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Upstream Global Consultant

Drilling Automation is Underway:
Insights from the Industry Roadmap

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President: DE WARDT AND CO
Program Manager: DSA Roadmap / DSABOK
Board Member: SPE DSATS
Guest lecturer / External PhD advisor: Colorado School of Mines

Relevant background

- I co-founded the Industry DSA Roadmap Initiative in 2013
- I led this initiative as Program Manager for over 6 years
- We reached out to 50 experts globally through 15 steering committee members
- It cost over $800,000 – we raised $215,000 through industry JIP (20 companies) to partially offset
- Affiliated with SPE / IADC / AUVSI / SwRI / Energitsics / OPC Foundation

I am taking the ‘helicopter view’

Report has 14 Sections / 325 pages

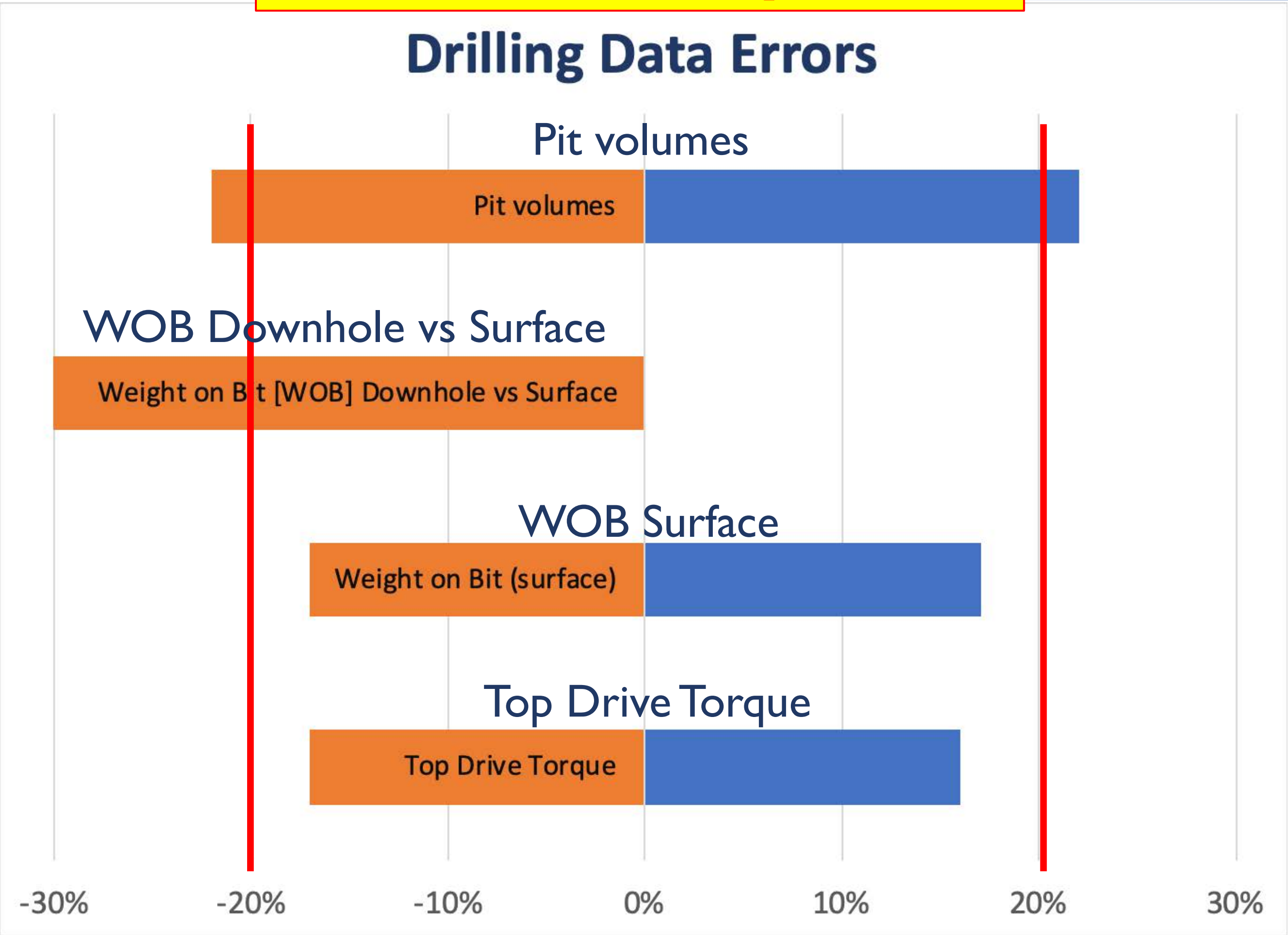
- Data quality
- Data flow
- Levels of Automation
- Systems Architecture
- Where next?

Drilling data exhibits some key quality data issues

Is +/- 20% acceptable?

- Errors stack up - sensor to data user
  - Sensor / installation / compensation / signal conversion / calculation / transmission
- Significant lack of meta data (data giving information about data)
  - Measurements have unknown quality
- **Who here knows the true accuracy of their drilling data?**

SPE 184741; SPE 189626; SPE 189636; SPE 139848



Drilling Systems Automation Decision and Control Framework – construct for data flow

- Purdue Reference Model for Computer Integrated Manufacturing (1989)
- International Society of Automation ISA 95 standard defined for industrial application
- Relevant for DSA
- Bottom up mapping overview (examples)

Level 4 - Enterprise Well Construction Management

Business-related activities needed to manage an operational organization

- Well Proposal
- Cost Estimation and Control
- Scheduling
- Supply Chain Management

Level 3 – Well Construction Operations Management.

Activities of work flow to produce the desired end products

- Well Design
- Drilling Process Management
- Risk / Uncertainty Management

Level 2 – Well Construction Execution Management

Activities monitoring & controlling

- Drilling Process Physics / Models
- Operation & Equipment States

Level 1 – Well Construction Machine Control

Activities involved in sensing and manipulating

- Machine Control – Machine Sensors

Level 0 – Well Construction

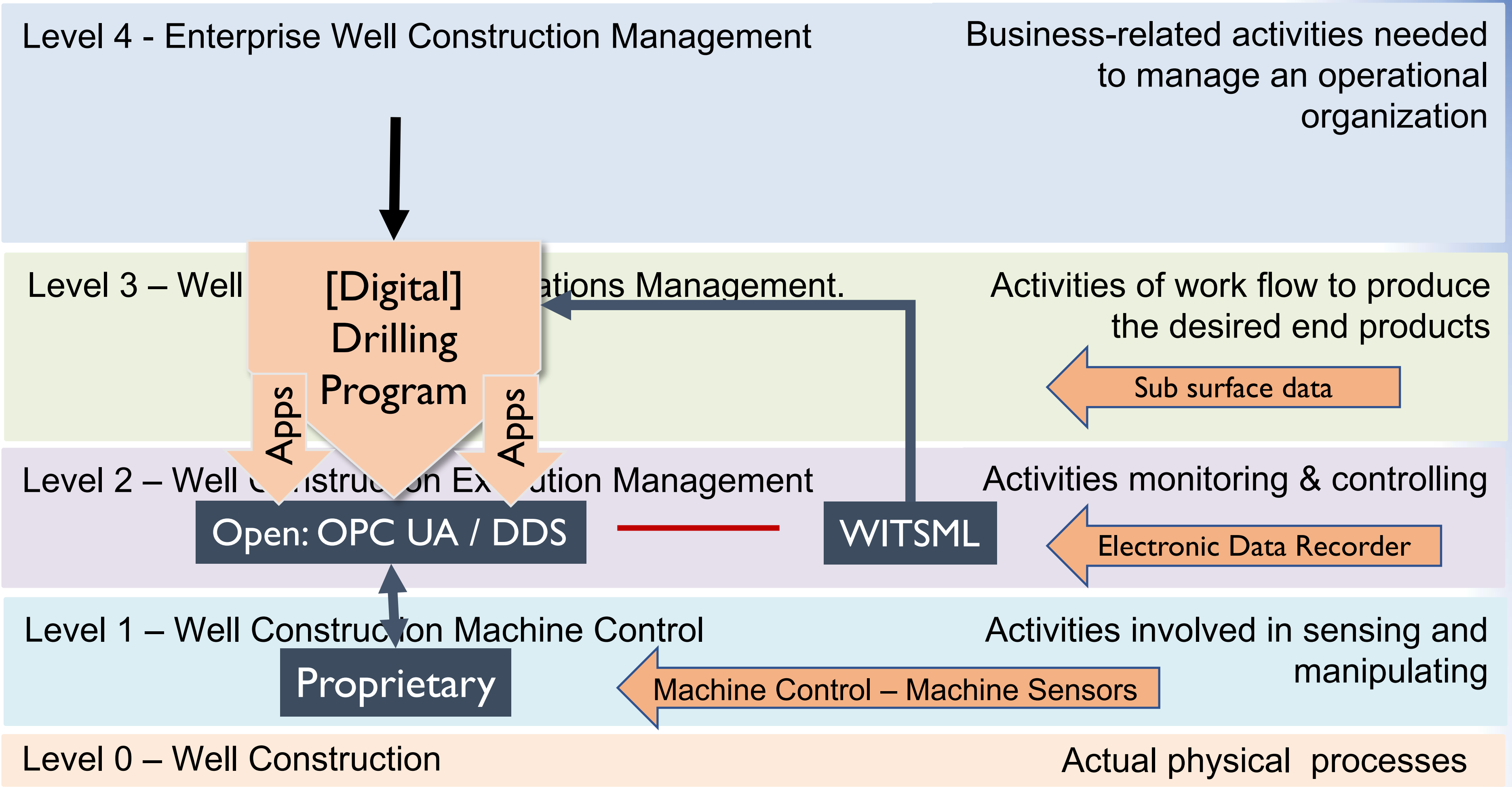
Actual physical processes

Data sourcing and communication is an challenge

WITSML - Well-Site Information Transfer Standard Markup Language employed for transmitting technical data between organizations in the petroleum industry

OPC UA - Open Platforms Communication Unified Architecture machine to machine communication protocol for industrial automation

DDS – Data Distribution Service application connectivity standard



Automation is not all or nothing

Humans will remain in the loop to various degrees

Mapping transition from manual through augmented to automated built upon huge depth of expertise & experience:

1. Sheridan et al, 1978
   - 10 levels of automation from manual to autonomous
2. Parasuramen et al, 2000
   - 4 cognitive functions for humans and automation
3. Save et al, 2014
   - Application matrix in European aviation automation industry initiative with pilots and air traffic control
4. DSA Roadmap adopted with permission

Levels of Automation Taxonomy [LOAT]

Supported Function	Information Acquisition	A	Information Analysis	B	Decision and Action Selection	C	Action Implementation	D
Done by Humans	Manually	A0	Memory analysis	B0	Human decision	C0	Manual control	D0
	Supported by artifact	A1	Supported by artifact	B1	Supported by artifact	C1	Supported by artifact	D1
Supported by Automation	Low level automation support	A2	Low level automation support	B2	Automated decision support	C2	Step-by-step action support	D2
	Medium level automation support	A3	Medium level automation support	B3	Rigid automation decision support	C3	Low-level support action execution	D3
	High level automation support	A4	High level automation support	B4			High-level support action execution	D4
	Full automation support	A5	Full automation support	B5				
Done by Automation					Low level automatic decision making	C4	Low-level action sequence automation	D5
					High level automatic decision making	C5	Medium-level action sequence automation	D6
					Full automatic decision making	C6	High-level action sequence automation	D7
							Full automation of action sequence	D8

Key issues for transitioning to higher automation levels

Supported Function	Information Acquisition	A	Information Analysis	B	Decision and Action Selection	C	Action Implementation	D
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	Supported by artifac		orted by art		upported by artifac		orted by artifact	D1
Supported by Automation	Low level automatio support		level autom ort		utomated decision pport		by-step action ort	D2
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	High level automati support		evel autom pport				level support action ution	D4
	Full automation support		Full automation s					
Done by Automation					w level automatic cision making		evel action ence automation	D5
					vel auto ion making		vel action e automation	D6
					ull automatic decisi making		-level action quence automation	D7
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Requires Decreasing Data Attribute Risk

Revised Human Competency Models

Requires Decreasing Operation Uncertainty

Advisory directional drilling

SPE 191408

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Automated directional drilling

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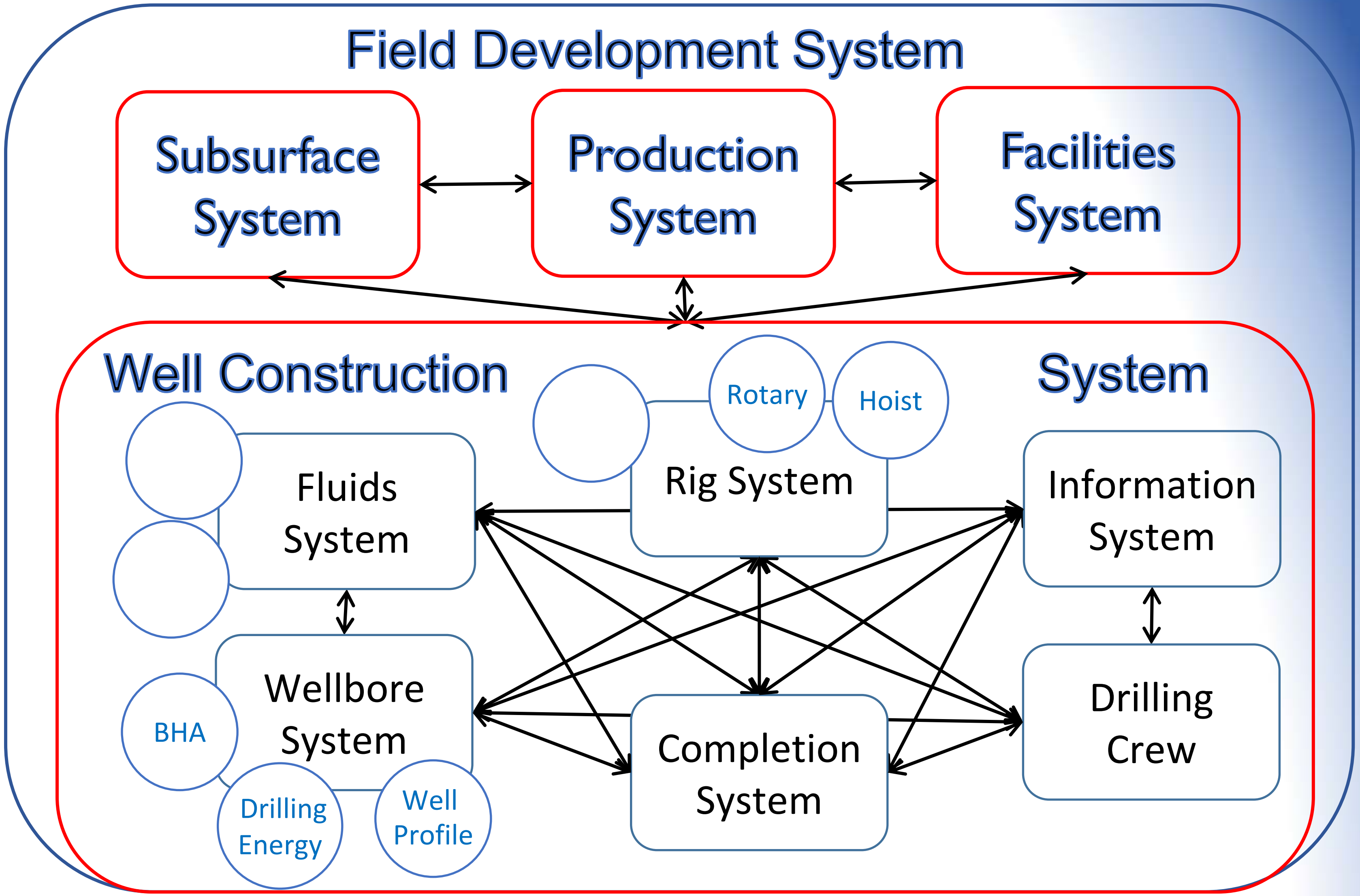
Drilling is a complex, poorly organized collection of systems and sub systems

- Minimizing complexity impact requires an industry architecture
  - Currently a common architecture does not exist
- Interoperability is not natural
  - Proprietary is perceived as competitive advantage
- Improved interoperability will support uptake
  - Demonstrated in other industries (aerospace, automobiles, telecommunications, ..)
- Bottom up implementation is underway with sub systems
  - Miss opportunities unless fit into an industry architecture
- Top down approach provides holistic value delivery
  - Maximum value generation

Systems of Systems view

- Now automating Systems of Interest:
  - Rotary / hoist / BHA / drilling energy / Well profile
- Opportunity is to plan comprehensive top down automation



Derived from International Council on Systems Engineering
Published in DSA Roadmap

Drilling Systems Automation brings value
initially to the operator

- Improving consistency over multiple cycles
  - tripping
- Reducing operational durations
  - drill a stand cycle time
  - improvement drilling rate of penetration
- Improving wellbore placement
  - automation higher frequency / lower latency than humans
  - connect to real time subsurface models for instantaneous geosteering
- Improving wellbore quality for lower production operating costs / downtime, increased production
  - lower tortuosity (e.g. Artificial Lift Systems)
  - reduced fluid drop out

Where next?

Pre-determinds - stable or predictable outcomes

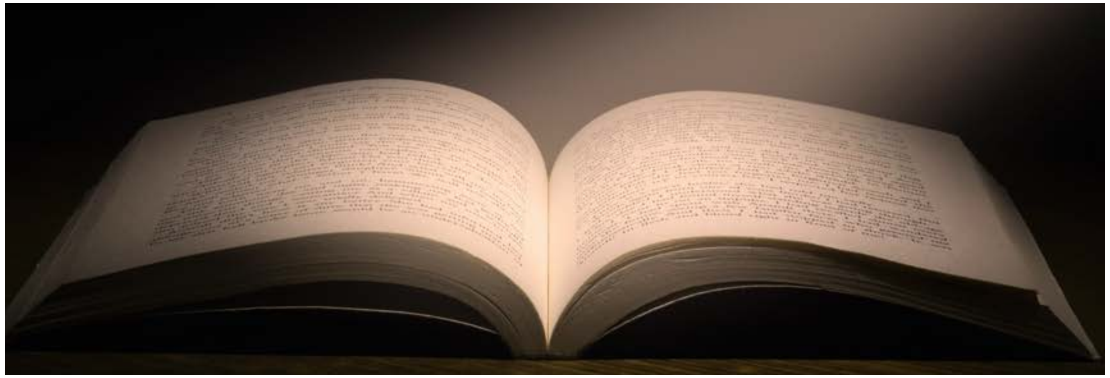
- Sensors and processed data in drilling systems continue to evolve slowly from some very basic technologies
  - Manually measuring mud parameters intermittently
  - Initiatives are underway
- Data acquisition and analytics is moving up the maturity curve (slowly)
  - Moore's law / lowering costs / advancing sensors
- Surface and downhole equipment are separate suppliers (typically)
  - Purchases of companies shifting but the dichotomy will remain
- Independent rig control systems
  - Rigs own their systems and their systems are not consistent across the fleet
  - Incentive to be the platform for automated systems

Uncertainties - unstable or unpredictable outcomes

- Downhole telemetry capability, cost and value
  - Low data rates / high latency versus high data rate / low latency?
  - Automate remotely downhole or automate through surface control loops
- Multiple sub systems of automation versus integrated system
  - Single entity / collaborators take lead?
  - Integration and interoperability – happen or not?
  - Risks from unintended consequences of independent sub systems?
- Asset obsolescence
  - Replace current assets with assets designed to incorporate automation?
  - Cost constrained business versus innovators with funding?
- Financial rewards
  - Going to the operators – will business models change?
  - Will the investors in the technology earn the returns (now is competitive advantage)?

Drilling systems automation is advancing rapidly

www.DSARoadmap.org



DSA Roadmap Report – 325 pages

www.DSABOK.org

Portal to DSA Sources

DSA Roadmap 'in-house' interactive workshop
is now available – contact jdewardt@dewardt.com

Thank you for listening

Thank you to AADE for this opportunity to present

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