

**NEXTOR** Annual Research Symposium

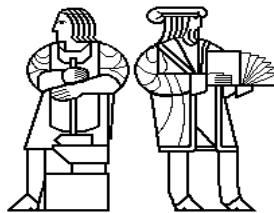
November 14, 1997

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Session III  
Issues for the Future of ATM

Reusable Launch Vehicles  
James Kuchar, MIT

# Integration of Reusable Launch Vehicles (RLVs) into Air Traffic Management



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# Separation Between Aircraft and Space Operations

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Problem identified by FAA Office of Commercial Space Transportation

## **Current mode:**

- Strategic segregation through Special Use Airspace (SUA)
- Large spatial and temporal buffer
- Based on range safety studies
- Few space operations --> limited impact on air traffic flow

## **Future:**

- Increased frequency of space operations
- Airspace demand conflicts between air and space operators
- Increased diversity of space vehicles (Reusable Launch Vehicles, RLV)
  - Similar to conventional aircraft in some phases of flight
- Need to make most efficient use of airspace

# Research Questions

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## Airspace allocation

- Exclusively to air (SUA not active)
- Exclusively to space (SUA active)
- Integrated / mixed use

## **Under what conditions could RLVs be integrated into ATM?**

- also other unconventional vehicles (e.g., unmanned aerial vehicle)

## **What would be the economic / flow / safety impacts?**

## **What additional technologies / equipment / procedures are required?**

**→ Studies needed to determine cost / benefit tradeoff**

# Approach

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MIT: Technology (e.g. sensor) and procedural (e.g. human factors) requirements

VPI: Traffic flow modeling and economic analysis

## **Project phases**

### Phase I

April - September, 1997

Identification of models and issues

### Phase II

October, 1997 - September, 1998

Preliminary analysis, recommendations

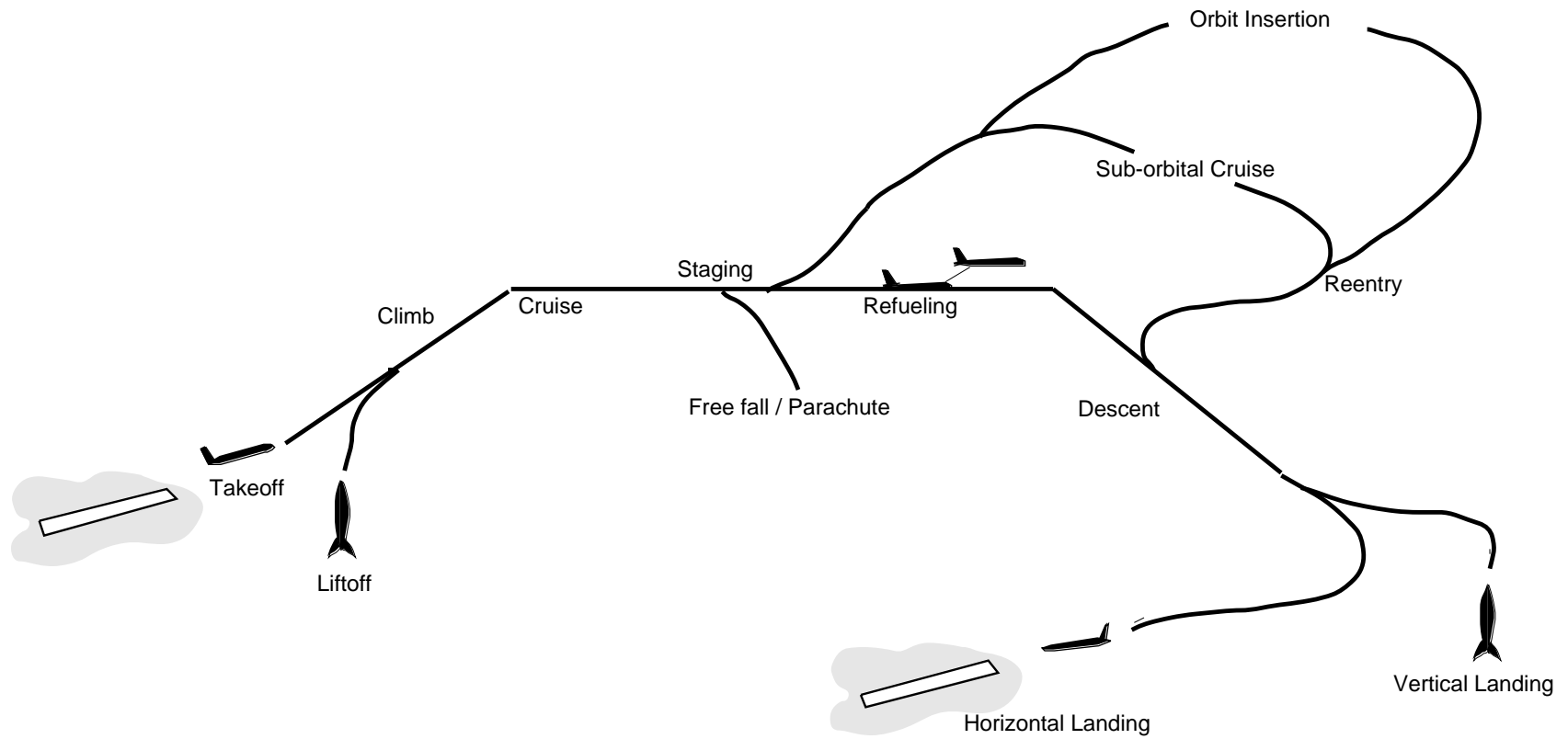
# MIT Activities in Phase I

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- Collected data on proposed RLVs
- Determined typical phases of flight / mission profiles
- Developed generalized model of airspace / air traffic / RLV operations
  - Agents
  - Information flow
- Identified 8 potential modes of operation, defined preliminary requirements  
examples:
  - Continue use of SUA (strategic segregation)
  - Controlled Space Activity Zone (c.f. Class B airspace)
  - Manage RLV as a conventional vehicle

# RLV Phases of Flight

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NASP	x		x	x			x		x	x	x	
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# Current Launch Monitoring Requirements (PAFB)

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- Instantaneous Impact Point (IIP)

  - Real-time display

  - Accuracy (3 )

    - Along-track: < 100' or 5% of range (whichever is larger)

    - Cross-track: < 100' or 0.5% range (whichever is larger)

  - Telemetered data update rate 20 Hz

  - IIP update rate 10 Hz

  - Maximum destruct delay of 1.5 - 3.5 sec

  - Tracking system reliability 0.999 over 1 hour

- Abort boundary based on safety studies

  - IIP outside abort boundary --> destruct / abort

# Separation Factors

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- Collision with vehicle
  - Sensors, guidance accuracy, geometry, velocity, time, maneuverability
- Wake vortex
- Exhaust / chemical plume / smoke
- Expended stages
- Auxiliary operations: chase planes, weather soundings
- Potential for catastrophic failure
  - departure from planned trajectory
  - explosion / debris

Taken together, uncertainties result in need for large safety buffer -> SUA

# Phase I Preliminary Recommendations

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## **Use SUA unless significant negative impact on air traffic occurs**

Operational simplicity

Most flexibility for RLV operations

Safety

Subdividing SUA may alleviate some traffic flow problems (charting issues remain)

Real-time feedback from RLV Operator to ATC could be beneficial

Controlled air traffic may enter certain regions of SUA on case-by-case basis

Additional controller tools, communications, procedures needed

Non-SUA modes of operation require more research

- Fundamental limitations of current / future ATM concepts

(e.g., max velocity, vertical rate, excursion from flight plan)

# MIT Activities in Phase II

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Additional research required to examine feasibility of non-SUA modes of operation

Appropriate safety buffer size and duration

Equipage and procedural requirements

Not clear what the limits of ATC are

Ability to manage high speeds / vertical rates

Display / procedure / control issues

- Determine relationships between vehicle characteristics and ATC requirements
  - Sensors / tracking
    - Update rate, accuracy
  - Human / automation
    - Display requirements