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Crew Health and Performance Integrated Data Architecture (CHP-IDA) Project

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CHP-IDA
Senior Human Factors Engineer
Dr. Amanda Smith (KBR) | 05.08.2024

93rd Annual Scientific Meeting Disclosure Information

- I have no financial relationships to disclose.
- I will not discuss off-label use and/or investigational use in my presentation.

Background

- For the past 60 years, crew have relied on 80+ expert ground personnel (and their data insights) to provide real-time guidance
- Exploration mission communication delays necessitate a paradigm shift from ground to onboard
- Crew will be more reliant on in-flight data to execute complex tasks, make time-critical decisions, and troubleshoot anomalies
- Constraints for exploration mission data include limited processing, storage, and channel capacity
- Ground personnel must maintain situation awareness of issues that may impact crew health and performance
- Currently data is spread across many systems and often requires cumbersome transfer and packaging; crew often cannot access this data

CHP-IDA's Goals for Exploration Missions

The **Crew Health and Performance Integrated Data Architecture (CHP-IDA)** is a cohesive *back-end platform* for *acquiring, processing, storing,* and *distributing* integrated CHP data from *disparate sources* for *both crew* and *ground users*.

Goals for Exploration Missions:

- To *integrate* CHP relevant data from disparate sources, systems, and applications to enable advanced analytics and support tools.
- To *provide a platform* for CHP application developers and authorized end users to *access the data they need* to meet specific mission needs.
- To *synchronize* CHP mission data, as part of the larger space mission architecture, *across vehicles, habitats, and on the ground*.

Crew Health and Performance (CHP) Domains and Data

CHP Flight Systems

Ground Ops
- Surgeon Support
- Procedures
- Mission Planning
- Risk Assessment
- Console Support

Countermeasures
- Exercise
- Nutrition
- Cardiovascular
- Immune
- Microbial …

Behavioral Health
- Monitoring
- Team
- Workload
- Sleep
- Recreation

Medical Capability
- Clinical Care
- Imaging
- Laboratory
- Medication
- Dental

Environmental
- Air/Water
- Toxicity
- Radiation
- Acoustic
- Microbial

EVA Health
- DCS
- Performance
- Pre-breathe

- **Domains depend on data to monitor crew health and performance and to characterize, mitigate, and reduce risks**
- **CHP data exists in *many* forms, each with different properties, including:**
  - Event data
  - Time series data
  - Analysis results and reports
  - Descriptive and predictive analytics
  - Photo, video, audio files
  - Consumables and inventory
  - Environmental data
  - Sensor data

Deriving Exploration Mission CHP Data Needs

Challenge

Use human-centered methods and domain expertise to discover future mission CHP data needs

Gather Information
- Knowledge Base
  - SME Interviews – Multiple Roles
    - Crew Operations
    - Timelines
    - Literature Reviews
    - Procedures
  - Supporting Documentation
  - Crew Comments Database

Generate Task Lists
- Task Analysis
- Workflow Analysis

Develop Scenarios
- Combinations of workflows, tasks, systems, relevant data generated or consumed
  - Feedback loop to engage SME community and extract details

Modeling & Analysis
- Modeling Data Generation and Usage
- Modeling Data Environment
- Modeling Exploration CHP Systems

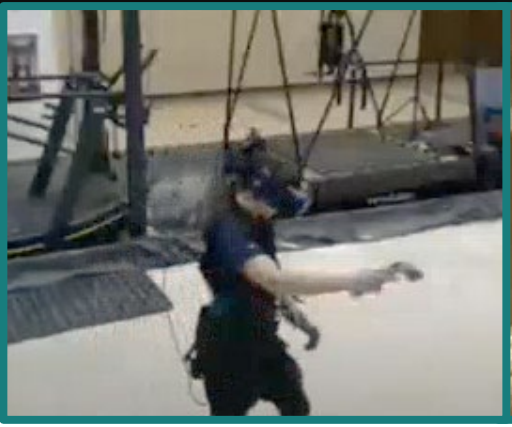
Result

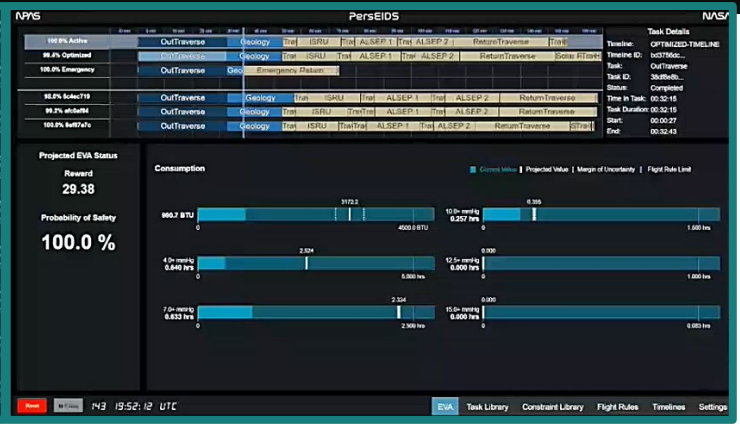
Extract CHP data and data architecture needs to influence the CHP-IDA platform's core capabilities

Exploration Mission Data Services Stack

Exploration Mission	• New Mission Profiles • Longer Comms Delay • Different Constraints • Further from Earth • Difficult Resupply • Harder to Evacuate
Integrated Mission Operations System	Supports **Exploration Mission** by enabling Independent Operations
CHP Domains	Provide **IMOS** capabilities through updated workflows & tools
CHP Domain Support Tools, Workflows, and Technologies	Use Mission Data to provide capabilities that **CHP domains** need to support layers above
Computation, Data, and Data Products	The Raw and Processed Data the **Support Tools** need to function
Crew Health and Performance Integrated Data Architecture (CHP-IDA)	A **Back-End *Platform*** that integrates data across CHP domains and systems in support of **Data Product** needs

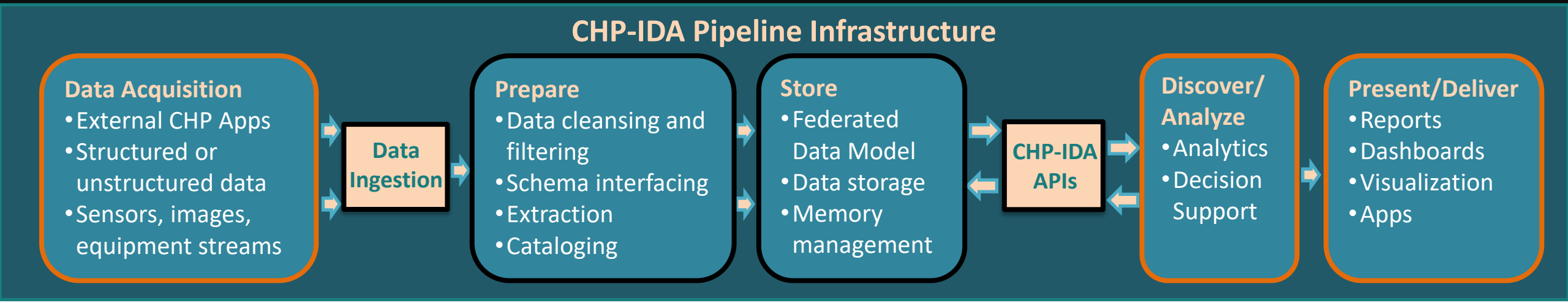
PersEIDS Integration Example





- **In 2023, CHP-IDA provided core product integration for the Personalized EVA (Extravehicular Activity) Informatics and Decision Support (PersEIDS) software application**
- **PersEIDS displays physiological state of crew and projects crew safety over time using parameters like metabolic rate**
- **Human-in-the-loop (HITL) VR proof-of-concept demonstrations using the CHP-IDA pipeline**
  - Participants completed representative EVA tasks (e.g., traverse, egress, science)
  - The timeline and performance informatics are monitored; timeline changes may be suggested if safety score falls below threshold

PersEIDS Integration Example



CHP-IDA services provided:

- Ingestion and automatic storage of heart rate data
- Analytics to generate metabolic rate
- Integration of data to support generation of PersEIDS predictive displays
- CHP-IDA APIs to manage/customize parameters while EVA (e.g., participant gender)

- Positive stakeholder feedback; end users appreciated dynamic projection of consumables

Periodic Health Status (PHS) Exam Scenario

CHP-IDA Capabilities

Data Ingestion & File Management

- Crew Medical Officer (CMO) uses a personal computing device (PCD) and a multifunction tool, *both integrated to the vehicle's CHP-IDA* to conduct a PHS
- **Heart rate, blood pressure, temperature, blood oxygen levels, ear and tympanic membrane images** (via otoscope), **open-ended exam form**, are all collected data *packaged as the crew member's patient file*

Schedule & Prioritize Data Synchronization

- Upon completion of PHS, CMO clicks a button to *send exam information to the vehicle's CHP-IDA*, which *manages transfer* of this information to CHP-IDA on the ground
- CHP-IDA on the ground *generates a notification* that data has been successfully transferred and is available to *view by authorized personnel*
- A Flight Surgeon reviews the data, compares it to previously collected data, updates the patient file with recommendations, and *sends the updated file to ground CHP-IDA*
- Ground CHP-IDA *manages transfer* back to CHP-IDA on vehicle

Notifications & Authentication

- CHP-IDA on the vehicle *generates a notification* that data has been successfully transferred and is available to *view by authorized personnel*

PHS Scenario Featured CHP-IDA Benefits

- The Periodic Health Status (PHS) exam is a frequent nominal event that currently combines *many* types of data, involves multiple end user roles, requires manual transfer and packaging of data, and lacks notifications
- Impact may be studied using models, demonstrations, and HITL tests
- PHS benefits with a CHP-IDA include:

Capability	Increased Efficiency	Increased Accuracy	Decreased Workload	Increased Awareness
Automated Data Ingestion and File Management	X	X	X	X
Data Synchronization	X	X		
Automated Transfer to Authorized Personnel	X	X	X	
Notifications	X		X	X

Path to CHP-IDA

- **CHP-IDA is a *Path-to-Flight* project**
- ***Low initial cost* reference implementation**
- ***Discover and prove out concepts* on the ground, using human-centered methods**
- **Establish a *foundation for a flight mission* using CHP-IDA**
- ***Provide IDA technology* to the CHP community**

CHP-IDA Project Approach

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amanda.l.smith-1@nasa.gov