MBSE Support for Airworthiness

Current Approach and Status of Development

Keith Siders
MBSE SME
AFLCMC/EZSI

Topics

- ***General Approach to Certifications***
- ***Acquisition System Data Package (ASDP)***
- ***Airworthiness SysML Profile***
- ***SysML 2.0 – Things to Come***
- ***Future Vision***

General approach to certifications

- **All certifications are for assessing *risk***
  - Non-compliance does not automatically mean redesign, rebuild, retest, etc.
  - Only if risk of non-compliance is too great
  - Non-compliance can be waivered after assessment
- **MIL-STD-461/464 EEE and TEMPEST**
  - Test limits are generally:
    - constraints for emissions,
    - performance requirements for susceptibility
  - Tests are standardized, setup and procedure
- **Cyber Security – NAVAIR RMF support in Cameo**
  - NIST controls -> criteria(?) -> requirements
  - Note: Navy SET site is hard to get to over VPN
  - It can only be accessed from a .mil domain
  - Link is available upon request to .mil domain participants
- **Airworthiness via MIL-HDBK-516C**
  - Specifies attributes of the system to meet criteria
  - Consider NAVAIR cyber requirements derivation process
    - Can similar be applied to AW criteria?

Approach to AW Digital Certifications

- Drive from a requirements/verification perspective
- Criteria assume some form of:
  - Observable design attribute (generally architectural/structural)
  - Testable parametric attribute (generally functional/behavioral)
  - Auditable process attribute (e.g., systems engineering – section 4)
- Make design attributes general system requirements
- Make parametric attributes test verifications
  - Similar to JSSG approach
  - Possibly as part of the JSSGs
    - JSSGs discuss airworthiness aspects, but
    - not connected formally to specific criteria (more on this later)

Acquisition & Sustainment Data Package (ASDP)

DRAFT ASDP – The digital data … lifecycle … **…fy the weapon systems through the**

Architecture

Tes… Pro… (t… spe…

Verification / Validation, & Accreditation Reports (Analysis, Demonstration, Inspection, Test and model / simulation) (tied to the specification)

Proble… De… R…

Software/ Firmware
- Source and Executable Code

Tra… math…

Functional Thread analysis

Critical Safety Item

Co… Sta… Accountin…
(per tail number)

Air Force Training System and Device Simulator Certification	**Cybersecurity Certification (ATO/IATT)**	Full Materiel Release Certification	Nuclear Certification requirements (ref AFI 63-125)	Modeling and Simulation Verification, Validation, and Accreditation	Spectrum Certification Compliance	**Aircraft Structural Integrity Program (ASIP)**	Assessment of Operational Test Readiness (AOTR)	Joint Military Intelligence Certification	
Air Transportability Certification	Command, Control, Communications, Computers, & Intelligence (C4I) Supportability Certification	Hazards of Electromagnetic Radiation to Ordnance (HERO) Certification	Insensitive Munitions Certification	Nonnuclear Munitions Safety Board (NNMSB) Certification	Training Device Certification	Avionics Integrity Program (AVIP)	Risk Management Framework for DoD IT	Radio Frequency Radiation (RFR) Hazards (RADHAZ) Certification	**Propulsion Systems Integrity Program (PSIP)**
Airworthiness Certification	Clinger-Cohen Act (CCA) Compliance Certification	Identification Friend or Foe (IFF) Equipment Certification	Joint Interoperability Test Certification	Operational Test & Evaluation (OT&E) Readiness Certification	UHF SATCOM Demand Assigned Multiple Access (DAMA) Certification	Mechanical Equipment and Sub-Systems Integrity Program (MECSIP)	Independent Logistics Assessment (ILA) and Logistics Certification	Seek Eagle	

Certifications/ Integrity Programs

…ol Data (ICD)
…se documents need …es to their Data Item Descriptions (DIDs). See backup slide for ICD example

The Product Level TDP per MIL-STD-31000B is NOT sufficient to Produce, Maintain, Sustain, and Modify weapon systems (see additional boxes)

Technology Development | Integrated Business Operations | Intelligence | Operational Data

Proposed New

Requirements drive the data needs

NOTE: Ensure Support Equipment is included in documents
NOTE: Ensure all are for System Integration Laboratories with delivery of the Modeling and Simulations utilized (Modeling and Simulation Verification and Validation report)

Digital Data Goals

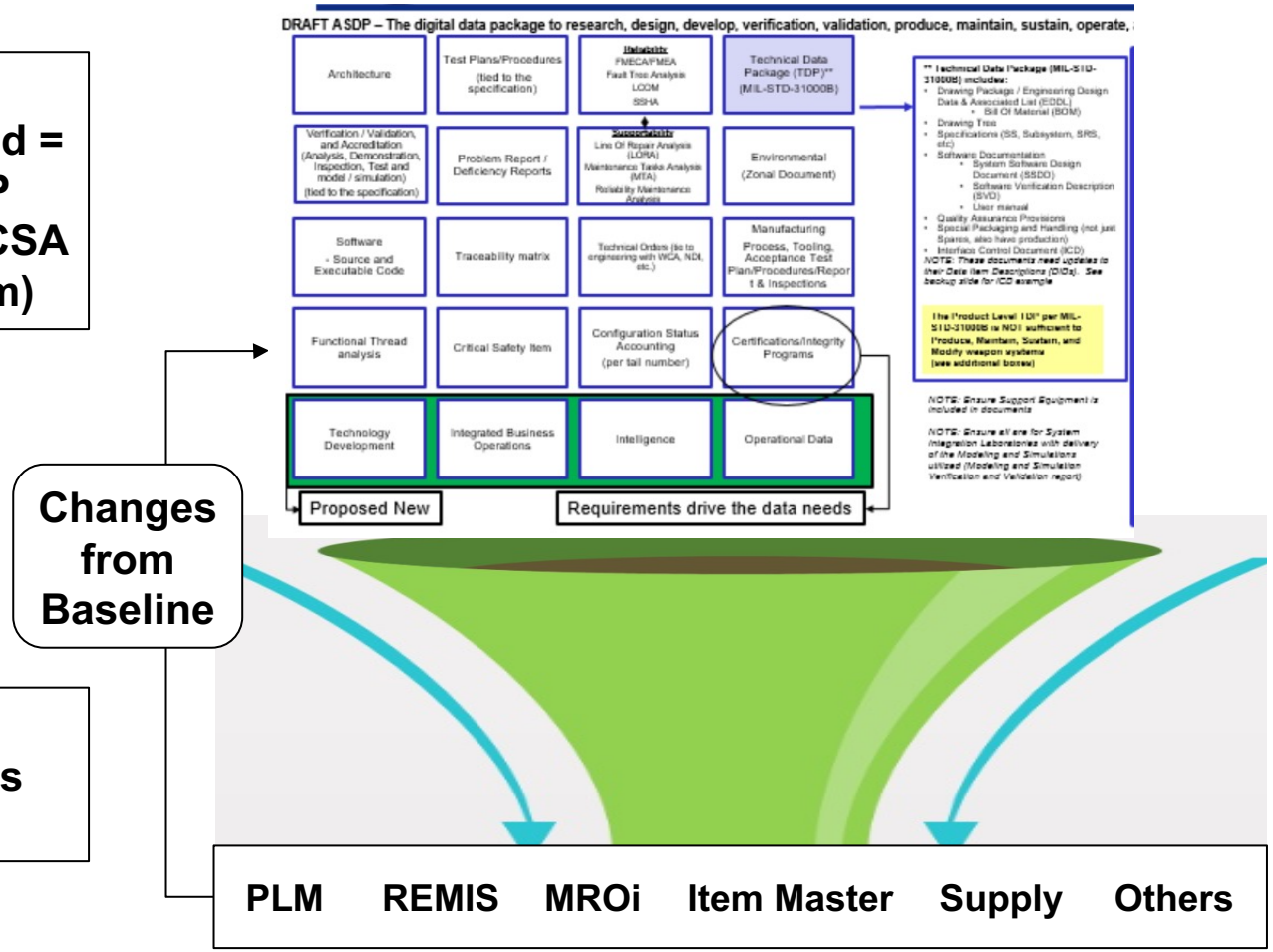
- Accelerate shift to all-digital programs
- Recommended contract language to obtain data and understand how to transmitted, stored & analyzed throughout the lifecycle
- Increase # reuse of data saving year and $Ms per program
- Increase use of personnel across programs

20 ASDP tiles and descriptions are agreed by all functionals and communities in AFMC during a data workshop held on 19 January 2021

Acquisition & Sustainment Data Package (ASDP)

AFLCMC… Providing the Warfighter's Edge

Acquisition
- **As Designed = BOI = ASDP**
- **As Built = CSA (by end item)**



Changes from Baseline

Sustainment
- **As Built / As Maintained**

PLM **REMIS** **MROi** **Item Master** **Supply** **Others**

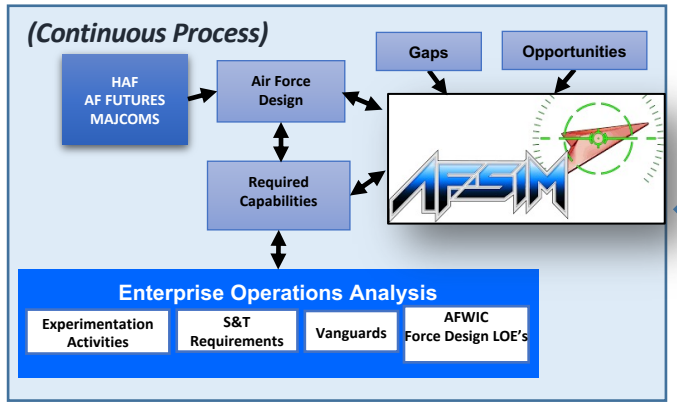
Areas under investigation:
- **Financial**
- **Schedule**
- **Operational**
- **Risk Mgt.**
- **Etc.**

Where is it stored, analyzed, accessed and linked?
PLM - Where is it stored, analyzed, accessed and linked? Authoritative Source of Truth
- **Teamcenter – Librarian or Dewey Decimal System**
- **ETIMS (Software/T.O.s)**
  - **Do we need data here (at least needs to be linked)**
- **Others**

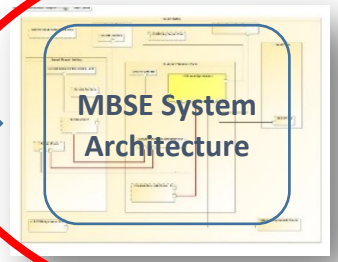
Defining the data will give the Air Force competitive advantage

Digital Ecosystem – GRA in Action

AFLCMC… Providing the Warfighter's Edge



Produce Digital CDD Model



Own the reference architecture and model in modern tools

Use Government Tech Stack for Continuous Review

Link Model with LogRA for PLM Integration

Tradespace & Operations Analysis

AF Futures
MAJCOMS
AFLCMC
SDPE
PEOs

Contracting Language

ASDP:
RFP
SOW/PWS
CDRLS/DIDs
SRD/TRD

System Development

Technical Reviews
Agile Development
Finance, Risk, & Log Mgt
Test & Certs

System Lifecycle

Supply
Maintenance
Product Support
Operations
Modifications

Standards | **Reference Architecture Models** | **Training** | **Tools** | **Data Architecture**

Digital Ecosystem Enabled By

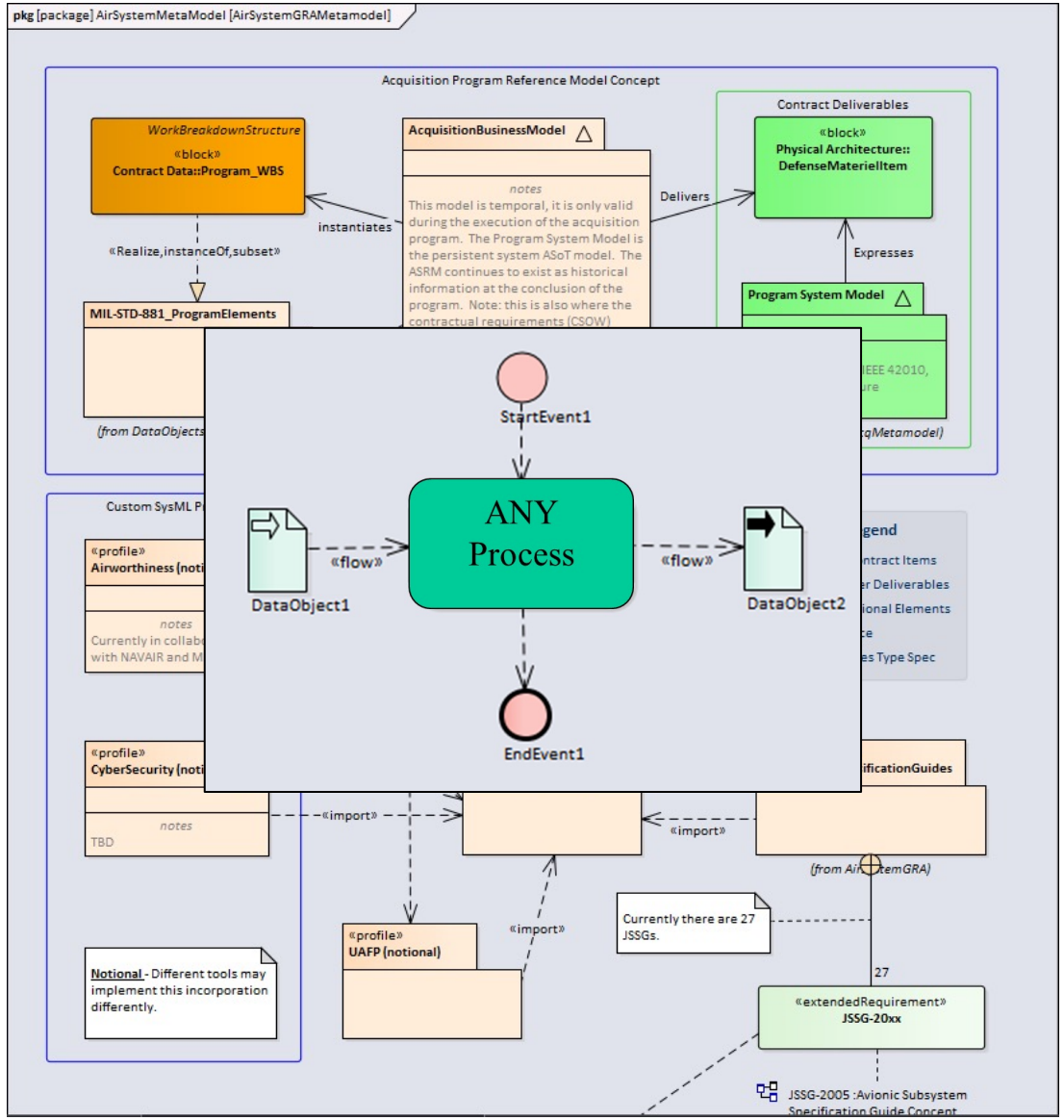
PLM / FENCES / CLOUDONE / PLATFORMONE

Acquisition Program Reference Model

Feeding the ASDP Beast

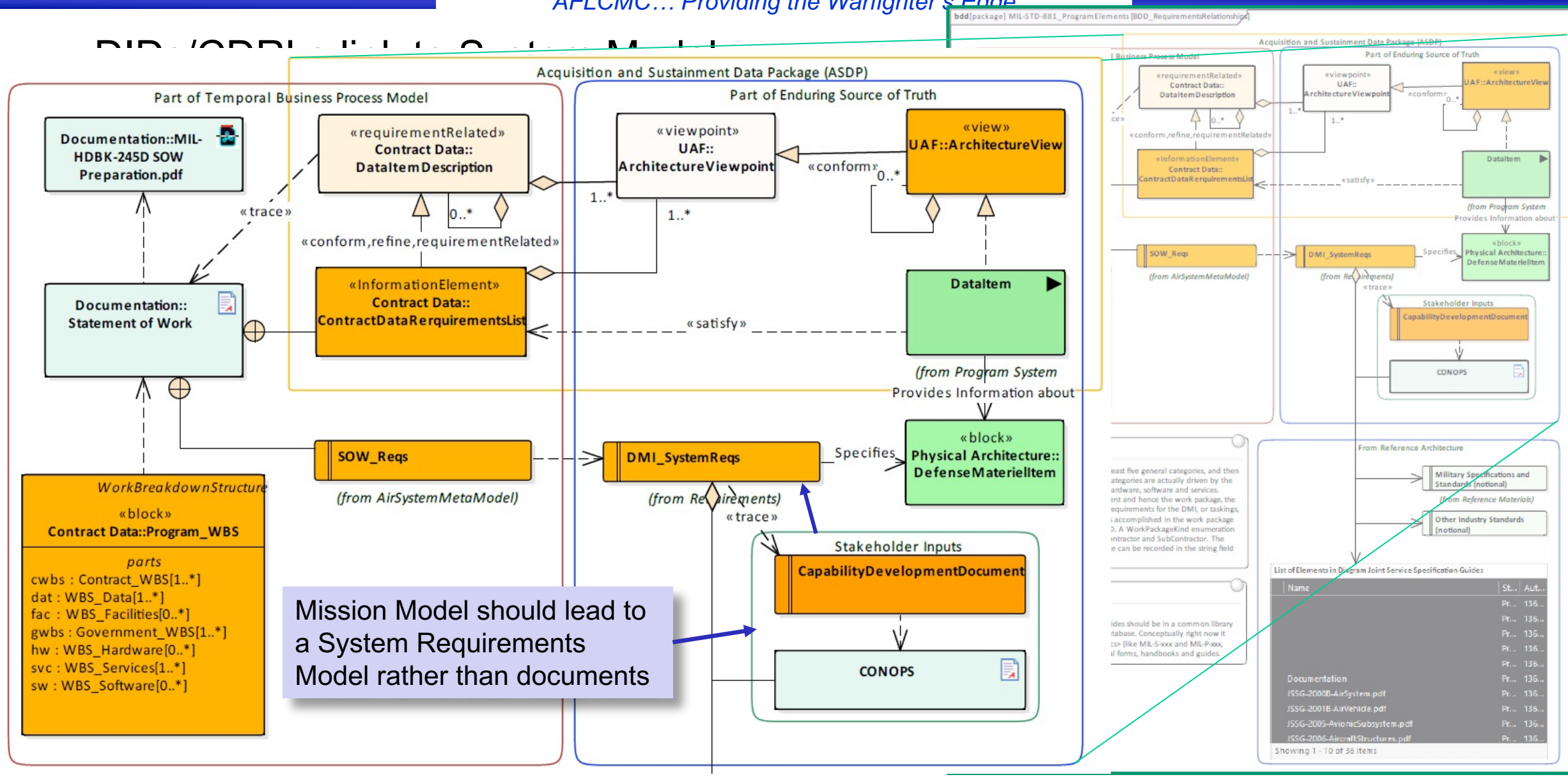
AFLCMC… Providing the Warfighter's Edge

- **ASDP Data – Specified by DIDs/CDRLs**
  - **Much ASDP data supports Airworthiness**
  - **Generated by the Business Process**
  - **New DIDs are being created**
  - **Other entities have to be involved**
    - **Contracting via CON IT w/PDS v2.6.2 (inc. CDRL schema)**
    - **ASSIST Database**
- **Basic Idea**
  - **Processes consume/produce objects**
- **If Acquisition Process**
  - **Inputs (CDD, CONOPS, System Requirements Model, etc.)**
  - **Program Initiated**
  - **Process Delivers End Items (Deliverables)**
  - **Program Ends**



ASDP Ties Acquisition Model to System Model

AFLCMC… Providing the Warfighter's Edge



The Airworthiness SysML Profile

Overview

- Short history
- Linkage with JSSGs for safety-critical aspects
  - Drives to AW requirements for the system
- Example of Application
  - JSSG-2009-8, Air Vehicle Electrical Power Subsystems
    - Power Distribution Requirements
- Using SysML v1.5 Property-Based Requirements

The Airworthiness SysML Profile

Short History

AFLCMC… Providing the Warfighter's Edge

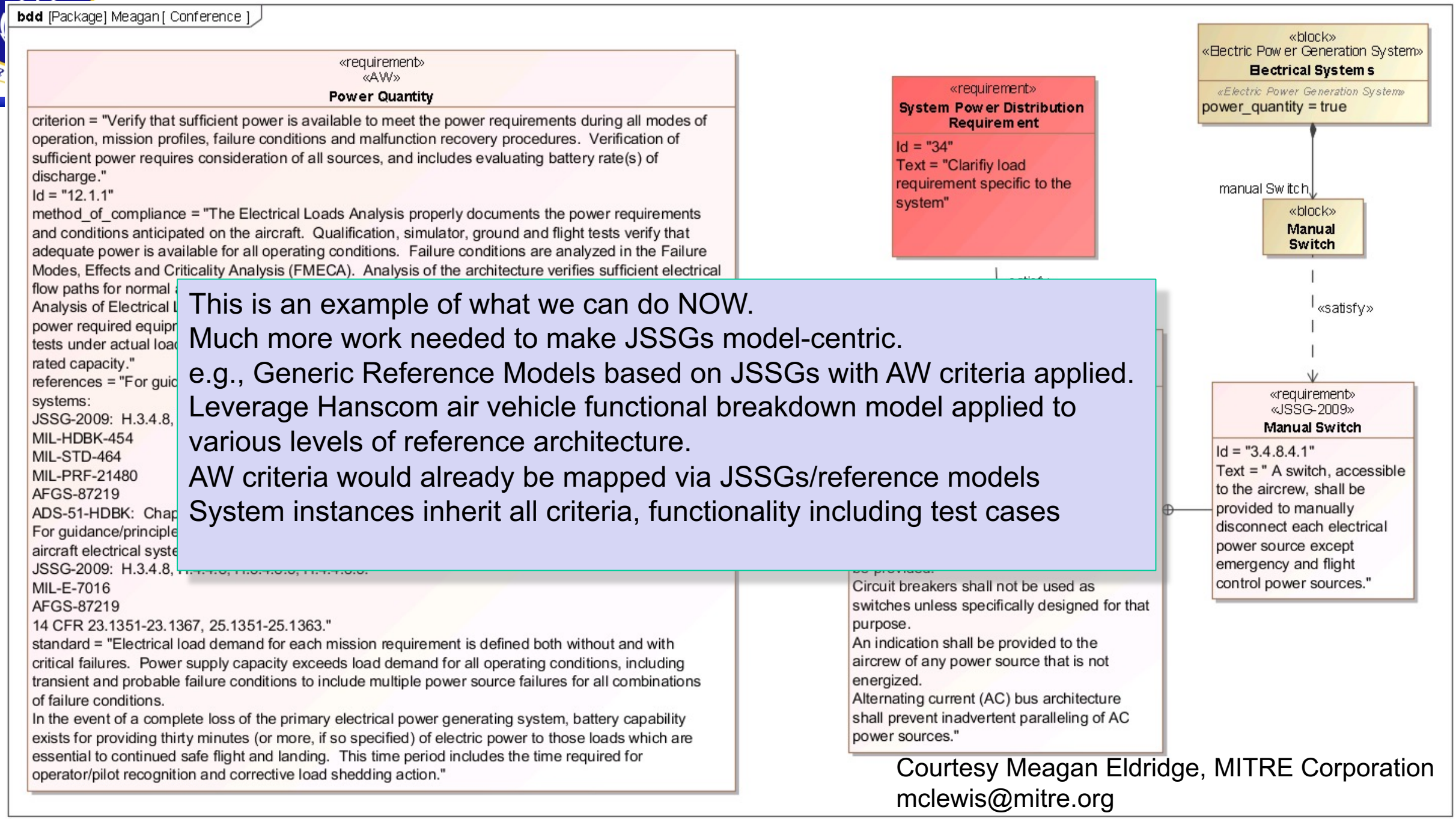
- **Three independent efforts all with same basic approach**
  - **Capt. Jeff King's masters thesis, Safety Critical Functions in Cameo**
    - **Created a metamodel for an AW profile for section 15 of MIL-HDBK-516C**
    - **Profile created to be tool-agnostic**
  - **NAVAIR separately created a profile, same concept, different metamodel**
    - **Profile very Cameo-centric leveraging Cameo-specific profiles/libraries**
  - **MITRE creating a profile – good "in-between"**
    - **Profile being created tool-agnostic in Cameo/MagicDraw**
    - **Has similar information as captured by NAVAIR**

The Airworthiness SysML Profile

Linkage with JSSGs

AFLCMC… Providing the Warfighter's Edge

- JSSGs follow basic system breakdown of MIL-STD-881 WBS
- JSSGs provide "section 3 and section 4"
  - System Requirements boilerplates/rationale/lessons learned
  - Systems Verification boilerplates/rationale/lessons learned
  - These could be used to derive generalized system models
    - A.k.a., government reference models (GRMs)
- Linkage with JSSGs for safety-critical aspects
  - Drives to AW requirements for the system
    - Performance Requirements and Design Constraints
      - Provides Observable Design Attributes
    - Test Requirements for Verification
      - Provides Testable Parametric Attributes



This is an example of what we can do NOW.
Much more work needed to make JSSGs model-centric.
e.g., Generic Reference Models based on JSSGs with AW criteria applied.
Leverage Hanscom air vehicle functional breakdown model applied to various levels of reference architecture.
AW criteria would already be mapped via JSSGs/reference models
System instances inherit all criteria, functionality including test cases

Courtesy Meagan Eldridge, MITRE Corporation
mclewis@mitre.org

- **Using Pro**
  Requirem

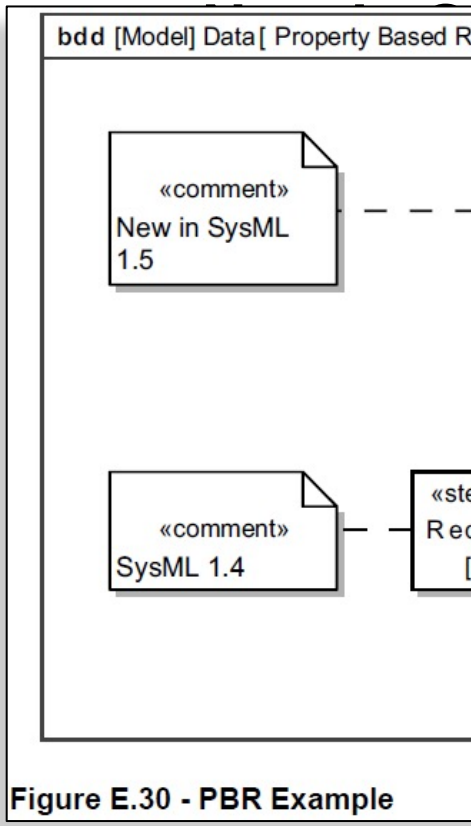


Figure E.30 - PBR Example

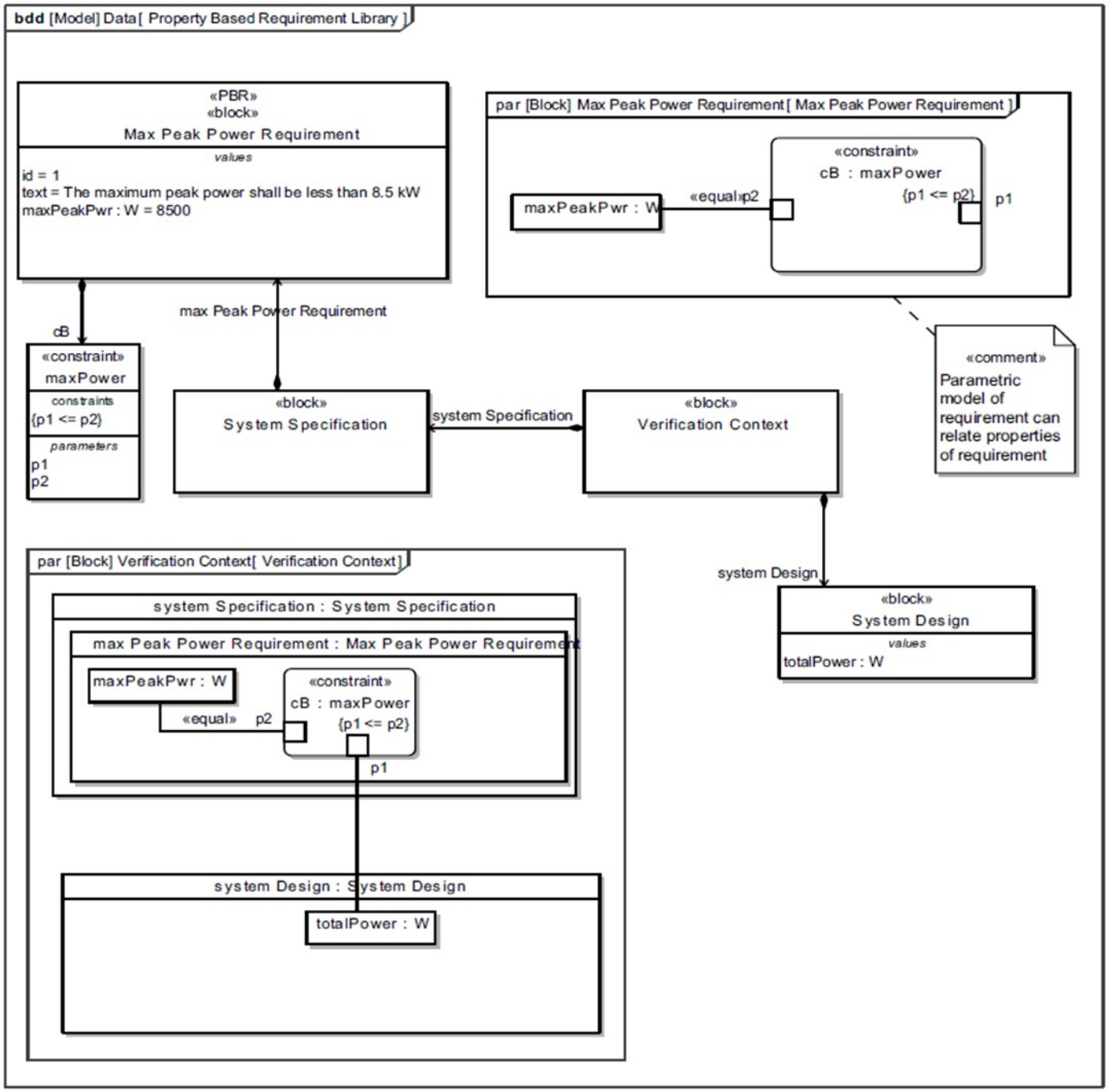
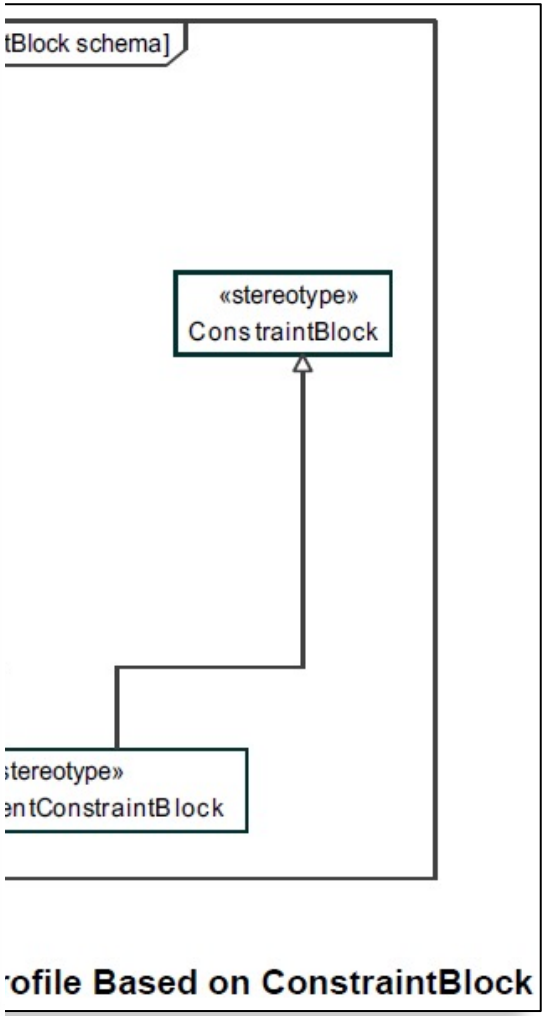


Figure E.31 - PBR



ofile Based on ConstraintBlock

SysML 2.0 – Things to Come

- **Current synopsis**
  - SysML Kernel based on KerML vice UML profile-based
  - Reduction in elements complexity – 200+ down to ~100
  - SysML 2.0 Team to define porting 1.x models to 2.0
  - OMG SysML 2.0 Document Release expected ~4QCY21/1QFY22
  - Initial Implementation being used to gather user feedback, finalize specifications
- **Main Website – https://github.com/Systems-Modeling/**
  - Link won't resolve from within AF networks (domain name ignored)
  - Has all SysML 2.0 information
    - The OMG RFPs for SysML Language, APIs and Services
    - Draft KerML 1.0, SysML 2.0 Graphical Notation, SysML 2.0 Textual Notation spec docs
      - View online, downloads tend to corrupt
    - Spec docs are licensed under *Creative Common Attribution 4.0 International License*
- **Various YouTube video sessions**
  - *[Episode 3] The MBSE Podcast – Unboxing SysML 2.0 (EN)* (~45min) – 25 NOV 2020
    - Hosted by Tim Weilkiens (SYSMOD author) and Christian Muggao
  - *SysML v2 Demonstration | Ed Seidewitz, Manas Bajaj* (~2 hours) – 1 FEB 2021
    - Manas Bajaj is a professor of SE at GaTech, co-founder of Intercax, LLC

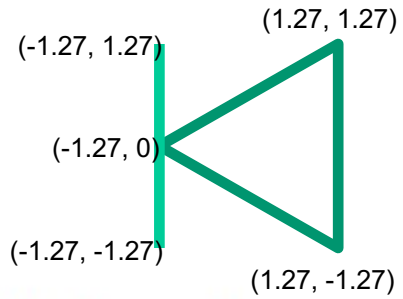
SysML 2.0 – Details to Date

- **Initial SysML 2.0 implementation – two project platforms**
  - **Eclipse project**
    - **Eclipse version 2021-03**
    - **In pre-alpha developmental release for comments**
  - **Jupyter project**
  - **Projects freely available via Git repository using Github**
    - **Java code development**
    - **Point github to website,**
      - **https://github.org/Systems-Modeling/SysML-v2-Release**
  - **"Support" via forum in Google Groups – https://groups.google.com/g/sysml-v2-release**
    - **You ask to join the group in order to participate**

SysML 2.0 – No Longer a Profile

- **Kernel-based Domain-Specific Language (DSL)**
  - Model elements have semantically defined textual format
  - Tool's parser imports/exports textual description
  - Still editable graphically
    - Can be viewed both ways
    - May be able to edit textually as well
  - Software CM tools will handle differencing/forking/merging very effectively
    - Model elements can now be managed textually like any software source code
  - XMI incompatibility is TBD, but may be moot
    - Will diagrams have a textual kernel format?
- **This approach is similar to CAD/CAE tools using S-expressions (as shown on right from Kicad 6 library)**
  - Example: partial 1N4001 diode symbol definition
    - from Diode.kicad_sym on github
  - Text is parsed to render diode symbol

```
(property "ki_fp_filters" "D*DO?41*" (id 6) (at 0 0 0)
  (effects (font (size 1.27 1.27)) hide)
)
(symbol "1N4001_0_1"
  (polyline
    (pts
      (xy -1.27 1.27)
      (xy -1.27 -1.27)
    )
    (stroke (width 0.254)) (fill (type none))
  )
  (polyline
    (pts
      (xy 1.27 0)
      (xy -1.27 0)
    )
    (stroke (width 0)) (fill (type none))
  )
  (polyline
    (pts
      (xy 1.27 1.27)
      (xy 1.27 -1.27)
      (xy -1.27 0)
      (xy 1.27 1.27)
    )
    (stroke (width 0.254)) (fill (type none))
  )
)
```



SysML 2.0 – Technical Debt of v1.x Models

- **Impacts to 1.x models**
  - **Search YouTube for "SysML v2 technical debt" or "SysML v2 Software Center"**
    - **Looking for *Lunch seminar: "Towards SysML v2 – Should you be worried about technical debt" (March 2021) – Software Center forum***
    - **Discusses issues with 1.x to 2.0 conversion**
  - **<<block>> replaced by "part definition"**
  - **Ports cannot be parts**
    - **I.e., apparently no Full Ports**
    - **Ports only expose internal interfaces, sounds similar to proxy ports**
- **Three scenarios**
  - **Non-breaking changes (e.g., support for variants)**
    - **Automatable conversion**
  - **Breaking/Resolvable changes (e.g., <<block>> to part definition)**
    - **Automatable resolution and conversion**
  - **Breaking/Unresolvable changes (i.e., requires human intervention)**
    - **Not automatable, but maybe automation-assisted**

Summary

- **AW Criteria have three compliance types**
  - **Design attributes**
  - **Parametric attributes**
  - **Process attributes**
- **Design and Parametric Attribute Criteria**
  - **Can be applied to Reference Model elements**
  - **Inheritable by a program instance**
  - **Directly supported through architecture and property-based requirements (PBR) objects**
- **Process Attributes will require Process Models implemented in PLM, etc.,**
  - **to provide automated assistance**
  - **Example: Process modeled in BMPN* generates BPEL**, loaded on a BPEL server engine within an enterprise environment such as a PLM platform provides *process enforcement***

***Business Process Modeling Notation**

****Business Process Execution Language**

Way ahead is clear, but lots of work to do

Questions

AFLCMC… Providing the Warfighter's Edge

BACKUPS

AFLCMC… Providing the Warfighter's Edge