

**IBM Watson**



# Watson Intelligent Advisors

**Discovery and Conversational  
Technology for Now and the Future**

**Dr. Graham Katz, IBM Watson AI Delivery**

**NASA Goddard Workshop on Artificial Intelligence  
11/29/2018**



## Two Faces of Natural Language Understanding

- Natural Language Interfaces (*with Speech*):  
*Alexa, Watson Assistant, Siri*
  - *Controlling lights, AV, HVAC equipment, robots with voice*
  - *Querying databases in natural language*
- Natural Language Understanding for reading, learning, and answering questions
  - *Extracting facts from unstructured text*
  - *Answering questions based on collection of documents*

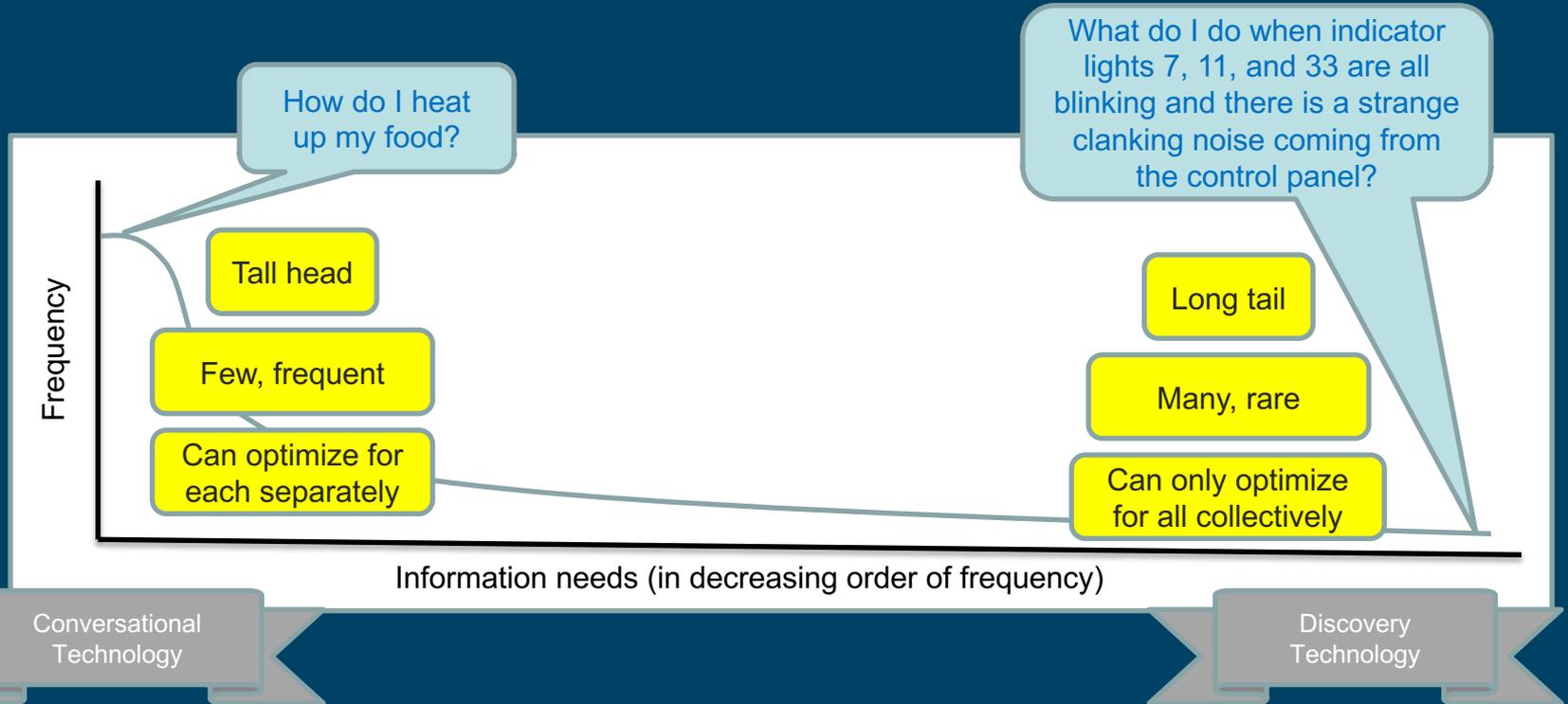


Rachel Avatar (Soul Machines)



Watson Jeopardy!

# Tall Head/Long Tail in information needs and technology



## Discovery Technology: Expert Advisor Applications

Provide information to experts to assist them in carrying out their jobs

NASA/IBM prototype developments

- Innovation Advisor: provide assistance to researchers engaged in scientific research to find information in related fields that might impact their field
- Pilot Expert Advisor: provide informational assistance to flight crew members to aid in troubleshooting



**Watson Discovery Advisor (WDA)** is an Discovery application for finding facts in large quantities of unstructured text based on the Watson Jeopardy! system. It exposes two main functions: answering factual questions and exploring discovered entities and relationships.

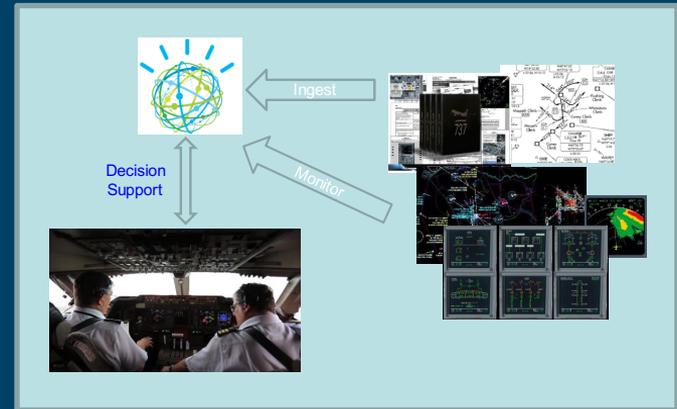
The screenshot displays the IBM Watson Discovery Advisor interface. At the top, a search bar contains the query "What year did IBM Watson win Jeopardy?". Below the search bar, the interface is divided into several sections:

- Passages:** A list of search results with snippets of text. One snippet mentions "During the next season (2009-10), a special edition of 'Celebrity Jeopardy!' was played in which twenty-seven contestants from past celebrity episode charity, with Michael McKean as the grand prize winner. The 'IBM Chat Watson' computer facing off against Jennings and Rutter in a two-game man-vs.-machine competition in Jeopardy's history. Watson locked up million, which IBM divided between two charities ( World Vision International)." Another snippet mentions "Jane Curtin, Michael McKean and Cheech Marin advanced to the top \$1 million for his charity, the International Myeloma Foundation. IBM Chat Watson 2011 and featured IBM's Watson computer facing off against Jennings and Rutter in a two-game man-vs.-machine competition in Jeopardy's history. Watson is a 'deep' question Jeopardy! win the grand prize of \$1 million, which IBM divided between two charities (Grid)." A third snippet mentions "Craig won the Tournament of Champions the following year, and in (unadjusted) in Jeopardy! history. Watson. Watson is a 'deep' question Jeopardy! Watson was entered into a two-game, three-day exhibition match against 2011. Watson won the match with a total of \$77,147. References: ..."
- Related Entities:** A section showing a graph of relationships between entities. The graph is titled "Barack Obama, Joe Biden" and shows connections between various entities like "hillary clinton", "us", "white house", "john mccain", "american", "united states", and "joe biden". The graph uses colored nodes (blue for people, green for organizations, yellow for locations) and lines to represent relationships.
- Filters:** A sidebar on the right allows filtering by relationship type and evidence. The "FILTER BY EVIDENCE" section shows a bar chart with a value of 346 - 2741 Docs and a "MOST" button. The "ISOLATED CONNECTIONS" section has options to "Include" or "Exclude" connections.

## Pilot Expert Advisor Vision

NASA Pilot Expert Advisor links aircraft systems with external sources of information to provide flight crews (experts) with relevant information based on IBM Watson Discovery Advisor (WDA) technology

- Long-tail Discovery application
- Integration of multiple data sources
- Core functionality based on WDA question answering



## Pilot Expert Advisor Project

NASA and IBM worked together to customize Watson Discovery Advisor to answer questions about the chosen use case through WDA domain adaptation

### Corpus Data Selection

Select and ingest relevant textual material, evaluating the technical requirements for ingesting each data source

### Domain Language Customization

Develop custom dictionaries to expand Watson's baseline of recognized terminologies, definitions, spellings, abbreviations,

### Machine Learning

Train the native candidate answer scoring algorithms by using collections of questions with known answers to train answer ranking models

## Pilot Expert Advisor Use Case: Loss of airplane-state awareness incident

**Flight:** Midwest Express 490 (B717-200)

**Visibility and Weather:** Night, thunderstorms in the area

Event occurred while climbing through 19,000 ft

- “**Rudder Limiter Fail**” message shows on crew alerting system
- 10 seconds later, wild pitch oscillations lasting ~ 8 minutes
- Altitude fluctuations between 10,600 – 23,300 ft;
- Speed fluctuations between 290 – 552 knots

NTSB findings

- Lighting strike caused pitot heat system to fail
- Pitot icing produced unreliable airspeed data

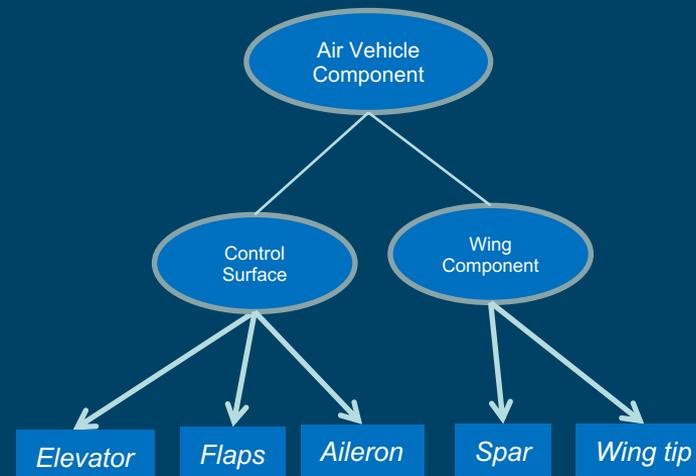


# Can Watson help?

## Pilot Expert Advisor Data Sources

Data Source	Description
<b>ASRS</b>	Flight crew reports. Acronyms, conventionalized and idiosyncratic abbreviation, first person perspective; unanalyzable content
<b>NTSB Accident Database</b>	Investigation reports. Textual factual data, highly Use Case relevant, some non-textual and semi-structured content
<b>Boeing 717</b>	Technical documentation. Much non-textual data; some textual factual data; highly Use Case relevant
<b>Basic Aviation Information</b>	General Aviation information. Much textual factual material, some non-textual content; large heterogeneous documents; may have relevance
<b>Title 14 CFR, Subchapter G</b>	Legal specifications. Regulatory and legal (not factual) text ; apparent low relevance to Use Case
<b>Aviation Weather (WX)</b>	Aviation weather science. Factual textual content; some semi-structured data; long heterogeneous documents
<b>SKYbrary Aviation Safety</b>	General aviation safety. Highly specific, factual, textual data; some semi-structured textual content

## Domain Taxonomy



The captain instructs the first officer to ask Watson: "What system malfunction causes the RUDDER LIM FAIL alert?"

## Pilot Expert Advisor Prototype

Ask a Question ▼ What system malfunction causes the RUDDER LIM FAIL alert

Document filters

- Source
  - Wikipedia
  - FactBook
  - ASRS
  - Aviation Weather
  - Basic Aviation
  - Boeing 717
  - NTSB
  - Skybrary
  - Title 14 CFR
- Published Date
  - Past week
  - Past month
  - Past year
  - Custom

mm/dd/yyyy to mm/dd/yyyy

Sorted by Relevance: Highest

### Key passages

1. "... Level 2 - shows in amber text with an amber box Level 1 - shows in amber text. Alert Definitions. RUDDER LIM FAIL is a level 2 alert, and shows with the MASTER **CAUTION** lights. This alert shows when the rudder throw limiter and the redundant rudder stop limiter systems are defective, and do not supply a rudder travel limit. A related consequence message shows with this alert. RUDDER RESTRICTED is a level 1 alert, and shows with the MASTER **CAUTION** lights. ..."  
*B717 Mx Manual Chpt 27 Flight Controls · NBO · 05/01/2016*
2. "... 20 Config Table Of Contents ANTISKID\_\_\_FAIL BRAKE OVERHEAT ELEVATOR SPLIT FLAP DISAG GEAR DOOR OPEN RUDDER LIM FAIL SLAT DISAG. 30 Elec Table Of Contents BUS DC XFER OFF BUS AC EMER OFF BUS DC EMER OFF GEN L OFF GEN R OFF GEN ALL OFF OR TOTAL LOSS OF AC POWER GEN APU OFF BUS AC GS OFF (Interim Procedure). ..."  
*B717 Flight Crew Operations Manual - Vol II · NBO · 05/01/2016*
3. "... FLAP DISAG (CONFIG) - Left and right flap positions disagree with each other or with commanded position. RUDDER LIM FAIL (CONFIG) - Both primary and secondary rudder limiters failed to unrestricted position. SLAT DISAG (CONFIG) - Left and right slat positions disagree with each other or with commanded position. ..."  
*B717 Flight Crew Operations Manual - Vol III · NBO · 05/01/2016*
4. "... AP.20.7 GEAR DOOR OPEN. .... **AP.20.13** RUDDER LIM FAIL. ....  
..... **AP.20.13** SLAT DISAG ....."  
*B717 Flight Crew Operations Manual - Vol II · NBO · 05/01/2016*

### Hypotheses

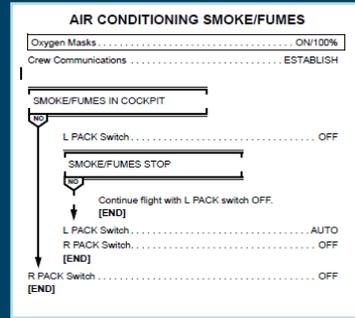
- pitot system malfunctions
- pitot
- P.80.34
- P.20.13
- CAUTION

st a hypothesis

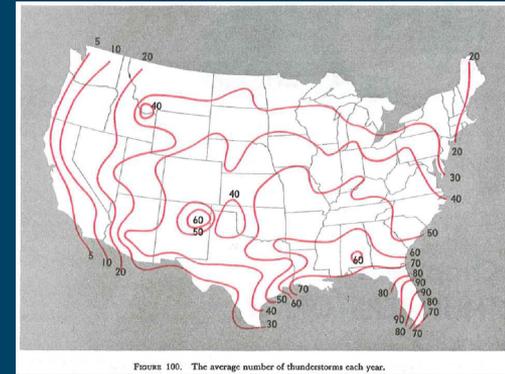
Watson returns pitot system malfunctions as the top hypothesis

## Key Challenges : Non-Textual Information

Watson reads text– but there are many sources of information in technical domains that are non-textual



Semi-structured text



Maps

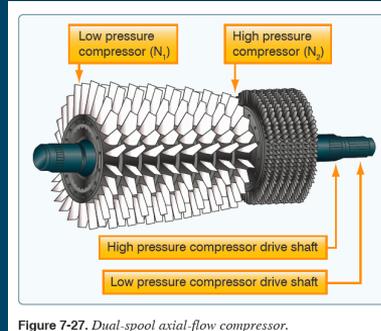


Figure 7-27. Dual-spool axial-flow compressor.

Diagrams

Type of error	Unchallenged errors		All primary errors <sup>a</sup>	
	Number of errors	Percent	Number of errors	Percent
Aircraft handling	9	12.9	46	19.8
Communication	5	7.1	13	5.6
Navigational	3	4.3	6	2.6
Procedural	11	15.7	73	31.5
Resource management	0	0	11	4.7
Situational awareness	13	18.6	19	8.2
Systems operation	1	1.4	13	5.6
Tactical decision	28	40.0	51	22.0
<b>Total</b>	<b>70</b>	<b>100.0</b>	<b>232</b>	<b>100.0</b>

<sup>a</sup> Primary errors are not dependent on making a prior error.

Tables

## Key Challenges: Non-Textual Information

**Example:** Question answering from Tables

*“What percentage of unchallenged errors are procedural?”*

*“15.7”*

Requires:

- Ability to parse table into rows and columns
- Ability to relate structure of table to “meaning”
- Ability to relate table interpretation to question

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## Key Challenges: Contextual Information

- In context, questions often mean more than they say:
  - “Where is the hydraulic pump switch?” actually means:  
“Where is the hydraulic pump switch on the aircraft I am flying?”
  - “What could cause that?” might mean:  
“What could cause that [RUDDER LIM FAULT] alert to display?”
- **Contextual Data Augmentation** component of Pilot Expert Advisor system provides the extra contextual data that user might leave out

## Embodied Conversational Agents

- Make use of physical and conversational context in interaction
- Utilize extra-linguistic information such as gesture and pointing



Cognitive Environment Laboratory, IBM Yorktown



ThinkLab, IBM Yorktown



Cognitive Immersive Systems Lab, RPI

## Summary

- Expert Advisor systems require discovery solutions that can address “long tail” information needs
- Technical domains have significant technical requirements related to
  - Domain specific terminology
  - Non-textual or semi-textual sources of information
- Intelligent Advisors of all sorts must leverage contextual information to increase naturalness
  - Embodied context
  - Informational context