Ground & Launch Systems
TA-13

Orbital Perspective

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Ground Operations – "The Obvious"

- Ground Operations Critical to Launch Success
  - Significant percentage of historical launch failures attributed to operations and / or processing errors and oversights
- Significant Component of Total Launch Costs
  - From 15% to as much as 40% depending on vehicle complexity
- Vehicle Design and Configuration Dictates Ground Operations Approach

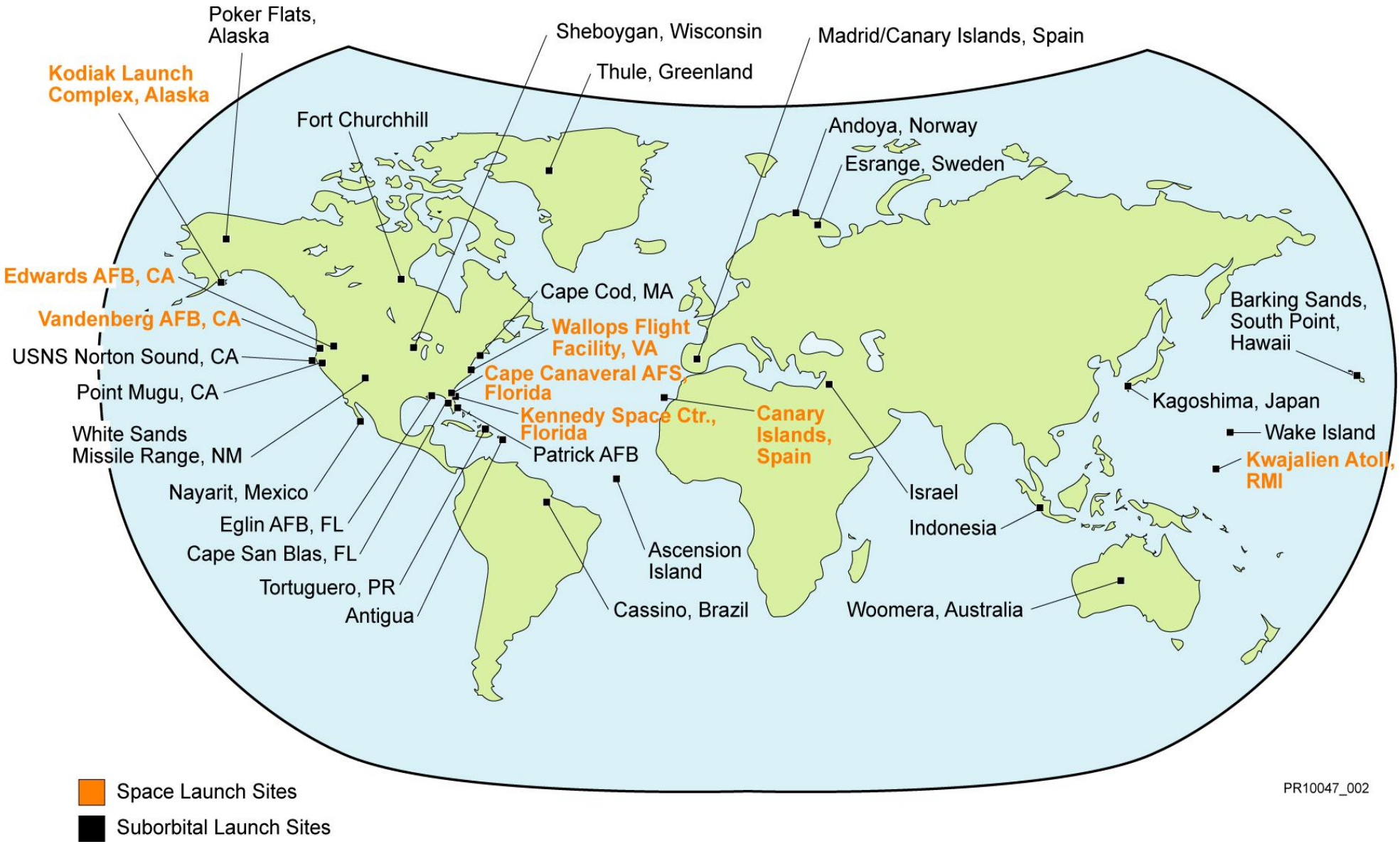
Ground Operations – "The Not-So Obvious"

- Vehicle on-pad time drives operations costs
  - Harder
  - Restricted
  - Subject to other variables (Weather, other launches, etc.)

- Launch sites are austere environments which are tough on infrastructure
  - Environmental effects
  - Launch effects

- Launch site cost is always a function of requirements
  - Requirements are always a function of vehicle, payload and mission complexities

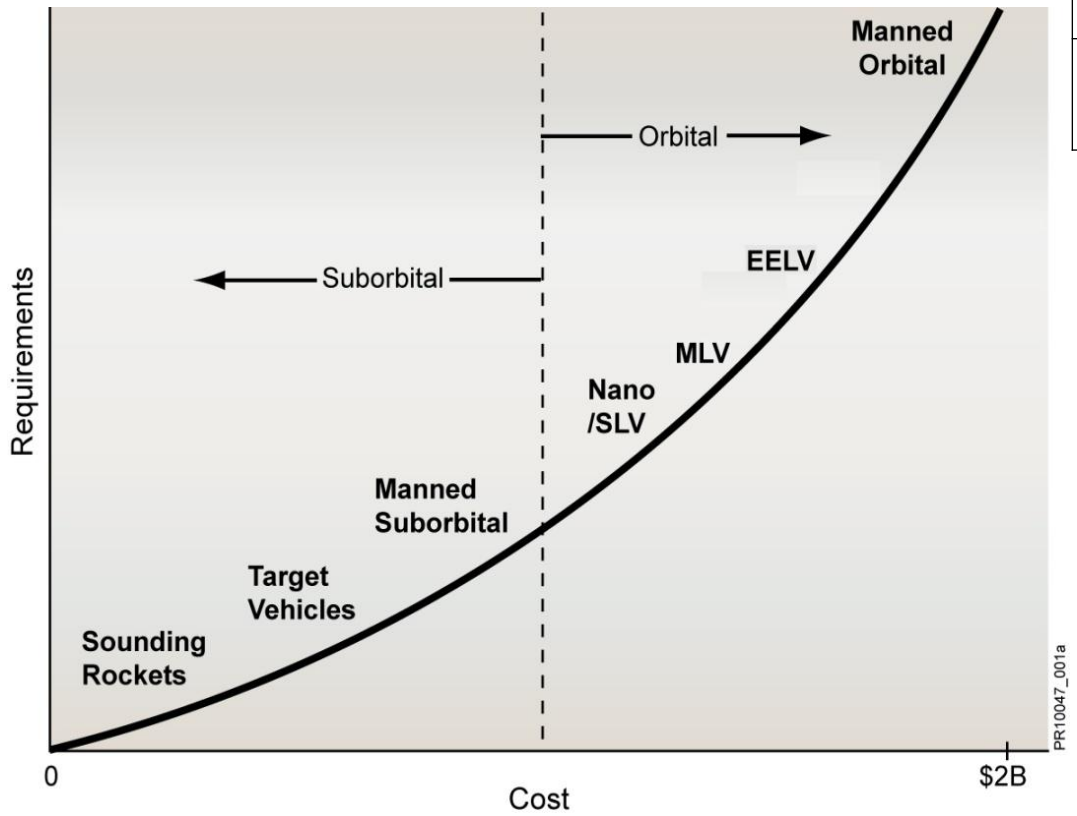
Orbital has Launched Over 600 Vehicles from 33 Launch Sites Throughout the World



Lessons Learned:
Launch Site Cost is a Function of Requirements

- Orbital has either designed and built, provided requirements to modify, or interfaced directly with existing infrastructure at each launch site
- Launch site cost is always a function of requirements
- Requirements are always a function of vehicle, payload and mission complexities:

Vehicle Propulsion	Liquid vs. Solid
Payload Size	Large vs. Small
Mission Type	Orbital vs. Suborbital
Launch Rate	High vs. Low
Payload Type	Manned vs. Unmanned



Experience Reveals:

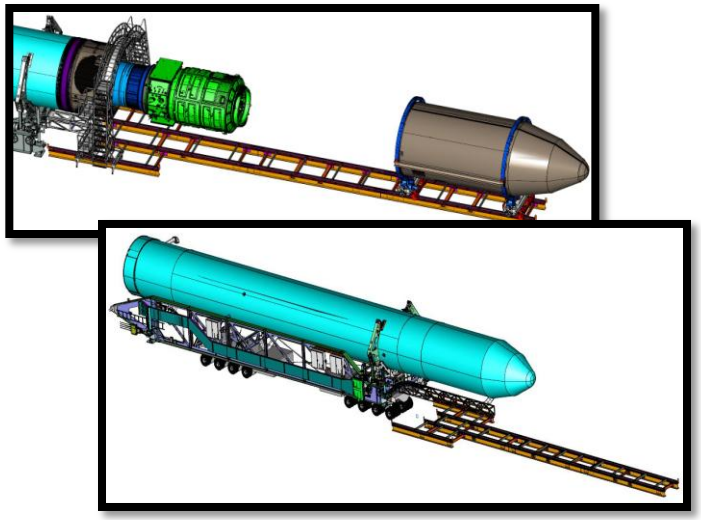
- Grouping similar requirements together is better than forcing ‘one size to fit all’
  - Broad capability launch sites like KSC/CCAFS likely need more than one integration facility and launch complex
- Using existing facilities is OK if they are ‘right-sized’ and users pay only marginal cost
  - Assumption is that the cost to maintain aging facilities is less than capitalizing a newer, more efficient facility now and in the reasonable future
  - Industry can only capitalize new facilities if there is a predictable and sustainable business base
- Sharing facilities works so long as user requirements remain compatible
  - Risks: one user’s problems ripple to all; insufficient users burdens all
- Requiring government agencies to capitalize common infrastructure is preferred
  - Typical role for these agencies (infrastructure meets *THEIR* requirements)
  - Supporting infrastructure promotes successful business and the creation of jobs

Innovative Approaches

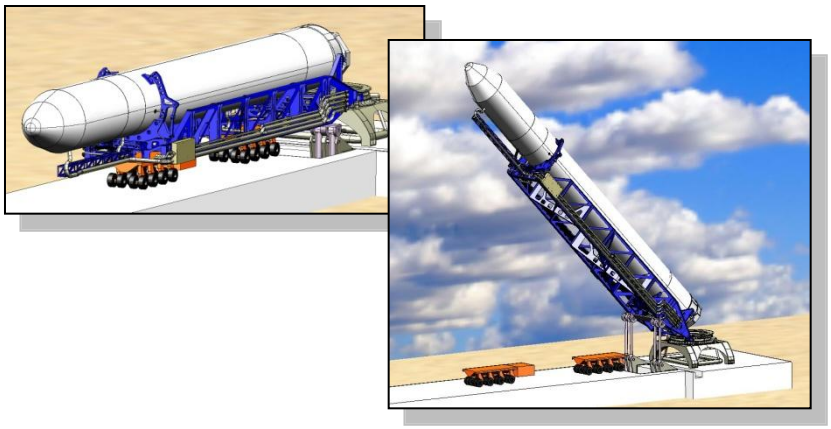
Lessons Learned

- Detailed, Repeatable Procedures
  - Routine, Scripted Operations
  - Excruciating attention to detail
- Small, Experienced Launch Teams
  - Cross-trained
- Streamlined Vehicle/Payload Integration and Testing via Simplified Avionics Interfaces and Offline Payload Encapsulation
- Highly Automated Fueling (and De-fueling) Systems

Taurus II Wallops Launch Site



Horizontal Integration for Fast, Safe, Efficient Processing



Transporter/Erector/Launcher System Designed for Safe, Rapid Transfer of LV to Pad

"Commercial" Ground Operations Approach

Payload Delivery

MPCV Delivery

SM Delivery*

*Not Assembled with MPCV

SRB Core Delivery

MPCV Vertical Integration & Processing

O&C

Short Duration Non-Hazardous Ops

SRB Vertical Integration & Processing

RPSF

Short Duration Hazardous Ops

OR

Payload Integration & Processing

SSPF

Short Duration Non-Hazardous Ops

OR

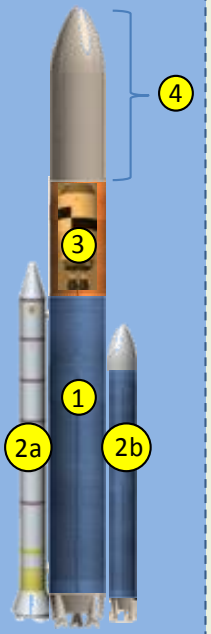
Launch Vehicle Assembly

VAB

- Vertical Integration and Assembly
- System-Level Processing, Inspection, and Verification

LV Assembly Sequence

1. Erect Core and Attach Vertically to MLP
2a. Attach SRB to Core
2b. Erect LRB Core and Attach Vertically to Core
3. Erect Stage 2 and Attach Vertically to Core
4. Integration and Assembly of Fairing, Cargo and/or Crew Elements to US or I-SS



Short Duration Hazardous Ops

LV Transport to Launch Pad

Mobile Launch Table + Rail System

Short Duration Hazardous Ops

Launch Pad

LC-39B

- "Clean Pad"
- LV Alignment to Launch Pad
- Automated Verification of Connections to LV
- Mobile Crew Gantry Aligned to LV
- Crew Ingress
- LV Fueling
- Pre-Launch Ops

Short Duration Hazardous Ops

LRB Mfg, Integration & Processing

Decatur

Long Duration Non-Hazardous Ops

LRB Core Delivery

Core Mfg, Integration & Processing

Michoud

Long Duration Non-Hazardous Ops

Core Delivery

Stage 2 Mfg, Integration & Processing

Michoud

Long Duration Non-Hazardous Ops

Stage 2 Delivery

Baseline

Alternate

Other

Ground & Launch Systems Processing Roadmap Comments

- Generally Agree with Broad Concepts and Perspective

- Many Projects and Initiatives Identified
  - Suggest focus on the few that will have the best synergy and most benefit to likely emerging NASA HLS systems
    - Vehicle Health Monitoring and Sensing Systems (Check-out)
    - Cryogenic Fluid Storage and Distribution System Insulation Materials
    - Helium Purging Optimization
    - Automated Fueling Systems
    - Corrosion Protection
    - Architectures to Support Distributed Mission Control