Conf Paper/IN/16

S/D

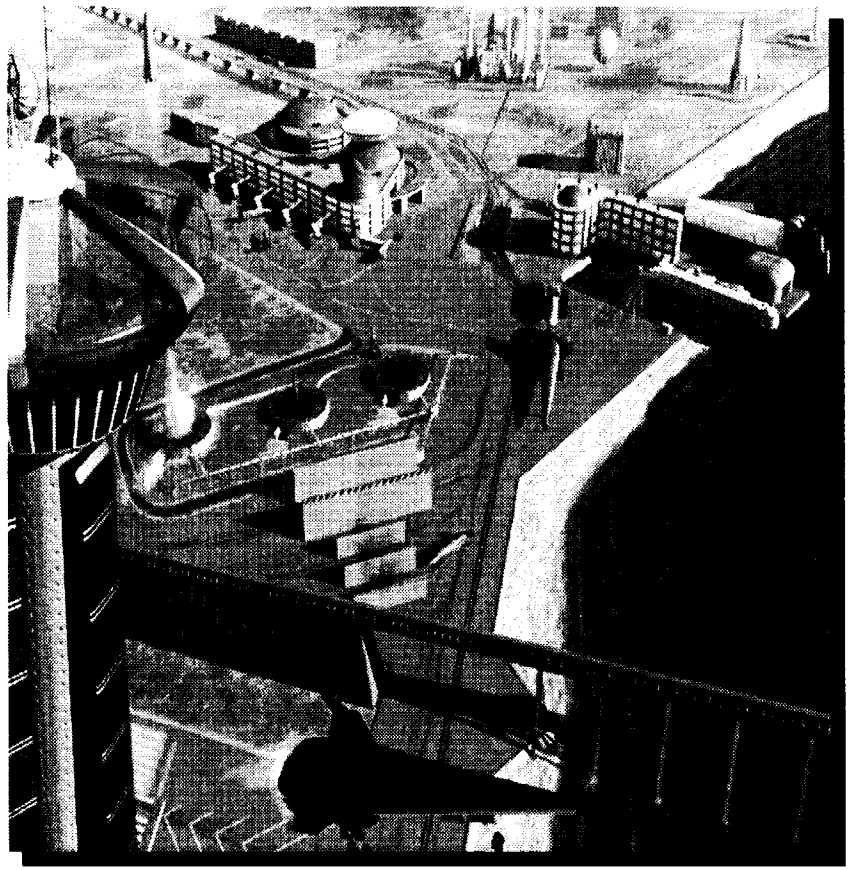
25P

Advanced Range Technologies

Richard A. Nelson
NASA/KSC
YA-E6
(321)867-3332
richard.nelson-2@ksc.nasa.gov

"ST Day 2000: Reducing Risk for the Next Generations"

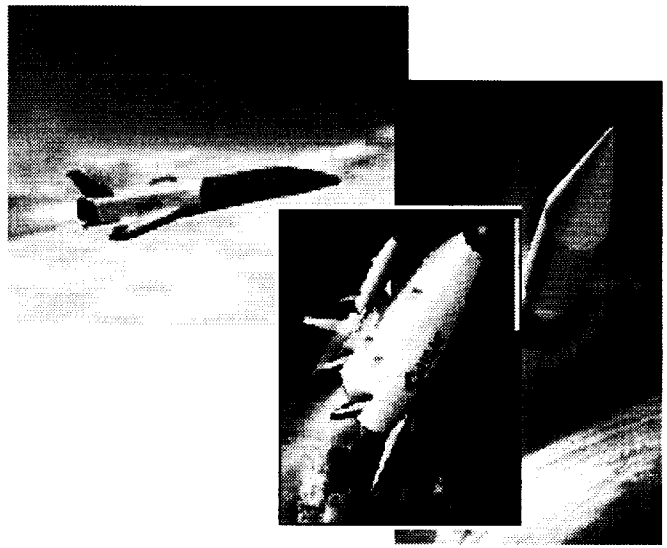
- Historically, the majority of the total life cycle cost for any complex system is attributed to operational and support activities
- Therefore, a primary strategy for reducing life cycle costs should be to develop and infuse spaceport technologies in future space transportation systems
- Advanced technologies will benefit current and future spaceports on the earth, moon, Mars, and beyond

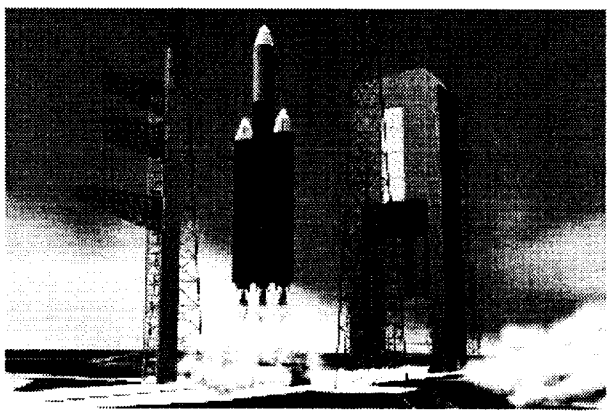


"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

Spaceport Technology Center

- **Current Weather & Range attributable delays and scrubs will limit future space launch cost/lb. goals**
- **Range infrastructure is falling behind needs for future Commercial, and next generation RLV launch systems**

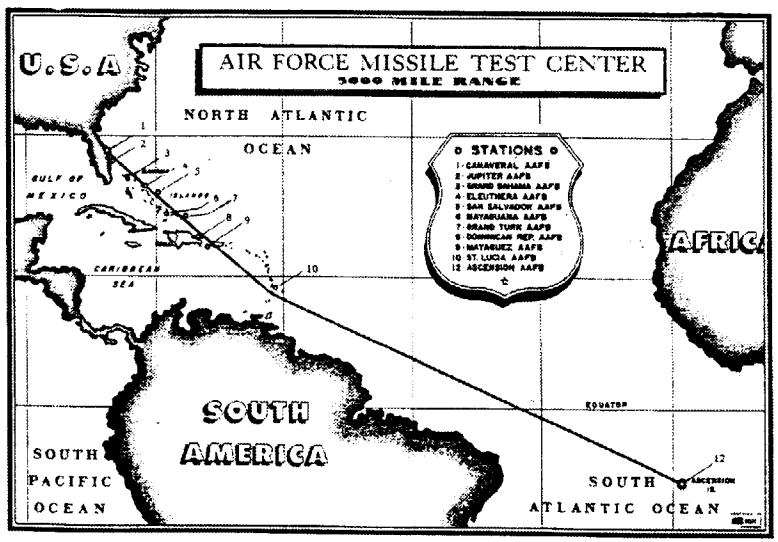




"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

Why X-Range R&D ?

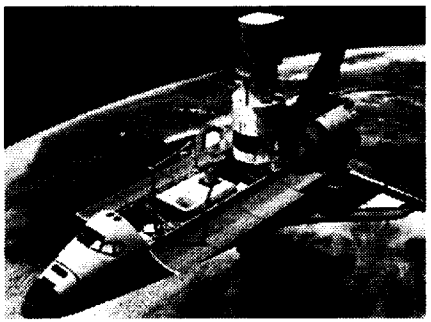
- **Range Technology History**
  - **Air Force was responsible for developing and operating the ER and WR since 1950**
  - **Infrastructure was historically capitalized by DoD programs**
  - **Commercial users only reimburse direct costs; technology upgrades remain DoD responsibility**



Advanced Range Technologies

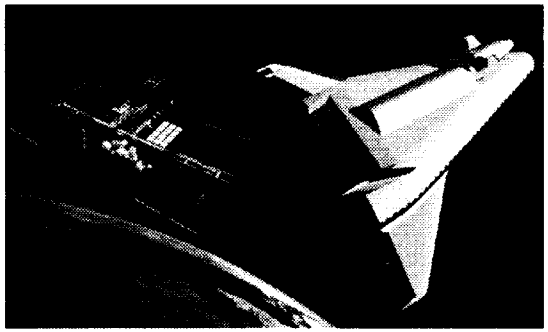
- **Global and U.S. Future Range Trends forecast strong growth**
  - **Emerging space launches need specialized technologies to enable their business plans**
  - **Launch services becoming mostly commercial**
  - **Factor of 2-10 volume increase in five years**
  - **FAA involvement increasing (Spaceport Licenses)**
  - **National Security remains Driver**
  - **> 14 Global Launch Ranges**

Advanced Range Technologies



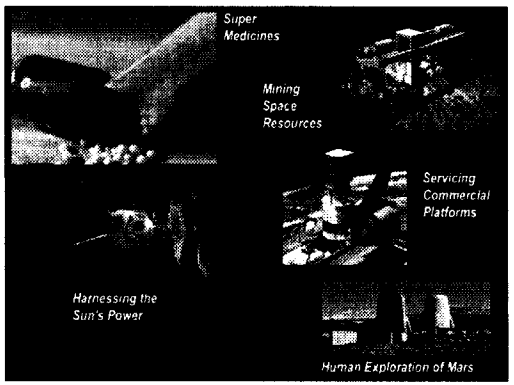
Today: Space Shuttle
1st Generation RLV

- Orbital Scientific Platform
- Satellite Retrieval and Repair
- Satellite Deployment



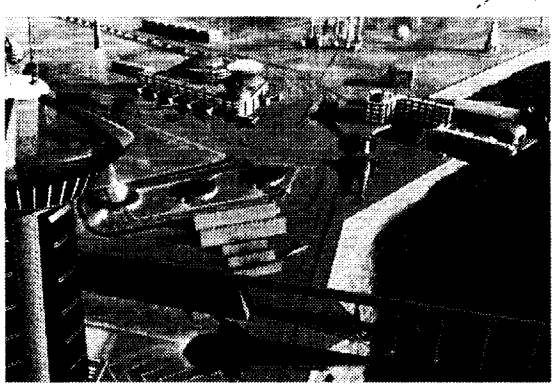
2010: 2nd Generation RLV

- Space Transportation
- Rendezvous, Docking, Crew Transfer
- Other on-orbit operations
- ISS, Orbital Scientific Platform
- 10x Cheaper
- 100x Safer



2025: 3rd Generation RLV

- New Markets Enabled
- Multiple Platforms / Destinations
- 100x Cheaper
- 10,000x Safer



2040: 4th Generation RLV

- Routine Passenger Space Travel
- 1,000x Cheaper
- 20,000x Safer

"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

Generations of Reusable Launch Vehicles

- **Vision**
  - **Guiding Assumptions**
    - 2020-2025 operational transportation to / from orbit
    - Launch assist (possibly MagLev, catapult, or other)
    - Fly back booster
    - 26 launch vehicles
    - Multiple spaceports (7)
    - A minimum of 2,000 missions annually
  - **Given these assumptions each 3rd generation vehicle**
    - Minimum of 77 missions/year with a Maximum of 4 days turnaround
    - Simultaneous operation with other vehicles at a Spaceport or multiple Spaceports
      - Launch
      - Landing
      - Vehicle processing
    - 'Seamless' interface with the National Air Space
    - On-board real-time access to weather, ATC and navigational data required for ascent and landing

Advanced Range Technologies

- **Goals**
  - **Double U.S. Range Surge Capacity**
  - **Factor of three Reduction in Delays and Scrubs**
  - **Demonstrate Flight Plan Operations**
  - **Reduce fixed and variable costs to our customers and government**
  - **Leverage Exploration Initiative, e.g., Planetary Range**

Advanced Range Technologies

- **Charter**
  - Develop/mature technologies and knowledge that support the goals of the future generations of Reusable Launch Vehicles (RLV) enabling greater access to/from space
  - Technologies developed will assure Safe and Efficient operations while providing increased launch/landing opportunities and thereby decreasing the $/lb to orbit
  - Transfer knowledge of range technologies so that they are available to future spaceport(s) and existing National range(s)
- **Consisting of five (5) technology focus areas:**
  - Weather Instrumentation & Systems
  - Space Based Range
  - Spaceport Range Systems
  - Decision Models & Simulations
  - Spaceport Information Systems Management

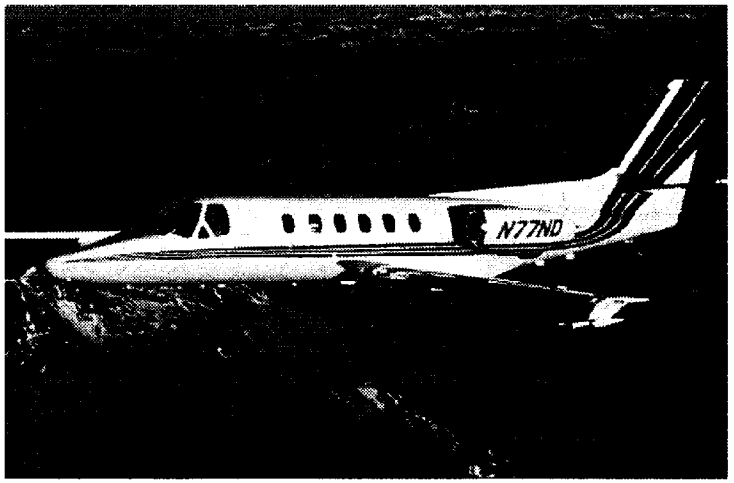
Advanced Range Technologies

♦ Weather Instrumentation & Systems

- **Description**
  - Develop and apply new technologies to weather instrumentation and systems in order to:
    - Reduce conservatism
    - Provide timely warnings for personnel and asset safety
    - Provide decision models with timely data

- **Candidate Projects**
  - Lightning Launch Commit Criteria Instrumentation and systems
  - Mesoscale Numerical Weather Prediction 4DDA
  - Integrated Weather Instrumentation Systems
  - Upper-level Wind Measurement/Forecast
  - Short term Forecasting Tech.

Advanced Range Technologies



Products
- Improved lightning launch commit criteria

Benefits
- Increased safety and fewer launch scrubs

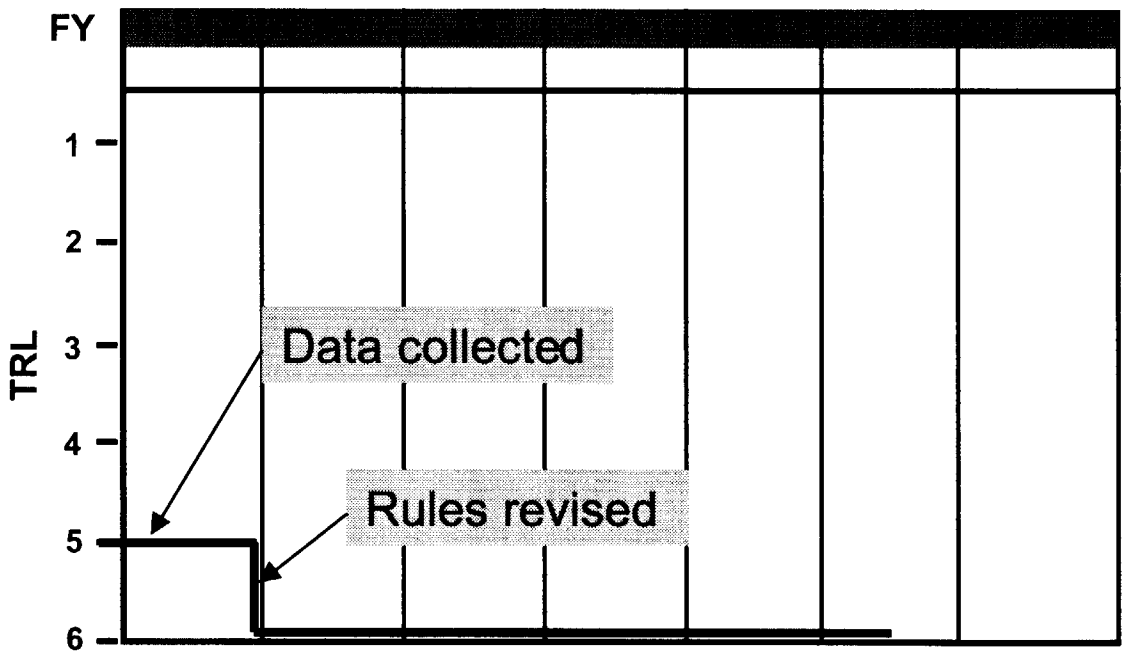
Customers
- All vehicles launched from American spaceports
- 2nd Gen Project Team

Current State of the Art
- Rules based on qualitative estimates

Performance Metrics
- Reduce standoff distances and/or time delays in rules by 20%

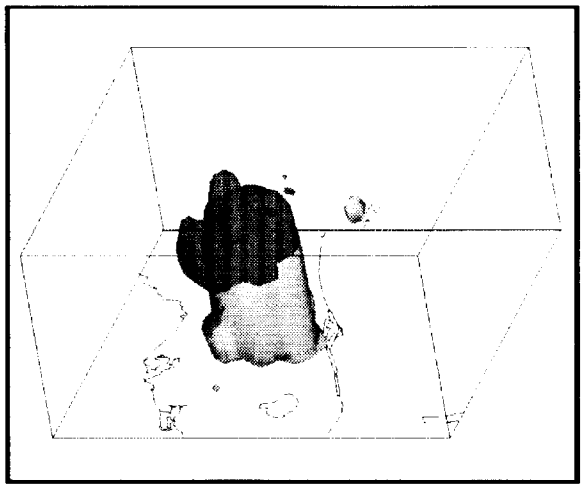
Risks
- Inability to obtain sufficient data

USG Participants
- KSC (lead), MSFC, USAF, NOAA, NCAR



"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

Lightning Launch Commit Criteria



Products
- Software permitting real-time (4D) data ingest into mesoscale numerical weather prediction systems

Benefits
- Improved accuracy and timeliness of forecasts of winds, precipitation, temperatures and hazardous conditions
- Improved safety due to better warnings
- Fewer false alarms and associated down time

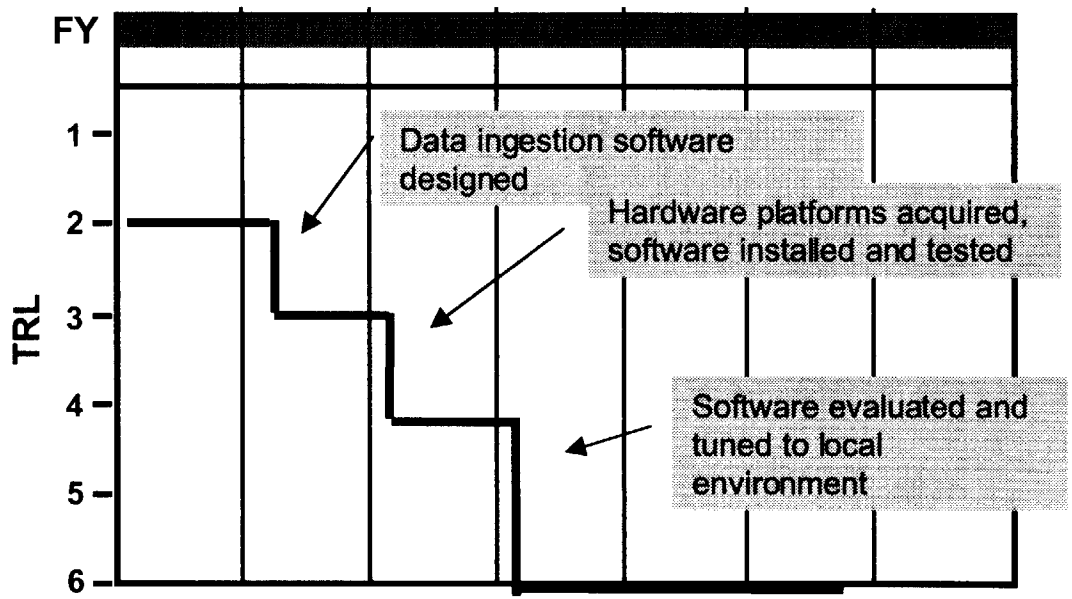
Customers
- All users of the Eastern Range
- 2nd Gen Project Team

Current State of the Art
- Models initialized every 6 to 12 hours, then free run

Performance Metrics
- Models updated with observations at least hourly

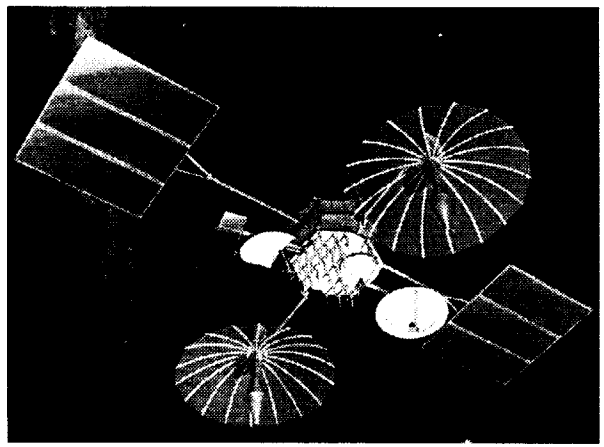
Risks
- Insufficient computing power available at reasonable cost

USG Participants
- KSC

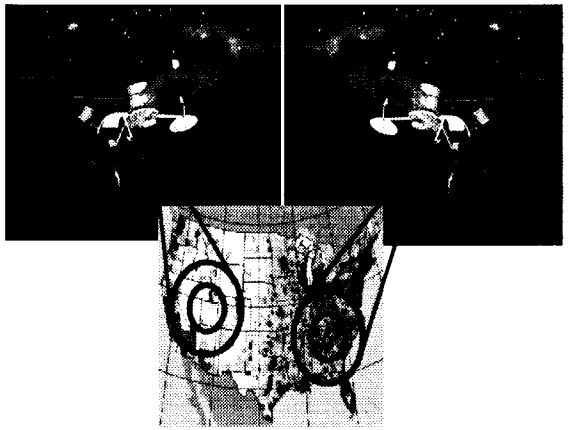


Mesoscale Numerical Weather Prediction 4DDA

- **Space Based Range**
  - **Description**
    - Provide integrated Range/Spaceport space based weather, communications, tracking and surveillance assets that may consist of:
      - A specific satellite platform with these capabilities, or
      - A constellation of individual satellites that fulfill these capabilities
    - Current tracking and telemetry data acquisition and distribution for space vehicle launch involves a geographically diverse set of assets which provide vehicle position determination from launch to orbit and return.
      - The use of these assets requires advanced scheduling, is very expensive and is only available in certain locations and for certain trajectories.
  - **Candidate Projects**
    - Digital Command Receiver Decoder Technology Range Safety commanding
    - Passive Coherent Locator (Metric Tracking)
    - Advanced DGPS/INS metric tracking systems
    - All weather Imaging
    - Air/Sea Surveillance



Advanced Range Technologies

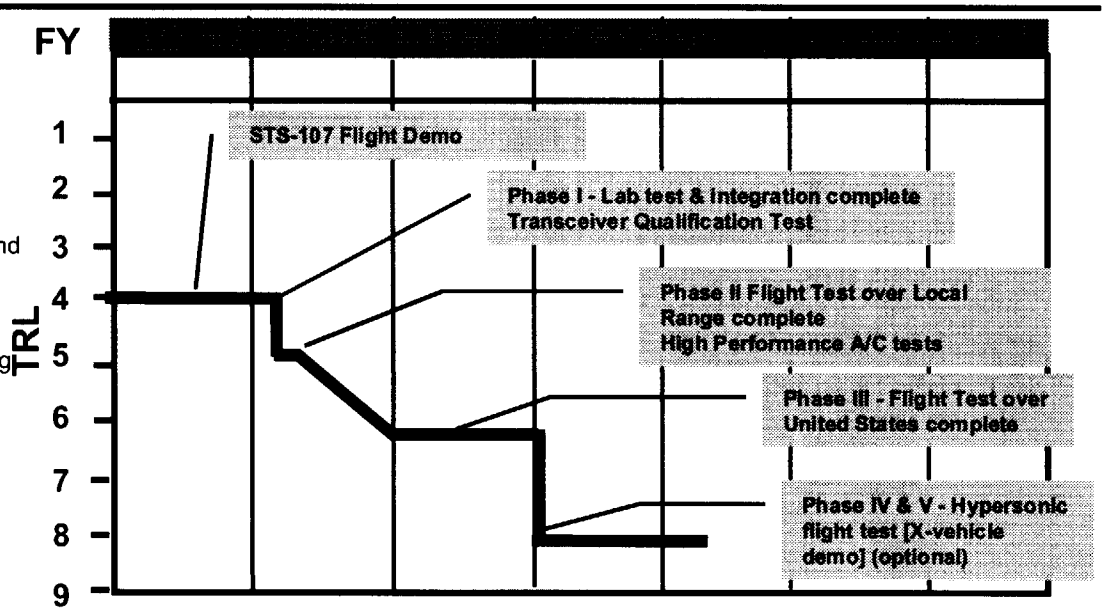


- Products

  Utilizing the TDRSS Space Network demonstrate the state-of-the-art transceivers and protocols will satisfy Range Safety Flight Termination and telemetry requirements. This will provide a reliable and alternative communications links for 2nd Generation reusable launch vehicles.
- Benefits
  - Safely reduce the cost by eliminating the need for downrange assets
  - Provides Space Based capability that will support multiple ranges/spaceports
  - Determine the feasibility and advantages of forward and return satellite links to transmit and receive telemetry data at Dryden.
  - Provide over the horizon tracking for current and future generations of hypersonic vehicles.
- Customers

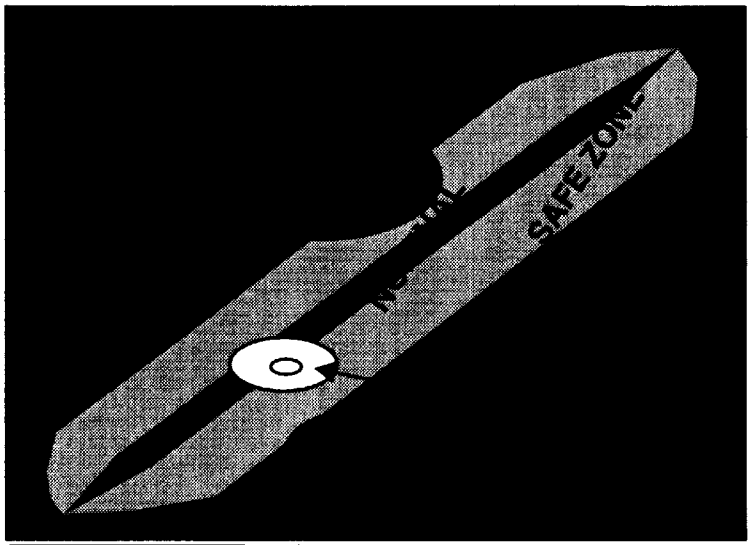
  Internal AST, HEDS; external DoD, FAA, future spaceports

- Current State of the Art
  - New programmable TDRSS transceivers-Soft Radios in qualification testing
  - Lighter/low power/multi-channel/GPS
  - Current range systems supporting hypersonic flights are ground based and primarily support aircraft testing
- Performance Metrics
  - High integrity, continuity and availability to meet safety requirements for manned spacecraft Range Safety commanding
  - Reducing the infrastructure and systems required for missions will lower the ops costs
- Risks
  - Low. Transceiver developed. by another program
  - Programmable
  - Timely Startup Funding to initiate procurements
  - Vendor deliverables to NASA
  - Flight test vehicle for Phase II & III
- USG Participants
  - DOD, FAA, NASA KSC, GSFC, DFRC



"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

Space Based Telemetry and Range Safety



Product

Development of an on-board real-time processor that will make autonomous 'Flight Termination' decisions based on:

- Vehicle performance
- Unsafe zones and islands
- Potential landing sights
- Flight path considerations, such as, real-time weather and Air Traffic Control (ATC)

Note: RLV Flight Termination will result in new abort scenarios that do not result in loss of vehicle

Benefits

Safe reduction of ground infrastructure required for Range Safety

Current State of the Art

Ground based infrastructure intensive 'Man-in-the-Loop' Range Safety Officer

Performance Metrics

Cost reduction as the direct result of elimination of ground infrastructure necessary to support Range Safety

Increased Crew and Mission Safety by providing greater 'abort' capability

Risks

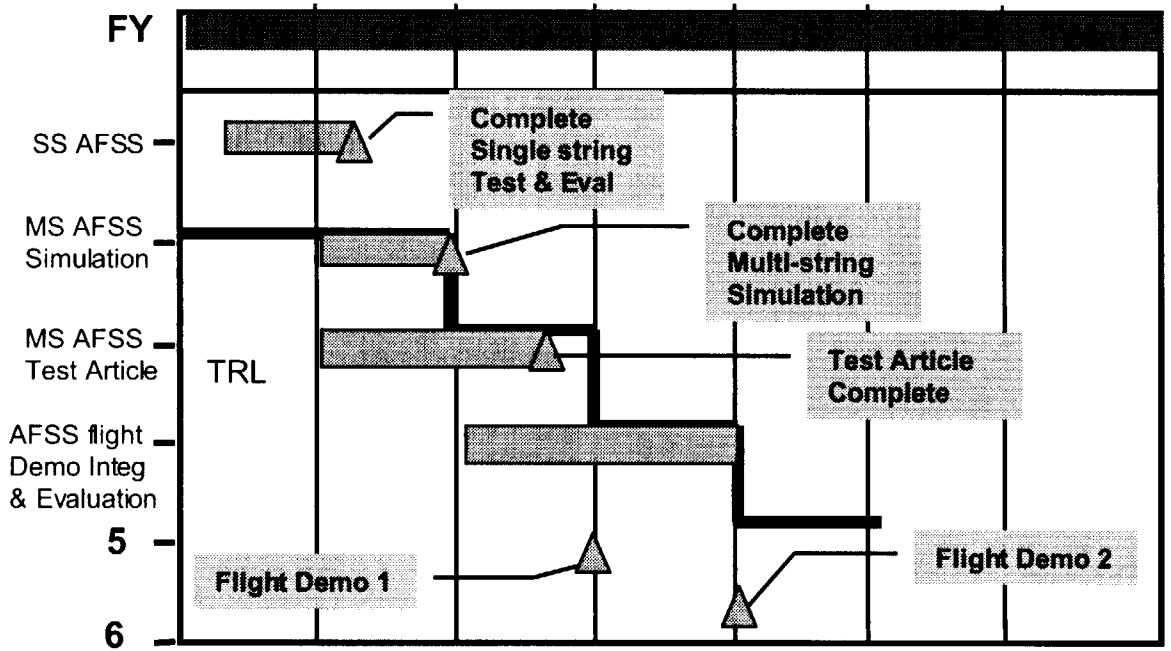
Access/availability of GPS/INS unit

Space Flight qualified processor speed

Participants/University

MSFC, KSC, DFRC

Lockheed Martin



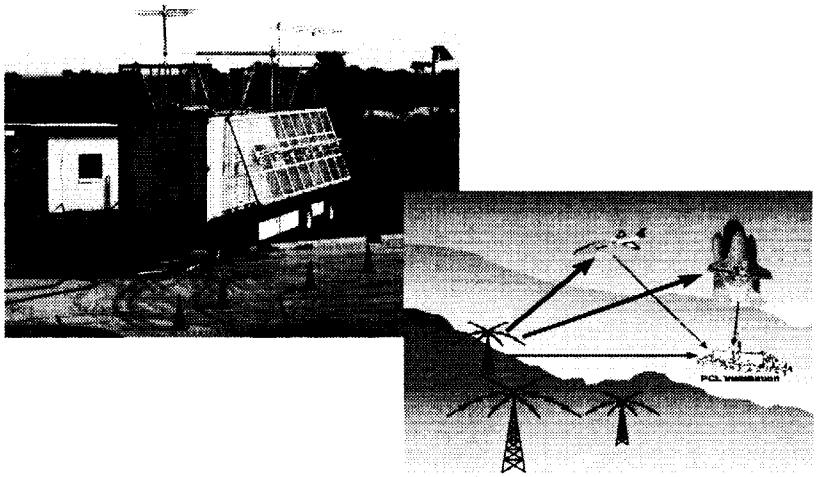
"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

Autonomous Flight Safety System

- **Spaceport Range Systems**
  - **Description**
    - Provide Spaceport range systems architecture that would integrate all range support into a single system.
    - Provide for an integrated and automated capability that will make re-configuration of range systems for various launch vehicles, timely and efficient.
    - Provides ground based assets for Spaceport to meet requirements:
      - **that can not be met by the Space Based Range capabilities**
      - **necessary to provide communications between the Spaceports and Space Based Range**

  - **Candidate Projects**
    - Passive Coherent Locator (Metric Tracking)
    - Advanced low cost, transition DGPS Landing Systems
    - Automated Range Resource Management System
    - Mobile Launch Head Range System
    - Air/Sea Surveillance
    - Range Dispersion Monitoring System

Advanced Range Technologies



Product

Provides for all weather precision surveillance and tracking.
PCL uses existing TV and FM broadcast transmitters as the illuminators for a multistatic Continuous Wave (CW) RADAR-like system with very high performance and survivability attributes

Benefit

Safely reduce infrastructure
Primarily a COTS solution will reduce O&M cost
Environmental clean
Continuous operation

Current State of the Art

Complex 30+ year old C-Band Radar(s)
Utilize vehicle transponders

Performance Metrics

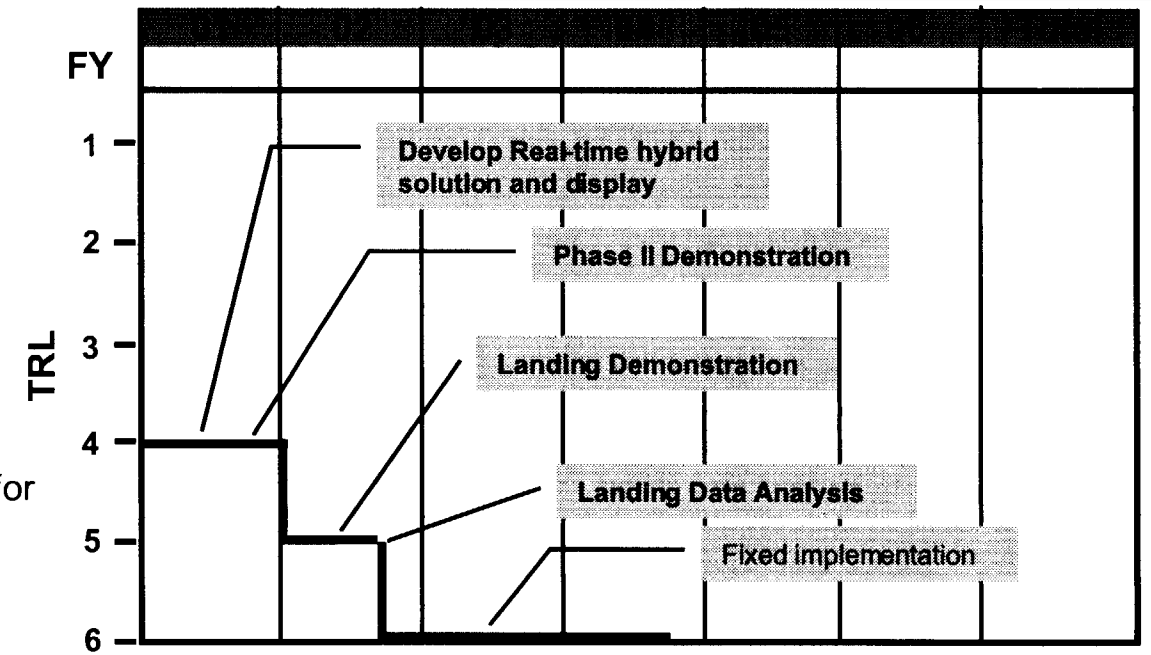
Reduced life cycle cost as compared to existing infrastructure and capability
Multi-role functionality

Risks

Low. easily characterized and modified for refinement of capability

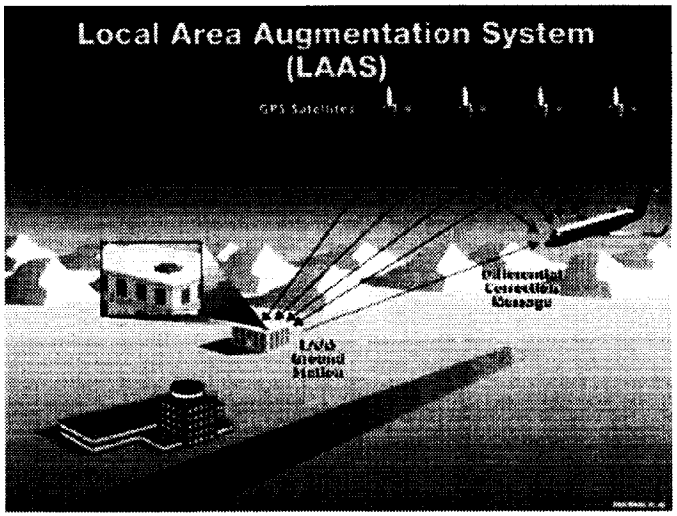
USG Participants

NASA KSC, MSFC and Lockheed Martin



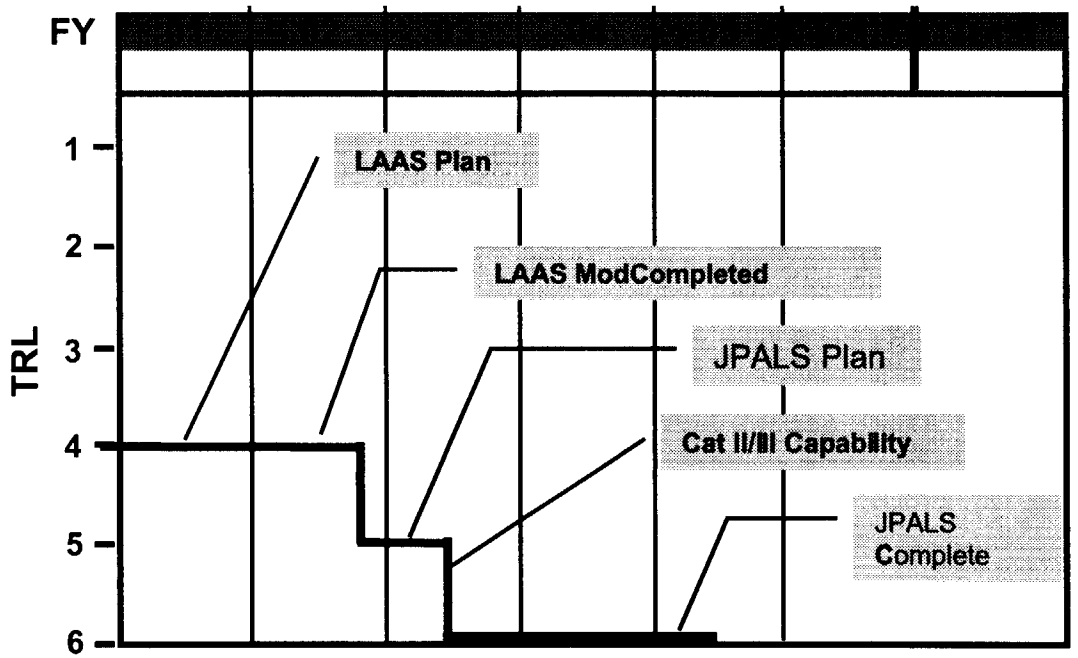
"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

Passive Coherent Location



- Products
  - DGPS ground stations at designated landing fields and compatible avionics
- Benefits
  - Use of current standards will share development costs with other government agencies (FAA and DOD)
- Customers
  - Internal AST, HEDS; external DoD, FAA, future spaceports

- Current State of the Art
  - FAA LAAS Category I system in Test
  - CAT II/III and JPALS TRL: 5/4 now.
- Performance Metrics
  - High integrity, continuity, availability, and accuracy to meet safety requirements for manned spacecraft landing.
- Risks
  - Low. Development done by FAA/DOD
- USG Participants
  - DOD, FAA, NASA KSC



"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

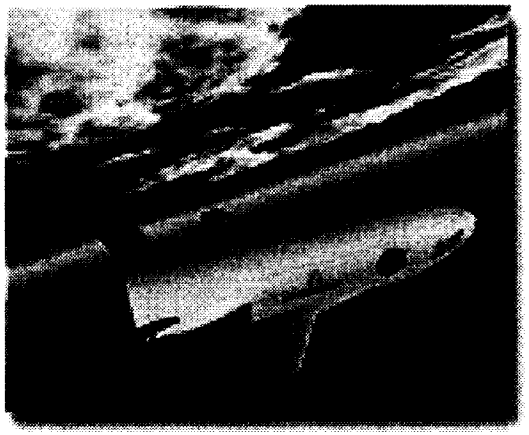
DGPS Precision Approach & Landing System

♦ **Decision Models & Simulation**

- **Description**
  - Existing models interject conservatism in order to compensate for computational and technology limitations.
  - New technologies exist that can reduce conservatism, while providing the fidelity necessary to ensure safe and cost effective models .

- **Candidate Projects**
  - Spaceport Dispersion Three-Dimensional Model (SD3D)
  - Decision Model Optimization
  - High Fidelity Plume Conflagration Model
  - Disaster Sheltering Assessment Improvements
  - Knowledge-based Toxic Hazard Repository
  - Real-time Dispersion Monitoring System (RDMS)
  - RLV Composites Combustion and Toxicity Assessment

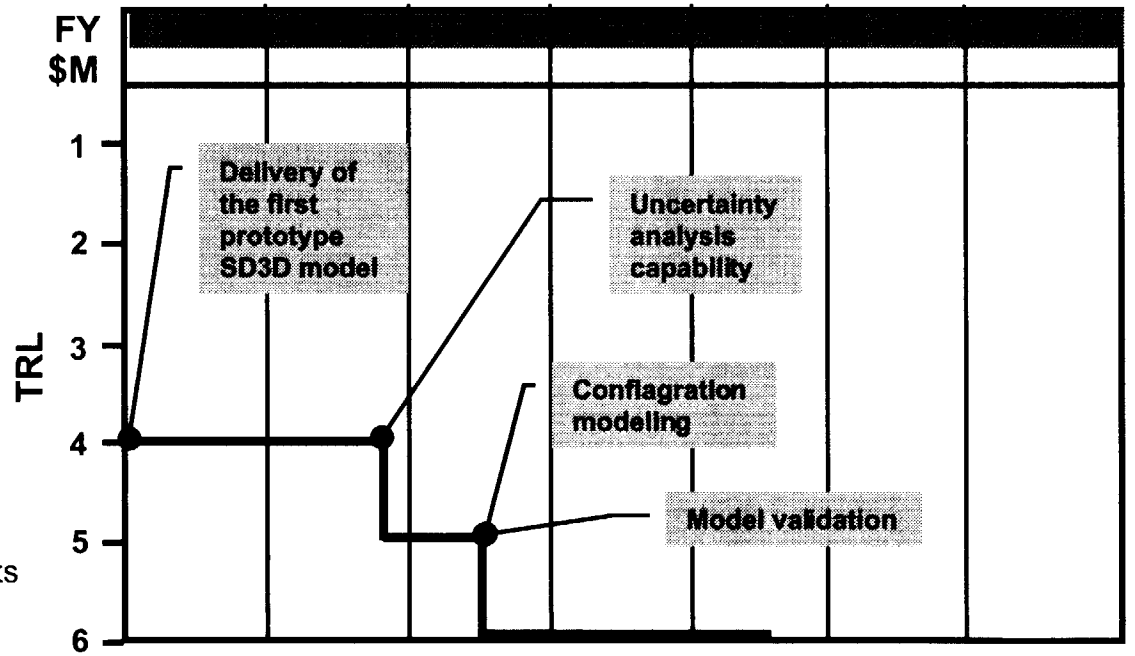
Advanced Range Technologies



X-37 Demonstrator

- Products: SD3D model with capabilities that include, but not limited to an uncertainty analysis capability, toxic dispersion improvements and validation, and high fidelity conflagration analyses
- Benefits: Spaceport hazards shall be cost effectively controlled/mitigated with the above developed, and validated model
- Customers:
  Internal - NASA RLV Spaceports; External - DOD, FAA, and future spaceports
  Technologies will benefit 2nd Gen. by providing accurate decision assistance for operations at any spaceport
- Common / Enhancing: Products reduce uncertainty and conservatism which in turn reduces turnaround time.

- Current State of the Art:
  Current capability based on a 20 year old empirical model (REEDM). The SD3D will replace this model.
- Performance Metrics
  Product delivery dates
  Demonstrated capability during operations
- Risks
  Getting model "accepted" onto the spaceport
  Compatibility of model with existing databases
- Participants
  KSC
  PAFB/CCAFS
  Spaceport Florida Authority and future Spaceports



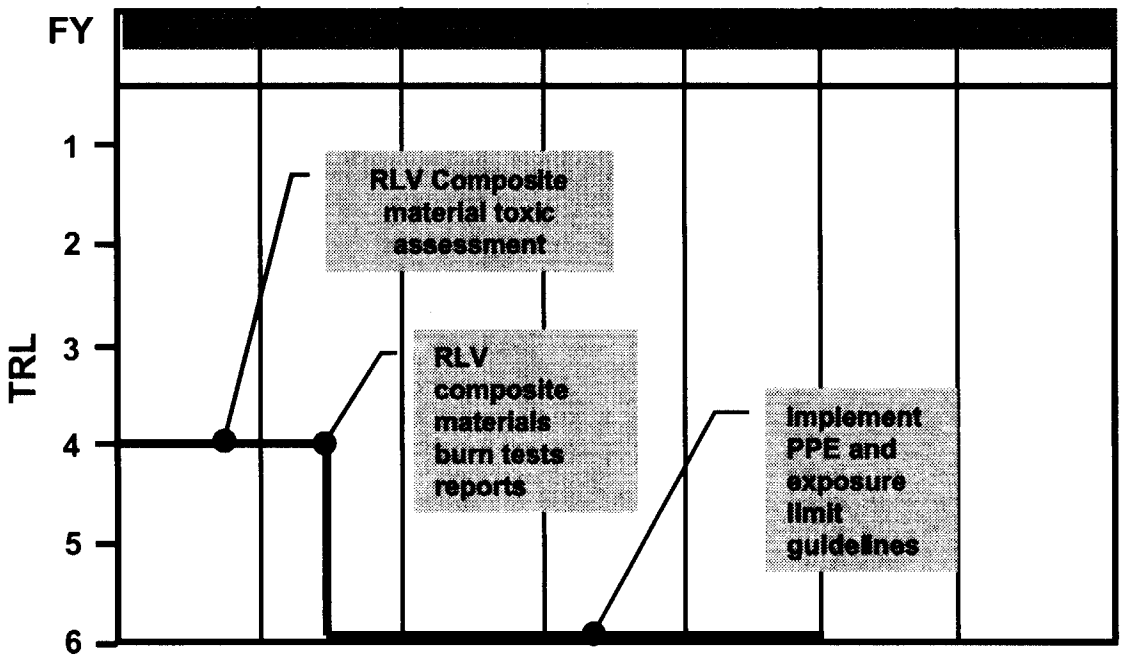
"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

Spaceport Dispersion Three-Dimensional Model (SD3D)

X-34 Demonstrator

- Products: Personal Protection Equipment (PPE) and exposure limit recommendations (if any) and procedures as it relates to RLV composite materials hazards
- Benefits: Spaceport composite material hazards (if any) will be cost effectively controlled/mitigated
- Customers:
  Internal- NASA Spaceports; External - DOD, FAA, and future spaceports
  Technologies will benefit 2nd Gen. by providing safety guidance for operations at any spaceport
- Common / Enhancing: Products provide safety guidance which reduces accidents and/or long term health effects

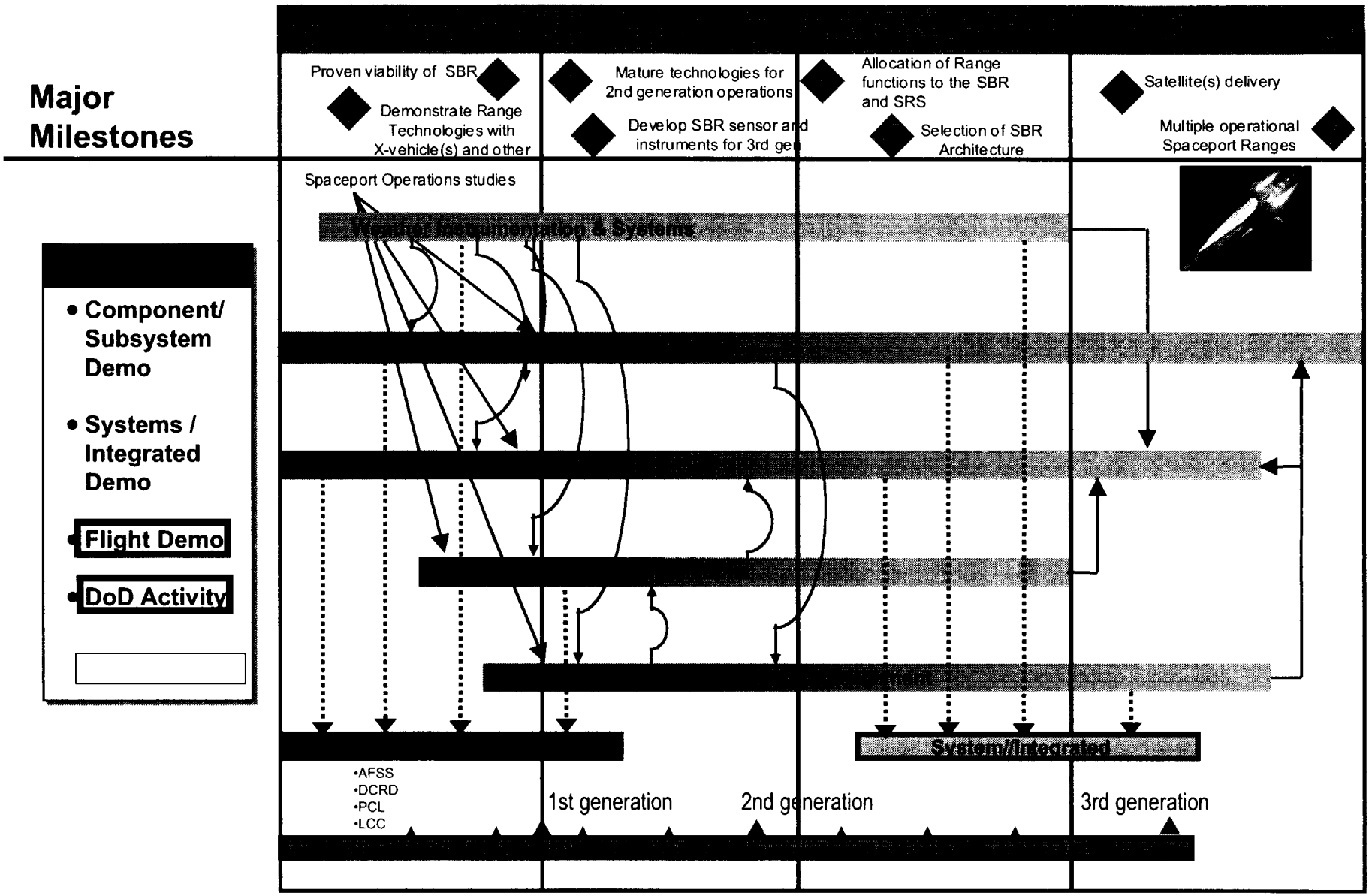
- Current State of the Art:
  The hazards associated with exposure to burning composite materials is a new area and not well understood
- Performance Metrics
  Composite material burn test dates
  Reports/recommendations on composite material hazards
- Risks
  "Piggy-backing" on burn tests planned by other agencies
  Availability of composite material test samples and propellant material to use in burn tests
- Participants
  KSC, MSFC, LaRC
  Army, PAFB/CCAFS and other AF organizations
  Spaceport Florida Authority and future Spaceports



"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

RLV Composites Combustion and Toxicity Assessment

- **Spaceport Information Systems Management**
  - **Description**
    - Advanced Space Based and Spaceport Range systems will require an architecture that:
      - provides for the sharing of range information
      - supports distributed processing
      - provides support for simultaneous ground and flight operations
        - to/from multiple Spaceports/Ranges
        - multiple vehicles
  - **Candidate Technologies**
    - Space Based Internet viewing of vehicle data and vehicle access to range services
    - Networks Administration and Management systems
    - Standardization of vehicle data interfaces
    - Standardization of range systems interfaces



"ST Day 2000: Reducing Risk for the Next Generations" - Advanced Range Technologies

Advanced Range Technologies

Potential Benefits

- **Lower per Launch Costs**
- **Shorter Lead-time**
- **Higher Through-put**
- **Lower number of Weather Scrubs or Delays**
- **Lower number of Range/Spaceport Scrubs or Delays**
- **Lower Infrastructure Capital & O&M requirements**
- **Converts fixed (non-reimbursable) to variable costs**
- **Outsourcing options**
- **Multi-Range/Spaceport Compatibility**

♦ **Customers**

Stakeholder	Interest
• KSC	Advanced Range Leadership, Strategic Planning & R&D
• MSFC	Space Transportation Program
• JSC	SOMO Shuttle
• FAA	License/Regulations
• Space Launch Industry	Low Cost & High Availability
• Spaceports – California, Florida, others	Site Infrastructure
• USAF	SMC, Space Wings, & EELV
• GSFC	TDRS Office

Advanced Range Technologies