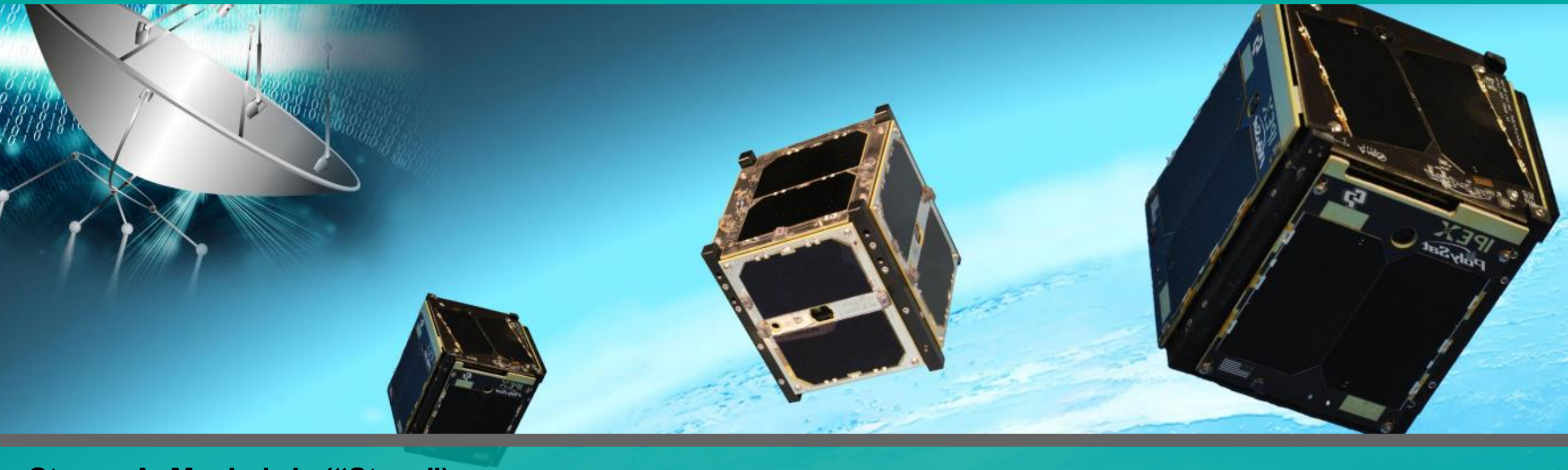
2019 CalPoly CubeSat Developer's Workshop & Conference



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Developing CubeSat Model Based Systems Engineering (MBSE) & Standards for Space (Ground & On Orbit)

April 22, 2019

OMG® & OMG Programs

Software / Hardware Standards

319 Organizations; 60+ Universities

Addressing IT standards for more than two dozen verticals, including: C4I, Communications, Finance, Healthcare, E-Government, Space, Industrial Internet of Things, etc.

The mission of the Object Management Group (OMG) is to develop technology standards that provide real-world value for dozens of vertical industries. OMG is dedicated to bringing together its international membership of end-users, vendors, government agencies, universities and research institutions to develop and revise these standards as technologies change throughout the years.

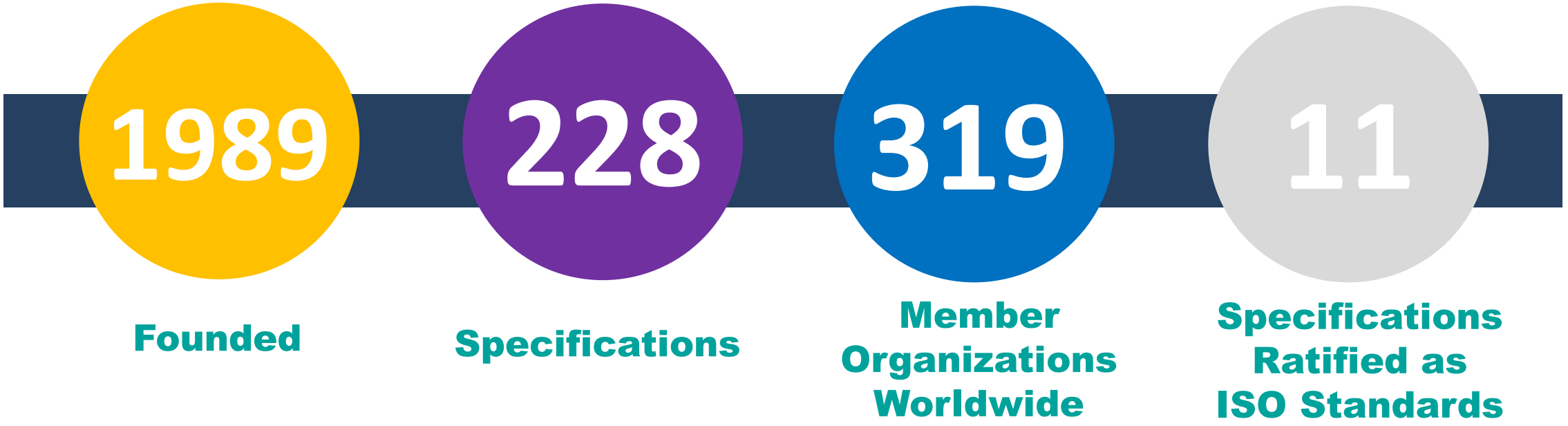
Industrial Internet of Things

216 Organizations
(Industrial Internet of Things)

Software Quality

726 Organizations – 8 Paid Sponsors
Cost = Free on Registration
(Cybersecurity Through ID'g Common Weakness Enumerations (CWE)

Who is OMG?



- One of the largest and longest-standing not-for-profit, open-membership consortia developing and maintaining computer industry specifications.
- Continuously evolving to remain current while retaining a position of thought leadership.
- Long-term maintenance of proven standards

About OMG

- Founded 1989
- International standards development organization
- 225+ specifications
- 325+ member organizations worldwide
- 11 specifications ratified as ISO standards

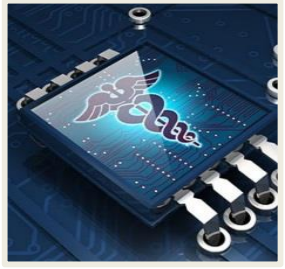
OMG Vertical Markets

Standards are developed by OMG using a mature, worldwide, open development process. With more than 25 years of standards work, the OMG one-organization, one-vote policy ensures that every vendor and end-user, large and small, has an effective voice in the process.

Finance

Government

Healthcare



Manufacturing

Military

Retail

Robotics

Space Exploration

Who Are OMG'ers ?

ACORD
Adaptive
Airbus Group
AIST
Amergint
Appian
ASMG
BAE Systems
Benchmark Consulting
Boeing
Carnegie Mellon Univ.
CA Technologies
CEA
Cisco Systems
Deere & Company
Dell Technologies
Diebold Nixdorf
European Space Agency
FICO
Ford Motor Company
Fujitsu
Georgia Tech
Genesco
Goldman Sachs
Holocentric
iGrafx
IBM
JARA
Johns Hopkins
Kongsberg Defence
Lockheed Martin
Mayo Clinic
MEGA International
MicroFocus
Microsoft
MITRE
NASA
NIST
No Magic
NOAA
Northrop Grumman
OCI
Oracle
Peraton
Perspecta
Petrosoft
PTC
QualiWare
Real Time Logic
RTI
Salesforce.com
SAP SE
Seiko Epson
Siemens
Software AG
Sparx Systems
State Street
THALES
The Aerospace Corporation
Thematix
Twin Oaks
Ulta Beauty
Vitech Corporation

Teal = Space Domain Task Force Members

Innovation Impacts

1960 – Jet performance data is downloaded by eyes & hand

2015 – Jet performance data is downloaded by hand

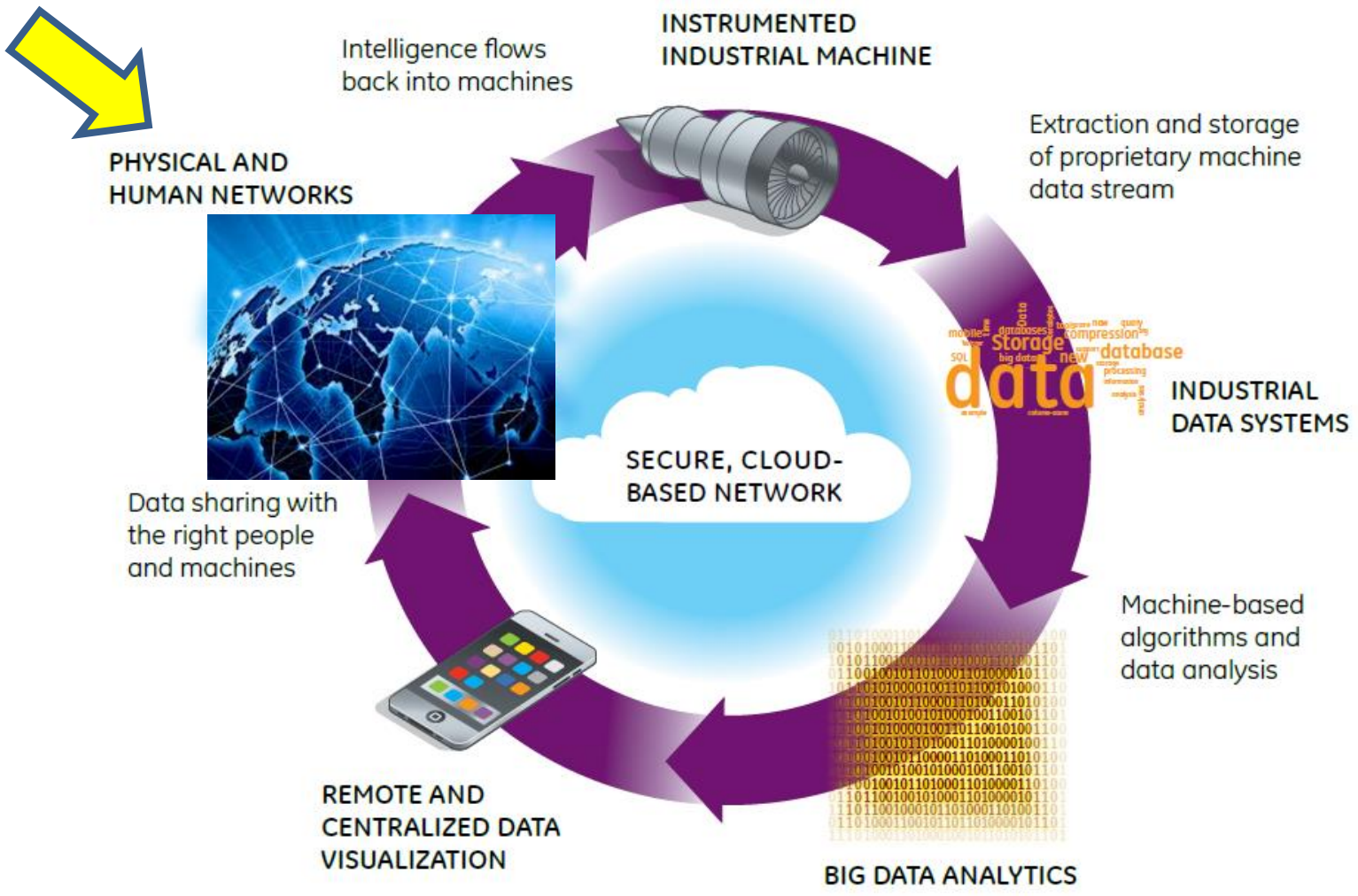
2017 – Jet Performance Data is Downloaded Wirelessly on the Fly & Performance Modified in Flight

Examples

industrial internet CONSORTIUM

CISQ™
Consortium for IT Software Quality™

A New Industrial Revolution With Multiple Impacts



Causing the Increased Need to address:

- Standards (OMG)
- Data Residency Challenges & Cloud Best Practices (OMG)
- Artificial & Actionable Intelligence (OMG)
- **Ontologies**
- IoT Architecture & Security (IIC)
- Software Quality (CISQ)

industrial internet CONSORTIUM

CISQ Consortium for IT Software Quality

Open Standards & Modeling Provide Savings & Focus

Targeting open standards **lowers Life-Cycle costs**, **Reduces Risk** & **Increases Resiliency and Returns on Investment (ROI)** through:

- **Increased Quality** (Specification, Designs and Implementation)
- **Vendor Neutrality** Specifications & Increased Competition
- **Increased Flexibility, Adaptability and Agility**
- **Higher** Levels of I**nnovation**
- **Increased Levels of Interoperability**
- More **Efficient Use of** Existing **Resources**
- Access to **a larger and better trained labor pool**
- **OMG Standards & Models are taught** in Comp Science & Cyber Security programs (community colleges as well as 4-year schools).
- **Reduces risk as well as cost** and **improves** overall resultant **product(s) by modeling behaviors** of systems

Open Standards enable users to focus on unique business/operational needs rather than common technical challenge(s)

Open Standards & Modeling Provide Savings & Focus

What's the Value?

Workforce flexibility	Interoperability	Process optimisation
Standard, best practice methods, inputs, and outputs ↓ Flexible distribution of tasks around workforce	Standard interfaces ↓ Flexible distribution of processes and information + Commodity services	Best practice, repeatable processes ↓ Optimisation (time, quality, cost) of flow of components and tooling
DoDAF (aka Unified Architecture Framework (UAF)) in EA practice	**CORBA, DDS, SCA, etc.**	**Modelling in service delivery (BPMN, UML, SysML) Ground Stations (XTCE, XUSP, GEMS, SOLM, C2MS)**

Attributed to: **Chris Frost** Fujitsu Distinguished Engineer FUJITSU

Open Standards & Modeling Provide Savings & Focus

Ways to Value from Standards & Standards Bodies

Standards Body offers:	Business gets value by:	Example:	Actions to take:
Access to latest industry standards, techniques, etc.	Using IP from standards bodies internally, and visibility of new industry trends	UAF used in internal EA framework and EA skills development.	• Active engagement by internal process owners • Promotion to internal technical communities
Publication and presentation platforms	Demonstrating capability and influencing the marketplace	Presentations delivered to conferences Own IP becomes industry best practice	• Present at conferences and other events • Propose IP to standards, white papers etc.
Networking opportunities	Visibility and knowledge of customers and partners	Working group membership maintains a relationship with important customer or partner	• Meet stakeholders • Ensure company engagement is visible

Industry Research Findings:

ISO study [1]: Profit contribution from standards ranges from 0.15% to 5%
BSI study [2]: increase in turnover from using standards of between 1.7% and 5.3%

1. ISO, 2014, "Economic benefits of standards", http://www.iso.org/iso/ebs_case_studies_factsheets.pdf
2. British Standards Institution, June 2015, "Economic benefits of standards – research reports", http://www.bsigroup.com/en-GB/standards/benefits-of-using-standards/research-reports/

Attributed to: **Chris Frost** Fujitsu Distinguished Engineer

Open Standards & Modeling Provide Savings & Focus

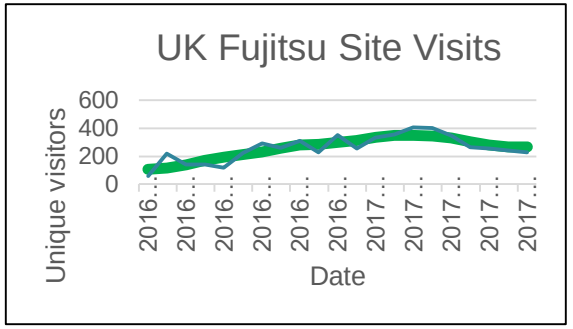
Measuring Value

1 – Practical Things Can be Counted

Business gets value by:	What to count:
1. Using IP	• Number of internal methods, guidelines, templates etc. • Number of projects using the standards or methods • Number of people trained / certified
2. Demonstrating business capability	• Number of presentations • Number of IP submissions (white papers etc.)
3. Networking with customers and partners	• Number of stakeholders met • Number of opportunities / suspects

Cost model Item	Purpose	Forecast GBP	Forecast JPY
Staff 1	Headcount cost	£ 243,529	¥ 31,658,770
Staff 2	Headcount cost	£ 102,126	¥ 13,276,338
Develop BP Collateral	SME Project costs for funding r&d development	£ 32,386	¥ 4,210,193
Support rollout BP	Project costs for funding rollout & promotion	£ 6,000	¥ 780,000
BP promotion	Travel and accommodation costs for promotion	£ 12,140	¥ 1,578,210
SME meetings - travel and accommodation	SME Travel and accommodation costs for r&d	£ 8,171	¥ 1,062,221
Miscellaneous expenses	Any other expenses	£ 57,367	¥ 7,457,726
Sub total	Sub total	£ 461,719	¥ 60,023,458
Contingency	Contingency	£ 46,627	¥ 6,061,480
TOTAL	Total	£ 508,346	¥ 66,084,939

2 – Estimate the ROI Case Study



Benefits model	
Site visits	3570
Use rate	50%
Savings per use	7.5h
Hourly rate	7000 Yen/hr
Benefits (Yen)	93.7 M Yen
Benefits (GBP)	0.72 M GBP

What's the ROI:

Benefits 0.72 GBP (0.93 US $)
Cost 0.51 GBP (0.66 US $)
ROI 41%

Attributed to: **Chris Frost** Fujitsu Distinguished Engineer

FUJITSU

CubeSats Are To Small for Standards

- Three F-18 Fighters drop over 100 Drones
- Drones Inter-react with Each other on the Fly & Communicate with
  - Each Other,
  - Ground Assets, and
  - Sea Assets
  - Command Assets
- Man "On the Loop" Versus "In the Loop"
- Demonstrates "Actionable Intelligence" versus "Artificial Intelligence"

Full 60 Minutes Segment:
https://www.cbs.com/shows/60_minutes/video/rMzZSMeETU_4wH7yAEMkTcSim_MOXD6f/the-coming-swarm/

Used 18 OMG Standards to Perform Testing Mission

https://youtu.be/NSxFDjPAV7M

OMG's Space Domain Task Force (SDTF)

What Is It ?

And What Does It Do?

Specifically Chartered To Foster the Development of Space-Related Standards

The OMG Space Domain Task Force (SDTF)

- Space professionals committed to greater interoperability, reduction in costs, schedule, and risk for space applications through increased standardization

- The SDTF works cooperatively with the CCSDS to ensure consistent space standards are developed.

- OMG's Space DTF is Fast But Not To Fast : 9 – 24 months to deliver a standard
- Final result will be specifications and interfaces NOT products
  - Implementations of OMG specifications by users
  - Those implementing specifications need not be OMG members
  - Specifications are *freely* available
- Collective wisdom - broad range of input
- Standards/Specifications based upon Gov't & Industry consensus

Specifications Freely Available

OMG Space Domain Task Force (DTF) Delivered Specifications

- XTCE (XML Telemetry and Command Exchange) (1.1)
- GEMS (Ground Equipment Monitoring Service)
- SOLM (Spacecraft Operations Language Metamodel)

Work-In-Process

- XTCE 1.2 Revision Task Force deadline March 2018 (Finalization by June 2019)
- C2MS (Cmd & Control Mission Services) in Finalization Task Force expected to be complete June 2019

Space & Other Relevant Specifications Being Initiated

- CubeSat Systems Reference Model (CSRM) (INCOSE & OMG Initiative)

Future Work being Considered

- **Ontology**, archiving, display, cyber
- Ground Station **Ontology** (Spacecraft Operations Language Metamodel),
  - http://www.omg.org/hot-topics/spacecraft-ground-systems-rfi.htm
- Data Archiving,
- Display Page Exchange
- Cyber Security

Other OMG Relevant Specifications to Consider

- Data Delivery Services (DDS)
- Information Exchange Framework (IEF)
- Cyber Security for Front Line Systems
- Secure Networking Communications (SNC) – Middleware and Related Services (MARS) Working Group
  - Space Telecommunications Radio Services (STRS) and
  - Hybrid Adaptive Network (HANw)
- Alarms & Event Notification and Scheduling
- Telescope Reference Model

XTCE & XUSP Status

XCTE

- XTCE 1.2 RTF has dispositioned 244 of the issues submitted.
- ALL of the remaining issues closed in ballot on Feb 12th and resolved.
- The resulting revised schema will be largely forward compatible with existing XTCE 1.1 documents and members of the RTF are developing tools to transform forward incompatibilities, e.g. element name changes
- RTF report submitted and OMG Architecture Board Approved Sep 2018
- XTCE 1.2 Specification Published Oct 2018
- XTCE 1.1 is being used by military, space agency, and commercial space programs as an open exchange format and upgrading to 1.2.

XUSP - a tailored version of XTCE to support CCSDS formats and typical field constraints

- XUSP RTF is awaiting publication of XTCE 1.2, since it is a defined subset profile of the XTCE specification. XUSP is a tailored version of XTCE to support CCSDS formats and typical field
- No pending issues, but after publication of XTCE 1.2 an issue will be submitted to address compatibility.

Command & Control Message Specification (C2MS)

What is it?

- A set of standard message formats for the exchange of information for C2 functions
- About 30 messages covering areas like events, telemetry frames or parameters, directives, navigation, commanding, and more.
- Aligned with key interfaces normally found in today's commercial C2 system products

Where did it come from?

- NASA's Goddard Mission Services Evolution Center (GMSEC) Interface Specification document provided the primary source material
- NASA will retire its ISD when C2MS is published
- Note: ONLY the message formats are being standardized, not the API or components

What is the status?

- NASA has worked with the Space Domain Task Force on C2MS for the past year and submitted the required materials for consideration in mid-February 2018
- OMG Architecture Board Approved in Sep 2018 and in Finalization Task Force for Completion
- Is available for specification download by March 2019 to OMG Members and will be finalized in June 2019

Fits on a Laptop

OMG Space DTF (SDTF) Future Backlog

- Telemetry Display Page Definition Exchange
  - No draft RFP exists, yet, just conceptual. Some interest, but this is a difficult problem.
- Ground Data Delivery Interface
  - No draft RFP exists, yet, but has been discussed as a companion spec to GEMS for delivering binary mission and housekeeping data within a ground station.
- Alert Management System
  - US Air Force EGS adopted the OMG C4I Alert Management Service (ALMAS) specification rather than request a specific space domain specification
- Goddard Core Flight Services (Cfs)
  - Goddard has several technologies with more general space industry applicability that are waiting for the results of the C2MS RFC from NASA for a possible path forward.
- Spacecraft Operations Ontology
  - In works, tough to do, about 10 ontology's being worked on now and being expanded (180 requested)

CubeSat Systems Reference Model (CSRM)

The International Council of Systems Engineers (INCOSE)

- Utilized OMG's Systems Modeling Language to Develop
- A CubeSat Systems Reference Model that provides information
  - For universities, students, businesses and developers of CubeSats
  - Provides Behavior modeling between subsystems
  - Validation & Verification (V&V) processes
  - Coordination points for launch

Model Based Systems Engineering (MBSE) [1]

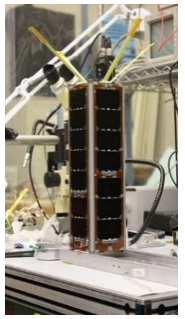
Formalized application of modeling to support requirements, design, analysis, validation, and verification

Systems Modeling Language ™ (SysML™) [2]

A graphical modeling language for modeling complex systems including hardware, software, information, personnel, procedures, facilities and Coordination's

Systems Engineering Methodology	System Modeling Tools	Interfaces with Other Models

Purpose: To Provides a CubeSat Systems Reference Model that CubeSat Teams can use as a starting point for their mission-specific CubeSat & Develop into a OMG Standard

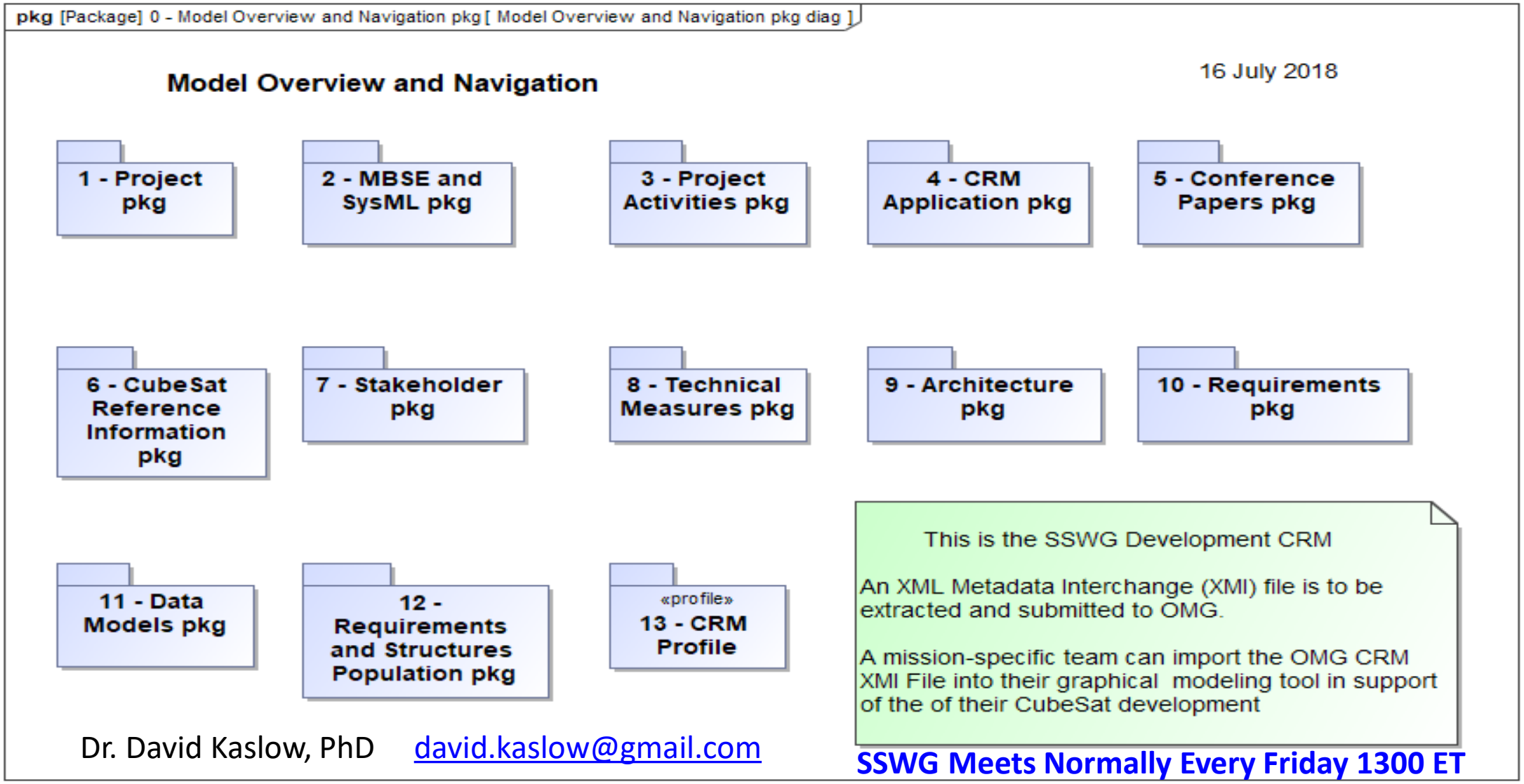


CubeSat Systems Reference Model (CSRM) (Continued)

- **SysML Model Elements that can be populated to specify the Logical Architecture of a CubeSat Enterprise System (Space & Ground)**
- **Logical Architecture decomposes the system into components that interact to satisfy system requirements**
- **The components are abstractions of physical Components that perform system functionality but without imposing implementation constraints**
- **The CSRM is systems engineering agnostic**
- **A mission specific team can import the CSRM into their graphical modeling tool to initiate their process for architecting, designing and developing their mission specific CubeSat Model (MCM)**
- **The MCM will be a repository for the systems engineering artifacts created by the mission specific Team**

CubeSat Systems Reference Model (CSRM)

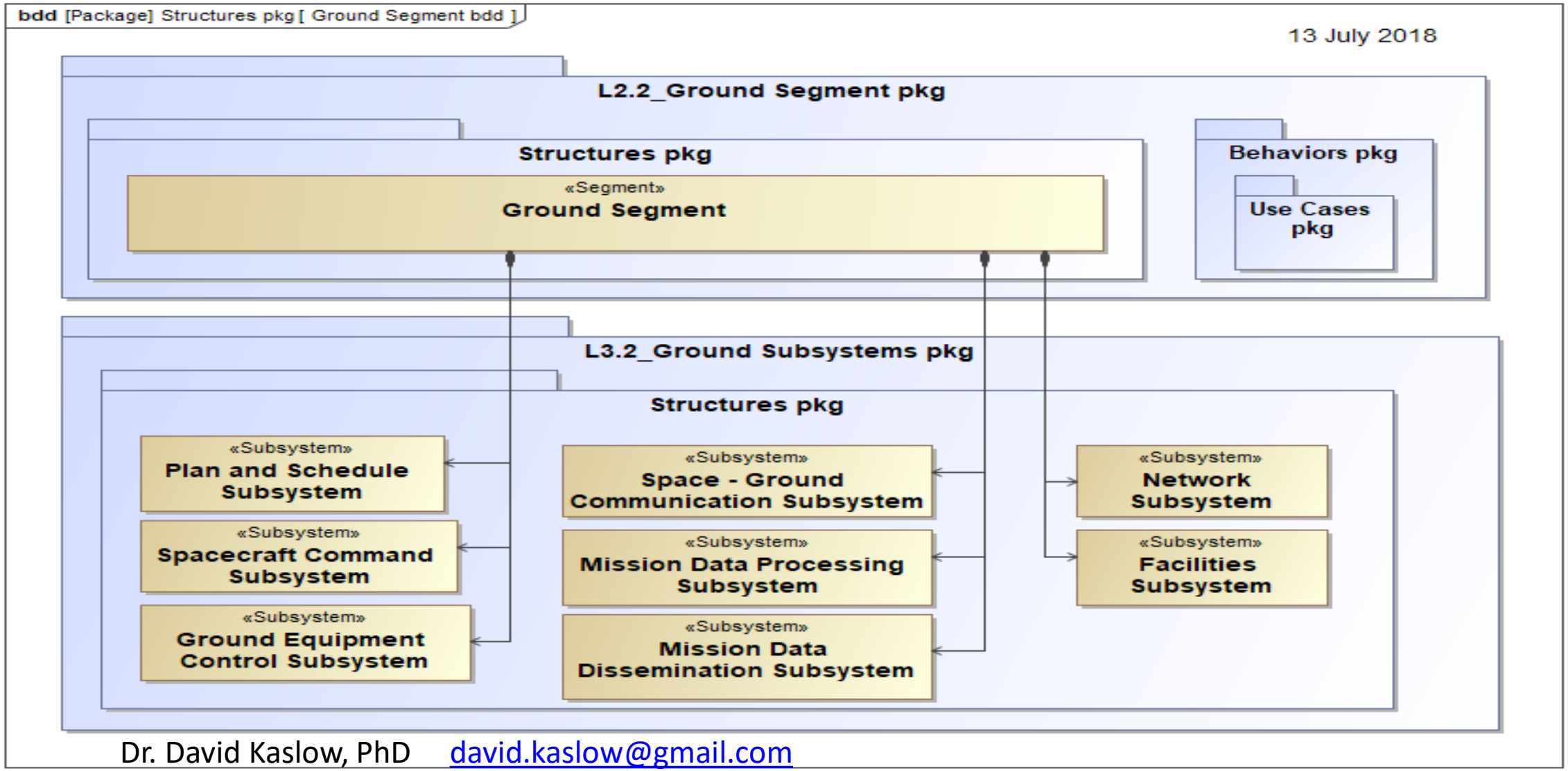
Model Overview & Navigation Package



Dr. David Kaslow, PhD david.kaslow@gmail.com

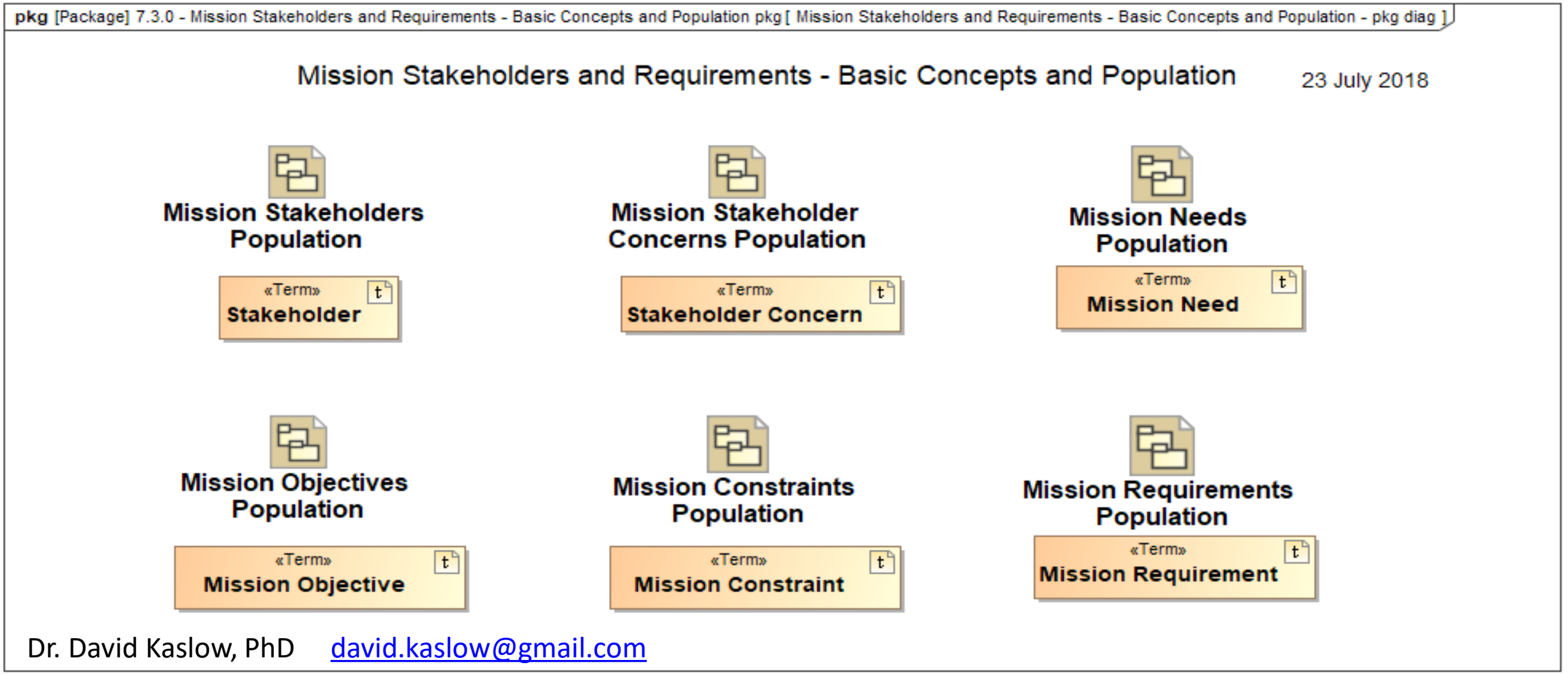
SSWG Meets Normally Every Friday 1300 ET

CubeSat Systems Reference Model (CSRM)
Ground Segment Structures Package



Dr. David Kaslow, PhD david.kaslow@gmail.com

CubeSat Mission Stakeholders & Req'ts



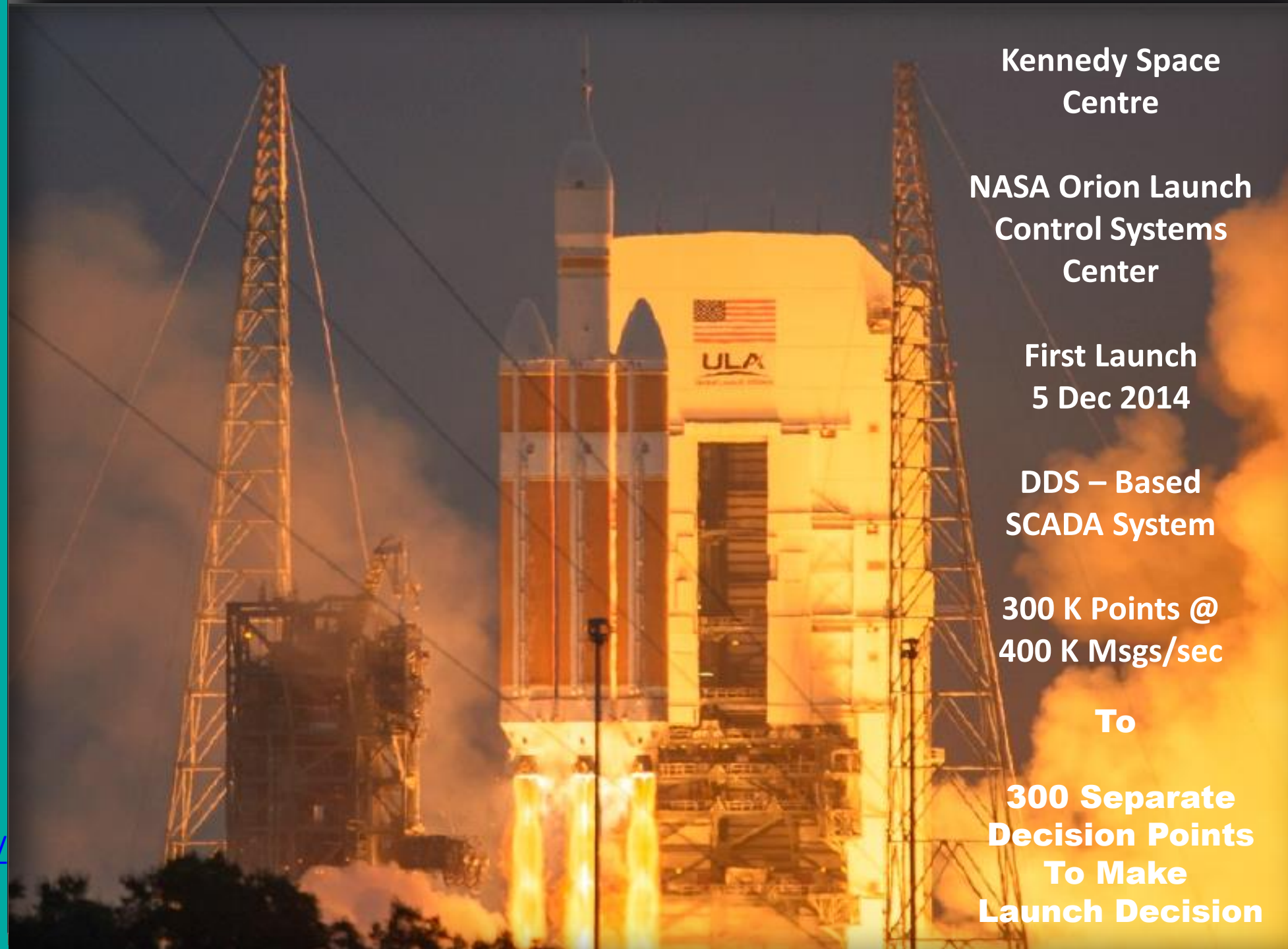
Dr. David Kaslow, PhD david.kaslow@gmail.com

OBJECT MANAGEMENT GROUP®

Data Distribution Service (DDS)

DDS

https://www.omgwiki.org/dds/



Kennedy Space Centre

NASA Orion Launch Control Systems Center

First Launch
5 Dec 2014

DDS – Based SCADA System

300 K Points @ 400 K Msgs/sec

To

300 Separate Decision Points To Make Launch Decision

Software Based Communications
DoD's SCA & NASA's STRS
OMG's SNC

Standards Based Requirements Approach

If Any of You Space Cat's Have Questions - You Can Be Directed To:

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(aka Da Dawg)
SVP Government & Industry Strategy
Tel: +1-703-231 6335
OMG HQ – Needham , MA
Tel: +1-781-444 0404
Fax: +1-781-444 0320

maclaird@omg.org
https://www.omg.org
https://www.iiconsortium.org
http://www.it-cisq.org

Note Pages Available Upon Request

OBJECT MANAGEMENT GROUP®

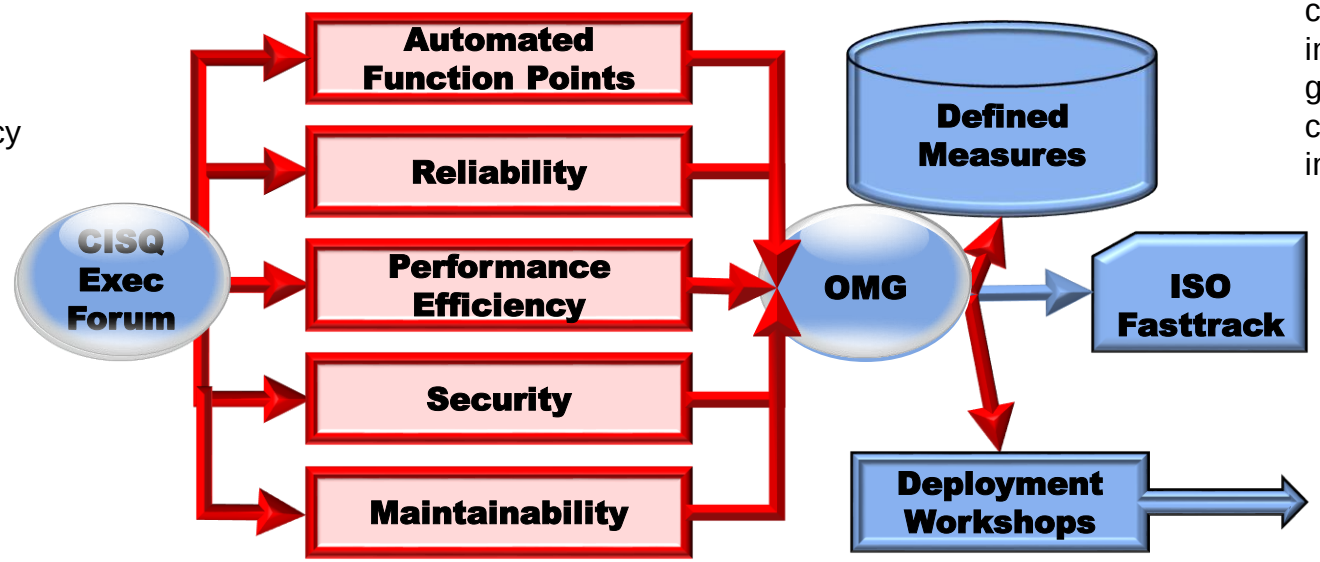
Back Ups

CISQ/OMG Standards Process & Published Standards

Software Sizing - Published
- Automated Function Points
- Automated Enhancement Points

Software Structural Quality - Published
- Security
- Reliability
- Performance Efficiency
- Maintainability

Consortium for IT Software Quality (CISQ) Work Groups



Technical Debt – Published
- A new OMG® standard for measuring the future cost of defects remaining in system source code at release
- The cost to fix structural quality problems constitutes the principal of the debt, while the inefficiencies they cause until fixed, such as greater maintenance effort or excessive computing resources, represent compounding interest on the debt

For future development…
- Extending the software quality measures to embedded and real-time systems, which is critically important for the Internet of Things (IoT)
- A measure of quality-adjusted productivity

The 22 CWEs in the Security Measure

- CWE-22 Path Traversal Improper Input Neutralization
- CWE-78 OS Command Injection Improper Input Neutralization
- CWE-79 Cross-site Scripting Improper Input Neutralization
- CWE-89 SQL Injection Improper Input Neutralization
- CWE-120 Buffer Copy without Checking Size of Input
- CWE-129 Array Index Improper Input Neutralization
- CWE-134 Format String Improper Input Neutralization
- CWE-252 Unchecked Return Parameter of Control Element Accessing Resource
- CWE-327 Broken or Risky Cryptographic Algorithm Usage
- CWE-396 Declaration of Catch for Generic Exception
- CWE-397 Declaration of Throws for Generic Exception
- CWE-434 File Upload Improper Input Neutralization
- CWE-456 Storable and Member Data Element Missing Initialization
- CWE-606 Unchecked Input for Loop Condition
- CWE-667 Shared Resource Improper Locking
- CWE-672 Expired or Released Resource Usage
- CWE-681 Numeric Types Incorrect Conversion
- CWE-706 Name or Reference Resolution Improper Input Neutralization
- CWE-772 Missing Release of Resource after Effective Lifetime
- CWE-789 Uncontrolled Memory Allocation
- CWE-798 Hard-Coded Credentials Usage for Remote Authentication
- CWE-835 Loop with Unreachable Exit Condition ('Infinite Loop')

Robert Martin
MITRE

OBJECT MANAGEMENT GROUP

Common Weakness Enumeration
cwe.mitre.org