Agenda

• Introduction

• Context
  – Information Models
  – Organizations Relevant to AP233 Development
  – STEP

• AP233
  – System Engineering Model History
  – AP233 Capabilities
  – AP233 Development Status

• Resources
Introduction

• In today’s world, information is abundant. We have no problems generating it. But we are challenged to find, organize, and exchange information.

• A standardized model of information can help. Such a model nearly completed its development for Systems Engineering. It is referred to as AP233 (AP = Application Protocol).
We will approach AP233 from 3 different directions.

But first a little more on “Information”
Information

• What is information?
  – We are surrounded, immersed, awash, bombarded by it
  – It doubles every 3 years (at least)
  – It exists in the natural world; it exists in cyber space
  – It becomes relevant through communication

• Definitions may help (from Oxford English Dictionary):
  – **Fact**
    *Something that has really occurred or is actually the case*
  – **Data**
    *Facts, esp. numerical facts, collected together for reference or information.*
  – **Knowledge**
    *The fact, state, or condition of understanding*
  – **Information**
    *Knowledge communicated concerning some particular fact, subject, or event*

…and for good measure:
  – **Semantics**
    *The relationships between linguistic symbols and their meanings*
Information, cont.

In a nutshell, this is what AP233 does for Systems Engineering

\[ \pi = 3.14159 \]

Re-used from “Information” by Hans Christian von Baeyer
Information Models

- STEP
- AP233
  - Information Models
  - Participating Organizations
Information Models

• Information Models abound. Just a small, random sample:
  – **Common Information Model (CIM) Standards**
    Distributed Management Task Force
  – **A Taxonomic Information Model for Botanical Databases**
    International Organization for Plant Information
  – **Geo-Information Models**
    Netherlands Geodetic Commission
  – **Core Model Of The Electronics Domain**
    IEC 62016

Others:
  – **Soil Erosion**
  – **Chemistry**
  – **Economic**

• What is characteristic about information models?
Characteristics of Information Models

• An information model is a formal description of an area of interest, a domain.
• It specifies the objects within the domain, the relationships between the objects, the attributes of the objects and the constraints upon the objects and their relationships.
• Many information models are international standards (often overlapping)
• Languages exist to unambiguously express information models. Some examples:
  – Business Process Modeling Language (BPML)
  – Unified Modeling Language (UML)
    • SysML is a domain-specific visual modeling language for systems engineering applications
  – EXPRESS (ISO 10303 – 11)
Participating Organizations

- STEP
- AP233
  - Information Models
  - Participating Organizations
Organizations

• **OMG** (Object Management Group)
  – is an open membership, not-for-profit consortium that produces and maintains computer industry specifications for interoperable enterprise applications

• **OASIS** (Organization for the Advancement of Structured Information Standards)
  – is a not-for-profit, international consortium that drives the development, convergence, and adoption of e-business standards

• **INCOSE** (International Council on Systems Engineering)
  – not-for-profit membership organization with the mission is to advance the state of the art and practice of systems engineering

• **ISO** (International Organization for Standardization)
  – is a network of the national standards institutes of 156 countries, with a Central Secretariat in Geneva, Switzerland, that coordinates the system.

• **PDES, Inc.**
  – the mission of PDES, Inc. is to accelerate the development and implementation of STEP.
# PDES, Inc. Members

<table>
<thead>
<tr>
<th>Industry</th>
<th>Large Vendor</th>
<th>Small Vendor</th>
<th>Government</th>
<th>University</th>
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<td>Rockwell Collins</td>
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<td>Theorem</td>
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AP233 Participants

Over the course of the project, numerous organizations have helped with AP233

- ATI
- BAE SYSTEMS
- BOEING
- ESA
- EADS
- EDS
- EuroStep
- Georgia Tech
- IBM
- I-Logix
- INCOSE
- John Deere
- Motorola
- MOD
- NASA/GSFC
- NASA/JPL
- NAVSEA
- NDIA
- NIST
- Northrup Gruman
- OMG
- PDES Inc.
- Raython
- Rockwell Collins
- Vitech
- Volvo Aero
ISO STRUCTURE

GENERAL ASSEMBLY:
- Principal officers
- Delegates of:
  - Member bodies
  - Correspondent members
  - Subscriber members

Policy development committees:
- CASCO
- COPOLCO
- DEVCO

Council standing committees:
- Finance
- Strategy

Ad hoc advisory groups

COUNCIL

TECHNICAL MANAGEMENT BOARD

REMCO

Technical advisory groups

Technical committees
ISO Technical Committee’s

- JTC 1  Information technology
- TC 1  Screw threads

- TC 19  Preferred numbers
- TC 20  Aircraft and space vehicles
- TC 21  Equipment for fire protection and fire fighting

- TC 182  Geotechnics
- TC 183  Copper, lead, zinc and nickel ores and concentrates
- TC 184  Industrial automation systems and integration
- TC 185  Safety devices for protection against excessive pressure
- TC 186  Cutlery and table and decorative metal hollow-ware

- TC 228  Tourism and related services
- TC 229  Nanotechnologies
Industrial automation systems and integration

Total number of published ISO standards related to the TC and its SCs: 420

Participating countries: 21

Observer countries: 22

<table>
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<th>Committee</th>
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<tbody>
<tr>
<td>TC 184/AG</td>
<td>Advisory group</td>
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<tr>
<td>TC 184/SC 1</td>
<td>Physical device control</td>
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<tr>
<td>TC 184/SC 2</td>
<td>Robots for industrial environments</td>
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<tr>
<td>TC 184/SC 4</td>
<td><strong>Industrial data</strong> (home of STEP – ISO 10303)</td>
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<tr>
<td>TC 184/SC 5</td>
<td>Architecture, communications and integration frameworks</td>
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</table>
## Industrial data

*Number of published ISO standards under the direct responsibility of the TC 184/SC 4 Secretariat:* 367

**Participating countries:** 20

**Observer countries:** 12

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<td>Quality committee</td>
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<tr>
<td>TC 184/SC 4/PPC</td>
<td>Policy and planning committee</td>
</tr>
<tr>
<td>TC 184/SC 4/AG</td>
<td>Change management advisory group</td>
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<td>TC 184/SC 4/WG 2</td>
<td>Standard for the neutral representation of standard parts</td>
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<tr>
<td><strong>Product modeling</strong> (home of AP233)</td>
<td></td>
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<tr>
<td>TC 184/SC 4/WG 3</td>
<td>Joint SC 4 - SC 5 WG : Manufacturing process and management information</td>
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<tr>
<td>TC 184/SC 4/WG 8</td>
<td>EXPRESS language, implementation methods and conformance methods</td>
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<tr>
<td>TC 184/SC 4/WG 11</td>
<td>Common resources</td>
</tr>
</tbody>
</table>
STEP

- AP233
  - Information Models
  - Participating Organizations
What is STEP?

• The STEP project was initiated in 1984 by ISO.

• **STEP** is a synonym, sometimes interpreted as
  
  *Standard for the Exchange of Product Model Data*

• The actual designation of the STEP standard is
  
  *ISO 10303 Industrial Automation Systems - Product Data Representation and Exchange.*
STEP Application

• **STEP**
  – provides a mechanism that is capable of describing product data throughout the life cycle of a product,
  – the description is independent from any particular system.
  – it is suitable not only for neutral file exchange, but also as a basis for implementing and sharing product databases and archiving

• **STEP standards are developed for specific application domains and referred to as Application Protocols (APs)**

• **An effort to modularize APs is underway for the benefit of reuse.**
What is an AP

An Application Protocol (AP) is a standardized representation of product data in a specific application context.

It includes:

- The description of the functionality (AAM, Application Activity Model)
- An application-oriented reference model from a user's point of view (ARM, Application Reference Model)
- Representation of the reference model through objects from the Integrated Resources as implementation view (AIM, Application Interpreted Model)
- Implementation guidelines and conformance conditions for implementations
STEP APs

AP202 Associative Draughting
AP203 Configuration Controlled 3D Designs of Mechanical Piece Parts and Assemblies
AP207 Sheet Metal Die Planning and Design
AP209 Composite and Metallic Structural Analysis and Related Design
AP210 Electronic Assembly, Interconnect, and Packaging Design
AP213 Numerical Control (NC) Process Plans for Machined Parts
AP232 Technical Data Packaging - Core Information and Exchange

**AP233 Systems Engineering**
AP212 Electrotechnical Design and Installation
AP214 Core Data For Automotive Design Processes
AP215 Ship Arrangement
AP216 Ship Moulded Forms
AP218 Ship Structures
AP221 Functional Data and their Schematic Representation for Process Plant
AP224 Mechanical Product Definition for Process Planning Using Machining Features
AP225 Building Elements Using Explicit Shape Representation
AP227 Plant Spatial Configuration

…more
What is Express?

• The modeling language for STEP is EXPRESS

• EXPRESS is a lexical, object flavored information modeling language and is defined in ISO 10303-11:1994.

• EXPRESS-G is an iconic language that provides a subset of the lexical modeling capabilities; this is defined in Annex D of ISO 10303-11:1994.
Sample Express

1 SCHEMA Bank;
2 ENTITY Branch;
3   SortCode : STRING;
4   BranchManager : Manager;
5   Tellers : SET[1:20] OF Teller;
6   Customers : SET[0:?] OF AccountHolder;
7 DERIVE
8   Staff : SET[2:21] OF Employee := BranchManager + Tellers;
9 END_ENTITY;
10
11 ENTITY Person
12   ABSTRACT SUPERTYPE OF (ONEOF (Male, Female) AND
13       (Employee ANDOR AccountHolder));
14   Age : INTEGER;
15 WHERE
16     age_cannot_be_negative : Age >= 0;
17 END_ENTITY;
18
N END_SCHEMA;
The **Requirement** entity is used to uniquely identify a requirement. There may be many versions of that requirement (requirement_version).
The **Requirement_version** entity represents a version of a requirement. This entity is used to record the different versions of a requirement.
The **Requirement_version_sequence** entity is used to relate a previous version (predecessor) of a requirement to the version that replaces it (successor).
AP233

- STEP
- Information Models
- Participating Organizations
AP233 History

• Systems Engineering Data Representation and Exchange Standardization (SEDRES)
  – the Root of AP233

• ESPRIT Project 20496
  – January 96 – March 99
  – ~45 work years
  – jointly European Commission and industrial partner funded

• An initiative to produce a tool-neutral solution to the lack of tool interoperability for the systems engineering domain

• Used specific tools and exchanges for validation
AP233 History, cont.

• **SEDRES-2** (January 2000 - December 2001)
  – The SEDRES-2 mission extended, validated and standardized the Systems Engineering (SE) data model and nurtured its practical implementation and multi-sector exploitation as a key enabler for the competitiveness of European industry.

• Final Draft data model #5 being reworked as PAS 20542
  – PAS = Publicly Available Standard (ISO terminology)

• A number of prototype tool interfaces demonstrate capability
  – SEDRES Project Final Event - December 2001 at BAE SYSTEMS (Warton, UK)
  – Included demonstrations
Overview of AP233

- Application Protocol 233 (AP233) is a modular, STEP-based data exchange standard, targeted to support the needs of the systems engineering community.

- The AP233 Project is collaborating with the Object Management Group (OMG) that has developed SYSML, a systems engineering extensions to UML and INCOSE (International Council on Systems Engineering), a systems engineering professional society.
AP233 Scope

• Using the STEP modular develop approach, AP233’s scope includes:
  – requirements (functional, architectural, property)
  – verification and validation
  – product functionality
  – architecture
  – (evaluation of) alternative solutions
  – traceability
  – product data management
  – project management information (cost, schedule, etc.)
AP233 Application Module Structure

**System Modeling**

- System Behaviour
  - Function-based Behaviour
  - State-based Behaviour
- System Structure
  - Physical Breakdown
  - System Breakdown
  - Zonal Breakdown
  - Interface
- Decision Support
  - Trade Study
  - Verification & Validation
  - Justification
- Requirements Management
  - Requirement Assignment
  - Effectivity Application
  - Classification Assignment
  - Document Assignment

**Program Management**

- Project Management
  - Work Structure
  - Schedule
  - Project Breakdown
  - Organization Structure
  - Project Management Resource Information
- Risk Management
- Issue Management

* approximate higher level aggregation of ~150 modules
Modules released to ISO by AP233 in 2008 as Technical Specification

Complete release of AP233 as Draft International Standard (DIS) expected in 2009

Modules published by PLCS (AP239) in 2004 and reused by AP233

Modules in need of rework because AP239 e2 updates
AP233 Role

- **Capture, Exchange and Archive Systems Engineering Information across Disciplines and Organizations.** AP233 enables
  - communication between similar tools in Systems engineering usage
  - communication between different tools both within and external to Systems engineering functions
  - holistic approaches to data sharing
  - fine grain configuration management to Systems engineering data
  - sharing of management data currently locked up in proprietary formats and tools
  - supports MBSE
Additional Information
References

**EXFF** - Engineering Exchange For Free

**EuroStep**’s AP233 Website

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The Future of System Engineering Tools, Steve Jenkins, JPL

NASA/ESA Product Data Exchange Workshop at NASA’s STEP site

AP233.ORG public site

Step Module Repository Project
# Sample of implementations

<table>
<thead>
<tr>
<th>Application Names</th>
<th>Module Set</th>
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<th>Status</th>
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<th>Comments</th>
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<tr>
<td>AP233 Demonstrator Tool</td>
<td>Requirements</td>
<td>Prototype</td>
<td>2001</td>
<td>Legacy</td>
<td>Ian Bailey</td>
<td>A freely available tool developed by Eurostep and funded by NASA and UK MoD to generate requirements test data.</td>
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<td>SLATE</td>
<td>Requirements</td>
<td>Commercial</td>
<td>2001</td>
<td>Legacy</td>
<td>Mark Sampson, John Nallon</td>
<td>Early adopters of AP233 Requirements in a commercial tool; SAVE AS feature built-in to the SLATE.</td>
</tr>
<tr>
<td>UGS TeamCenter SE</td>
<td>Requirements</td>
<td>Commercial</td>
<td>2003</td>
<td>Active</td>
<td>Mark Sampson, John Nallon</td>
<td>UGS TeamCenter SE is a follow-on product to SLATE after UGS acquisition.</td>
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<td>DOORS</td>
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<td>Test</td>
<td>2001</td>
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<td>VTT</td>
<td>Requirements</td>
<td>Commercial</td>
<td>2002</td>
<td>Active</td>
<td>Eurostep-Finland</td>
<td>VTT (Finnish Government R&amp;D Centre) contracted with Eurostep-Finland to develop a dual-language (Finnish/English) requirements management tool for the building and construction industry using an early version of the AP233 Requirements data model.</td>
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<tr>
<td>3SL CRADLE</td>
<td>Requirements</td>
<td>Prototype</td>
<td>2002</td>
<td>Active</td>
<td>Julian Johnson, Ian Bailey</td>
<td>UK MoD funded this prototype to demonstrate ability to move MoD’s requirements in DOORS into and out of...</td>
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Thank You

… and are there any question?