

National Aeronautics and Space Administration



# Supply Chain Research & Analysis for Space Systems

*Goddard*  
SPACE FLIGHT CENTER

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Supply Chain 2018 Conference  
October 23, 2018



## Presentation Topics

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- Goddard's Supply Chains
- Strategic Challenge / Supply Chain Risks
- Supply Chain Management / Risk Management
- Supply Chain Research & Analysis
  - Purpose / Key Attributes
  - Analytical Framework
  - Core Process / Report Types
  - Products of Interest
  - Case Examples
- Bringing It All Together
- Summary / Discussion



# Diverse Mission Portfolio

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## Transiting Exoplanet Survey Satellite (TESS)

Medium Class Explorer

NASA GSFC performed project management

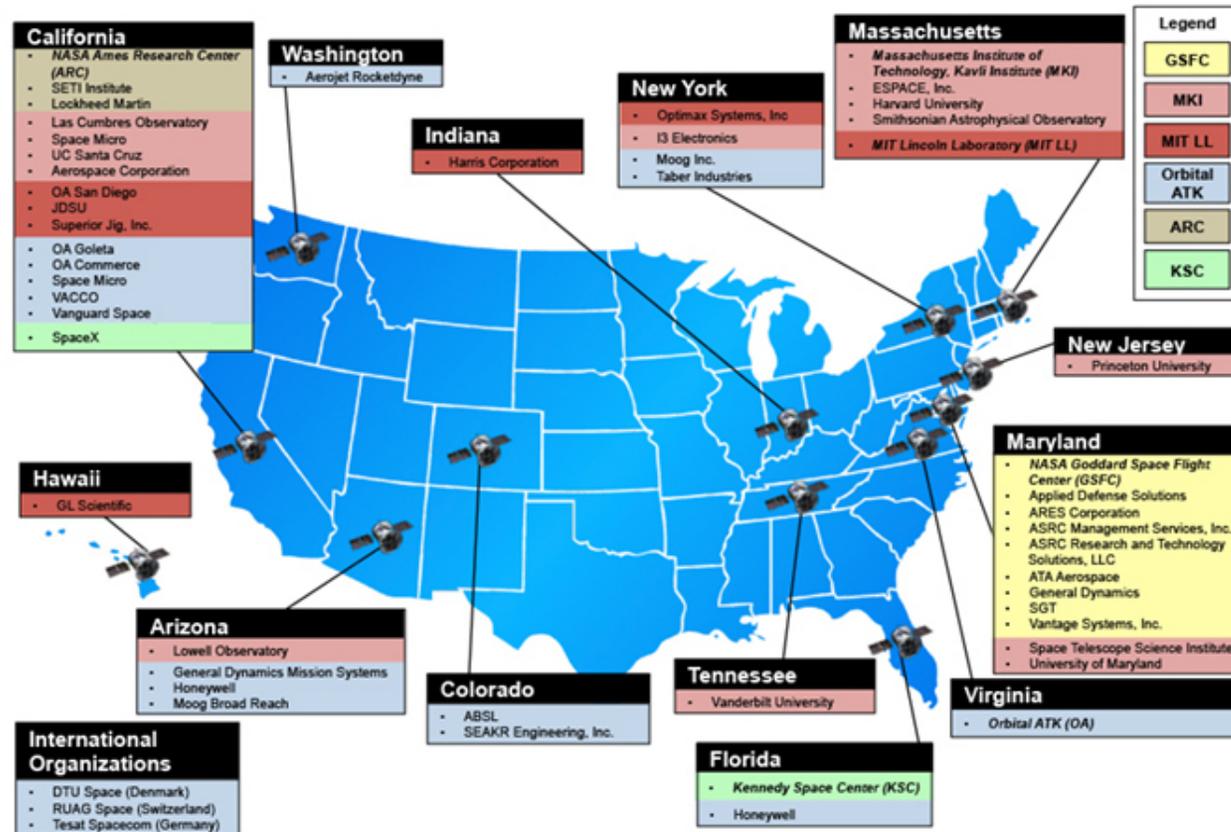
Launched April 18, 2018





# Major Partners and Subcontractors

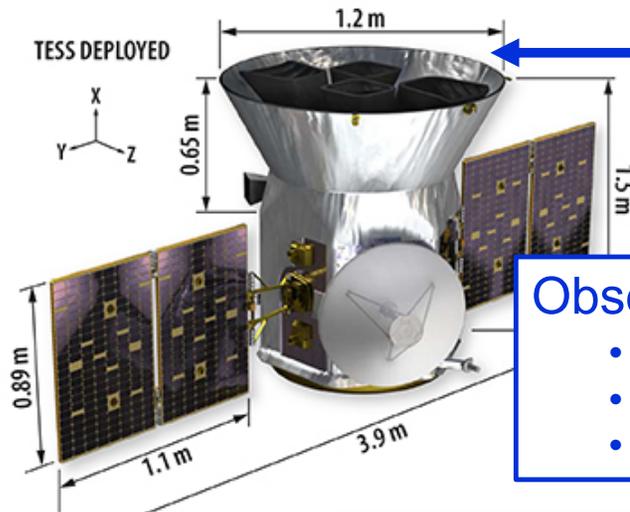
## Transiting Exoplanet Survey Satellite (TESS)





# System / Supply Chain Complexity

Transiting Exoplanet Survey Satellite (TESS)



Observatory (system) = spacecraft + instrument

- Subsystems, components, assemblies, parts
- 314+ product line items tracked
- 63+ suppliers identified, located in six countries

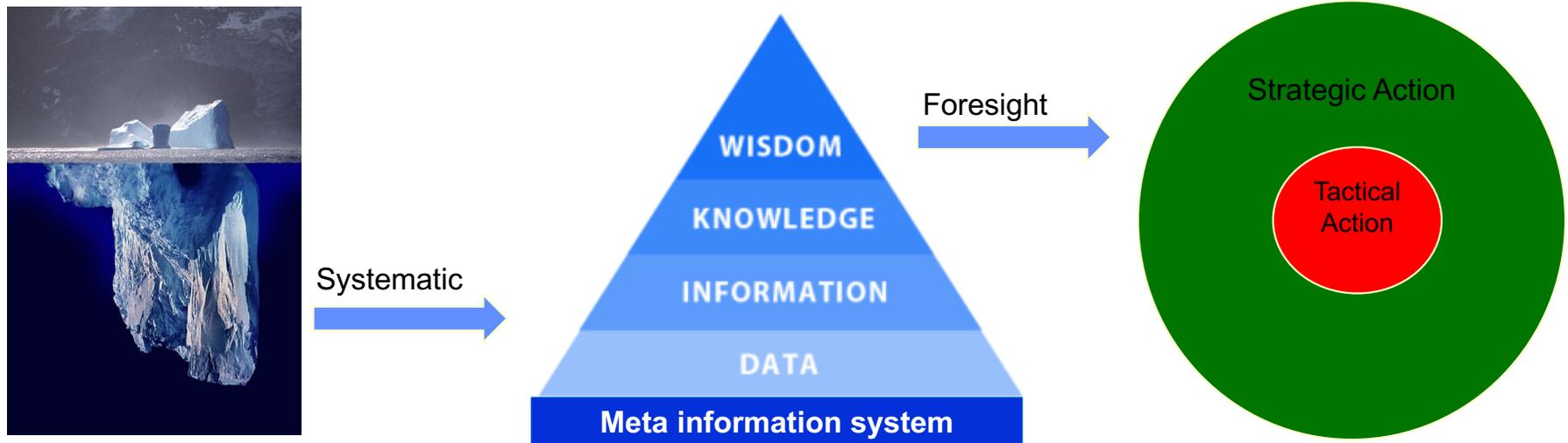




## Strategic Challenge / Supply Chain Risks

- GSFC mission projects rely upon interconnected, multi-tiered supply chains subject to a broad array of risks that can disrupt the provision of high quality, affordable products and services when needed

***Building Knowledge and Processes for Informed Planning, Oversight and Decision Making***



*As we know, there are known knowns; there are things we know we know. We also know there are known unknowns; that is to say we know there are some things we do not know. But there are also unknown unknowns – the ones we don't know we don't know. Donald Rumsfeld, Secretary of Defense, 2002*



# Supply Chain Management

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## Mission Performance

Spacecraft, Science Instruments, Ground Systems

-  = Safety & Mission Assurance
-  = Flight Projects Management
-  = Engineering & Technology
-  = Procurement

## Outcomes

- Quality Products and Services
- On-Time Delivery at Acceptable Cost
- Innovative Problem-Solving / Continual Improvements
- Risk Reduction

## Core Functions



### Supplier Development

- Technology Investments
- Procurement Policy
- Small Business Program
- Outreach

### Acquisition

- Acquisition Strategy
- Proposal Team Building
- Procurement (direct and indirect)

### Performance Management

- Project Management / Contract Oversight
- Mission Assurance Requirements
- Surveillance, Inspections and Alerts
- Parts to System-level Testing

### Evaluation & Risk Management

- Project Lifecycle Reviews
- Internal Management System Assessments
- Supply Chain Assessments, Research & Analyses
- Project and Enterprise Level Risk Management

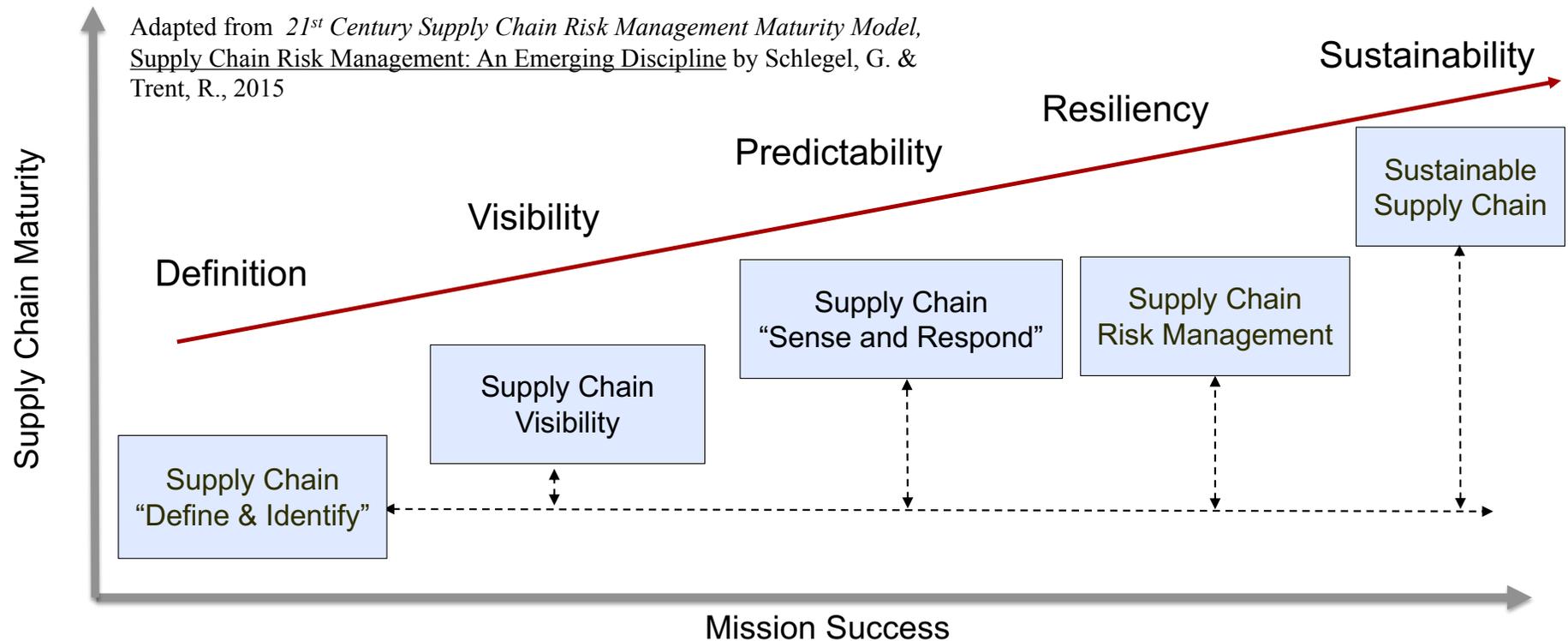
Meta and other Information Systems for Process / Data Management and Informed Decision-Making



# Supply Chain Risk Management

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Adapted from *21<sup>st</sup> Century Supply Chain Risk Management Maturity Model*,  
*Supply Chain Risk Management: An Emerging Discipline* by Schlegel, G. &  
Trent, R., 2015



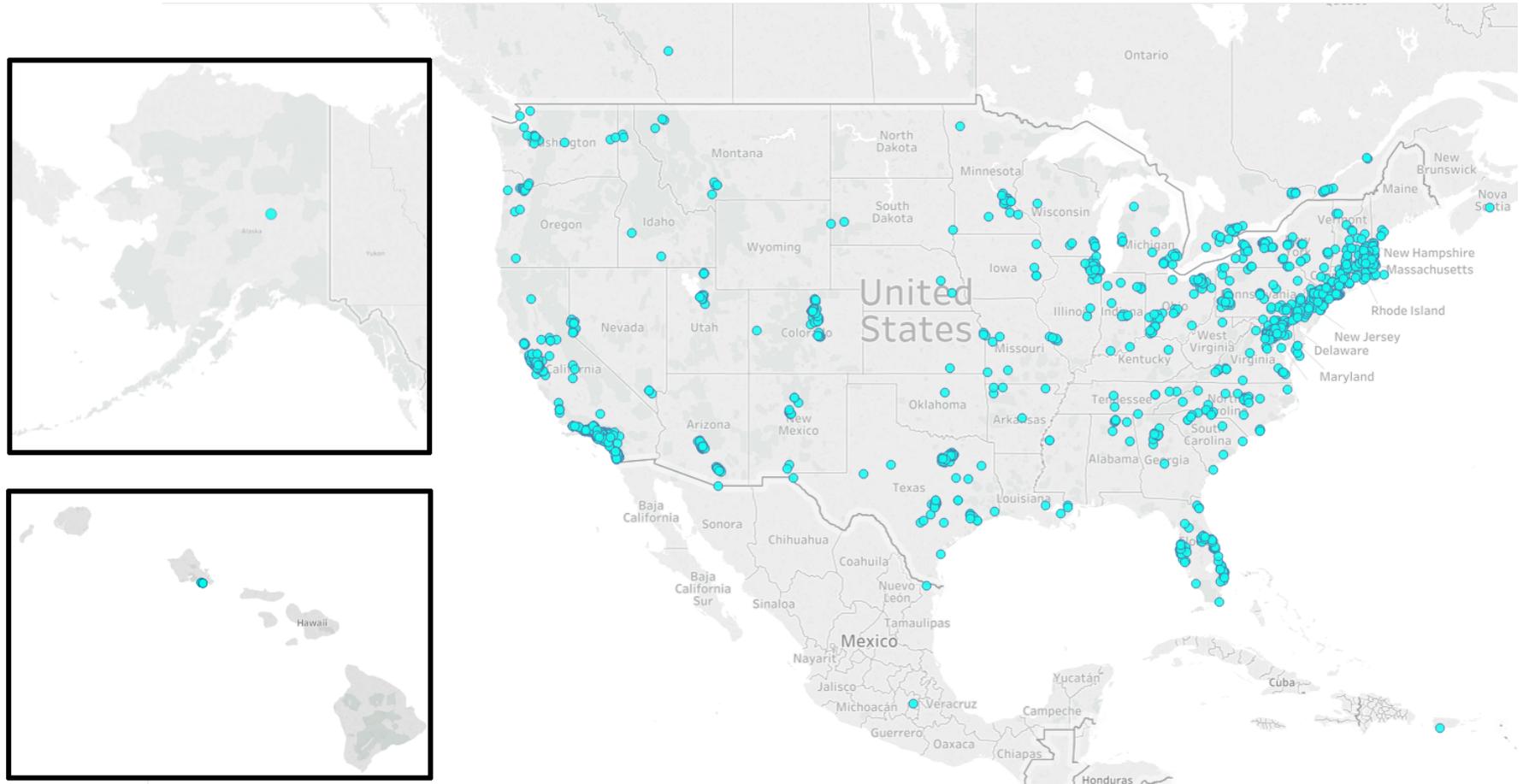
- *Project Management & Procurement*
- *Project Lifecycle Reviews*
- *Internal Management System Assessments*
- *Supply Chain Assessments, Research & Analysis*

- *Supply Chain Mapping & Analytics*
- *Integrated Risk Management*
- *Meta Information System*
- *Digital Transformation*



# U.S / North America Locations of Suppliers

Goddard Space Flight Center



Source: NASA's Meta information system as of 10/17/2018; maps of Hawaii and Alaska not to scale.



# Worldwide Locations of Suppliers

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Source: NASA's Meta information system as of 10/17/2018



# Purpose / Key Attributes

Supply Chain Research & Analysis

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## Purpose

- Provide insight into the operating environment, capabilities, performance and viability of current and potential suppliers for GSFC mission projects

## Key Attributes

- Holistic analytical framework
- Guided by priorities, concerns, needs and products / services of interest
- Open source information + NASA / U.S. Government information
- Internal use only
- Non-intrusive
- Timely, Affordable
- Sound, Credible
- Lean, multidisciplinary team
- Complementary to traditional project management / SMA disciplines and methods



# Analytical Framework

## Supply Chain Research & Analysis

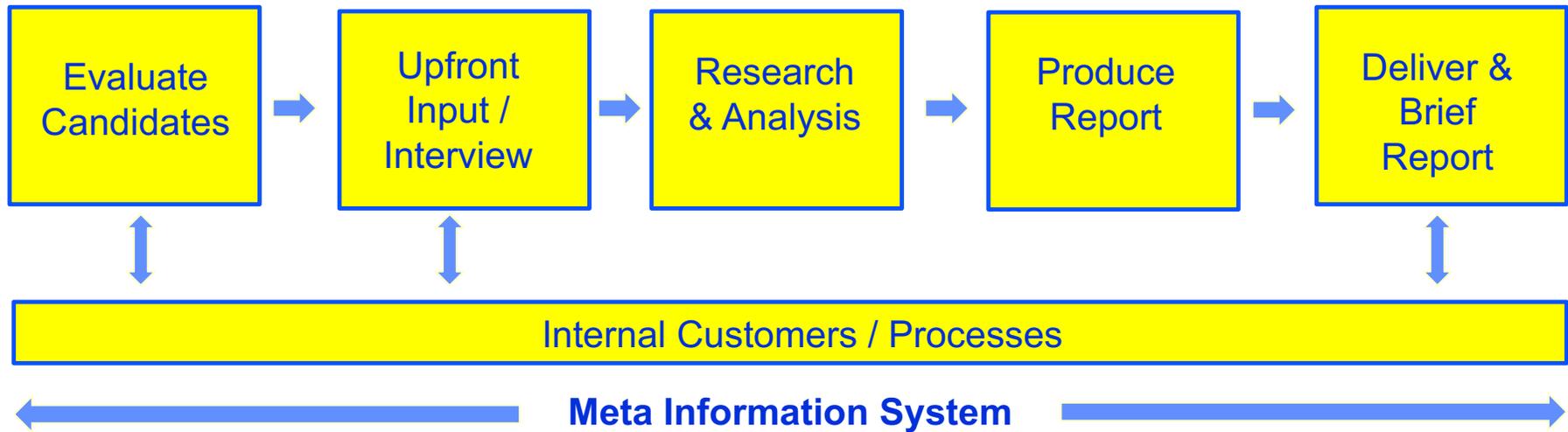
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Categories	Key Factors
Technical / Production	Quality Management, Manufacturing, R&D/Innovation
Business Enterprise	Leadership, Organization, Workforce, Supply Chain Management, Financial Health, Business Alliances
Market	Industry Position, Market Trends, Regulatory/Legal
Security	Socioeconomic Environment, Cybersecurity, Physical Security



# Core Process / Report Types

Supply Chain Research & Analysis



## Levels of Research & Analysis / Report Types

- Rapid Supplier Insight
- Supplier Information Profile
- Supplier Information Profile & SWOT (Strengths, Weaknesses, Opportunities, Threats) Analysis



# Some Products of Interest

## Supply Chain Research & Analysis



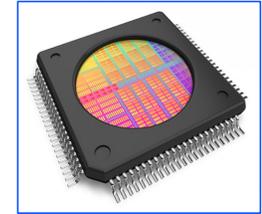
Bipropellant Thruster Valve



Lithium-Ion Battery



Solar Array



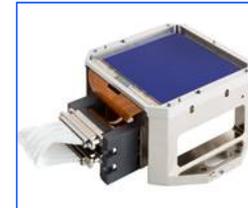
Semiconductor



Thruster Engine



Spacecraft Bus



Charge-coupled device



Inertial Reference Unit



Optical Encoder



Software



Star Tracker



# Case Examples

## Supply Chain Research & Analysis

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- Case 1: Very small, privately-held company (less than 10 employees) located 3500+ miles from GSFC under contract to produce components on the critical path of several GSFC mission projects
  - Leadership / business continuity: “one-man show”
  - Inadequate quality management, history of delivery delays and security concerns
- Case 2: Well-established, recurring commercial source (~\$300 million / year) of a critical component for GSFC mission projects under acquisition by a large corporation (~\$3.0 billion / year)
  - Possible operational disruptions due to acquisition
- Case 3: Very large enterprise (~\$10 billion / year) with multiple subsidiaries that supply key components / subsystems for GSFC mission projects experienced prior cyberattack and illicit technology transfer events
  - Future security incidents could impair design / production
- Case 4: Entrepreneurial business established in 2001 with experience in design / technology development for space systems identified as a potential subcontractor to develop and integrate micro-satellites for a possible mission
  - Home-based company led by an entrepreneur lacks capabilities at present...no discoverable facility for production/integration/test nor quality management

Supplier Research & Analysis reports illuminate strengths, weaknesses, opportunities and threats in providing insight and situational awareness



# Case Example

## Supplier Research & Analysis to Risk Management

### Sourcing of XXXXX for GSFC Flight Projects

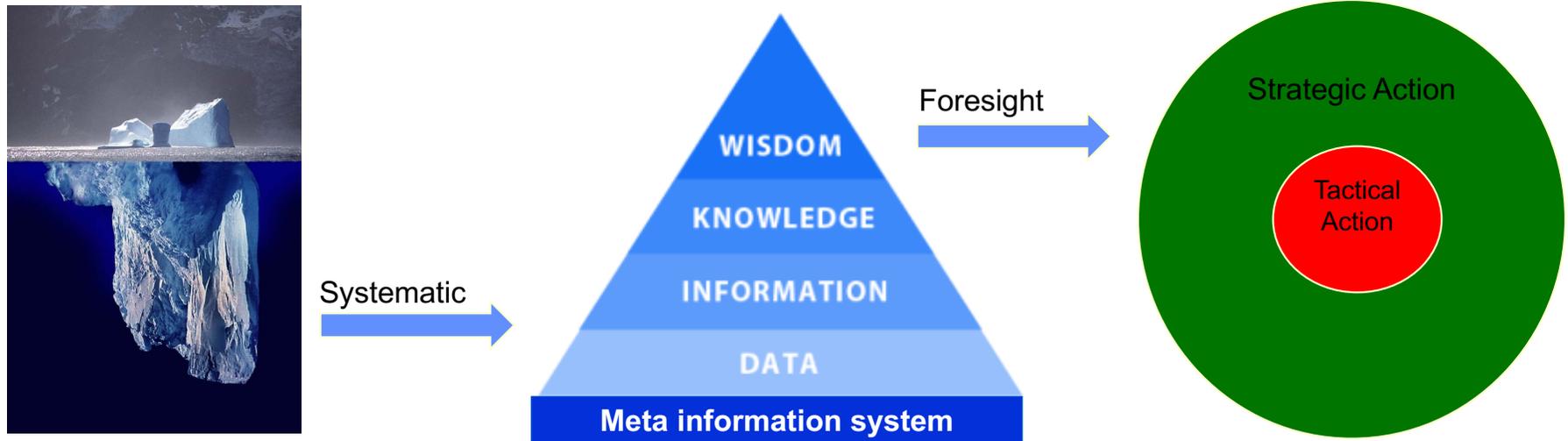
		Risk Statement (Condition; Consequence)	Approach: Research	Notes/Actions:
	Risk Rating Rationale			
<p style="text-align: center;"><b>LxC = 2x4</b></p> <p style="text-align: center;"><b>Risk Area: Supply Chain</b></p> <div style="display: flex; align-items: center; justify-content: center;"> <div style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: 8px; margin-right: 2px;">Likelihood</div>  <div style="writing-mode: vertical-rl; transform: rotate(180deg); font-size: 8px; margin-left: 2px;">Consequence</div> </div>	<p><b>Likelihood:</b> Likelihood of XXXXX experiencing disruption or termination of its production of XXXXX is low but credible given the relative vulnerabilities of the organization.</p> <p><b>Consequence:</b> Disruption or termination of XXXXX production could increase technical uncertainty, cause schedule delays and add to planned costs for multiple GSFC projects. Use of XXXXX that are defective could result in mission failure.</p>	<p><b>Given that</b> multiple GSFC projects are reliant upon two suppliers of XXXXX of which one (XXXXX) is vulnerable to business and market issues that could disrupt or terminate production; <b>there is a possibility</b> that GSFC projects could be effectively limited to a de facto sole source (XXXXX) <b>resulting in:</b></p> <ol style="list-style-type: none"> <li>1. insufficient production capacity to meet requirements on schedule at planned cost, and/or;</li> <li>2. the need to urgently and reactively establish alternative sources with associated technical uncertainty, schedule delay and additional cost.</li> </ol> <p><b>Context:</b> Supplier Research &amp; Analysis reports provided insight into two suppliers of XXXXX upon which GSFC projects are reliant: XXXXX and XXXXX. GSFC experience with suppliers of XXXXX and XXXXX is limited primarily to XXXXX (as a key supplier to XXXXX) and XXXXX.</p> <p>XXXXX is a small privately-owned, family-run manufacturing company located in XXXXX with a workforce of ~ 35 to 50 employees and annual revenue of ~ \$10 million. As such, it is relatively vulnerable to business and market risks that could disrupt its operations. Supplier of XXXXX products for: GOES 16(R), S, T, U; IceSat-2, JPSS 1, 2, 3, 4; JWST; Landsat-9; Lucy; Restore-L; RRM3; TESS, Europa Clipper Propulsion, and a potential supplier for WFIRST.</p> <p>XXXX (manufacturing facility in XXXXX) is a privately-held subsidiary of XXXXX public corporation (revenue of \$1.2 billion in 2017). The organization's products are used in GSFC projects, including DSCOVER, JWST, LandSat-8 (LDCM), MAVEN, NICER, TDRS-12/L and Europa Clipper Propulsion.</p>	<p><b>Actions per XX/XX/2018 meeting:</b></p> <ol style="list-style-type: none"> <li>1. Investigate and determine if suppliers of XXXXX have established or pending relationships with alternative, qualified suppliers of XXXXX.</li> <li>2. Continue supplier research to identify and gain insight into current / potential suppliers of XXXXX and XXXXX.</li> </ol>	<p><b>Risk Coordinator:</b> Code 382/J. Root <b>Risk Originator:</b> Code 382/J. Root</p> <p><b>Update as of X-XX-2018:</b> Action 1: XXXXX Action 2: XXXXX</p> <p><b>Recommendation:</b> monitor periodically to maintain awareness.</p>



# Bringing It All Together

## Meta Information System

- Integrated platform for process performance, data / information management and analytics supporting NASA mission performance, GSFC quality management and GSFC integrated risk management (includes supply chain risks)
- Meta applications bring together data / information / processes to provide insight into suppliers and their products / services for space systems
- Extending Meta capabilities to identify / assess / communicate / manage supply chain risks within and across the supply chains of GSFC mission projects

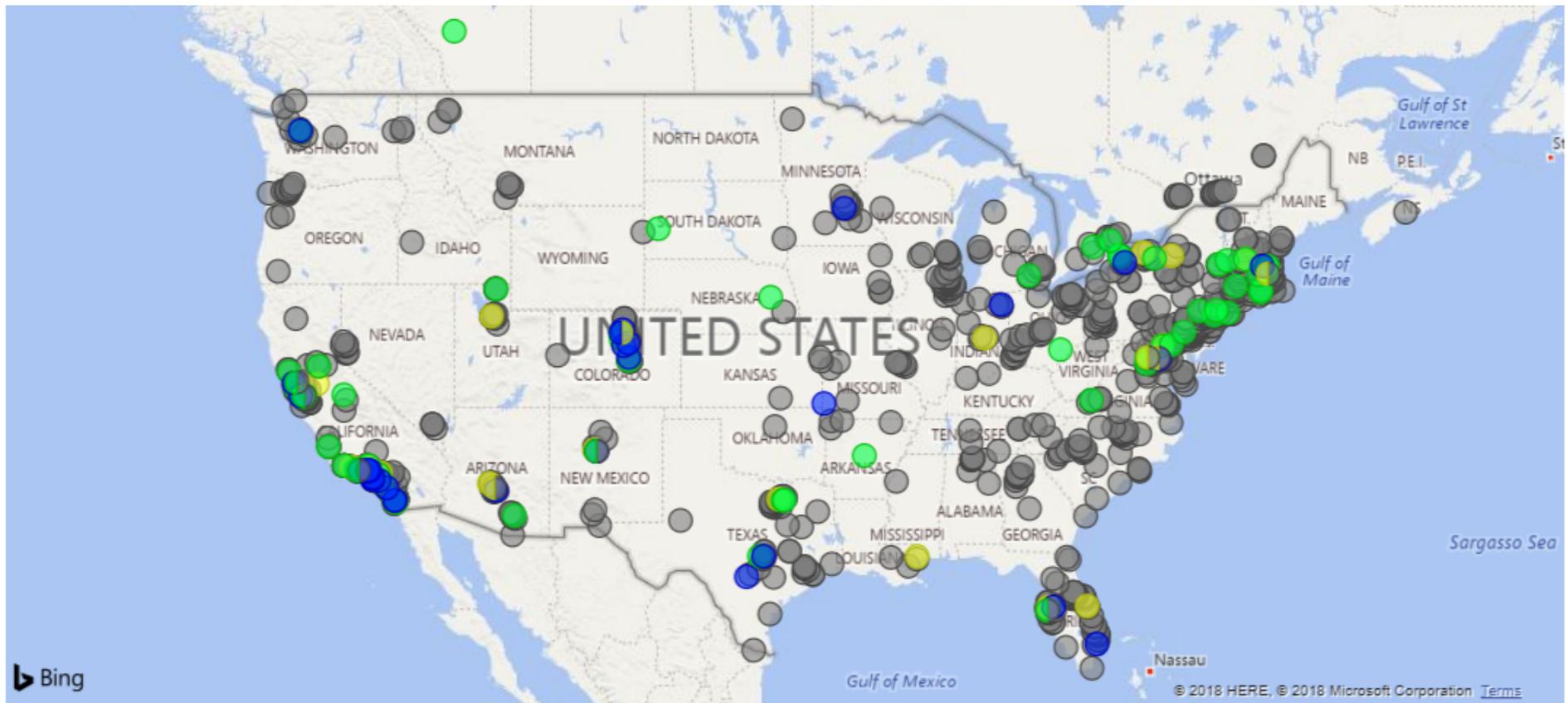




# Suppliers, On-site Assessments, Research & Analysis

U.S / North America

Supplier = ● On-Site Supplier Assessment = ● Supplier R&A = ● Supplier Assessment + R&A = ●





# Suppliers, On-site Assessments, Research & Analysis Worldwide

Supplier = ● On-Site Supplier Assessment = ● Supplier R&A = ● Supplier Assessment + R&A = ●

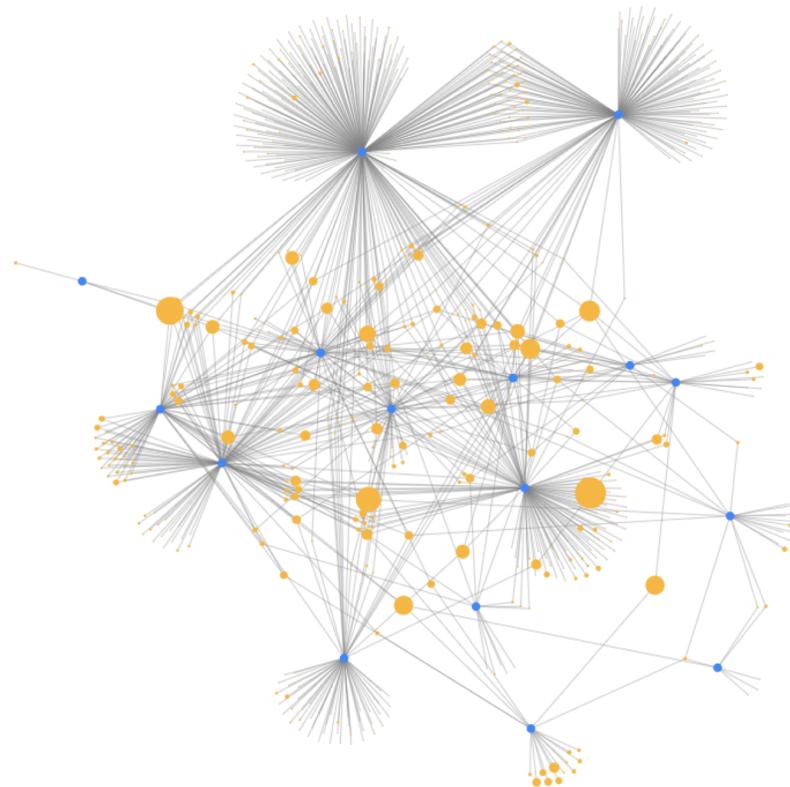




# Visual Supply Chain Analytics

## Meta Information System

Project Supplier Relationships



- Project
- ATLAS
  - CASSINI
  - Fermi (GLAST)
  - GEDI
  - GOES-16 (R)
  - GOES-17
  - ICESat-2
  - ICON
  - IXPE
  - JPSS-1
  - JPSS-2
  - JWST
  - JWST Sunshield Elements
  - LandSat-9
  - LCRD
  - Lucy
  - MAVEN
  - MMS
  - MOMA
  - NICER
  - O2O
  - OSIRIS-REx
  - PACE
  - POES
  - PSP
  - Restore-L
  - SDO
  - TESS
  - TIRS-2
  - WFIRST
  - XARM

Note: blue nodes = projects; orange nodes = suppliers. Sizing of supplier nodes dependent upon the number of project relationships



## Summary / Discussion



### An Old Proverb

For want of a nail the shoe was lost;  
For want of a shoe the horse was lost;  
For want of a horse the rider was lost;  
For want of a rider the battle was lost;  
For want of a battle the kingdom was lost;  
And all for the want of a horseshoe nail.

In proven and innovative ways we are building knowledge for informed planning, oversight and decision-making as we reduce the risks of exploring the Earth and space in achieving mission success

Thank you! Jonathan Root, [jonathan.f.root@nasa.gov](mailto:jonathan.f.root@nasa.gov)