Health-Ready Components and Systems

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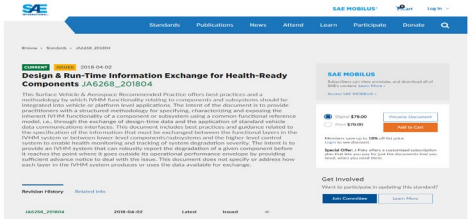
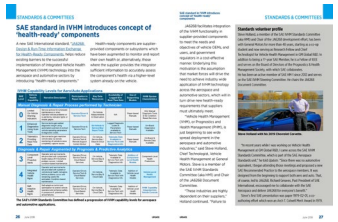
ROLLOUT PLAN

- Promote JA6268:
  - Press Release



  - Feature article in SAE periodical ***Update*** with follow-ons planned



  - Promotion at conferences launched and ongoing

  - Website with links to surveys soliciting information

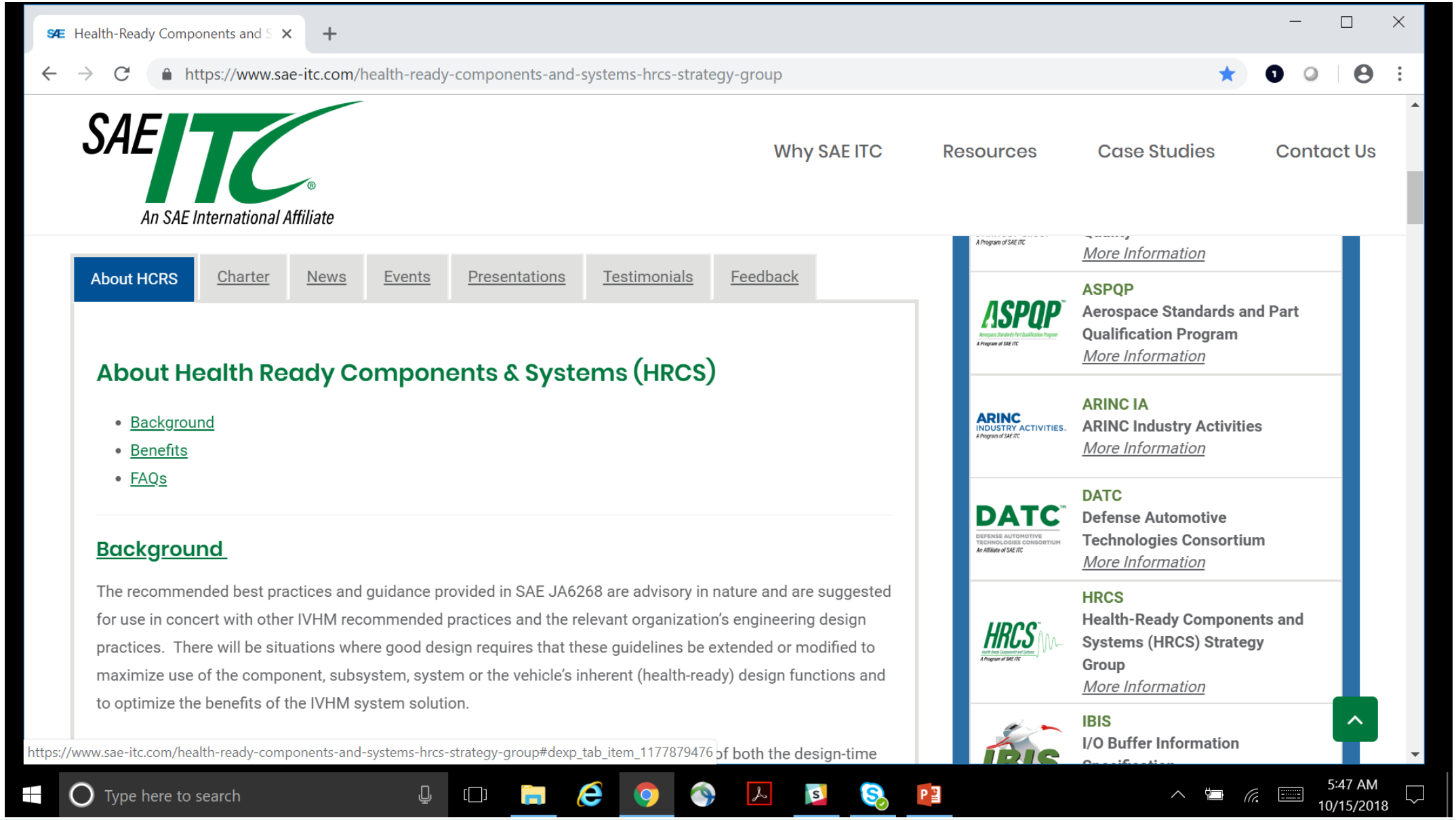
PRESENTATIONS AT CONFERENCES

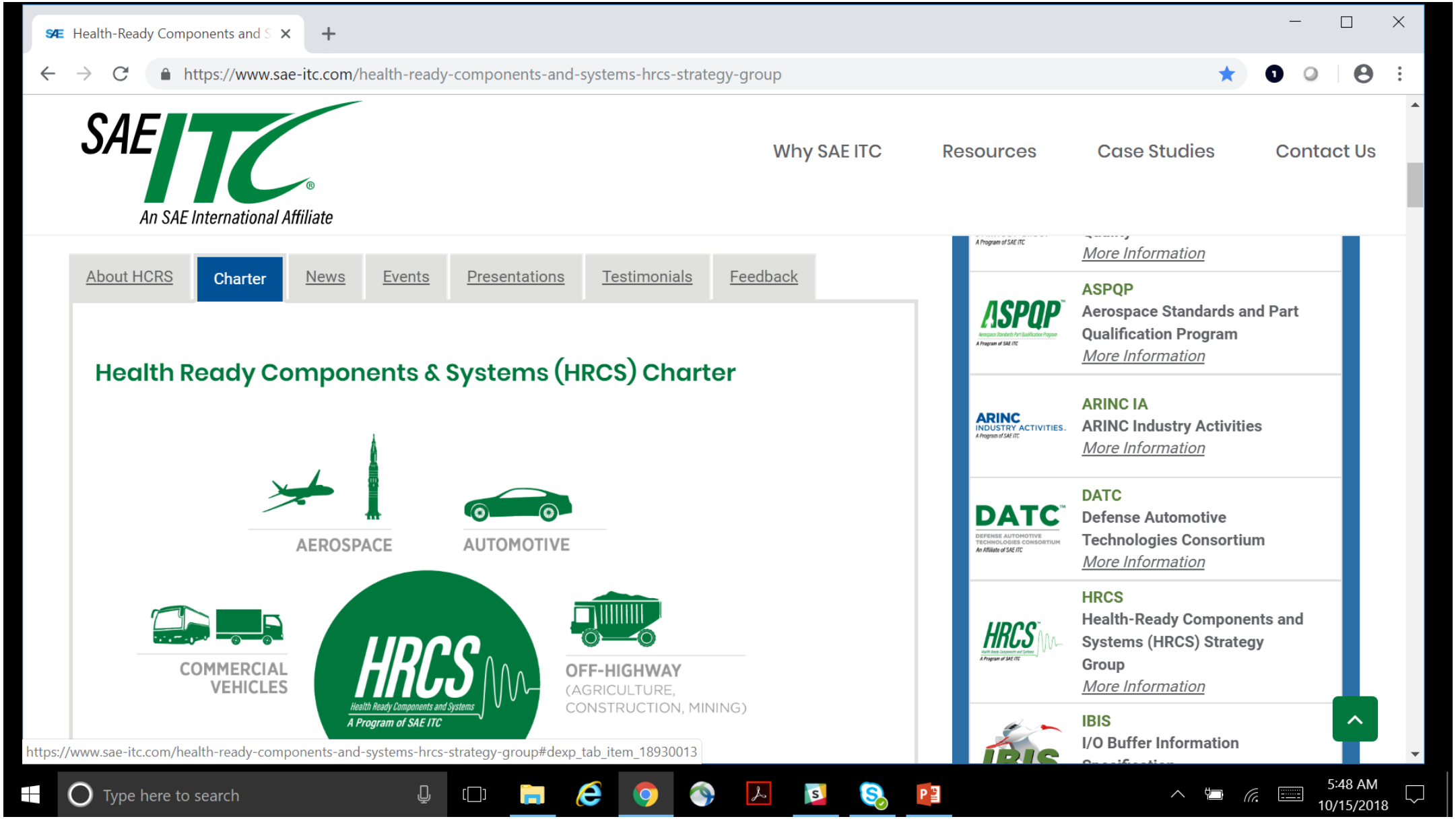
- HM-1 Committee September 10-13 (Atlanta, GA) hosted by Delta
- ATA-TMC Conference September 17-18 (Orlando, FL)
- OSD CBM+ Action Group September 20 (Washington, DC)
- PHM Conference September 24-28 (Philadelphia, PA)
- SAE Aerospace Standards Summit October 2-3 (Tysons, VA)
- SAE ADAS Conference October 9-11 (Detroit, MI)
- EFB Users Forum November 13-15 (London, UK) hosted by Inmarsat

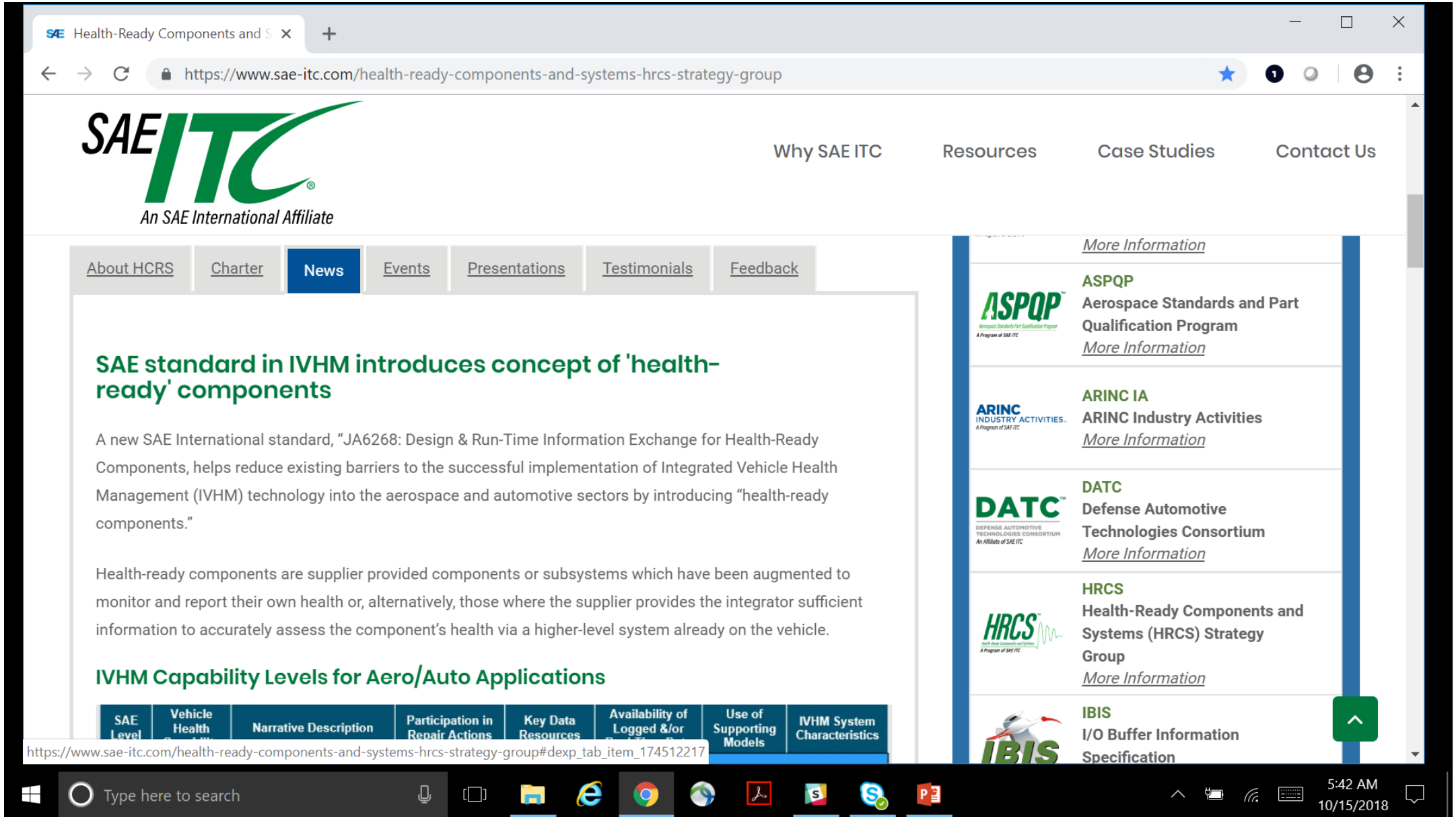
WEBSITE DEVELOPMENT

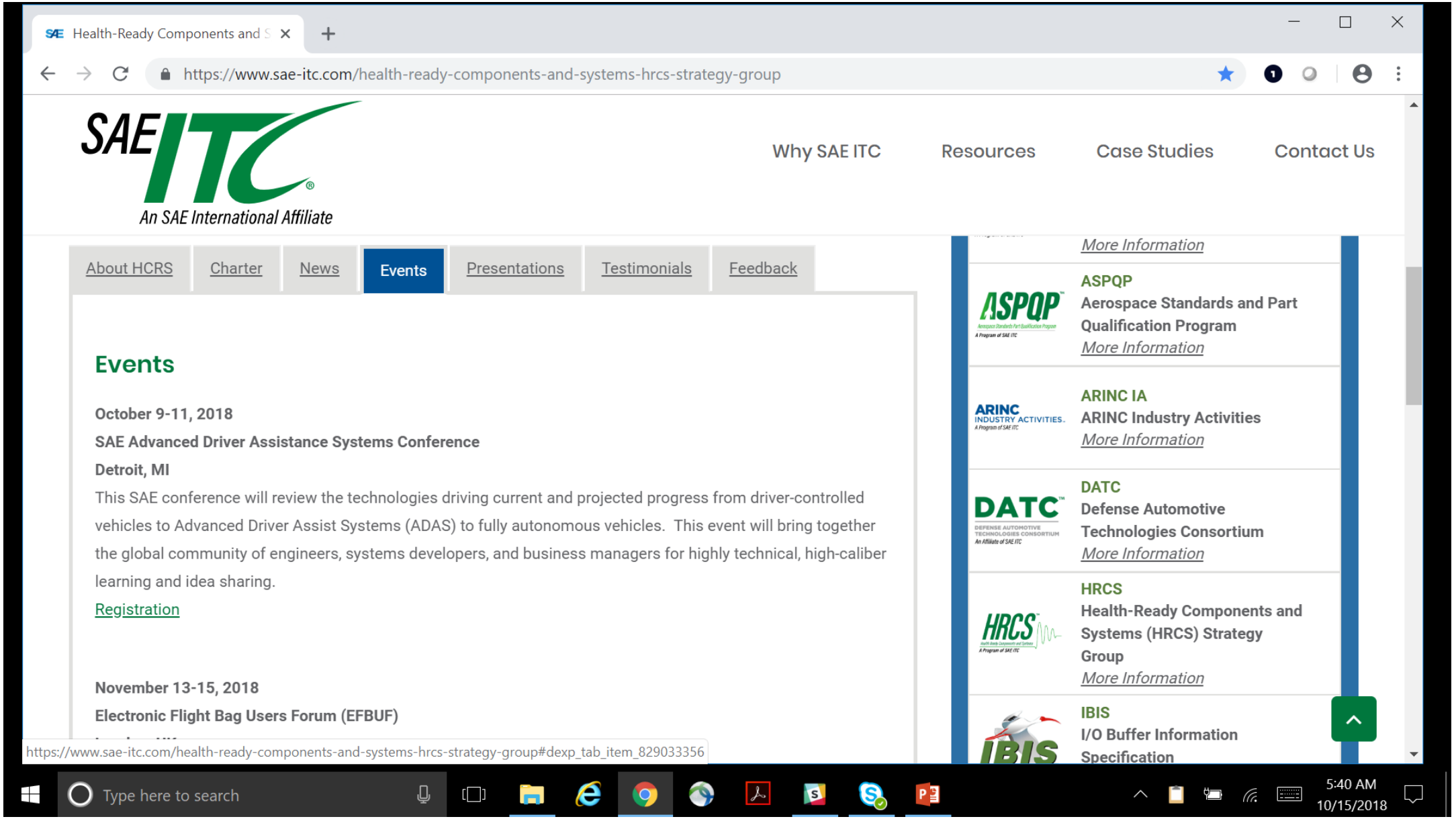
- Website is the main landing page, with tabs for:
  - About HRCS
  - Charter (draft)
  - News
  - Events
  - Presentations
  - Testimonials
  - Feedback
  - Anticipated future tabs for members and sponsors

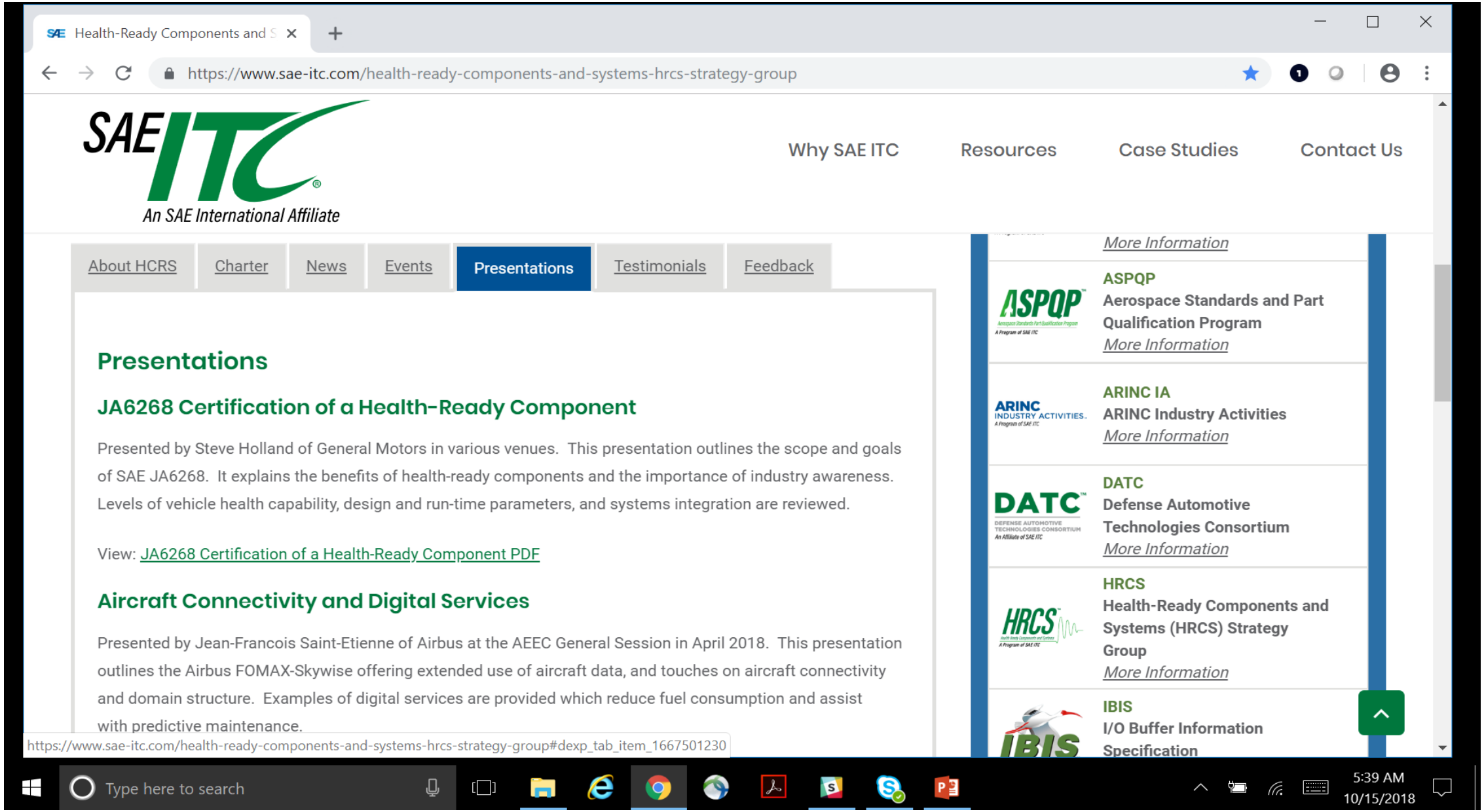
- https://www.sae-itc.com/health-ready-components-and-systems-hrcs-strategy-group

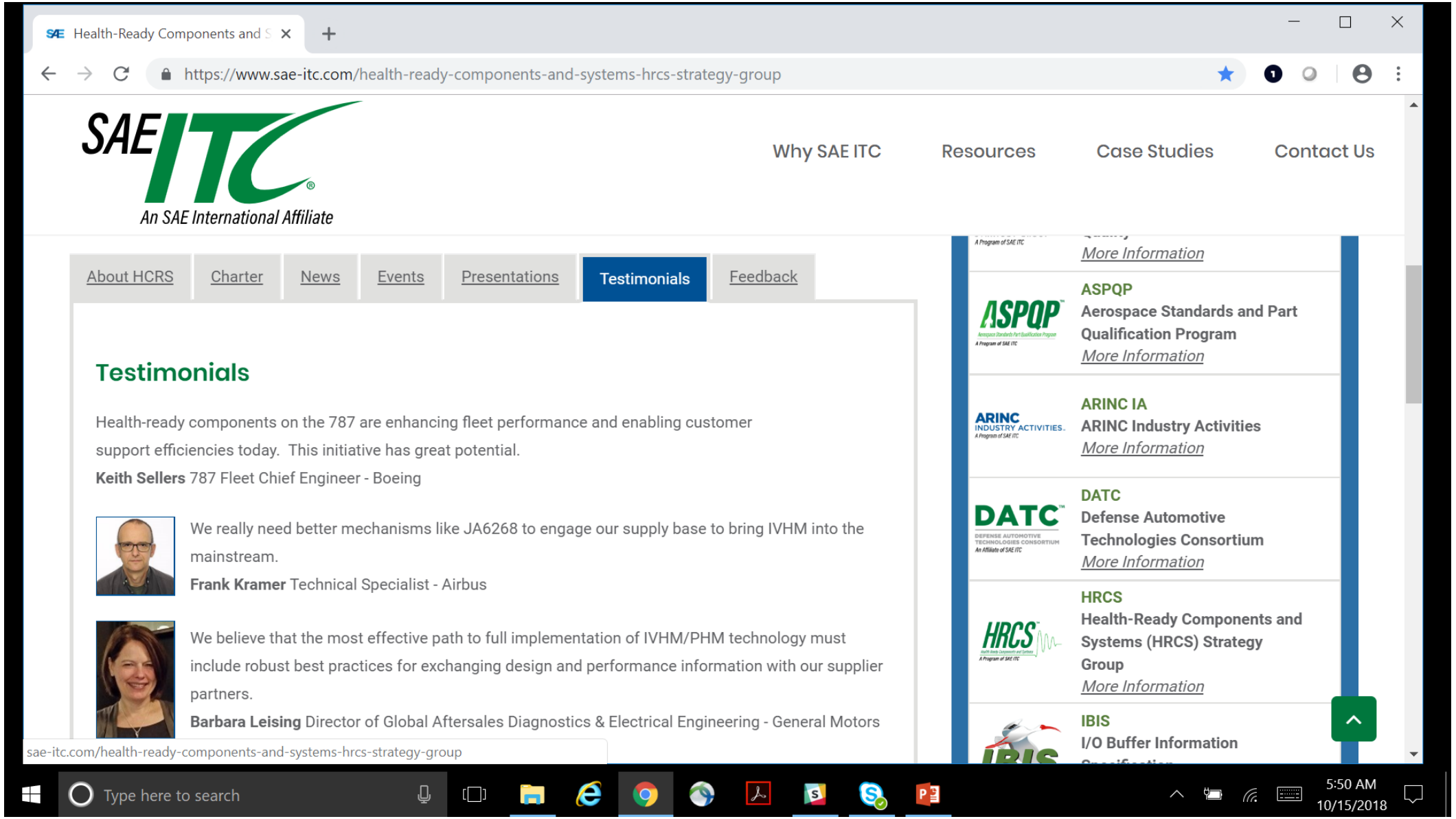


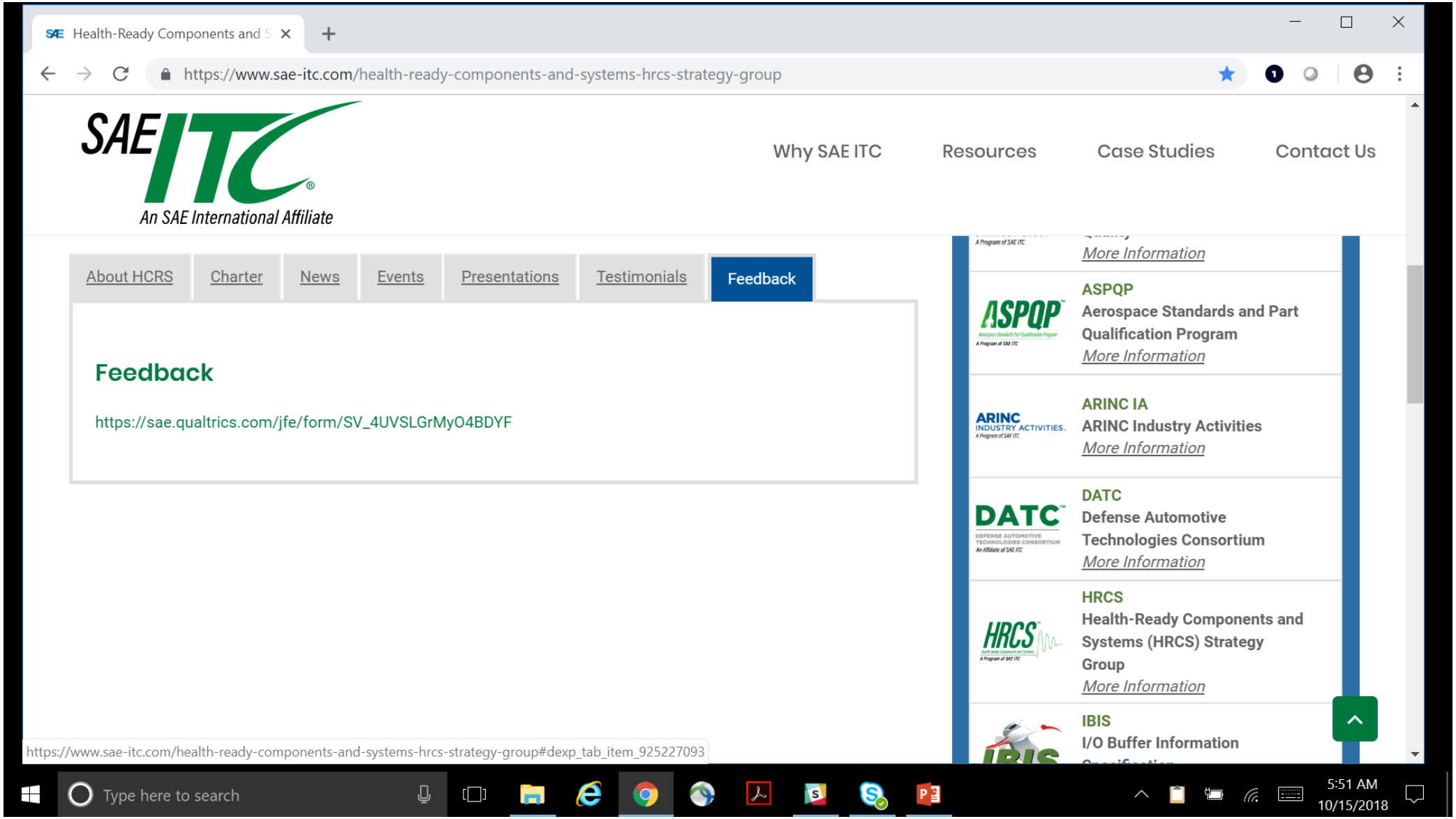












HEALTH-READY COMPONENTS AND SYSTEMS PROGRESS

- Application of JA6268 in request for proposals/bidding
- Subsystem components and HRCS infrastructure
- Pilot program to certify a component as health-ready by year end

IMPLEMENTING JA6268: *PARADIGM SHIFT*

- Status of JA6268:
  - Balloting completed & approved by HM-1 January 30th
  - SAE Aerospace Council approved March 28th
  - Published April 2nd https://www.sae.org/standards/content/ja6268_201804/
  - SAE Motor Vehicle Council briefing with favorable reply April 12th
  - Promotion at conferences launched and ongoing
  - **Initiated development of HRCS Database with completion targeted for year end 2018**

WHY WE PROVIDE REGISTRIES AND DATABASES

- Enable participants to find information they are seeking in a cost effective manner.
- Provide assurance that a consistent process was followed and information is correct.
- Ensure a neutral, unbiased approach.
- Share costs.
- Provide contacts for more information or issue resolution.
- Leverage shared knowledge and technology

HRCS DATABASE

SAE JA6268™ CERTIFICATION PROCESS

(Initial Draft)

IVHM CAPABILITY *(VEHICLE LEVEL)* (SOURCE: SAE JA6268™)

Illustrating industry evolution in use of diagnosis & prognosis for vehicle maintenance

SAE Level	Vehicle Health Capability	Narrative Description	Participation in Repair Actions	Key Data Resources	Availability of Logged &/or Real-Time Data	Use of Supporting Models	IVHM System Characteristics
Manual Diagnosis & Repair Process performed by Technician							
0	Limited On-Vehicle Warning Indicators	Service actions for scheduled maintenance or when Operator notices problems or is alerted by indicator lights or simple gages.	**Operator/Driver & Service Tech**	On-Vehicle Measurements & Observation	N/A	Paper-based Manuals	Only Manual Diagnostic Tools & No Condition-Based Services
1	Enhanced Diagnostics Using Scan Tools	Service techs gain added diagnostic insight using automated scanners to extract vehicle operating parameters & diagnostic codes.	Operator/Driver & Service Tech	**On-Vehicle & Service Bay/ Depot Tools**	Logged Diagnostic Codes & Parameters available to Service Tech	Paper-based Manuals	On-Board Diagnostics Available
2	Telematics Providing Real-Time Data	Service techs gain real-time vehicle data via remote monitoring of vehicle to more completely capture issues.	Operator/Driver, Service Tech & Remote Support Center Advisor	On-Vehicle, Service Bay / Depot & Cloud Data	**Telematic Data Available to Service Tech with Diagnostics Info**	Paper-based Manuals	On-Board & Remote Data Available
Diagnosis & Repair Augmented by Prognosis & Predictive Analytics							
3	Component Level Proactive Alerts	Operator and service techs are provided with component health status (R/Y/G) before problem occurs . Limited condition-based maintenance.	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	**Addition of Component-Level Health Models**	Component-Level Health Predictions
4	Integrated Vehicle Health Mgmt.	Operator and service techs are provided with system or vehicle level health indicators before problems occur with remaining useful life estimated. Condition-based maintenance.	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	Addition of Vehicle-Level Health Models	**Vehicle-Level Health Management**
5	Self-Adaptive Health Mgmt.	Self-adaptive control and optimization to extend vehicle operation and enhance safety in presence of potential or actual failures.	Operator/Driver, Service Tech & Cloud-Based Services	On-Vehicle, Service Bay & Cloud Data	Telematic Data Available to Service Tech with Diagnostics Info	Addition of Vehicle-Level Health Models	**IVHM Capability Integrated into Vehicle Controls**

ISO FUNCTIONAL REFERENCE MODEL *(COMPONENT LEVEL)**

*(adapted for use) ISO13374-1 (2002). Condition Monitoring and Diagnostics of Machines Geneva, Switzerland

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IVHM Functional Block	Description	IVHM Process Stage
Data Acquisition (DA)	This function collects the sensor data and health state information from the equipment internal monitors, the system data bus or data recorder.	Sense / Acquire
Data Manipulation (DM)	This function processes and transforms the sensor data and health state information collected by the DA.	Transfer
State Detection (SD)	This function evaluates equipment state conditions against normal operating profiles and generates normal or abnormal condition indicators.	Transfer
Health Assessment (HA)	This function provides information to determine the current state of health of equipment.	Transfer
Prognostics Assessment (PA)	This function provides future state of health, performance life remaining, or remaining useful life (usage) indicators.	Analyze
Advisory Generation (AG)	This function provides actionable information to operational and maintenance personnel or external systems.	Act

SAE HRCS HEALTH-READY COMPONENTS REGISTRY (CORE INFO)

(SAE JA6268™ Chapter 9)

- Component Name (and known aliases)
- Supplier's catalog reference number (or numbers)
- Suppliers contact information and DUNS number, CAGE Code or other industry standard supplier identifier (if applicable)
- Validation approach can be based upon (a) design-time information, (b) run time information or (c) both design-time and run-time information
- Format of Health Ready info which provides a mathematical model (or mathematical relationships) in a machine-readable format to allow for a proper interpretation and use of specific component parameters
- Integrator/OEM name providing the validation along with their contact information and DUNS number (if applicable)
- Dates validation was completed and date which the validation expires (if applicable)

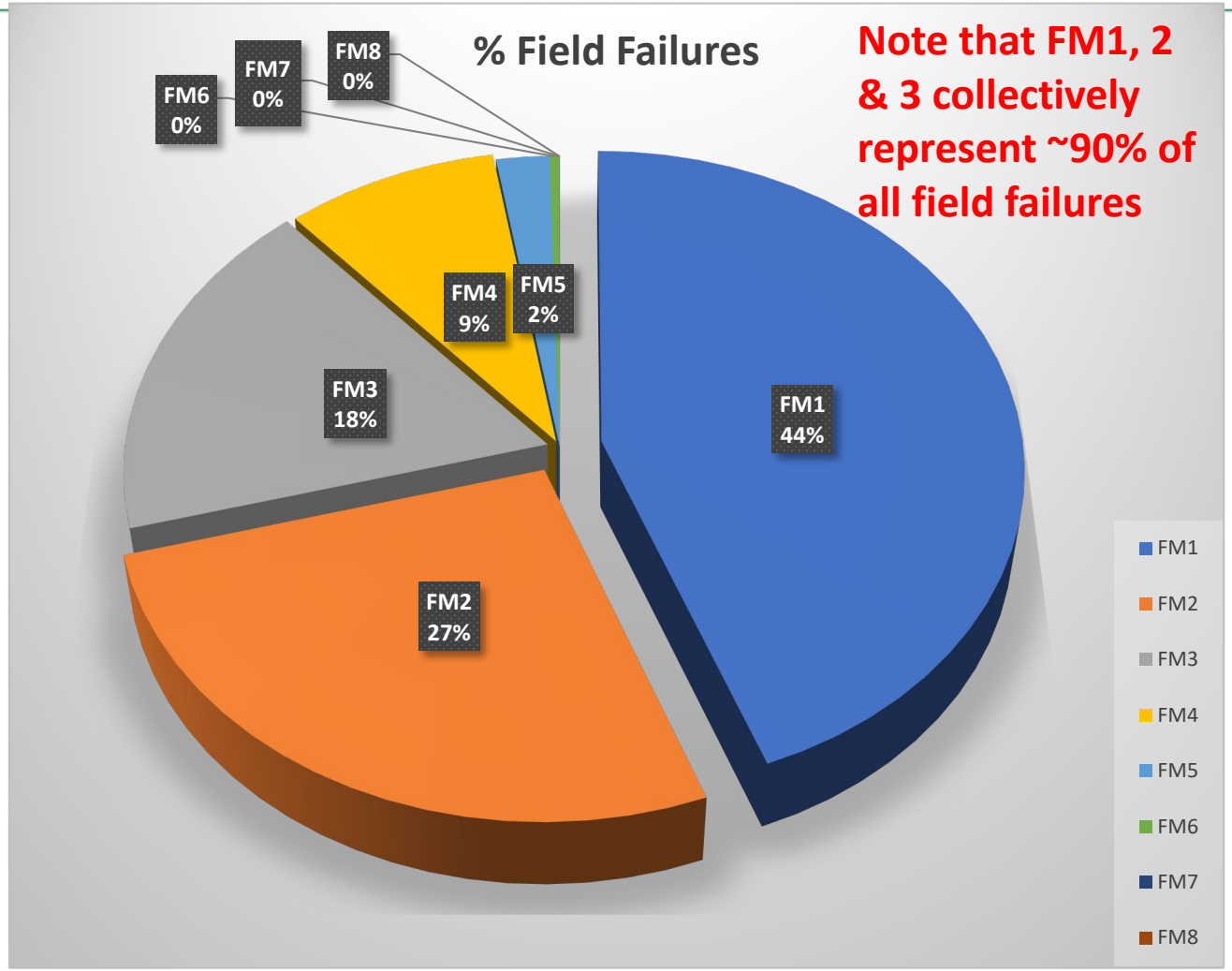
\+ *Other items to be determined by HRCS SG (all non-proprietary)*

PRIORITIZE FAILURE MODES BY FREQUENCY OF OCCURRENCE

Failure Mode	IPTV Expected in 1st 5 * Years	% Field Failures
FM1	10.0000	44.2605
FM2	6.0000	26.5563
FM3	4.0000	17.7042
FM4	2.0000	8.8521
FM5	0.5000	2.2130
FM6	0.0900	0.3983
FM7	0.0030	0.0133
FM8	0.0005	0.0022
Total	22.5935	100.0000

* or other reference period

IPTV=Incidents Per Thousand Vehicles



OTHER CONSIDERATIONS

- **Frequency of failures** (expressed as IPTV) as shown prior slide is clearly important. It is unlikely different modes will have uniform likelihood of occurrence in the field but, there are also other important factors to consider:
  - **Cost Per Vehicle** (CPV) – This measure tells us how costly on average it is to repair a vehicle once a given failure mode has happened
  - **Severity** (Type) – This measure tells us how important this failure mode is in terms of loss of functionality or its impact on vehicle safety
    5. ***Most Severe:*** Non-operational Vehicle or Safety Issue
    4. Urgent Vehicle Repair
    3. Important Repair or Customer Inconvenience
    2. Minor Vehicle Repairs
    1. ***Least Severe:*** Routine Vehicle Maintenance

SAE JA6268™ THREE CERTIFICATION STAGES

Stage 1: *Functional Self Assessment*
Stage 2: *Failure Modes Assessment*
Stage 3: *Detailed Design Assessment*

Note:

- *Stage 1 is intended to provide a provisional certification with a low barrier to entry.*
- *Stages 2 & 3 are enhanced by seeking an OEM/ integrator to validate the supplier-provided assessment.*

STAGE 1: FUNCTIONAL SELF-ASSESSMENT, PART A

Part A only requires 6 entries (0-100%) to estimate coverage of Field Failures for each ISO category

IVHM Functional	Common IVHM Function or Process	General Description	% Coverage of Field Failures (if not provided, enter 0)
Data Acquisition (DA)	Data Management	System function and process to control, protect, manage, deliver and enhance the value of health state data and information for the user community.	0
	Data Transfer Interface	System function or system to download or communicate raw data, health state indicators and information for consumption by downstream systems.	
	Data Capture	System function may be a specialized data acquisition module that has analog feeds from sensors, collects processed data from a data bus or provides the software interface to a smart sensor.	
Data Manipulation (DM)	Feature Extraction	System function to manipulate data and compute certain statistical indicators from degradation (predictor) parameters.	0
	Data Normalization	System function to manipulate data and compute a limited range of values within a norm.	
	Data Processing	System function to manipulate data to compute health state indicator(s) or extract information for down stream systems.	
State Detection (SD)	Parametric Data Analysis	System function to process degradation parameter data streams captured in a predefined event, anomaly condition or using external equipment.	0
	Onboard Diagnostics	A dedicated system function for self-diagnostics and reporting of system failures.	
	Built-in-test (BIT)	The integrated system function that monitors and controls system self-tests to detect and report system failures to downstream systems.	
Health Assessment (HA)	BIT Filtering & Correlation	System function and process to manage false alarms, fault persistence and correlate primary and secondary diagnostic trouble (BIT) codes to operational capabilities.	0
	Fault Isolation Analysis	System function and process to resolve reported failure ambiguities using model-based diagnostics or multiple data observations.	
Prognostics Assessment (PA)	Time-to-fail Assessment	System function to monitor, record, assess and report equipment degradation parameter data and produce predicted performance life remaining estimates.	0
	Usage Monitoring & Assessment	System function to monitor, record, assess and report equipment life usage parameter data and produce predicted remaining useful life estimates.	
Advisory Generation (AG)	Decision Support Analysis	System function and process for the transformation and analysis of health state data and information to produce prescriptive actions for the user community.	0
	Health Reporting	System function to monitor, record and report health state data and information for consumption by downstream systems.	
	Caution Warning Indicators	System function to monitor, record, assess and report safety critical equipment failures and produce caution and warning indications for operators.	

STAGE 1: FUNCTIONAL SELF-ASSESSMENT, PART B

Part B asks Supplemental Questions for Covered Failure Modes Identified in Part A to quantify sophistication

- **For Data Acquisition and Manipulation (DA & DM)**
  - Machine readable description of input parameters?
  - Machine readable procedure to convert raw parameter inputs into engineering units?
- **For State Detection (SD)**
  - Size of the ambiguity group (single root cause or a list of "n" possible root causes)?
- **For Health Assessment (HA)**
  - Did the supplier identify key parameters to assess onset of failure modes (machine readable)?
  - Did the supplier identify key relationships (or models) to interpret when those parameters indicate onset of a given failure mode (machine readable)?
- **Prognostics Assessment & Advisory Generation (PA & AG)**
  - Average advance notice (RUL—Remaining Useful Life expressed in days)?
  - Accuracy of forecasted failures (expressed in typical % false positives; % false negatives)?

STAGE 2: FAILURE MODES ASSESSMENT

Similar to Stage 1 but based on all known failure modes instead of just aggregate performance

Failure Mode Description	% Coverage of Field Failures	Avg Cost of Repairs (CPV) $	Severity of Failure (5-1)	Typical RUL Notice (in days)	% False Positives	% False Negatives	Health Indicators ID'd (text)	Relationships / Models ID'd (text)	Size of Diagnostic Ambiguity Group (n)	Machine Readable Information Exchange	…
1											
2											
3											
4											
"n"											

STAGE 3: DETAILED DESIGN ASSESSMENT (16 TABLES)

Stage 3 is the most complete, providing design data. Each table has clarifying information for the covered topics.

		ISO 13374 (OSA-CBM) Implementation Level / SAE JA6268™ Interface Name	None	Data Acquisition (DA)	Data Manipulation (DM)	State Detection (SD)	Health Assessment (HA)	Prognostic Assessment (PA)	Advisory Generation (AG)
Design-Time Interfaces	1	Table of Corrective Actions	X	X	X	X	X	X	X
	2	Table of Interfaces	X	X	X	X	X		
	3	Table of Parameters	X	X					
	4	Table of Failure Modes	X	X	X	X			
	5	Table of Condition Indicators			X	X			
	6	Table of Health Indicators				X	X	X	
	7	Table of Predictive Indicators					X	X	
	8	Table of Reported State/Mode Indicators		X	X	X	X	X	
	9	Table of Loadable Software and Data Files	X	X	X	X	X	X	X
	10	Table of Automatically Reported Configuration Indicators				X	X	X	X
	11	Table of Internally Managed Data Recordings				X	X	X	X
	12	Table of Suggested, Externally Managed, Data Recordings	X	X	X				
	13	Table of Suggested, Externally Executed Algorithms	X	X	X				
	14	Table of Corrective Actions to Health Indicator Relationships	X	X	X	X	X	X	
	15	Table of Corrective Actions to Interface Anomaly Relationships	X	X	X	X			
	16	Table of Indicator to State/Mode Validity Relationships	X	X	X	X			

HRCS STRATEGY GROUP CHARTER

- **HRCS Strategy Group CHARTER**
- **Foreword**
  - Integrated Vehicle Health Management (IVHM) technology has the potential to enable significant benefits for a myriad of assets (aircraft, automotive, trucking, shipping, rail, mining, and other industries) in terms of performance, availability, and safety. However, the level of deployment of IVHM implementations has been limited with respect to high-end functionality such as predictive analytics or prognostics. One of the primary barriers is the lack of uniform information sharing methods between OEMs and their supplier base. This key barrier is addressed by SAE JA6268, Surface Vehicle and Aerospace Recommended Practice: “Design & Run-Time Information Exchange for Health-Ready Components.”

CONSORTIUM DEVELOPMENT

Mission

SAE Industry Technologies Consortia (ITC) enables organizations to connect, collaborate and positively impact global industries by empowering implementation of precompetitive solutions and innovative technologies.

Vision

We are a trusted global leader in consortia-based collaborative tools and services for highly technical industries' operations and supply chain, especially automotive and aerospace.

Collaborative Innovation. Trusted Implementation.

BENEFITS OF MEMBERSHIP

- Voting privileges for all Consortium activities
- Complimentary event attendance
- Free access to Consortium specifications and publications
- Discounted listing fees for HRCs in the registry
- Professional training courses and development
- Protection of operating in a legal environment
- Establish key relationships and trusted networks
- Implement strategic business improvements and innovative technologies
- Co-develop, publish, and gain access to standards, tools, products, programs, and services
- Meet your needs and objectives via comprehensive management and operational support

HOW CAN YOU GET INVOLVED NOW?

- Nominate components for provisional listing in registry
- Volunteer to participate in registry development
- Submit pilot program recommendations
- Please return suggestions by November 30thth to Peter Grau at: peter.grau@sae-itc.org

WHY JOIN THESE EFFORTS IN THE HRCS SG?

- Network with other experts in the field in a legal, precompetitive environment
- Have a voice in HRCS development direction and priorities
- Establish a uniform approach to information sharing between OEMs and Suppliers
- Gain access to performance data of components in the field, improve products
- Increase vehicle reliability and customer satisfaction

PUTTING JA6268™ INTO PRACTICE: EARLY ADOPTERS!

- HRCS engagement efforts around JA6268™
  - Delta Airlines letter to Suppliers inquiring about JA6268™ Compliance ✓
  - US Navy interest ✓ / US Army interest ✓
  - GM supplier communication on future directions?
  - What about your organization?
- Certifications & Pilots
  - Nexteer EPS ✓ (Stage 2)?
  - Honeywell Turbochargers ✓(Stage 3)?
  - ATA VHM pilot for UPS, Fedex, Walmart, etc.?
  - What about your organization?
- Identifying inaugural members of SAE HRCS SG & Compelling Deliverables
  - Targeted Visits (e.g., Boeing Seattle, Airbus Toulouse)?
  - Delta, GM, Nexteer, Boeing, Airbus, FAA, NHTSA, NIST, CNRC, …?
  - What about your organization?

PUTTING JA6268™ INTO PRACTICE: EARLY ADOPTERS *BY TIER*

- Major System Suppliers
  - GE, UTC, Honeywell, Bosch
  - What about your organization?
- Operators
  - Delta, DoD, UPS, FedEx, Walmart
  - What about your organization?
- OEMs and Integrators
  - Boeing, Airbus, GM, BMW
  - What about your organization?

QUESTIONS?

THANK YOU!