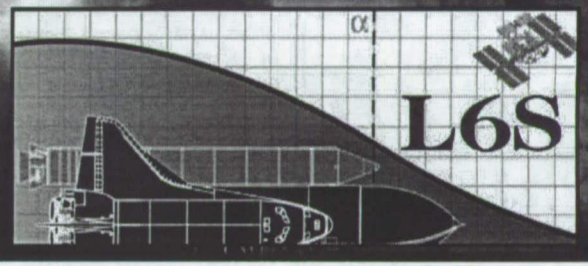
# Simulation Modeling for Space Exploration


## United Space Alliance, LLC (USA)

Dave Tucker

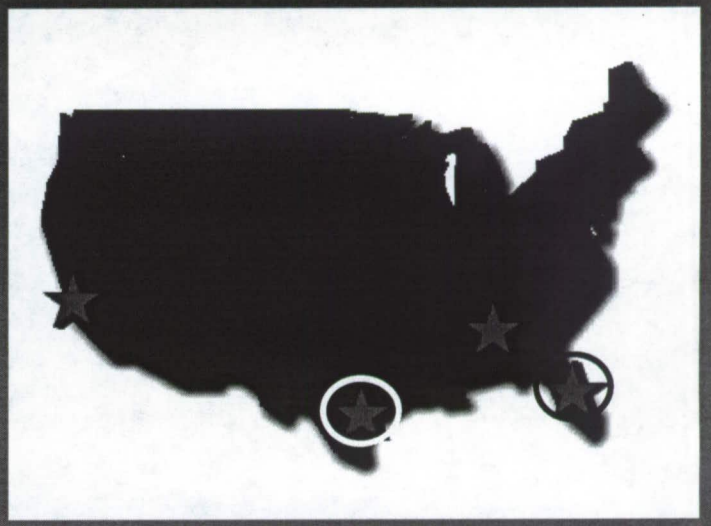
May 2006

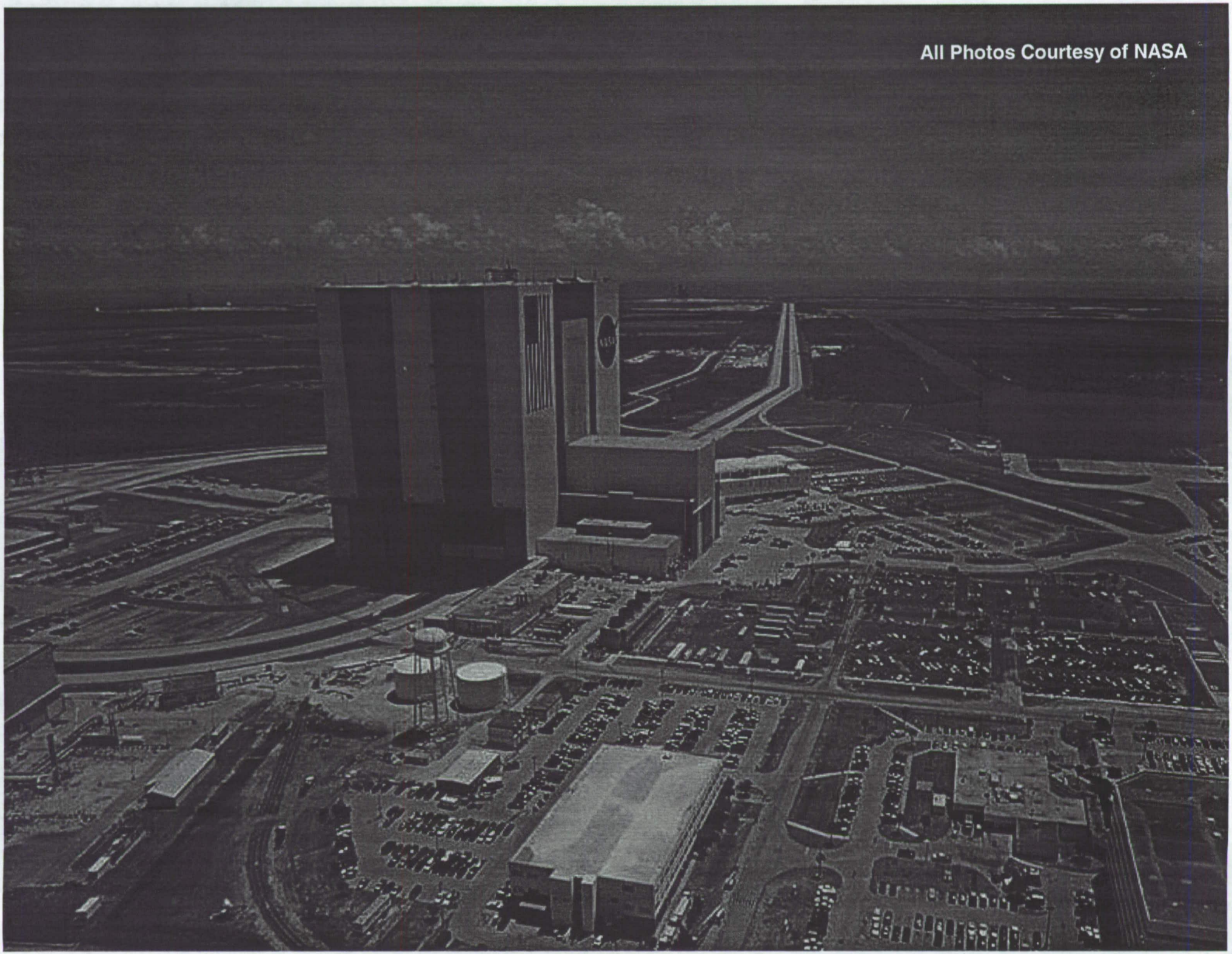



# United Space Alliance (USA)

## Who are we?

- Prime Contractor to NASA for Space Flight Operations Contract
- Responsible for all Space Shuttle Fleet & International Space Station processing operations
- Two primary locations:
  - Johnson Space Center, TX
  - Kennedy Space Center, FL
- About 10,000 employees

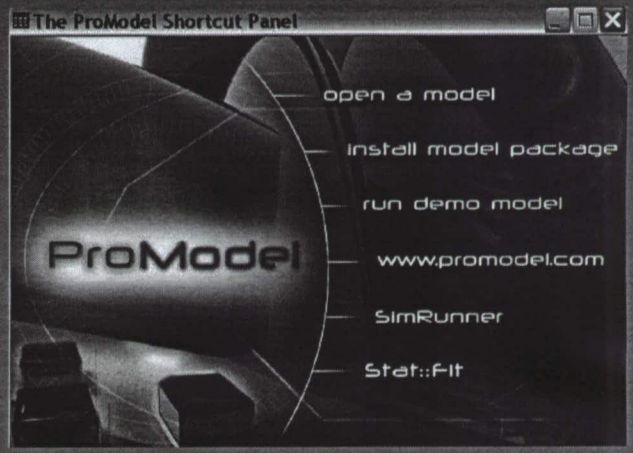



All Photos Courtesy of NASA

# United Space Alliance (USA)

## Simulation Experience:

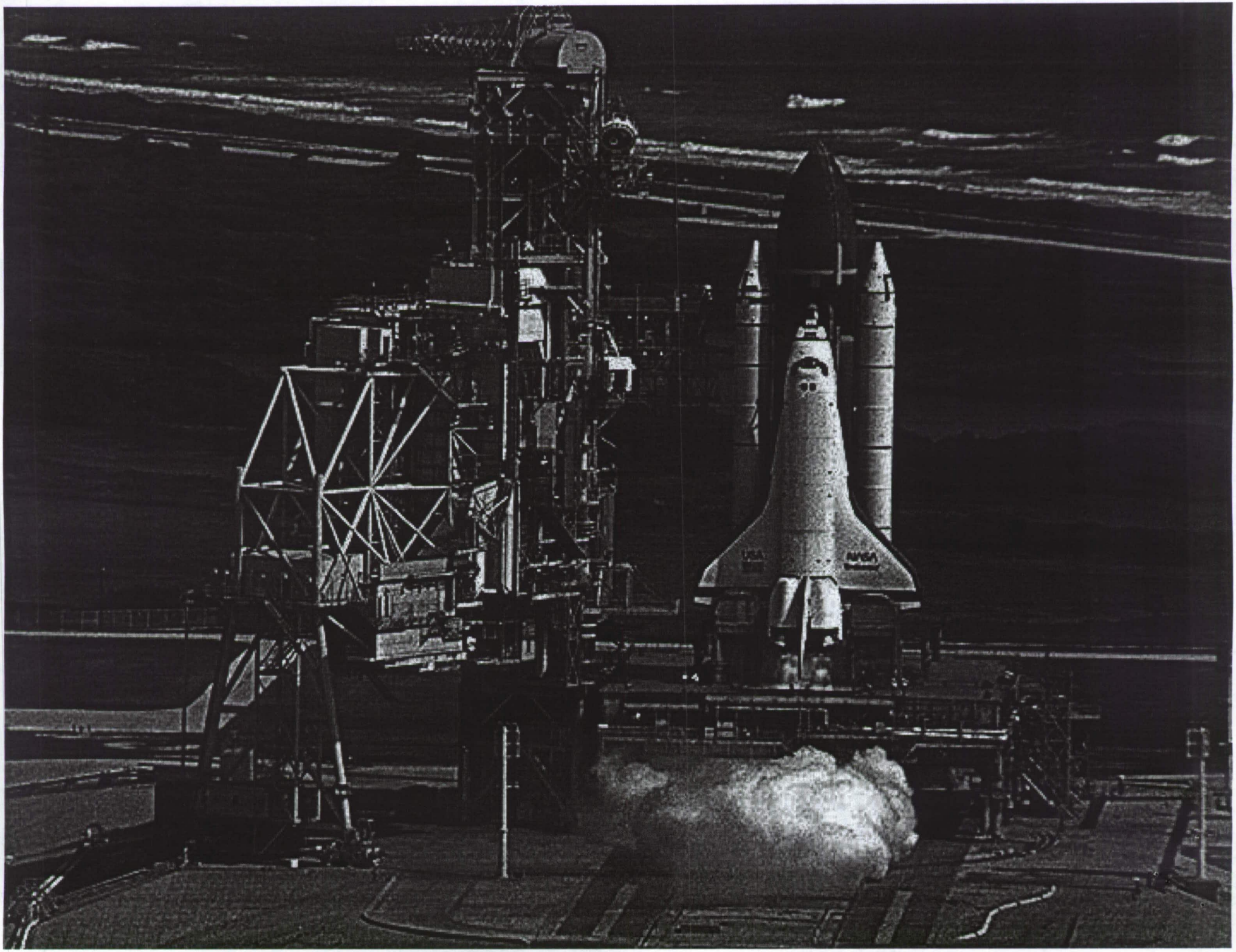
- Six years using ProModel
- Also use PM Process Simulator with Visio
- About three dozen USA employees trained in PM
- Primary ProModel users: IE's, P&M, & other staff
- Completed over two dozen simulation projects
  - Shop Layouts
  - Paper Processes
  - Flight Hardware Processing
  - Manufacturing Operations

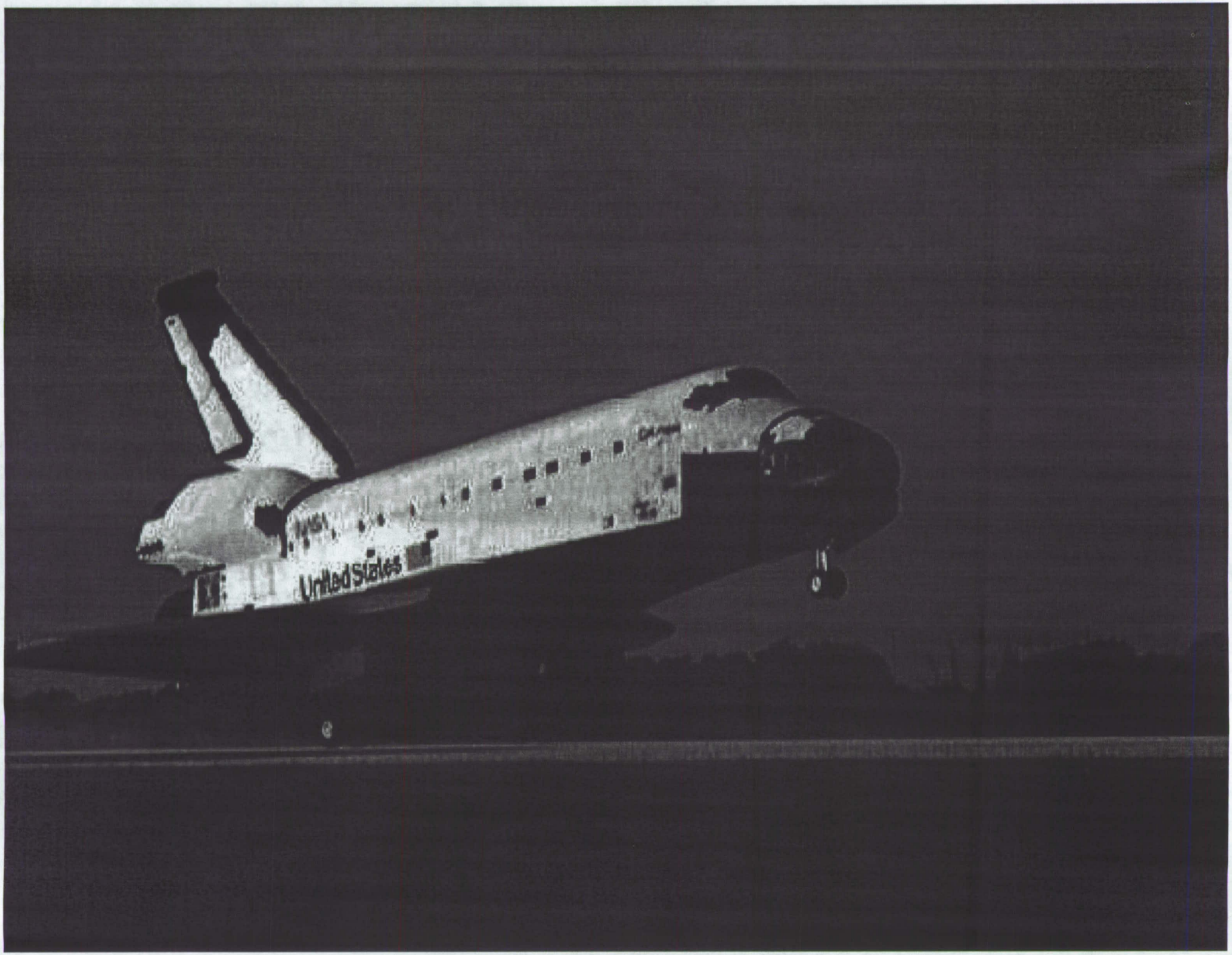


# Today's Shuttle Program

## Space Transportation System:

- Fleet of three Space Shuttle Orbiters
- Solid Rocket Boosters (SRBs) & External Tank (ET)
- Transport crews & cargo to low earth orbit & International Space Station (ISS)
- Orbiters land at Kennedy Space Center in FL or Edwards Air Force Base in CA
- Orbiters & SRBs are refurbished; ET is not
- Flown over 100 Shuttle Missions since 1981

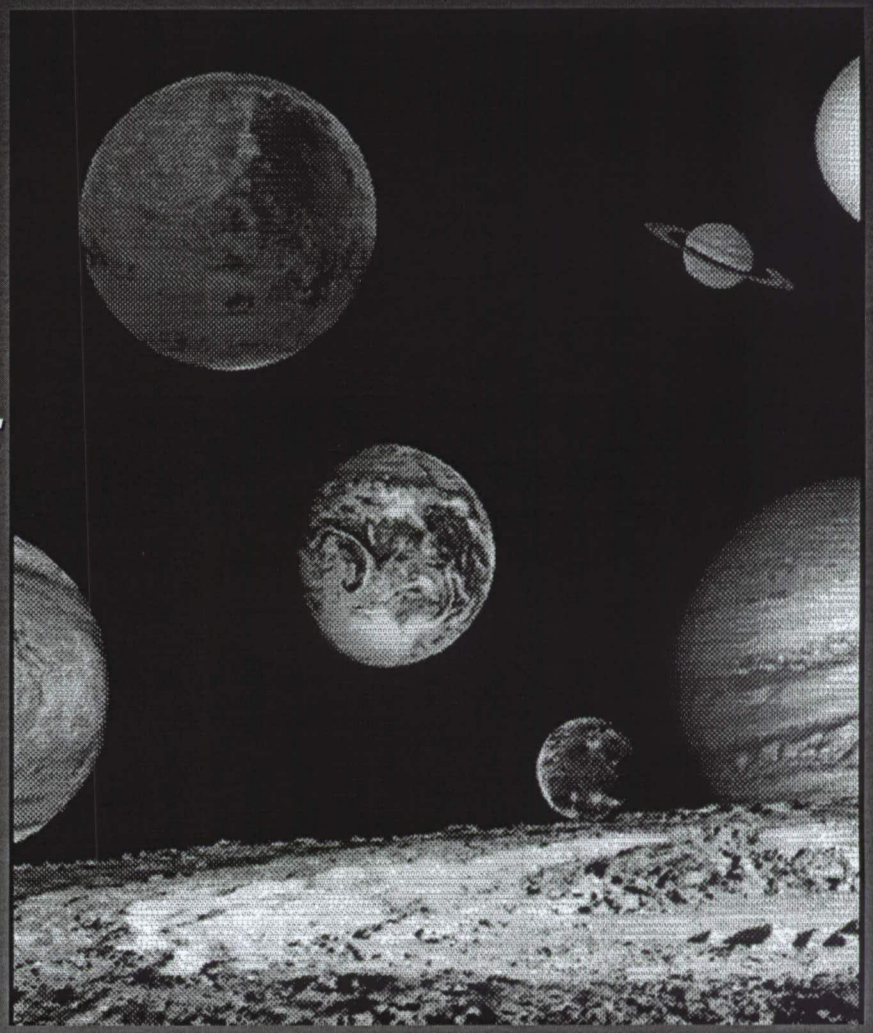



United States

# Tomorrow's Space Program

## Vision for Space Exploration:

***On January 14, 2004, President Bush put NASA on a new course into the cosmos. The Vision for Space Exploration focused the agency on a bold new mission: landing humans on the moon before the end of the next decade, paving the way for eventual journeys to Mars and beyond.***

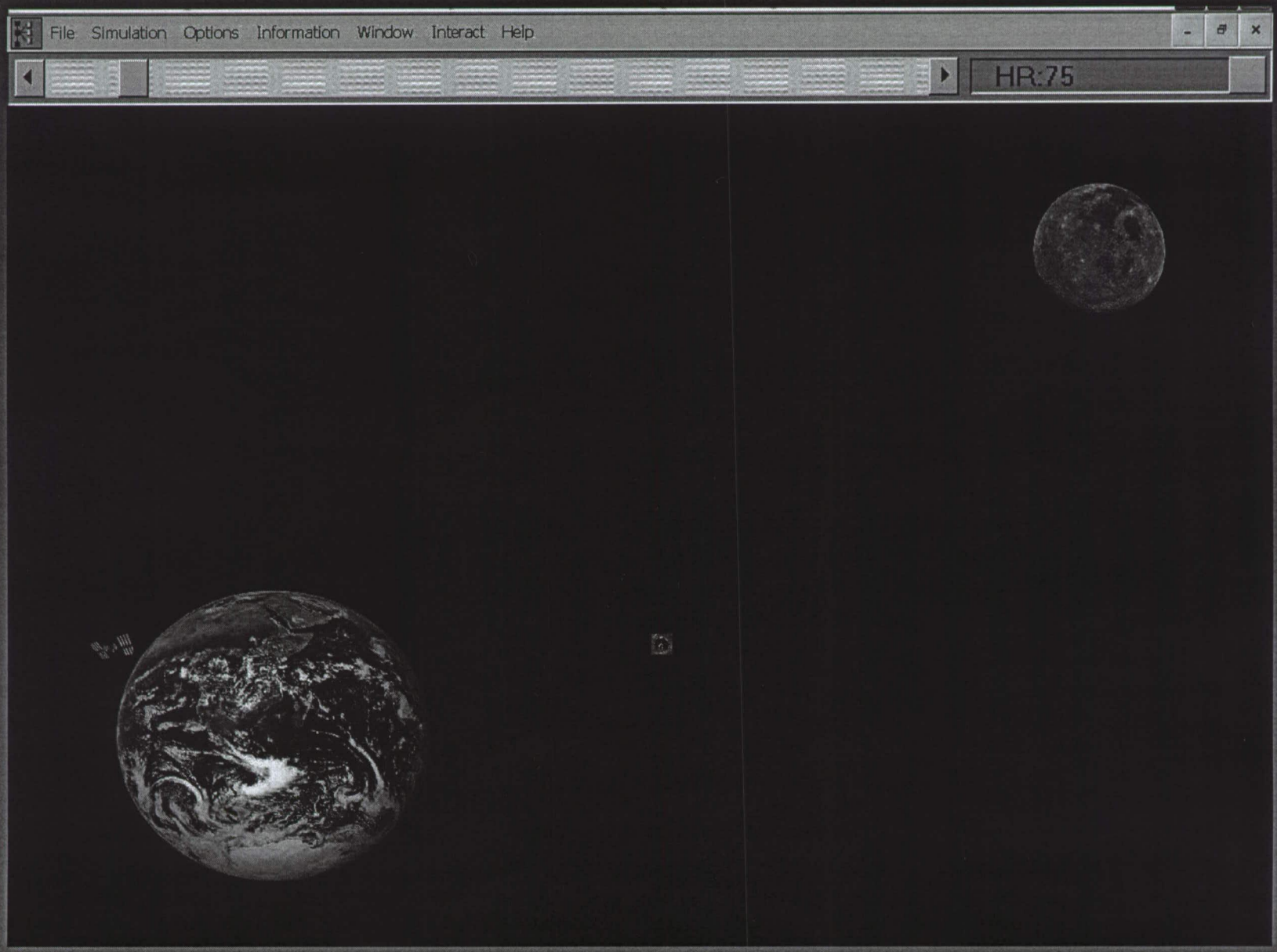


# Vision for Space Exploration

## United Space Alliance:

- Partnered with several leading companies to develop concepts for space exploration
- Worked on separate teams
- Recommendations presented at NASA Headquarters in Washington, D.C.

# Early Model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# Concepts Explored

## Key Points:

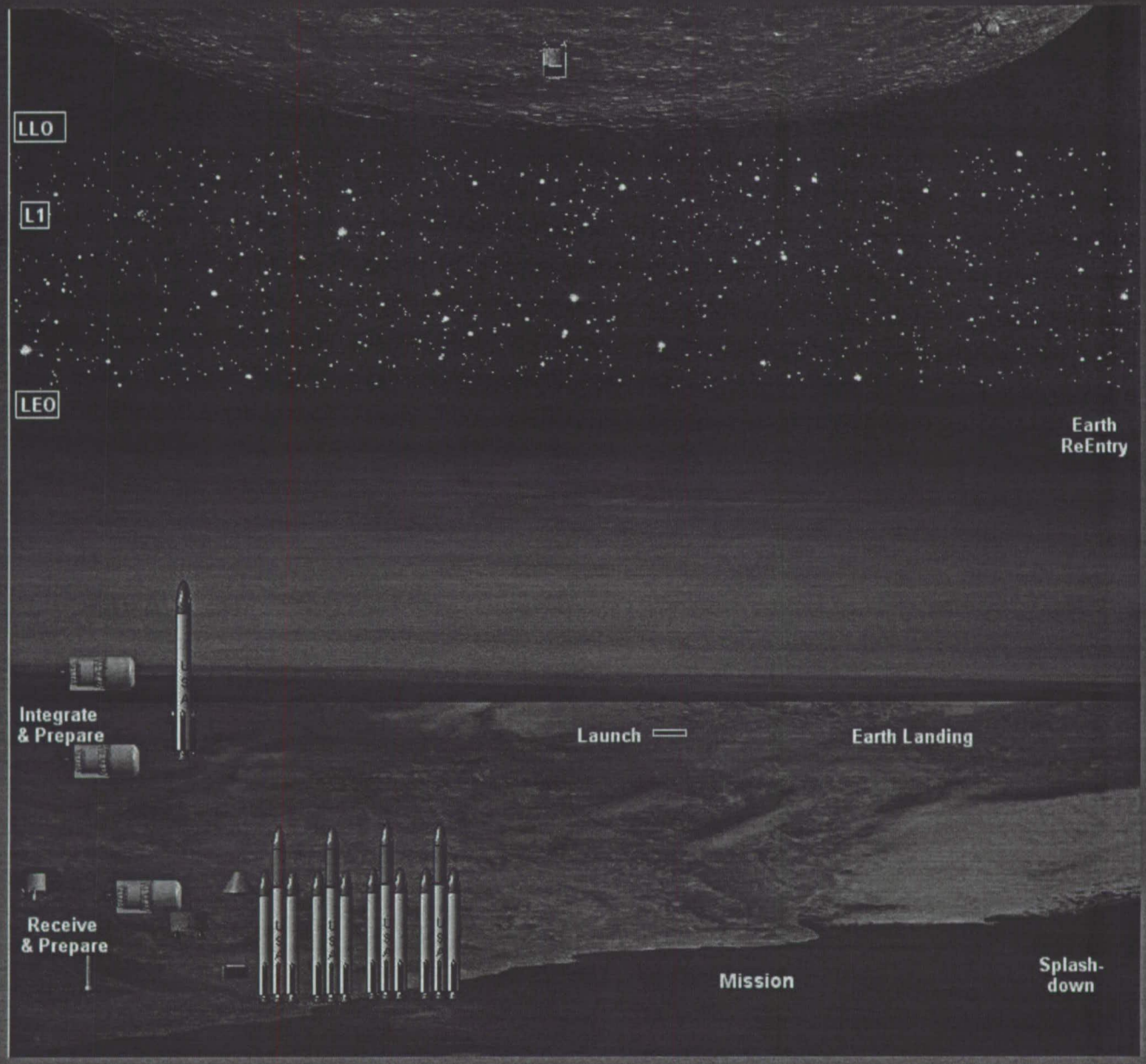
- Missions utilize multiple "single stick" rocket launches to deliver payloads & crew to orbit
- Rockets have different hardware modules onboard depending on mission
- Rockets not reusable; however, some payload modules might be recovered and used again
- Mission progressions must meet NASA timeline milestones

# Exploration Model

## ProModel Simulations:

- Created over a dozen different mission designs
- Built in variability including launch delays, etc.
- One run contains flight manifest sequence of all missions spanning about 20 years
- Created several baseline models
- Performed 100 replications for each study
- Graphics library grew to over 85+ MB

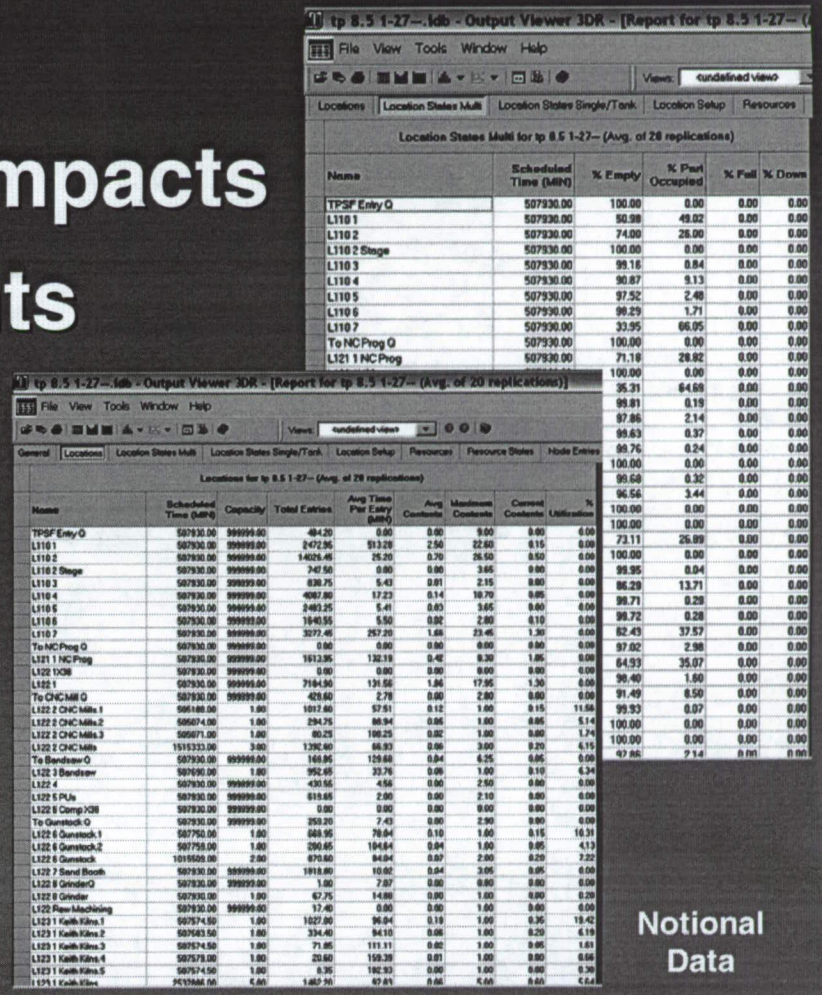
# Exploration Model



# Applications

## Output Results:

- Process Cycle Times
- Mission Sequencing Impacts
- Inventory Requirements
- ➢ Reliability Impacts
- Metric Tons Flown
- Crew Days on Moon
- Consumables
- Others




Notional Data

# Reliability Impacts - Example

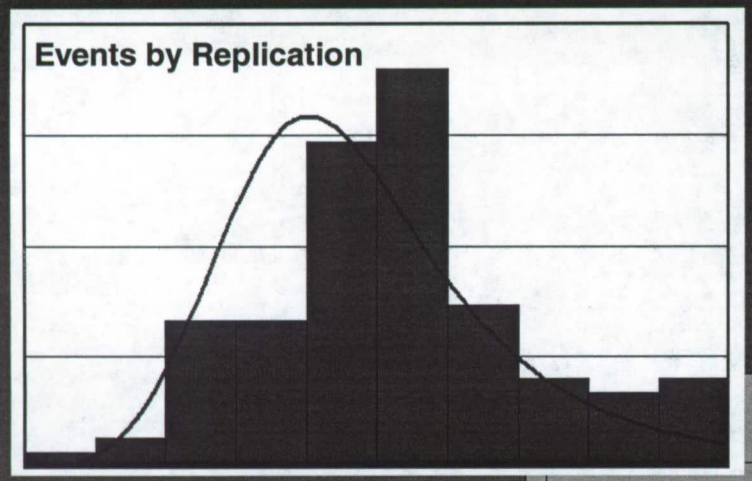
## ProModel Simulation Model:

- Inputs an Excel spreadsheet with probabilities that negative events might occur at different stages of a mission, I.e., "probability that a rocket fails to deliver its payload to orbit"
- Model creates an Excel output file recording each event along with mission, rocket, date, location, payload modules on board, etc.
  - Derived Best, Worst, & Average Cases
  - Created a list of hardware needs

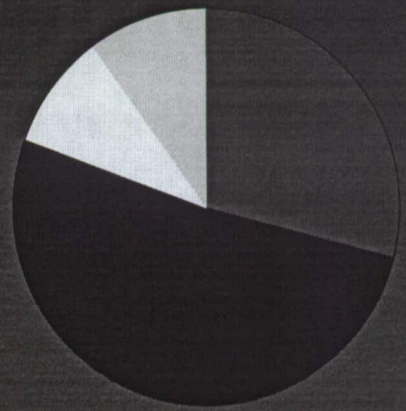
# Reliability Impacts - Example

## Notional Data:

| Day # | Mission # | 1st Entity Element | Launch | Location | RE Type |
|---|---|---|---|---|---|
| 96.63, | 1, | e_ELV_Heavy, | 3, | l_Unload_Leo1, | 1 |
| 1435.92, | 4, | e_ELV_Medium, | 5, | l_Launch_Pad, | 2 |
| 1876.59, | 5, | e_ELV_Heavy, | 3, | l_Unload_Leo1, | 1 |
| 2120.67, | 7, | e_ELV_Medium, | 5, | l_Launch_Pad, | 3 |
| 4814.92, | 15, | e_Earth_Departure_Stage, | 3, | l_LEO, | 5 |




Events by Location

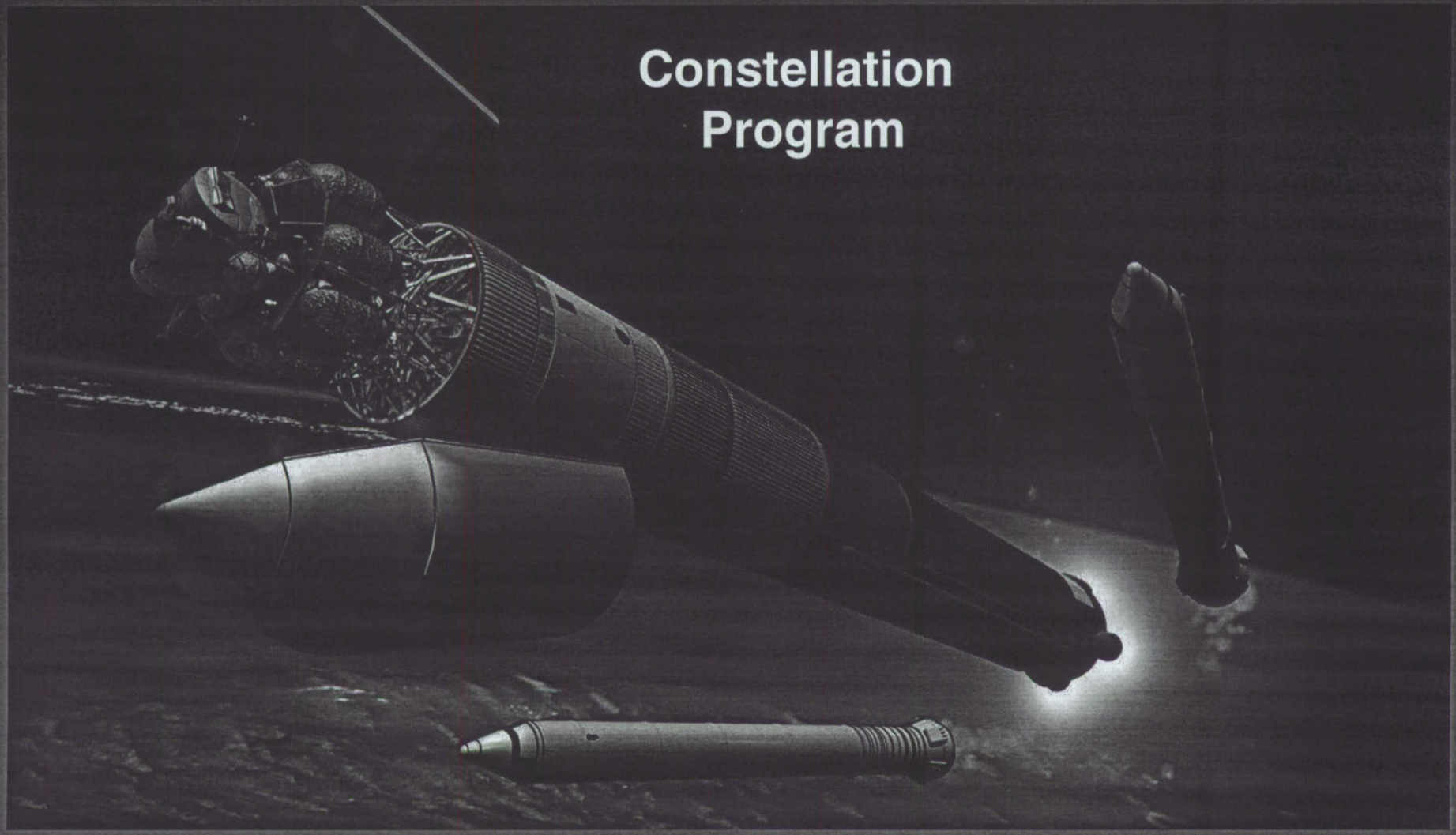



Average Spares Required from Events:

| | |
|---|---|
| 2 ELV-H | 1 ELV-M |
| 2 EDS/PEDS | 1 Cargo |
| 1 LSAM | 2 CM |
| 1 MM | 2 SM |
| 1 Hab | |

# Concept Defined by NASA

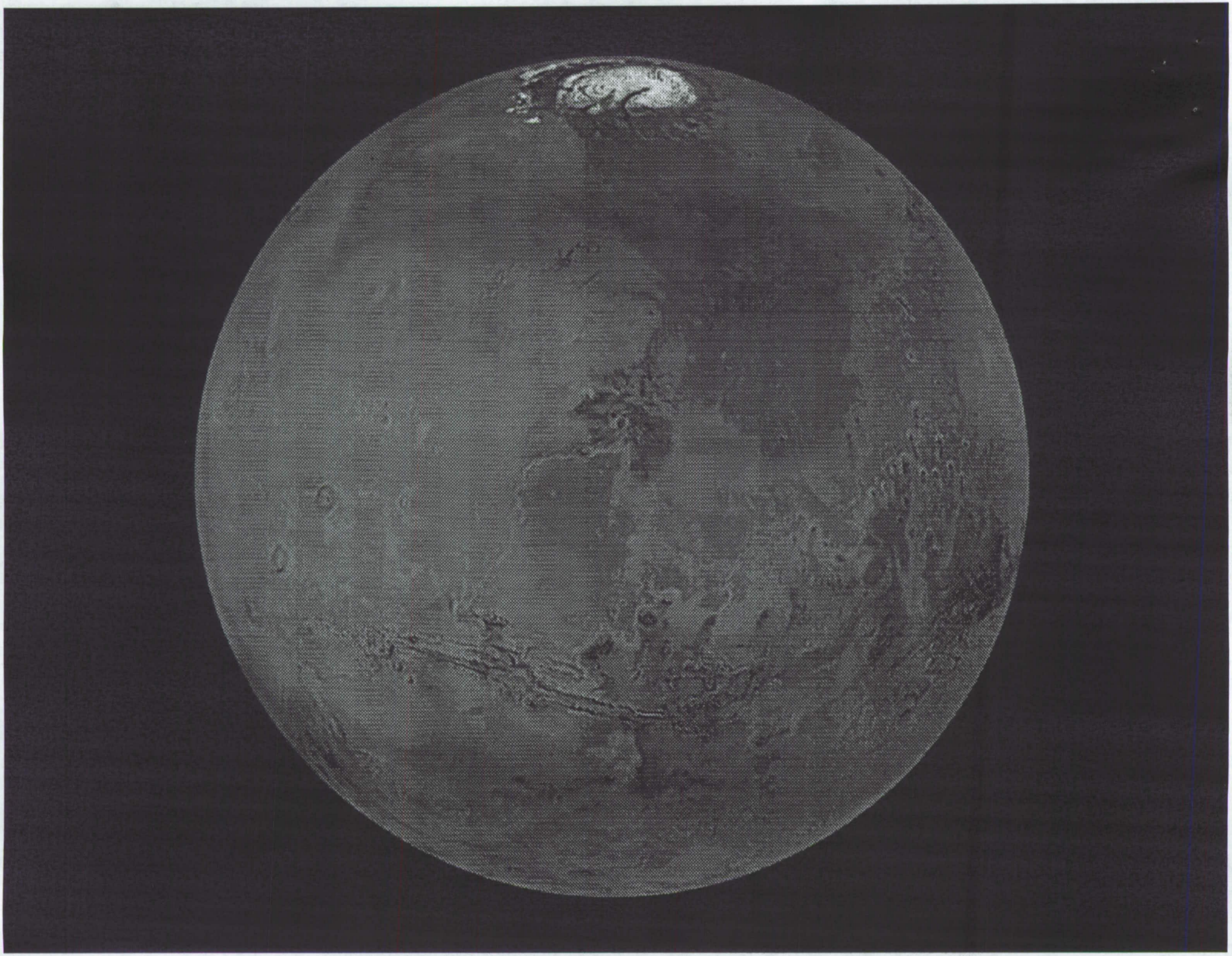
## Shuttle Derived Launch Vehicles (SDLV):

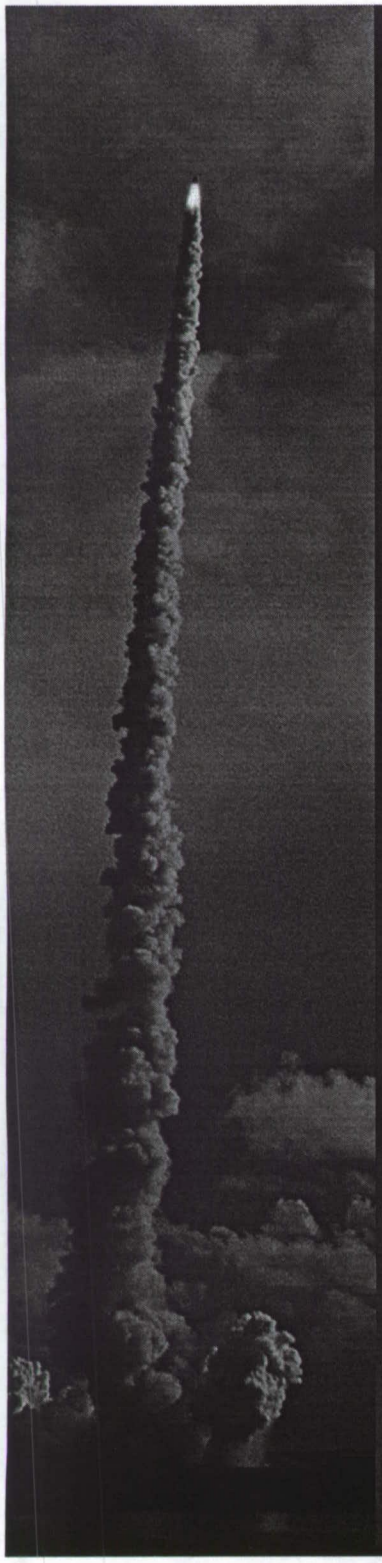


# Next Steps

## ProModel Simulation Projects:

- Developing SDLV models
- Opened more opportunities for simulations
  - Expanded M&S interest within USA
  - NASA emphasis on M&S in contracts
- Process simulation continues to be a vital tool in USA's Lean Six Sigma process improvement efforts

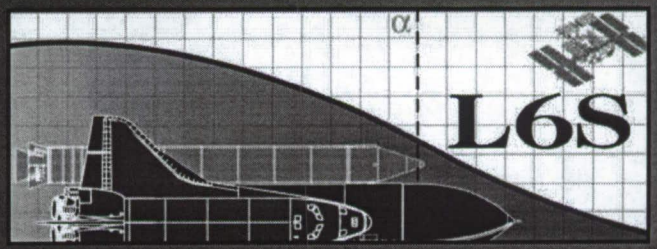




USA®

United Space Alliance

# Thank You




Best of
Hubble Photos
Viewable at http://hubblesite.org/
Or http://nix.nasa.gov/