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The NASA Human Space Flight Supply Chain…
On Earth…

The NASA Human Space Flight Supply Chain…
Extending to Space…

1. Earth and Earth Orbit

2. Moon and Lunar Orbit

3. Node/Arc

4. Element

5. Process

Transportation from Node 1001 to Node 1501
Element(s): 1 2 3 4 5 6 7 8

6. Date

Date: 07-Dec-1972
Day 3

7. Node Information

Node Name | Position
---|---
1001 NASA KSC | 29N 81W
1017 Pacific Ocean | 18S 166W
2009 Apollo 17 Landing | 20N 31E
1501 LEO Parking Orbit | P 296 A 296 I 29
2507 LEO inclined | P 112 A 112 I 20

8. Element Information

<table>
<thead>
<tr>
<th>EL#</th>
<th>EL Name</th>
<th>TRA</th>
<th>ACT</th>
<th>DIS</th>
<th>CRW</th>
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<tbody>
<tr>
<td>1</td>
<td>S-IC X X</td>
<td></td>
<td></td>
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<td></td>
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<tr>
<td>2</td>
<td>S-II X X</td>
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<td>3</td>
<td>S-IVB X X</td>
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<td>4</td>
<td>SLA X</td>
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<td>5</td>
<td>CM X</td>
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<td>6</td>
<td>SM X</td>
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<td>LM DS X</td>
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<tr>
<td>8</td>
<td>LM AS X</td>
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10. MOE

<table>
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<tr>
<th>MOE</th>
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<tbody>
<tr>
<td>Crew Surface Days (CSD)</td>
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<tr>
<td>Expl. Mass Delivered (EMD)</td>
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<tr>
<td>Exploration Capability (EC)</td>
</tr>
<tr>
<td>Up-Mass Cap. Util. (UCU)</td>
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<tr>
<td>Total Launch Mass (TLM)</td>
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<tr>
<td>Rel. Scenario Cost (RSC)</td>
</tr>
<tr>
<td>Tot. Scenario Risk (TSR)</td>
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</table>

Rel. Expl. Capability (REC) | 0.00 [n.d.]

Courtesy of: [http://spacelogistics.mit.edu/about.htm](http://spacelogistics.mit.edu/about.htm)
A Supply Chain of over 1500 Suppliers…

Space Shuttle Program Active Supplier Distribution by State

Data Source: Mike Galluzzi
NASA Supply Chain Manager
Strategic Sustainment Office

Qualified (Active) Supplier Count Distribution

<table>
<thead>
<tr>
<th>Orbiter</th>
<th>RSRM</th>
<th>ET</th>
<th>SSME</th>
<th>SRB</th>
<th>TOTAL</th>
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<tbody>
<tr>
<td>812</td>
<td>395</td>
<td>68</td>
<td>147</td>
<td>119</td>
<td>1,541</td>
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</table>

Supplier Color Count Code

- 1 - 18
- 19 - 36
- 37 - 54
- 55 - 72
- 72+

As of: 12/04

The NASA Exploration Supply Chain, SCOR, Simulation & Analysis
A Space Shuttle Operation Flowing:

- ~$1B per year in material purchases as items, flight and ground element hardware, projects and tangible goods
- + ~$3B per year in information as services, labor and intangibles

- in a low volume market with set demand for the transportation product of about 5 launches per year...
- with flight and ground technology that is usually custom, developing and not mature by commercial standards, and also low volume...
- incurring variance in all parts and processes, due to low volumes...
- while morphing into a new product line simultaneous with on-going operations...
- fulfilling as payload and ultimate “deliver-able” the parts and the in-space construction of an International Space Station in Low-Earth Orbit.
Amidst flawed tracking systems for following the money...

Follow the *money*  (...if you can)

- In May of 2004, the Government Accounting Office sent a Report to the Subcommittee on Space and Aeronautics, Committee on Science, House of Representatives
  - “NASA’s lack of Disciplined Cost-estimating Processes Undermines NASA’s Ability to Effectively Manage its Programs”.
- Numerous other similar critiques have surfaced over the decades…
Supply Chain Scope…two extremes…

Logistics is improved by good supply chain management.

SCM as “deliver” only part of an organization.

We are here

The combination of art and science that goes into improving the way your company finds the raw components it needs to make a product or service, manufactures that product or service and delivers it to customers. Plan, make, source, deliver, return.
Perspective, Kennedy Space Center Shuttle Ops

The NASA Exploration Supply Chain, SCOR, Simulation & Analysis

Edgar Zapata / Mike Galluzzi / NASA
Flight Systems

- From one launch, to a two launch solution
- From Low-Earth orbit only operations to Lunar and Planetary capability
Constellation Launch Vehicle Elements

Ares I Crew Launch Vehicle

- First Stage (5-Segment Reusable Solid Rocket Booster (RSRB))
- Forward Frustrum
- Upper Stage
  - J-2X Upper Stage Engine
  - Interstage
- Spacecraft Adapter
- Forward Skirt
- Crew Exploration Vehicle (CEV) (Crew Module / Service Module)

Ares V Cargo Launch Vehicle

- Core Stage
  - LOx/LH2
  - Five RS-68 Engines
  - Al-Li Tanks/Structures
  - Two 5-Segment RSRBs
- Interstage
- EDS Stage
  - LOx/LH2
  - One J2S+ Engine
  - Al-Li Tanks/Structures
- LSAM

Instrument Unit

LOx/LH2
NASA Future Plans & Needs

- **Ground Systems**
  - Migrating from reusable systems being processed to receipt of more expendable elements…
Our Exploration Supply Chain Definition

We define an Exploration Supply Chain as:

The integration of NASA centers, facilities, third party enterprises, orbital entities, space locations, and space carriers that network/partner together to plan, execute, and enable an Exploration mission that will deliver an Exploration product (crew, supplies, data, information, knowledge, and physical samples) and to provide the after delivery support, services, and returns that may be requested by the customer.
The NASA Human Space Flight Space Transportation Supply Chain “As-is” viewed as an Enterprise Level Network

The Space Operations Supply Chain “As-is” Space Shuttle as a Relationship Network of Enterprises – These exchange Materials or Information

Suppliers Suppliers

Suppliers Suppliers

Main Suppliers

My Enterprise

Suppliers Suppliers

Customer / Requirements

ISS @ JSC

NASA Exploration Supply Chain, SCOR, Simulation & Analysis

Edgar Zapata / Mike Galluzzi / NASA
The NASA Human Space Flight Space Transportation Supply Chain “To-be” viewed as an Enterprise Level Network

The Space Operations Supply Chain “To-be” Orion / Ares I as a Relationship Network of Enterprises – These exchange Materials or Information

<table>
<thead>
<tr>
<th>Suppliers Suppliers Suppliers</th>
<th>Suppliers Suppliers</th>
<th>Main Suppliers</th>
<th>My Enterprise</th>
<th>Customer / Requirements</th>
</tr>
</thead>
<tbody>
<tr>
<td>S’S’Suppliers</td>
<td></td>
<td>Prime @ KSC</td>
<td>KSC @ FL Launch &amp; Landing</td>
<td>ISS @ JSC</td>
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<tr>
<td>SRB FWD ASSY Suppliers</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>ATK @ UT</td>
<td></td>
<td>Other Suppliers</td>
<td></td>
<td></td>
</tr>
<tr>
<td>R-dyne @ CA</td>
<td>CLV 2nd Stage @ TBD</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>OSC LAS</td>
<td></td>
<td>Other Suppliers</td>
<td>MEFC @ AL</td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>(Non-Prime)</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>Other Suppliers</td>
<td>JSC @ TX</td>
<td></td>
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<tr>
<td></td>
<td></td>
<td>(Infrastructure/ GrndOps Logistics)</td>
<td>SSC @ MS</td>
<td></td>
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</tbody>
</table>

The NASA Exploration Supply Chain, SCOR, Simulation & Analysis

Edgar Zapata / Mike Galluzzi / NASA
The NASA Human Space Flight Space Transportation Supply Chain “As-is” viewed as an Functional Units…and Resources

The Space Operations Supply Chain “As-is” Space Shuttle as Physical Locations of Major Enterprise Physical Functional Units – Each of these belongs to an Enterprise

These Operations Management and Information Functional Units @ KSC flow into all the more specific Physical Locations above as enabling processes
Simulation and SCOR - E2O Supply Chain Sim
http://science.ksc.nasa.gov/shuttle/nexgen/supply_chain_main.htm

The Exploration Earth-to-Orbit Supply Chain Simulation project –
• NASA KSC
  • Edgar Zapata, PI
  • Mike Galluzzi, Shuttle SC Manager
• Productivity Apex Inc. of Orlando Fl.
  • Sam Faye, Ph.D
  • Mansooreh Mollaghasemi Ph.D

Enterprise Definition
Flow the Materials
Attach the Information
Map to SCOR
Simulate

Capture the knowledge
Represent the data
Estimate the “to-be”
E20 Supply Chain Sim
Scenario Analysis

- Capability to analyze different, advanced operating scenarios and new initiatives:
  - New designs & architectures
  - Practices
    - e.g. VMI / VOI, RFID, e-Shop Floor, commonality, modularity, etc.
• Define a Supply Chain on a geographic and Space-time map.

• Automatically generate the process flow of the end-to-end Space Exploration Supply Chain

• Automatically generates the Key Performance Indicators relevant to the Supply Chain
Simulation templates consistent with SCOR – Plan, Source, Make, Deliver, and Return
- Automatically generate simulation models.
E2O Supply Chain Sim
Visualize the improvements…

Ability to model “what-ifs” that follow both time and money
Improvements by:
• Understanding the supply chain at a strategic level
• Design of the supply chain
• Application of best practices – quantified as to potential effects

The Complexity…it CAN be managed,
understood…and turned into useful knowledge
How dynamic is the future state? Shaping demand rather than accepting it.

**Present State**
Linear, push manual practice

Supply

Demand

10% is what we see... results... and all that "other processing stuff" where the time and money is... 90% what we don't see.

Accepting demand
New technology an exception
Deterministic optimization

**Future State**
Circular, self-renewing simulation model

Sustaining

Demand Management

Program Interface ETO Sim
Configuration Mgt.

Repair Cost SAP R/3 ERP
Logistics ESI

10% Direct Visible overlap of operations

Assets

Shaping demand
Embedded technology insertion
Probabilistic planning optimization
Explorations Systems Analysis and Technology Assessment Project

- This research and development project:
- Will create a model that provides linkage between the what, how and why of Launch and Landing costs and flow times, reflecting on future affordability and responsiveness for space launch, specifically the Exploration architecture.
- Locate the rudders
- Communicate to key decision makers and stakeholders
- Quantify
- Model
ESATA & The Iceberg: Root Influences, $ and Time
http://science.ksc.nasa.gov/shuttle/nexgen/ESATA_main.htm

The NASA Exploration Supply Chain, SCOR, Simulation & Analysis

KSC Launch & Landing Effects Ground Operations (LLEGO) Model Prototype 10-2-06

The NASA Exploration Supply Chain, SCOR, Simulation & Analysis
Complexity and reliability influence product outcomes such as cost, safety, responsiveness (time to process a launch) and growth potential.

Strive to establish, understand and quantify design operability drivers and influence on the product outcomes.

Work with designers, collaborate early and often.

**Upper Stage**
- 280-klb Liquid Oxygen/Liquid Hydrogen (LOX/LH₂) stage
- Expendable
- 5.5-m diameter
- Aluminum-Lithium (Al-Li) structures
- Instrument unit and interstage
- RCS/roll control for First Stage flight
- CLV avionics system
- NASA-led design and development

**STS Derived SRB**

**CEV / Orion Crew Exploration Vehicle**

The NASA Exploration Supply Chain, SCOR, Simulation & Analysis

Edgar Zapata / Mike Galluzzi / NASA
Closing

♦ Project “E₂O SC Sim” is currently go through November
  ● Project runs through June 2007.
♦ Project “ESATA / LLEGO” is go through August 2007

♦ Work to date has shown:
  ● SCC SCOR as an Efficient Approach for Managing and Understanding the Complexity in the NASA Exploration Supply Chain
  ● Ability to connect knowledge based ontology approach to an automatically generated simulation via a graphic user interface
    – Program once, use many times!

♦ A Supply Chain Perspective has already proven useful in just organizing data – what is flowing? Where? Why? What information is virtual? What are the enabling processes? The match to “resources” and NASA flow of product, even at low volume, is especially applicable.