The Role of Standards in Designing and Maintaining Complex Systems

Ravi Rajamani

May 2018

Standards in Large Engineering Design Projects

- Standards are very useful (critical), when used judiciously.
- No big engineering project today can be completed without the use of some set of standards.
- Aerospace systems are particularly dependent on standards because of their safety criticality.
- Industry associations have stepped up to the challenge of developing standards at the behest of authorities.

Where Standards are Needed for Survival (1/2)

The Great Baltimore Fire of Feb 7, 1904

- Burned for 30 hours, engulfed 70 city blocks & 1,526 buildings; resulted in loss of 2,500 businesses.
- Engine companies from Washington, DC arrived first by train. But could not assist!
- Cities and counties of Altoona, Annapolis, Chester, Harrisburg, New York, Philadelphia, Wilmington, and York sent fire companies.
- Resources used: 1,231 firefighters, 57 engines, 9 trucks, 2 hose companies, 1 fireboat, and 1 police boat.

Momar D. Seck and David D. Evans , “Major U.S. Cities Using National Standard Fire Hydrants, One Century After the Great Baltimore Fire,” NISTIR 7158, National Institute of Standards and Technology, Gaithersburg, MD 20899, Aug 2004

Where Standards are Needed for Survival (2/2)

- *The lack of uniform threads on fire hydrants is commonly cited as a factor in the massive destruction!*
- The National Bureau of Standards (NBS; now NIST) later that year started working on standardizing these dimensions
- Even today different cities have different designs. Fire trucks carry adapters to make hoses fit hydrants

Added lesson: Standards are essential, but they can be tough to enforce!

Momar D. Seck and David D. Evans , “Major U.S. Cities Using National Standard Fire Hydrants, One Century After the Great Baltimore Fire,” NISTIR 7158, National Institute of Standards and Technology, Gaithersburg, MD 20899, Aug 2004

…and Where They Evidently Are Not…

SAE Integrated Vehicle Health Management (IVHM) Committee HM-1

- Five rotorcraft standards inherited from RITA (Rotorcraft Industry Technology Association) now called the Vertical Lift Consortium (VLC) around 2003.

- AS4831A (Software Interfaces for Ground-Based Monitoring Systems)
- AS5392 (Health and Usage Monitoring System, Rotational System Indexing Sensor Specification)
- AS5393 (Health and Usage Monitoring System, Blade Tracker Interface Specification)
- AS5394 (Health and Usage Monitoring System, Advanced Multipoint Interface Specification)
- AS5395 (Health and Usage Monitoring System Data Interchange Specification)

HM-1 Committee:
https://www.sae.org/servlets/works/documentHome.do?comtID=TEAHM1

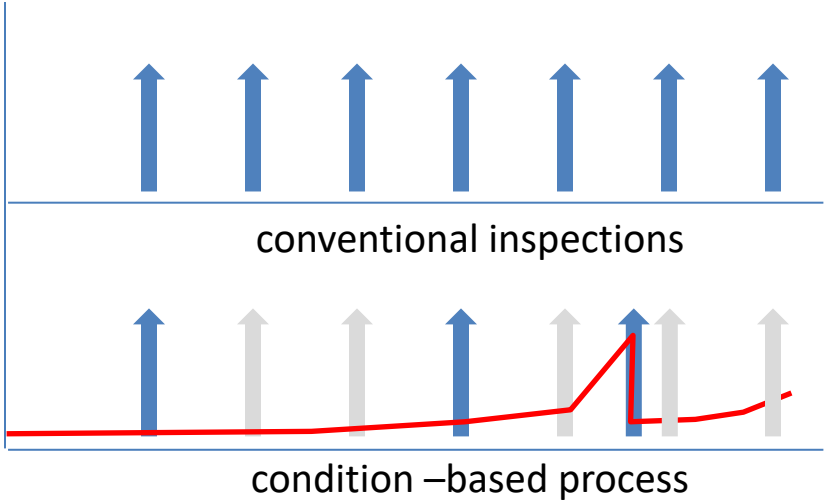
Characteristics of Good Standards Development

- **Guidance**, **not Law**: Generally a standard is a requirement, not law.
- **Voluntary**: Often is voluntary. Alternate means of compliance could be acceptable. But sometimes they are “required!”
- **Due process**: Has highly visible procedures for the creation and application.
- **Openness**: Ensures all interested parties can participate actively in the standards development process.
- **Consensus**: A clearly defined process exists for approval of a standard. Consensus does not imply unanimity.
- **Balance**: Balloting groups include all interested parties and avoid an overwhelming influence by any one party.
- **Right of appeal**: Anyone can appeal a standards development decision at any point, before or after a standard has been approved (with some caveats).

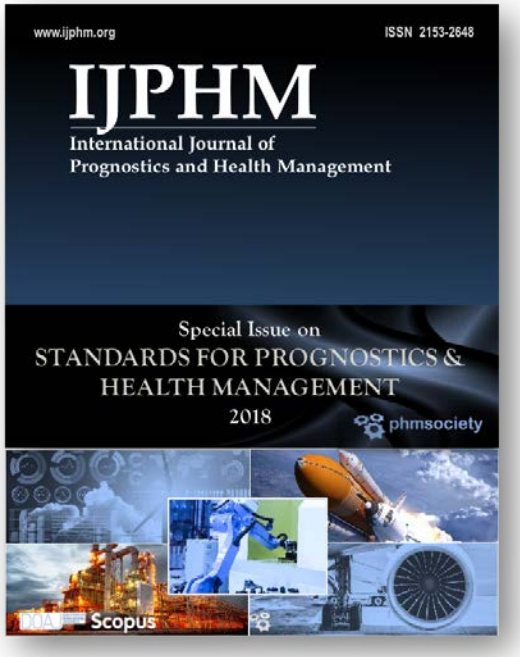
Courtesy: Sony Mathew, Schlumberger via IEEE

Example: Obtaining Maintenance Credits

- Can PHM systems be used to get maintenance credits?
- E-32 (Propulsion Health Management) has issued ARP5987 to take the first “systematic” steps in defining a process.
- Some legacy systems already exist:
  - Engine vibrations
  - Use of EHM for ETOPS
  - Oil debris monitoring
  - Usage-based lifing based on derated takeoff



PHM Society IJPHM Special Issue on Standards



- International Journal of PHM (IJPHM)
- Special issue on "*Standards for Prognostics & Health Management,*" to be published in 2018
- Please contribute papers; NIST should be well represented!

Summary

- Standards are very useful when used judiciously.
- Not all published standards are used.
- Aerospace systems depend critically on standards for design and testing.
- Health management standards are not as prevalent as these.
- There is a great interest within the aerospace community to develop standards that will allow the use of PHM systems for obtaining maintenance credits.
- PHM for manufacturing systems can be very beneficial and standards are needed.
- Please contribute to the IJPHM special issue on STANDARDS!