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Space Administration

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Advanced Range Technologies- Unmanned Aircraft Systems (UAS)

NASA John F. Kennedy Space Center
Advanced Systems

KSC is the National Center for Next-Generation Range Technology Development and Demonstration

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White House directs NASA-KSC and Air Force to lead Next-Generation Range Concepts

White House directs NASA-KSC and Air Force - Cooperatively formulate a *national vision* for the development and implementation of next-generation Range concepts on the primary U.S. space launch bases – ER, WR, Kennedy Space Center. - Presidential Signature – April 6, 2000

Report: "*The Future Management And Use of the U.S. Space Launch Bases and Ranges*";
White House working group co-chairs: Office of Science and Technology Policy; National Security Council

- **Why? To Enhance National Security through *strategic* launch base improvements that come from increased commercial space launches**

- **Implementation? *MOA Between NASA and the Air Force.***

  The Advanced Range Technologies Working Group **(ARTWG), under the national leadership of NASA and the USAF, was chartered to lead the nation's "Future Management and Use of the U.S. Space Launch Bases and Ranges" to develop a plan to examine, explore, and proceed with next-generation range technology development and demonstration.**

- **UAS technology? NASA and AF identified the need for UAS/HAA (High Altitude Airship) technology to support launch and landing operations through the integration of space-based range sensor systems.**

Goal

➢Next generation range technologies will be essential to improve safety and reduce costs by orders of magnitude.

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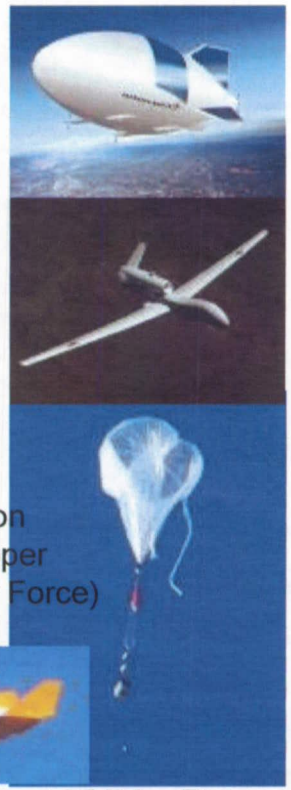
Unmanned Aircraft Systems

A national team (Advanced Range Technology Working Group – ARTWG) led by NASA and the Air Force determined that an integration of Unmanned Aircraft Systems (UAS) -- such as fixed wing/rotary wing unmanned aircraft systems, High Altitude Long Endurance (HALE) unmanned systems, and steerable balloons -- is required to supplement existing range assets for the future management and use of U.S. space launch bases and ranges.

Future range operations will integrate manned and unmanned aerospace systems in the National Air Space (NAS) enabling high launch rate operations.

UAS range functions as identified by the NASA programs and the Air Force:

- **To be a relay site** between launch vehicles and ground-based operations control centers
- To provide data relay for tracking, telemetry, and launch vehicle commanding
- **To provide rapid responses; tracking and surveillance ~thermal, optical, radar systems**
- **To support nuclear missions and launch anomalies** by providing ability to safely measure the contents of a launch plume in the event of an accident as the plume floats into the NAS towards populated areas
- **To permit real-time, simultaneous monitoring of near-field and far-field booster splash down zones**
- **To obtain toxic release data** to improve toxic release models and risk management planning
- **To provide broadband communication** extending to large areas
- To provide real-time weather sensing platforms at various altitudes (i.e., wind, precipitation, lightning)
- **To monitor environmental impacts** (e.g., manatees, eagles, sea turtles, vegetation) and improve wildfire prevention and surveillance



Talon
Topper
(Air Force)

Balloon Ascent / Glider Return

✓ **Air Force 45th Space Wing and NASA-KSC share a joint requirements process for UAS operations at CCAFS, PAFB, and Kennedy Space Center => Eastern Range.**

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NASA Shuttle Landing Facility

NASA-KSC is dedicated to providing to customers access to the Shuttle Landing Facility for ground and flight activities for approved operations. The Shuttle Landing Facility (SLF) is a FAR Part 139 compliant airport. The SLF runway is 15,000 feet long and 300 feet wide

Kennedy Space Center (KSC) is located on the east coast of Florida, comprised of 140,000 acres but only a very small part of the total acreage of KSC has been developed or designated for NASA operational and industrial use. KSC consists of prime habitat for unique and endangered wildlife; Both KSC and Cape Canaveral Air Force Station (CCAFS) airports have Class D airspace wholly within zones of Restricted airspace.

Eastern Range Special Use Airspace.
The Eastern Range (airspace) is controlled by the AF 45th Space Wing. The Eastern Range utilizes a set of airspaces of various types as defined by the FAA. Some of these defined airspaces overlap, but each type has specific control requirements per FAA regulations.

Aerial view of SLF from the south

Low level aerial view of SLF of parking area

UAS operations may be confined to specific airspaces, may extend far beyond these airspaces, or be restricted to a small subset of an airspace or two.

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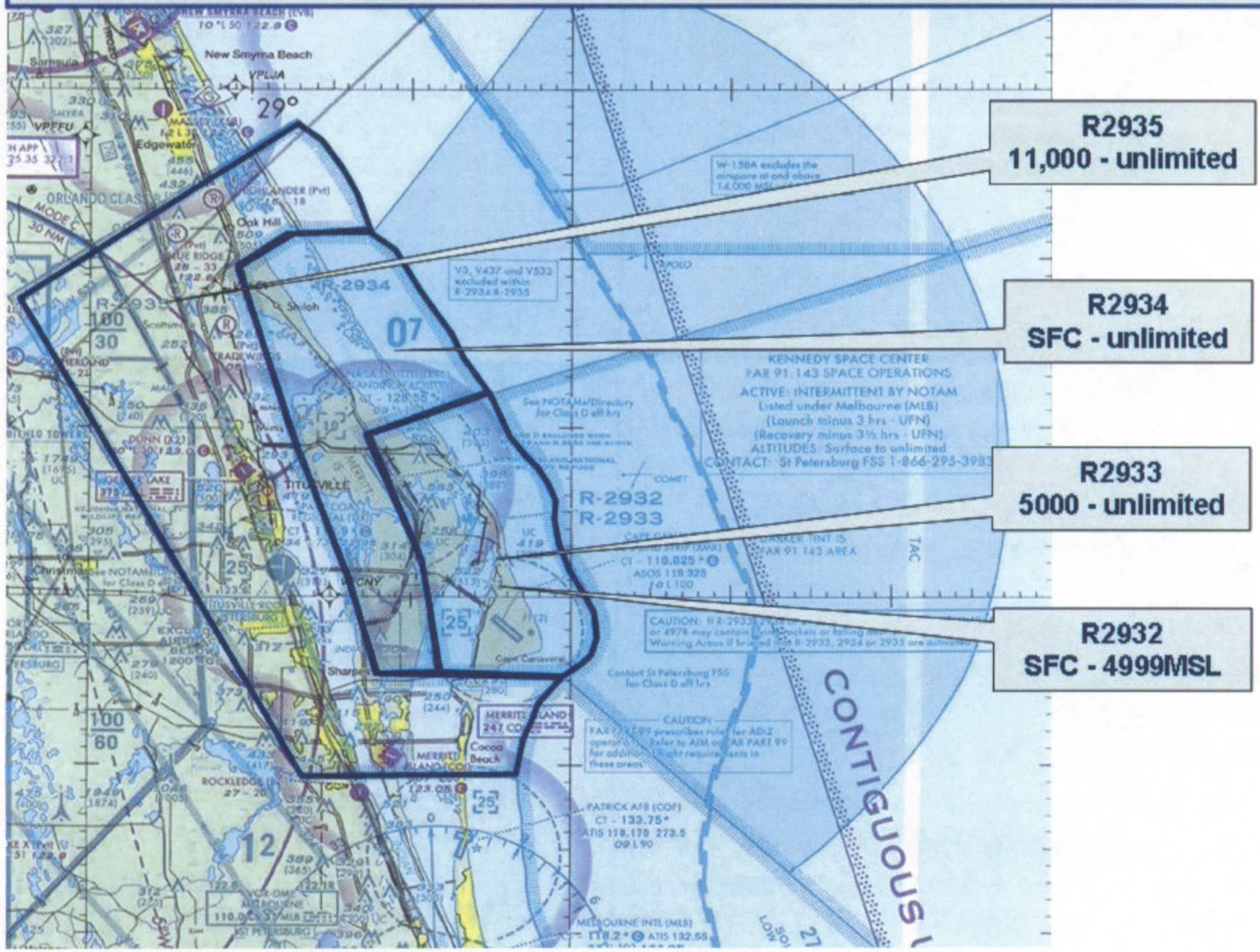
Eastern Range Special Use Airspace

RESTRICTED AIRSPACE



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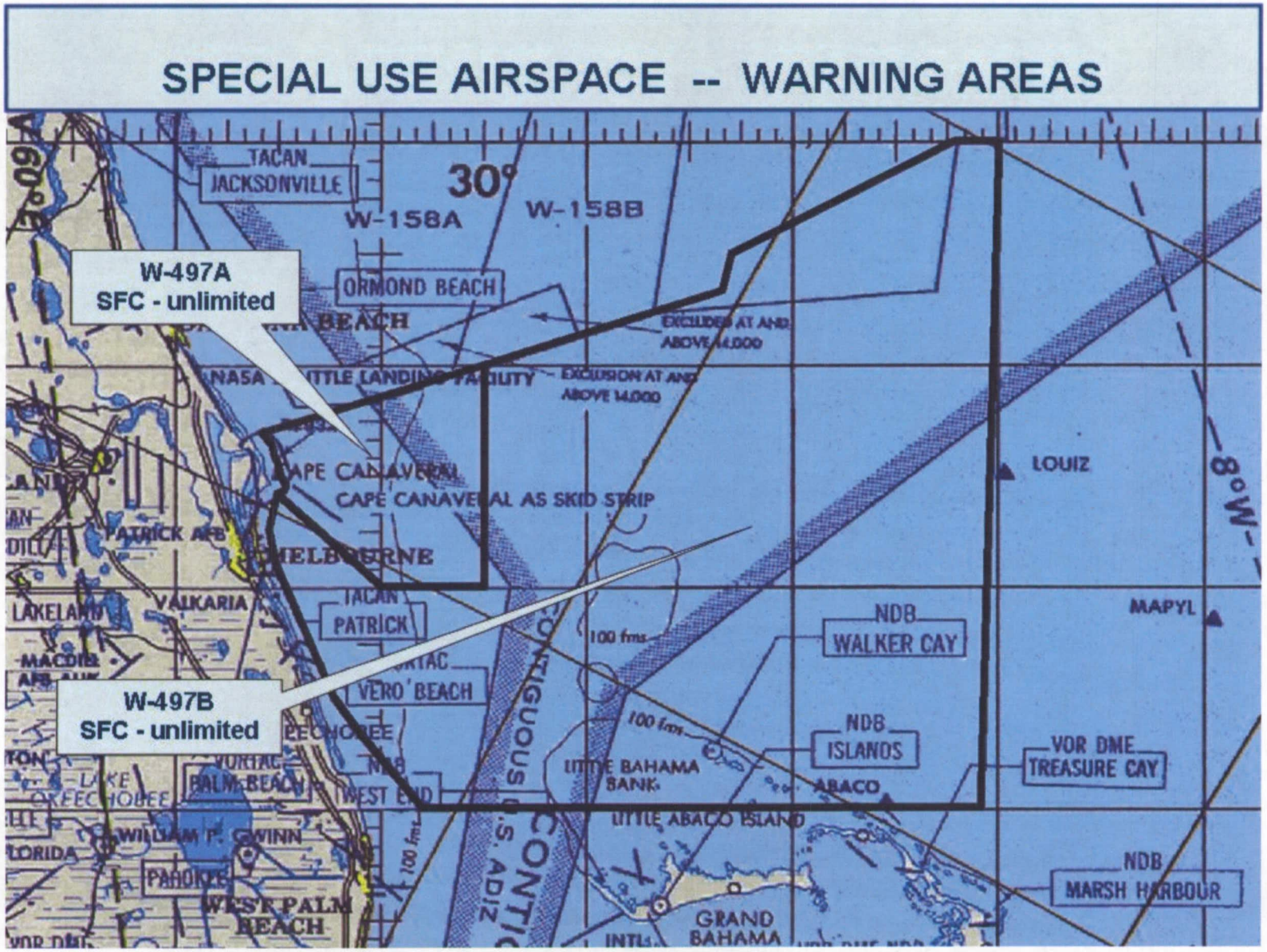
Eastern Range Special Use Airspace



NASA-AF UAS Program Plan

- **Establish NASA-AF UAS Customer Process, UAS Requirements, UAS Concept-of-Operations (CONOPS) for mission support**
- **Build UAS customer base for development and demonstration of instrumentation and systems to meet NASA-AF range CONOPS goals**
- **Partner with Services, Agencies, and Coalition elements to provide the best capabilities for future launches, with the benefit of simultaneous mission needs and cost sharing**
- **Seek the very best technical and operational concept solutions from Defense, industry and academic sources**
- **Host national range demonstration events to leverage "try before you buy" for govt. agencies, giving CONOPS requirements for system operational goals to encourage commercial partnering, and forging partnerships to create new technology and operational concept solutions for U.S. space launch bases and ranges**

KSC Vision for Future Role in UAS Development and Implementation

UAS for Future Ranges:

- Platforms for Tracking and Surveillance utilizing
  - Thermal Imaging
  - Optical Imaging
  - MMW Imaging
  - Radars

- Platforms for Sensing technologies
  - Weather
  - Chemicals

- Platforms for Telemetry Relays for extended range and redundancy to:
  - Other aerial platforms
  - Ships
  - Ground stations
- Platforms for Communications extending to large area
  - HDTV
  - Wireless systems (iNET)
  - Space Internet (IRIS)

How will they be operated?

✓Autonomous systems

✓State-of-the-art Ground Stations
- Control and Monitor swarms
- Integrate with manned vehicle displays
- Utilize virtual reality displays

Strategy

✓Establish model of future range incorporating all types of sensors and platforms and communication systems for a responsive Range.

✓Perform major work in architecture and ground control systems.

Technology Gap:

KSC has the opportunity to be a world leader in state-of-the-art range architecture which includes simultaneous monitoring and control of Manned and autonomous unmanned vehicles (swarms) in FAA airspace utilizing leading edge communication systems and ground control Stations, incorporating mixed reality (virtual and real) systems. This model can be extended to extra-terrestrial spaceports.

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DFRC Aircraft

http://www.nasa.gov/centers/dryden/aircraft/index.html

Global Hawk

Dryden recently acquired two Global Hawk Advanced Concept Technology Demonstrators.

Ikhana

NASA operates this modified Predator B to conduct long-duration Earth science missions and validate promising aeronautical technologies.

Ikhana is a Choctaw Native American word for "intelligent, conscious, or aware." NASA uses this airborne platform to demonstrate and validate electronic sensor technologies, conduct long-duration Earth observation; and develop technologies that improve the capability, reliability, and safety of manned and unmanned aircraft.

UAS Paradigm Development

- **Requirements applied to a spectrum of UAS operations**
  - Tailor from RCC 323-99, "*Range Safety Criteria for Unmanned Air Vehicles*"
  - Succinct risk requirements and an appendix with informational guidance
- **Develop a risk control process**
  - Spectrum of issues
  - Requires a variety of controls
  - Manage risk without compromise to established risk criteria
- **Logic trees to facilitate UAS Range User understanding of requirements and potential alternatives**
  - Calling various requirements from AFSPCM 91-710 as a function of risk generating issues
  - Enabling consideration of an array of risk mitigation solutions
- **Goal is to attain a business acumen**
  - Versus delivering a requirements onslaught
  - Minimized top-level performance-based requirements
  - Supplement by an appendix of suggested, but not required, solutions
- **Contingency Management Systems (CMS)**
  - CMS is a system that may be aboard a UAV in order to fulfill risk mitigation necessary to bring risks to within acceptable thresholds
  - As such, it may be a key factor into the Range Safety approved risk management solution for a particular UAS operation
  - Activation of a CMS shall not increase the risk to people or property
- **Establishing Areas of Responsibility (AORs)**
  - The Air Force Range Commander
  - Range Safety
  - Range User
  - Aircraft Manager
  - Engineering
  - The Center Director, NASA Kennedy Space Center
  - UAS Range User with unique Class D Controlled Airspace authority
  - Federal Aviation Administration (FAA)
  - Some overlap of responsibilities is likely to occur

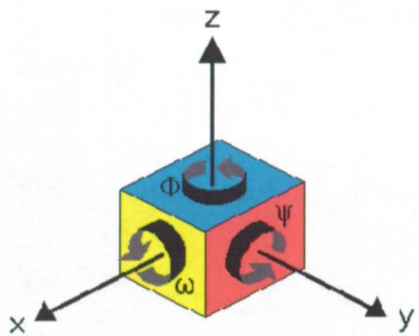
Managing Risk: Degrees of Freedom

Parameters to Consider

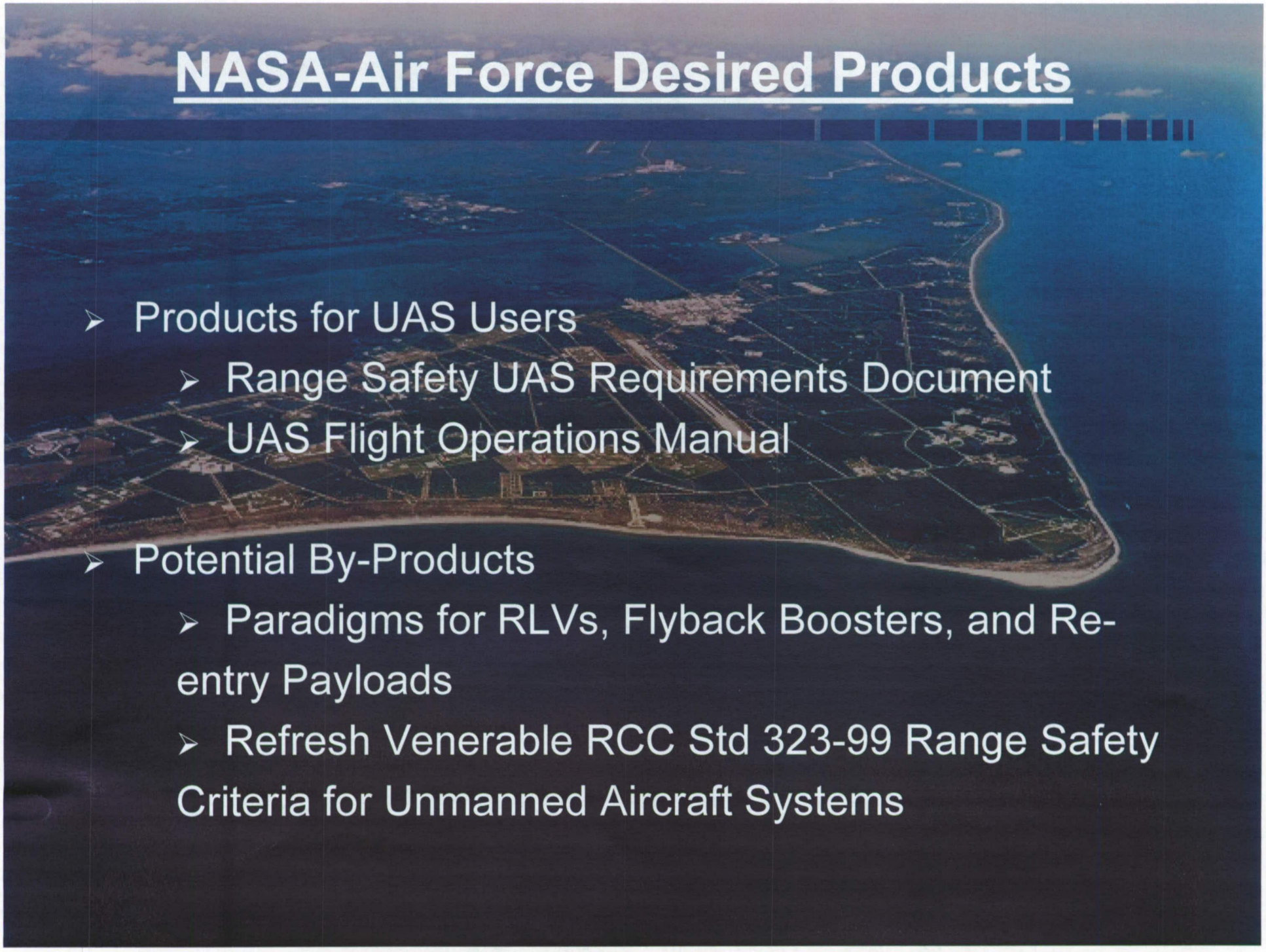
- **Risk Criteria – least likely to be altered**
- **Hazard Recognition - Flight Safety Analysis**
  - **Vehicle Reliability**
    - Failure modes
    - Probabilities of Failure
    - Breakup characteristics
    - Consequence assessment
  - Momentum
  - Propellant
    - Distance traversable
    - Combustion and dispersal
  - Proximity and dwell time to people and critical assets
  - Uncertainty
- **Flight and Airspace Controls**
  - Safety Action Lines
  - Control box limits
  - Flight path limits
  - Fuel load/distance limits
  - Freedom of flight/maneuver limits
- **Contingency Management Systems**
  - Debris and other hazards from Range Safety System action
  - Coefficient of restitution
  - Reliability/Uncertainty

High Performance Work Team

- **Consists of Range User and Range Safety**
  - Identify an array of acceptable risk solutions
  - Find solution most preferred by the Range User
- **Give the Range User Information to Design To:**
  - Selection of UAV Platform
  - Payload and Mission Profile to meet mission goals as well as Range requirements



NASA-Air Force Desired Products



- Products for UAS Users
  - Range Safety UAS Requirements Document
  - UAS Flight Operations Manual
- Potential By-Products
  - Paradigms for RLVs, Flyback Boosters, and Re-entry Payloads
  - Refresh Venerable RCC Std 323-99 Range Safety Criteria for Unmanned Aircraft Systems