of R & D investments, guided by systems studies, including long-term, high-risk technology research and focused demonstrations.
- Extensive leverage of related R & D programs, U S & International

PARTICIPANTS

- NASA Centers, DOE, Other Agencies, Industry, Universities, International Space Agencies

MAJOR MILESTONES

YEAR ITEM

TECHNOLOGY ELEMENTS

- Technologies for recycling of plastics and other materials into items, such as containers, furniture, soaps, etc., that can be used during the mission
- Stowage hardware solutions designed to reduce mass (Soft Stowage)
- Smart Stowage system for tagging essential objects for monitoring, location, and data acquisition purposes
- Techniques for cleaning dirty garments and other soiled items
- Expert information system to aid in inflight repairs /maintenance
- Low mass solutions for the repair and replacement of parts
- New food preservation and preparation techniques designed to increase the storage life of food for long-duration missions while reducing mass and waste
- Methods for increasing the palatability, variety, and nutrition intake for long-duration mission diets

STRATEGIC TECHNOLOGY APPROACHES

2.3.2: LIFE SUPPORT SYSTEMS

2.3.2.1: AIR REVITALIZATION

- Remove CO_2 from vehicle & habitat atmospheres
- Process CO_2 to provide for O_2 for crew breathing
- Generate O_2 for crew breathing
- Control of trace gas contaminants

While minimizing mass, volume, power, thermal, & crew time requirements:

- Develop CO_2 removal technologies for use in microgravity (transit vehicle) & hypogravity (planetary surface habitat) to control CO_2 to SMACs
- Process all CO_2 in order to recover oxygen for reuse
- Generate O_2 and control to SMACs
- Control trace gas contaminants to SMACs

- Reduce overall mass of the life support system by a factor of 2 over the ISS baseline by FY04
- Reduce overall mass of the life support system by a factor of 3 over the ISS baseline by FY09

Strategic Goal:
Provide high-reliability, self-sufficient life support systems that minimize mass, power, volume, & crew time requirements

SMACs: Spacecraft maximum allowable concentration

STRATEGIC TECHNOLOGY APPROACHES

2.3.2 LIFE SUPPORT SYSTEMS

2.3.2.2 WATER RECOVERY

Remove organic contaminants from all wastewater

Remove inorganic contaminants from all sources of waste water

Insure potability of water in storage tanks & at human-use points

While minimizing mass, volume, power, thermal, & crew time requirements; and, while recovering >90% of all waste waters:

- Develop technologies to remove organics from wastewaters to SMAC's
- Develop technologies to remove inorganics from wastewaters to SMAC's
- Develop technologies to insure potability of water in storage tanks & at human-use points

- Reduce overall mass of the life support system by a factor of 2 over the ISS baseline by FY04
- Reduce overall mass of the life support system by a factor of 3 over the ISS baseline by FY09

Strategic Goal:
Provide high-reliability, self-sufficient life support systems that minimize mass, power, volume, & crew time requirements

2.3.2 LIFE SUPPORT SYSTEMS

2.3.2.3: BIOMASS PRODUCTION

Grow food crops for crew food, air revitalization, & water recovery

→

While minimizing mass, volume, power, thermal, & crew time requirements:

- Develop technologies to grow food crops in a microgravity environment (transit vehicles) to provide up to 15% of the crew's needs; AND
- Develop technologies to grow food crops in a hypogravity environment (planetary surface habitats) to provide up to 90% of the crew's needs
- With concomitant CO_2 uptake, O_2 production, and production of transpirate water

→

- Reduce overall mass of the life support system by a factor of 2 over the ISS baseline by FY04
- Reduce overall mass of the life support system by a factor of 3 over the ISS baseline by FY09

→

Strategic Goal:
Provide high-reliability, self-sufficient life support systems that minimize mass, power, volume, & crew time requirements

STRATEGIC TECHNOLOGY APPROACHES

2.3.2: LIFE SUPPORT SYSTEMS

2.3.2.4: FOOD PROCESSING

- Process bulk-stored products into menu items for crew consumption
- Process space-grown crops to storable items or directly to menu items

→

While minimizing mass, volume, power, thermal, & crew time requirements:

- Develop technologies to process bulk-stored items and/or space-grown crops in a microgravity environment (transit vehicles)
- Develop technologies to process bulk-stored items and/or space-grown crops in a hypogravity environment (planetary surface habitats)
- Produce minimum dust, noise, and limit equipment cleaning requirements (e.g., water)

→

- Reduce overall mass of the life support system by a factor of 2 over the ISS baseline by FY04
- Reduce overall mass of the life support system by a factor of 3 over the ISS baseline by FY09

→

Strategic Goal:

Provide high-reliability, self-sufficient life support systems that minimize mass, power, volume, & crew time requirements

2.3.2: LIFE SUPPORT SYSTEMS

2.3.2.5: SOLID WASTE PROCESSING

Process solid wastes to recover resources for reuse

While minimizing mass, volume, power, thermal, & crew time requirements:

- Develop technologies to process solid wastes in a microgravity environment (transit vehicles) (e.g., de-watering & sterilization for storage)
- Develop technologies to process solid wastes in a hypogravity environment (planetary surface habitats) to recover >85% of composite wet mass

- Reduce overall mass of the life support system by a factor of 2 over the ISS baseline by FY04
- Reduce overall mass of the life support system by a factor of 3 over the ISS baseline by FY09

Strategic Goal:

Provide high-reliability, self-sufficient life support systems that minimize mass, power, volume, & crew time requirements

STRATEGIC TECHNOLOGY APPROACHES

2.3.2: LIFE SUPPORT SYSTEMS

2.3.2.6: THERMAL CONTROL

Provide thermal control by acquiring waste heat, transporting it, and either using it (e.g., for drying crops) or rejecting it to the space environment.

→

While minimizing mass, volume, power, thermal, & crew time requirements:

- Develop technologies to acquire, transport, and use or reject waste heat in a microgravity environment (transit vehicles) (e.g., light-weight radiators & high efficiency heat exchangers))
- Develop technologies to acquire, transport, and use or reject waste heat in a hypogravity environment (planetary surface habitats)

→

- Reduce overall mass of the life support system by a factor of 2 over the ISS baseline by FY04
- Reduce overall mass of the life support system by a factor of 3 over the ISS baseline by FY09

→

Strategic Goal:

Provide high-reliability, self-sufficient life support systems that minimize mass, power, volume, & crew time requirements

STRATEGIC TECHNOLOGY APPROACHES

2.3.2: LIFE SUPPORT SYSTEMS

2.3.2.7: INTEGRATED GROUND TESTING – BIO-PLEX

Provide a HEDS ground test facility capable of safe, high-fidelity, long duration, autonomous testing with human test crews

Provide a high-fidelity test bed for biomedical research, human factors, environmental monitoring, etc.

Provide a high-fidelity test bed for evaluation of mission operations & training protocols

- Facility must be capable of conducting high-fidelity tests of candidate technologies necessary for HEDS missions
- Facility must be able to carry out atmospherically-sealed tests where all material loops (air, water, waste, food) are closed with only inputs of energy and information
- Facility must be capable of continuous tests >365 days

- Reduce overall mass of the life support system by a factor of 2 over the ISS baseline by FY04
- Reduce overall mass of the life support system by a factor of 3 over the ISS baseline by FY09

Strategic Goal:
Provide high-reliability, self-sufficient life support systems that minimize mass, power, volume, & crew time requirements

2.3.2 LIFE SUPPORT SYSTEMS

DESCRIPTION

- Provide highly reliable, self-sufficient life support systems which minimize mass, power, volume, & crew time requirements for vehicles & planetary habitats

APPROACH

- Develop technologies for providing
  - ✓ a breathable atmosphere, potable water, crop production, food processing, solid waste processing, & thermal control
- Demonstrate fully-tested mature technologies

POTENTIAL PARTICIPANTS

- Industry, universities, NASA centers, other federal agencies, international space agencies

POTENTIAL APPLICATIONS

- ISS
- HEDS missions

EXPECTED BENEFITS

- Enabling HEDS technology for self sufficiency
  - ✓ open-loop systems too mass intensive – must recycle
  - ✓ re-supply not practical
- Necessary to minimize mission risk while maintaining high levels of crew productivity

MAJOR MILESTONES

2001 Laboratory integrated water recovery system test complete; BIO-Plex build-up

2002 BIO-Plex Operational Readiness Inspection

2003 BIO-Plex 120-day closed chamber integrated test

2004 Delivery & integration of advanced life support technologies

2005 BIO-Plex 240-day closed chamber integrated test

2006 Advanced technologies to further reduce life support system mass
BIO-Plex 525-day closed chamber integrated test

2009 TBD, pending final analyses of test results

TECHNOLOGY ELEMENTS

- Air revitalization – CO_2 removal; O_2 generation; trace gas contaminant control; temperature & pressure control
- Water recovery – Collection & transport of waste water; organics & inorganics removal; maintenance of potability
- Solid waste processing – Collection & transport of solid wastes; recovery of resources for reuse; stabilization & storage of residues
- Biomass production – source for food; concomitant CO_2 uptake/O_2 production & transpirate water production
- Food processing – process bulk-stored and space-grown products for crew nutrition
- Thermal control – efficient heat acquisition, transport, rejection

STRATEGIC TECHNOLOGY APPROACH

2.3.3 ENVIRONMENTAL MONITORING & CONTROL

2.3.3.1 TOXICOLOGY

Analytical monitoring systems must be "smart systems" to function autonomously and provide the necessary information about the environment. Ground support will be unavailable in most situations

Specific compound sensors are required for distribution based on risk assessment, e.g., particulate monitor in airlocks or leak detector on heat exchangers

The total analytical system must be an extremely small package, utilizing few resources and requiring little maintenance activity

- Reduce crew involvement by 50%
- Protect crew health by enhancing the ability to cope with contingencies

Provide sensor response to specific risk in less than 2 minutes

Conservation of 20% more resources by early detection of air quality contingency events

- At least a 50% reduction in total system weight and volume (~25kg)
- A minimum of 70% less resources, e.g. carrier gases

Smaller size and resource reduction will permit systems to be distributed based upon risk assessments

Total system under computer / software control
- Instrument control
- Diagnostics / instrument health
- Data analysis
- Data interpretation (e.g., identification of unknowns)
- Recommended actions
- Possible feedback to other systems

- May be specific sensor or multiple sensors
- Monitoring interest
  - particulates
  - VOCs, e.g. benzene
  - reactive species, e.g. formaldehyde
- Multiple sensor locations

- Miniaturization without loss of required performance
- Small size and smart systems will permit distribution
- Technologies include spectroscopy, mass spectrometry, and ion mobility spectrometry
- Multiple technologies to address different monitoring interests

Strategic Goals:

Reduce resource allocation and launch costs by miniaturization and autonomous systems

Reduce crew health and safety risks by improving system response time

VOC: Volatile organic compounds

2.3.3 ENVIRONMENTAL MONITORING & CONTROL

2.3.3.1 TOXICOLOGY

DESCRIPTION

- Monitoring spacecraft internal environments for future missions beyond LEO, will require small, autonomous sensors measuring air contaminants, rapidly and in multiple locations in order to protect crew health. Additionally, monitoring particulates becomes a major issue in planetary habitats where dust is prevalent, e.g. Moon and Mars.
- **APPROACH**
- A diverse portfolio of R & D investments should include short-term low risk technology and long-term, high-risk technology research and focused demonstrations.
- Extensive leverage of related R & D programs, U S & International

PARTICIPANTS

- NASA Centers, DOD, Other Agencies, Industry, Universities, International Space Agencies

MAJOR MILESTONES

2001	Convene expert panels to assess potential technology candidate technologies in key areas (e.g. VOCs, particulates)
2005	Complete testing of candidate breadboard units
2008	Complete ground-based testing of prototypes and prepare for flight experiments
2011	Flight units ready for operational use

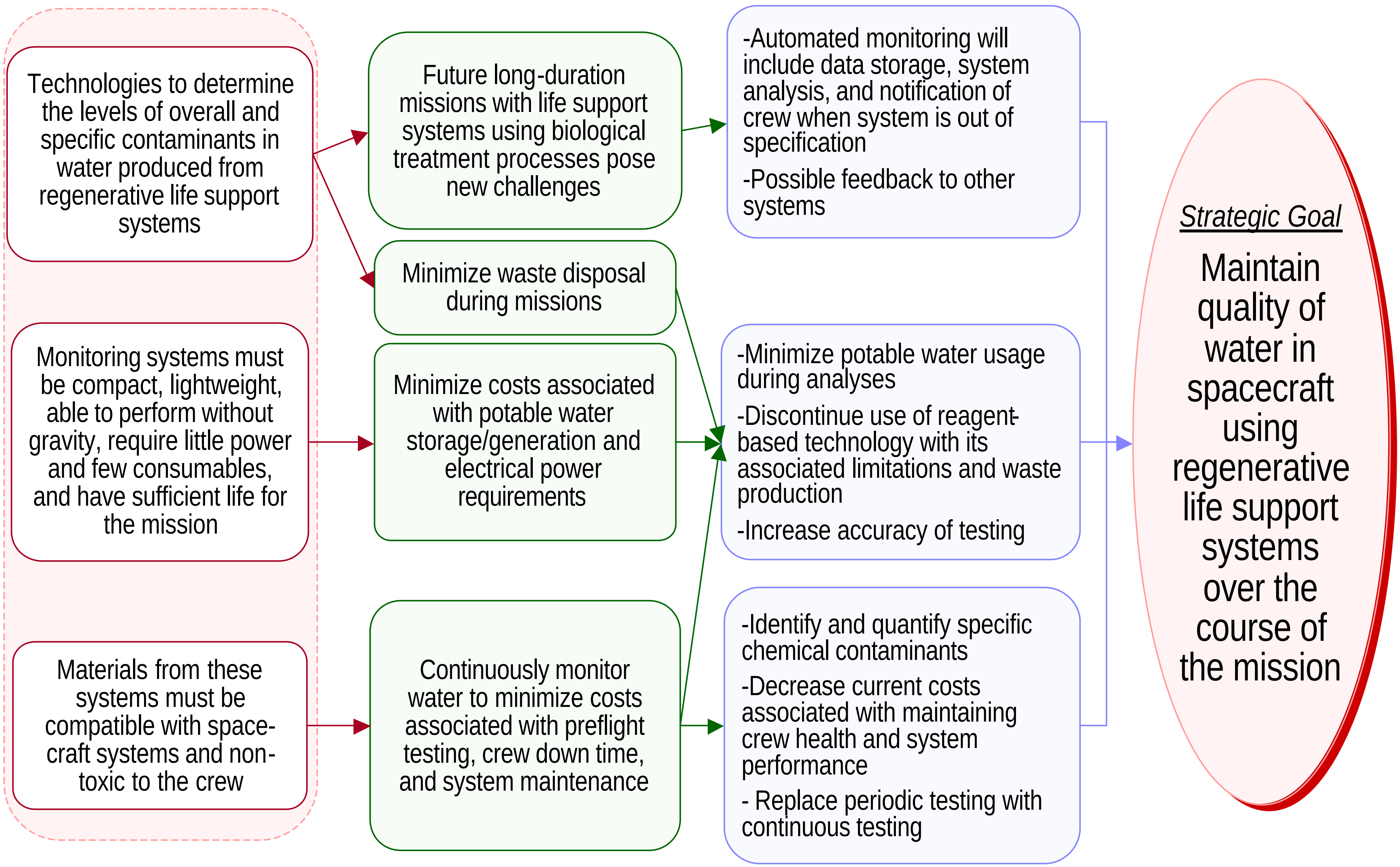
TECHNOLOGY ELEMENTS

- Analytically powerful instruments in very small packages
- Totally automated operation including interpretative software
- Development of artificial intelligence systems
- Detect compounds with specificity and no interference from other nominal spacecraft contaminants
- At trace levels, accurate identification (>95%) and quantitation (<+/-50%)
- Particulate counting, sizing, and composition (including ultraparticulates)
- Power and data connections are the only resources
- Reliability is a key factor since the sensor will be required to operate successfully for at least 3 years.
- The maximum maintenance should not exceed minor upkeep every 6 months (e.g., filter changes)
- Potential technologies
  - •Miniaturized /Spectrometers
  - •Spectroscopy detectors
  - •Ion Mobility Spectrometry on a chip
  - •Electrochemical/biological sensors on a chip
- Development of sensor distribution networks

RESEARCH & TECHNOLOGY EXECUTIVE SUMMARY

2.3.3 ENVIRONMENTAL MONITORING & CONTROL

2.3.3.2 WATER



2.3.3 ENVIRONMENTAL MONITORING & CONTROL

2.3.3.2 WATER

DESCRIPTION

- Development of methods and instrumentation for monitoring contaminant levels and toxicity in water from spacecraft and planetary base water reclamation and supply systems

APPROACH

- A diverse portfolio of R&D investments guided by NASA water quality experts including long-term, high-risk and miniaturization technology research followed by flight demonstrations

POTENTIAL PARTICIPANTS

NASA Centers, DOE, Other Agencies, Industry, Universities, International Space Agencies

POTENTIAL APPLICATIONS

- Monitoring of water quality in semi-closed and closed systems such as spacecraft, planetary bases, submarines, homes, and office buildings
- Monitoring of water quality in industries such as water purification, waste disposal, pharmaceuticals, semiconductor, and health care

EXPECTED BENEFITS

- Expanded capability to measure water quality contaminants in spacecraft
- Analytically powerful instruments in very small packages
- Labor savings for the space program including crew time
- Decreased risk of crew consuming unhealthy water

MAJOR MILESTONES

2001 Convene expert panel to assess technologies

2003 Develop breadboards and conduct proof-of-concept testing for competing technologies

2005 Develop prototypes for ground-based and in-flight demonstration testing of technology

2009 Flight units built and certification testing commences

2011 Reconvene expert panel to assess technology

TECHNOLOGY ELEMENTS

- Reagentless total organic carbon analyzers
- Miniaturized gas chromatograph/mass spectrometers for specific organic contaminants
- Advanced electrochemical sensors
- Direct spectroscopic methods using non-hazardous reagents
- Miniature capillary electrophoresis and ion chromatography systems for monitoring mineral and nutrient levels
- Miniature systems for analysis of trace metals in water
- Microgravity compatible sampling and preconcentration techniques for water quality contaminants
- Instrumentation to measure the toxicity of recycled water

STRATEGIC TECHNOLOGY APPROACHES

2.3.3 ENVIRONMENTAL MONITORING & CONTROL

2.3.3.3 MICROBIOLOGY

Automated systems will enable environmental systems to be monitored without preflight training and repetitious analyses during flight

Automated systems must be compact, light weight, able to perform without gravity, require little power and few consumables

Materials from these systems must be compatible with space craft systems and non-toxic to the crew

Limit crew involvement to replacement of minor consumables (as needed) or microbial remediation (if necessary).

Minimize biohazardous trash disposal during missions

Minimize costs associated with potable water storage/generation and electrical power requirements

Monitoring systems should be used to continuously monitor air and water to minimize costs associated with preflight testing, crew down time, and unnecessary disinfection

- Automated monitoring will include data storage, system analysis, and notification of crew when system is out of specification
- Possible feedback to other systems

- Minimize potable water usage during analyses
- Discontinue the use of media-based technology with its associated limitations and trash production
- Increase accuracy of testing

- Identification and enumeration of microorganisms
- Decrease current costs associated with maintaining crew health and system performance
- Replace periodic testing with continuous testing

Strategic Goal

Automate microbial monitoring systems to reduce resource allocation of launch and flight costs

2.3.4 ENVIRONMENTAL MONITORING & CONTROL

2.3.3.3 MICROBIOLOGY

DESCRIPTION

- Development of automated sensors for monitoring microbial flora

APPROACH

- Advanced imaging, immunofluorescent labeling, molecular enumeration and identification

POTENTIAL PARTICIPANTS

NASA Centers, DOD, Industry, Universities

POTENTIAL APPLICATIONS:

- Microbial monitoring in semi-closed systems such as submarines, aircraft, and office buildings
- Microbial monitoring in industries such as harmaceuticals, water purification and health care

EXPECTED BENEFITS:

- Detection of unculturable pathogens
- Widespread/portable microbial analytical capabilities
- Labor savings for the space program

MAJOR MILESTONES

2001 Convene expert panel to assess technologies

2003 Re-convene expert panel to review feasibility of competing technologies

2005 Develop prototypes for ground based and in-flight testing of technology

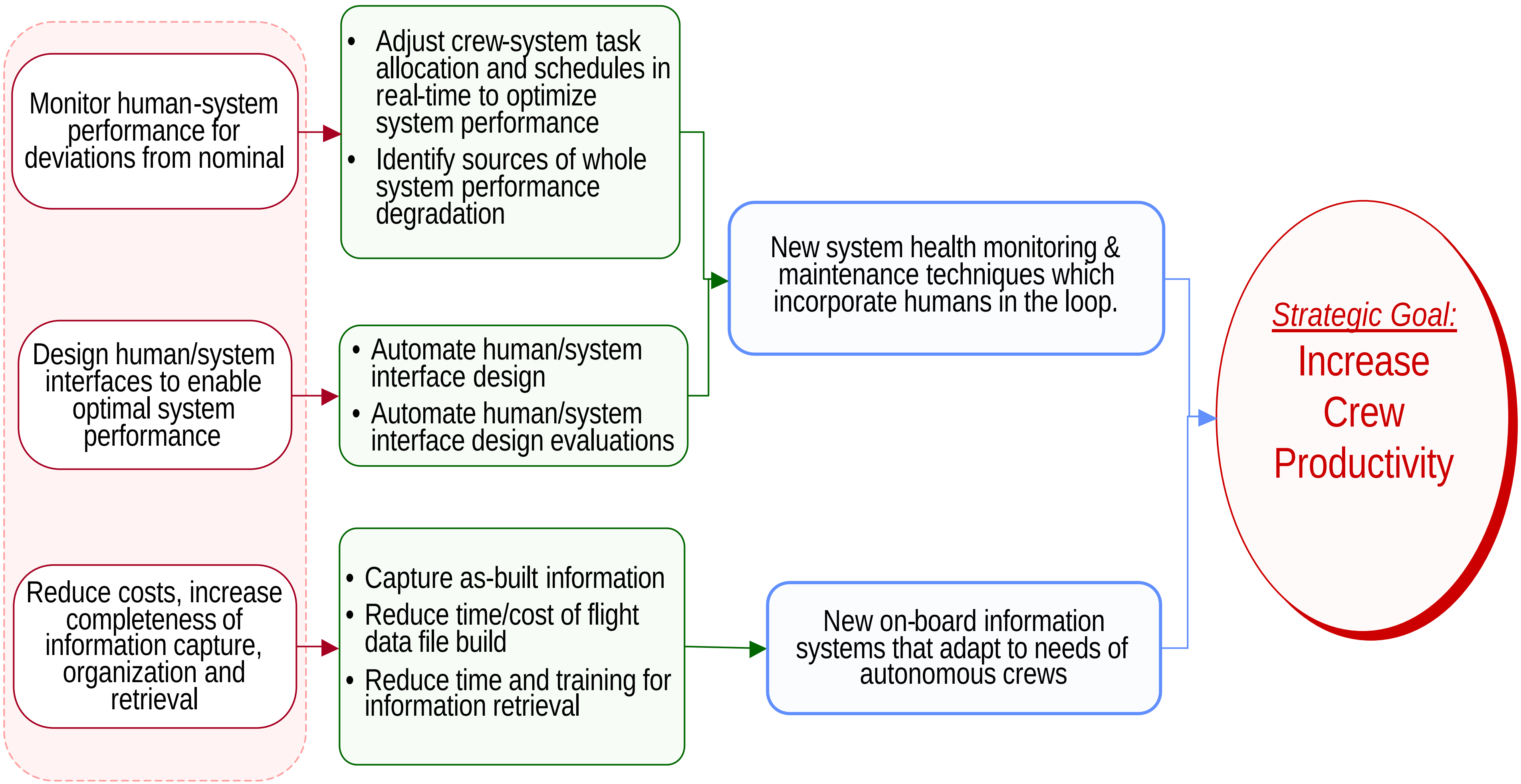
2009 Flight units built and testing commences

TECHNOLOGY ELEMENTS

- Resources limited to power and small volume, non-expiring consumables
- Ability to quantify all microbial flora and identify and enumerate medically significant microorganisms
- No more than minor maintenance every 6 months
- Must interact with on board computer systems

STRATEGIC TECHNOLOGY APPROACHES

2.3.4 HUMAN FACTORS



See detailed conclusions in:

D. Stillwell, R. Boutros, and J. Connolly. "Chapter 18: Crew Accommodations," pp. 575-606 in W. Larson and L. Pranke *Human Spaceflight: Mission Analysis and Design*, McGraw Hill, 1999

2.3.4 HUMAN FACTORS

Reduce training costs and time →

- Create adaptive training programs geared to space flight
- Create just-in-time training programs
- Create tools for automated lesson development
- Develop training assessment tools

→ On board training system that provides refresher training and training for new or infrequent tasks

→ *Strategic Goal:* Reduce training time and costs

Reduce environmental stress →

- Reduce ambient noise
- Enable reconfigurable habitat design
- Reduce time required for IFM

→ New design, construction methods to provide a habitat adaptable to crew needs during all mission phases

→ *Strategic Goal:* Reduce stressors to increase productivity

IFM: In-flight maintenance

2.3.4 HUMAN FACTORS

DESCRIPTION

- As mission duration increases, human factors, behavior, and crew performance become increasingly critical factors in the success of both exploration-class and low-Earth orbit (LEO) missions. Recognition of the importance of these factors in mission design leads to increased crew productivity and helps ensure that crew tasks can be accomplished. The ultimate goal of this topic is to ensure successful mission performance through maintaining crew well-being.

APPROACH

- A diverse portfolio of R & D investments, guided by systems studies, including long-term, high-risk technology research and focused demonstrations.
- Extensive leverage of related R & D programs, U S & International

PARTICIPANTS

- NASA Centers, DOE, other agencies, industry, universities, International Space Agencies

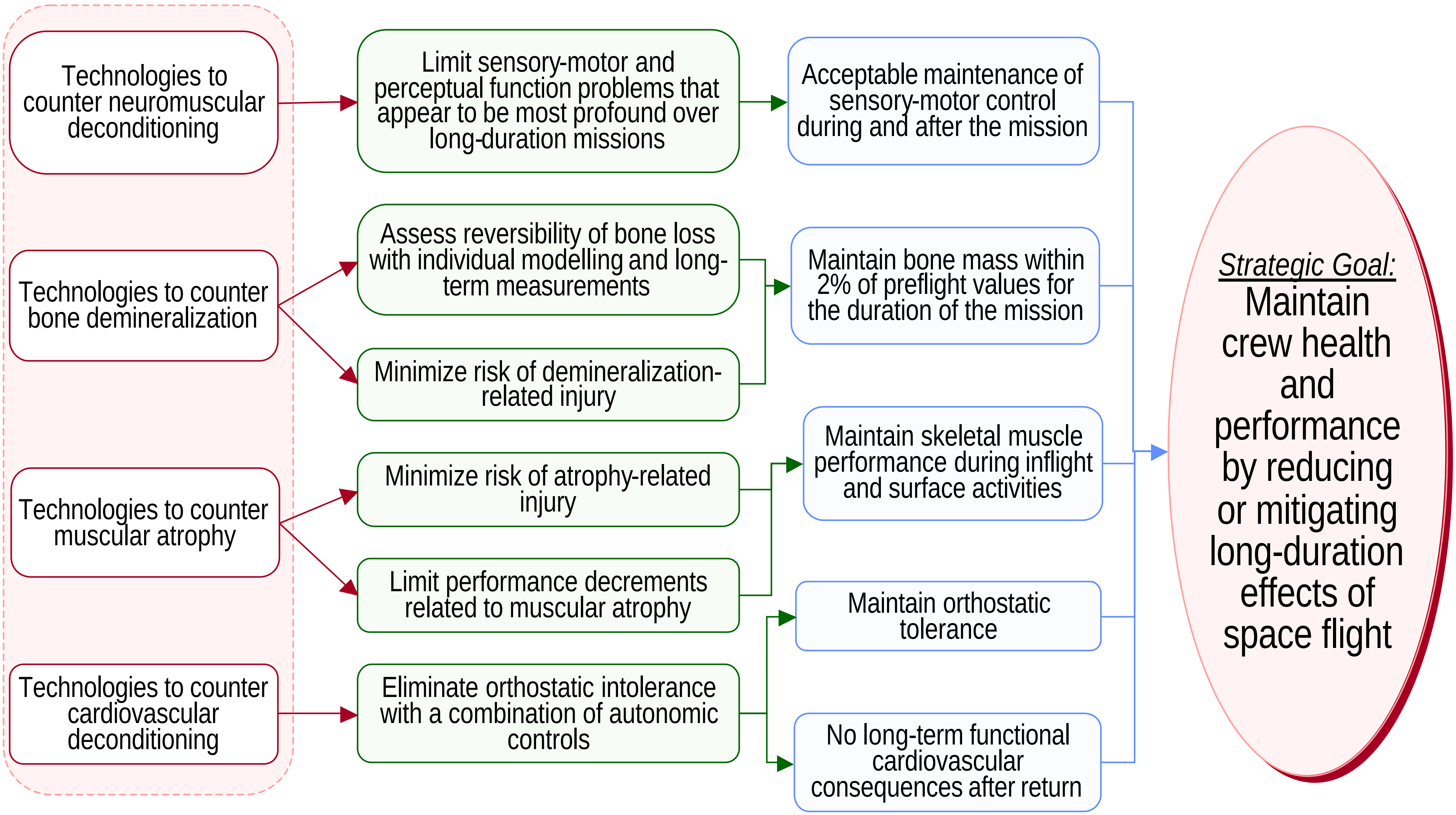
MAJOR MILESTONES

TECHNOLOGY ELEMENTS

- Technologies and tools for measuring performance in tasks
- Tools and techniques for modeling complex missions with multiple participants
- Tools for design time information collection/capture for training
- Tools for monitoring individual and group performance over time
- Advanced VR system and authoring languages for VR training systems
- Measurement techniques for determining personal space, time, and privacy requirements
- Tools to measure to measure personal preference for habitability factors in individual crew members
- New materials, designs, and construction methods to provide a habitat adaptable to crew needs during all mission phases
- Automate human/system interface design
- Automate human/system interface design evaluations

STRATEGIC TECHNOLOGY APPROACHES

2.3.5 ADAPTATION & COUNTERMEASURES



2.3.5 ADAPTATION & COUNTERMEASURES

DESCRIPTION

- Technologies for improving human adaptation to space mission environments need to be developed for the new beyond low-Earth orbit missions envisioned by NASA.
- Significant decrements in several human systems have been noted under certain space flight conditions, including bone, muscle, heart and vestibular.

APPROACH

- A diverse portfolio of R & D investments, guided by systems studies, including long-term, high-risk technology research and focused demonstrations.
- Extensive leverage of related R & D programs, U S & International

PARTICIPANTS

- NASA Centers, DOE, other agencies, industry, universities, international space agencies

MAJOR MILESTONES

YEAR ITEM

TECHNOLOGY ELEMENTS

- Artificial gravity countermeasures (intermittent or continuous rotation of centrifuge or spacecraft)
- Inflight, compact, light-weight equipment to measure bone mineral density (BMD)
- Finite element analysis methods and equipment for skeleton measurements/analysis with minimal radiation
- Countermeasures program to maintain orthostatic tolerance for landing, planetary excursion, emergency, entry, egress, and postflight rehabilitation
- Ways to evaluate the role of proprioceptive and somatosensory information in sensorimotor functions
- Techniques for measuring orientation and perceptual disturbances
- Tests/devices for evaluating adaptive changes in spatial orientation during spaceflight
- Means for preflight adaptation to altered sensory inputs to reduce sensorimotor disturbances, spatial orientation and perceptual disturbances, and space motion sickness

STRATEGIC TECHNOLOGY APPROACHES

2.3.6 SPACE MEDICINE & HEALTH CARE SYSTEMS

Advanced Systems Concepts

- Advanced spectroscopy
- Advanced iontophoresis
- Highly focused, high energy ultrasound
- Ultrasensitive sensor technology
- Gene maps
- Advanced biomaterials
- Voice recognition
- Pattern recognition
- Real-time 3D imaging
- Highly efficient water purification technologies
- Nanotechnology

Technology Challenges

- Non-invasive blood parameter monitoring
- Automated endoscopy
- Robot-assisted surgery
- Non-invasive bone healing
- Artificial blood products
- Closed-loop respiratory systems
- Low-power, compact oxygen generation systems
- Non-invasive surgery
- Programmable microprobes and sensors
- Image database of pathologies
- DNA monitoring systems
- In-situ biomaterial manufacturing
- Closed-loop drug delivery systems
- In-situ IV fluids formulation
- Micro/fractional-gravity fluid suction with air/fluid classification

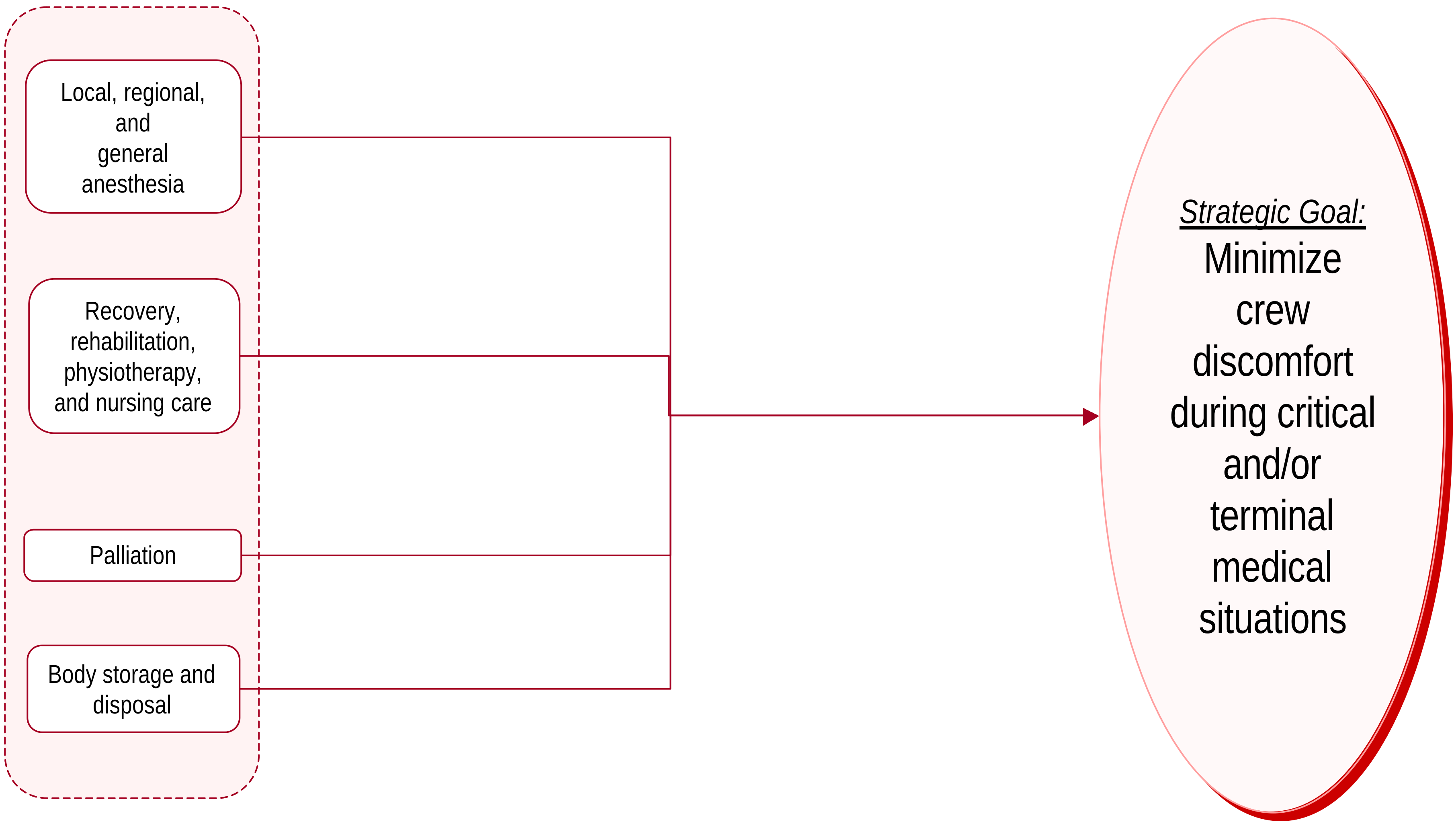
Increase crew survival rates and return

- Major surgery with advanced trauma life support
- Advanced cardiac life support including defibrillation, cardioversion, and pacing
- Storage and administration of autologous, donor, or substitute marrow and blood products
- Advanced respiratory care
- Parenteral or enteral nutrition

<u>Strategic Goal:</u>
Maximize crew independence and survival during a critical medical situation

STRATEGIC TECHNOLOGY APPROACHES

2.3.6 SPACE MEDICINE & HEALTH CARE SYSTEMS

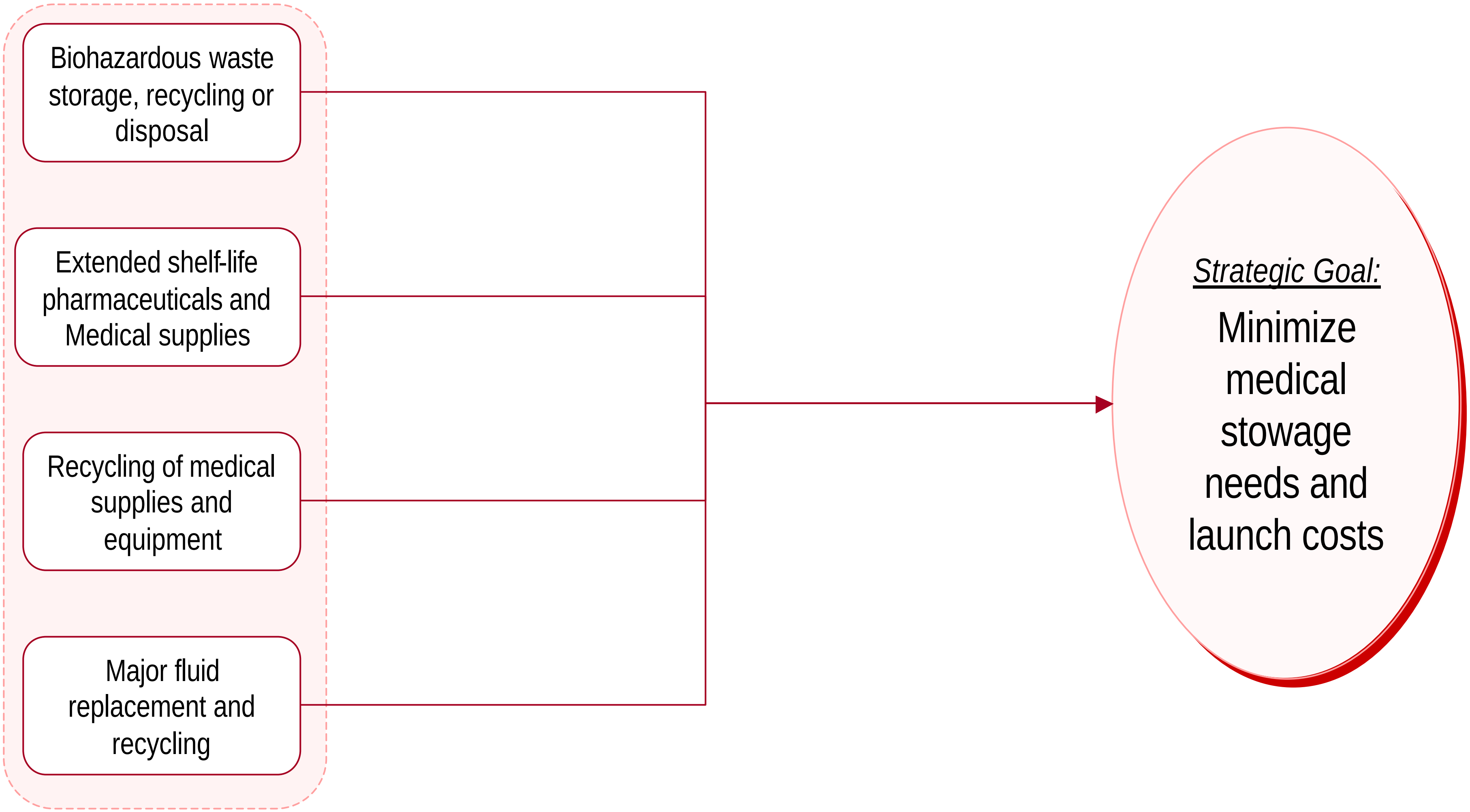


Level 4: Technology Challenges

Level 3: Architecture-Level Goal

STRATEGIC TECHNOLOGY APPROACHES

2.3.6 SPACE MEDICINE & HEALTH CARE SYSTEMS

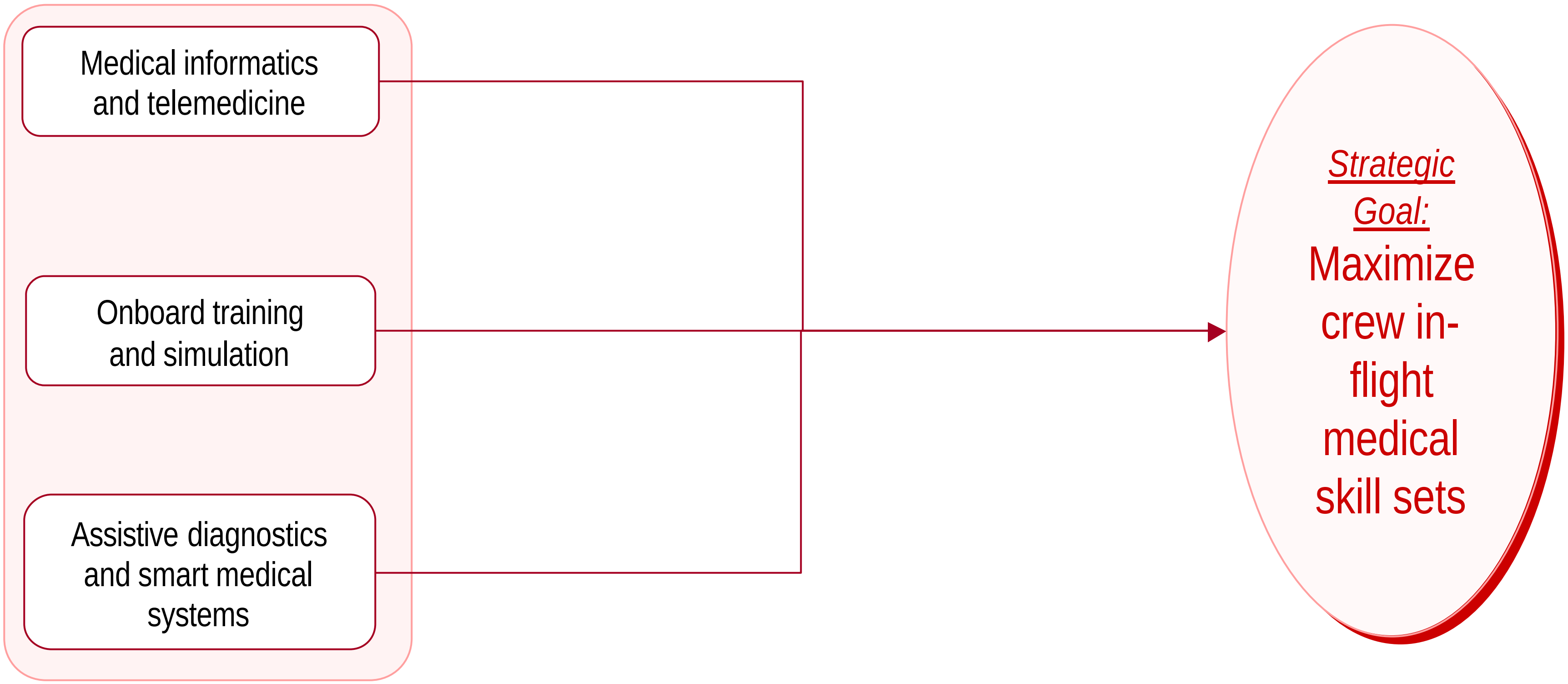


Level 4: Technology Challenges

Level 3: Architecture-Level Goal

STRATEGIC TECHNOLOGY APPROACHES

2.3.6 SPACE MEDICINE & HEALTH CARE SYSTEMS



Level 4:
Technology Challenges

Level 3:
Architecture-Level Goal

STRATEGIC TECHNOLOGY APPROACHES

2.3.6 SPACE MEDICINE & HEALTH CARE SYSTEMS

Strategic Goal:

Maximize crew independence and survival during a critical medical situation

Functional Objectives

- Major surgery with advanced trauma life support
- Advanced cardiac life support including defibrillation, cardioversion, and pacing
- Autologous, donor or substitute marrow and blood products storage and administration
- Advanced respiratory care including microgravity suction with air/fluid classification
- Parenteral or enteral nutrition

Advanced System Concepts

- Non-invasive blood parameter monitoring
- Endoscopy
- Robot-assisted surgery
- Non-invasive bone healing
- Oxygen therapeutics and blood substitutes
- Closed-loop respiratory systems
- Low-power, compact oxygen generation systems
- Artificial organs/cloned organs

Technology Challenges

- Wireless broadband telemetry
- Biocompatible materials
- Nanotechnology as applied to air filters*
- Non-invasive drug delivery
- Highly focused, high-energy ultrasound
- Three-dimensional non-invasive imaging

*** "Common thread" with Environmental Monitoring & Contol**

Level 3: Architecture-Level Goal → **Functional Objectives** → **Advanced System Concepts** → **Level 4: Technology Challenges**

2.3.6 SPACE MEDICINE & HEALTH CARE SYSTEMS

DESCRIPTION

- A multi-disciplined program designed to increase the in-flight health care capabilities through advanced medical technologies and procedures, training techniques, and telecommunications.

APPROACH

- Established relationships with the Department of Defense, the Telemedicine and Technology Research Center (TATRC), Academia, and Industry to leverage resources and common interests

PARTICIPANTS

- NASA Centers, DOD, Other Agencies, Industry, Universities, International Space Agencies

MAJOR MILESTONES

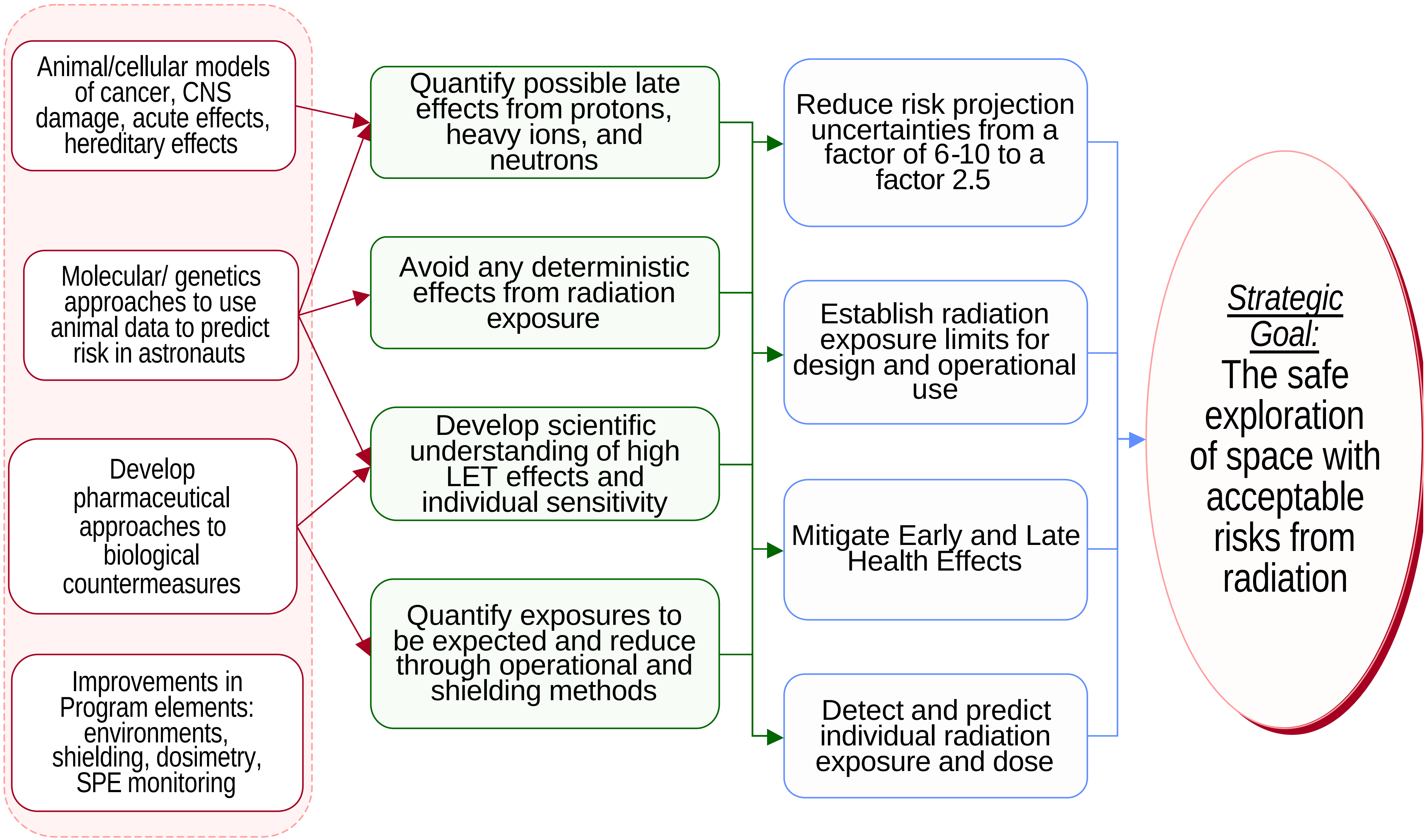
YEAR	ITEM

TECHNOLOGY ELEMENTS

- Advanced medical procedures designed to diagnose space specific medical risks
- Non-invasive imaging
- Non-invasive and minimally invasive blood analysis and techniques
- Advanced training platforms and scenarios
- Methods for decreasing crew medical training requirements
- Test bed identification and implementation
- Technology monitoring, assessment, and forecasting of industry
- Artificial Blood and Hemoglobin-Based Oxygen Carriers
- Expert Medical Systems; Smart Medical Databases
- Medical Informatics
- Telecommunications and medical data security

STRATEGIC TECHNOLOGY APPROACHES

2.3.7 BIOLOGICAL RISK PREDICTION & MITIGATION



SPE: solar particle event

RESEARCH & TECHNOLOGY EXECUTIVE SUMMARY

2.3.7 BIOLOGICAL RISK PREDICTION & MITIGATION

DESCRIPTION

- Future missions beyond low-earth orbit will subject crews to levels of radiation higher than current space programs have encountered with a significant fraction of exposures from heavy ions. Goal are to understand the possible risks with sufficient accuracy to advise crews and to develop methods to mitigate effects using operational, shielding, and pharmaceuticals approaches.

APPROACH

- A diverse portfolio of R & D investments, guided by systems studies, including long-term, high-risk technology research and focused demonstrations.
- Extensive leverage of related R & D programs, U S & International

PARTICIPANTS

- NASA Centers, DOE, NCI, NIA, Universities, International Space Agencies

MAJOR MILESTONES

1. First data set for Leukemia in an animal model for heavy ion exposures
2. First data set for Solid tumors in an animal model (at least two)
3. Knowledge of mouse strain dependence of tumor induction from heavy ions
4. Understanding of role of microlesions in late CNS effects
5. Reduce uncertainty levels in risk prediction in order to begin design phase for Mars mission by 2010

TECHNOLOGY ELEMENTS

- Animal/ cellular models of human carcinogenesis including tumor induction data
- Animal/cellular models of late deterministic effects including cataracts, accelerated aging, etc.
- Molecular biology and genetic approaches to extrapolate animal data to predict risks in humans
- Scientific understanding of action of pharmaceuticals on high-LET lesions
- Scientific understanding of individual variations to radiation sensitivity for high-LET radiation
- Models, sensors and systems to measure the effects of radiation upon humans
- Chemical and biological modifiers and radioprotectants including gene therapy approaches
- Early warning system for predicting/ monitoring Solar Particle Events