Crew Health Integrated Management System -- CHIMS --

ESR – Executive Summary report

APPROVAL

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Crew Health Integrated Management System (CHIMS)	
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EXECUTIVE SUMMARY REPORT

This project has been prepared in the framework of the ESA contract n° 4000130060/20/NL/MG of the project "*Crew Health Integrated Management System (CHIMS)* (ESA-TRP-TECMMG-SOW-012729)" by a French consortium composed of MEDES, NewClin and AXEAL-Heverett.

Introduction
In the framework of crewed space missions are getting longer and exploration-class missions will bring crews farther away from Earth. Communication delays between spacecraft and the ground support, increase with the distance, which disrupts the usual "real-time" procedure in case of medical emergency with ground-based medical support as currently used on ISS. This situation is reinforcing the need to enhance the crew autonomy regarding medical aspects.

The CHIMS software intended to integrate inputs data from users, sensors and log & spreadsheets. Then, CHIMS processes all the information, perform an analysis and provide as output, recommendation and guidance for the user.
The objectives of the CHIMS activity are to design, develop, verify, demonstrate and validate a prototype software tool that can accept data (both occasional entries and continuous entries, e.g. from medical devices), analyse it, compare it to a specific reference/target, and, according to thresholds, provide recommendations for subsequent action (if required).
Thresholds aimed to be adaptable and recommendations influenced by external weighted (prioritised) modifying factor in the following three health-related operational activities/scenarios:
- **Exercise:** the use of exercise countermeasures
- **Nutrition:** macro- and micronutrient, and fluid intake
- **Emergency:** management of medical emergencies scenarios.

The following figure details each responsibility of the consortium:

MEDES

project management
background
system validation
recommendations

newclin

concept & design
development
technical test

AXEAL

safety
technical test plan
technical documentation

State of the art

The state-of-the-art and the literature review presents the following findings:

Field	Findings
Nutrition	• The experts confirm that the items to be tracked by CHIMS are the Energy intake, the proteins, the carbohydrate, the nutrients mentioned in the SoW and Water. • The experts confirm that for CHIMS, the tracking of the Vitamins is out of scope. • Recommendations should be proposed over one week or two weeks; this period should be able to be changed by the user. • Crew preferences will be loaded before the flight and should be considered as a modifying factor, and not a yes/no data. • Nutritional recommendations are not going to be evaluated individually for CHIMS, data recommended for age group (including difference male/female) should be used. • CHIMS shall trigger some alert on sensitive parameters only (such as Na+, proteins, iron etc...) provided by the experts
Exercise	• Exercise Data comes from the NASA system in the form of Excel sheet • Engineering data files (coming in time series) need to be requested. Nominal protocol data do not contain the engineering file information. • Following the results of an astronaut from an exercise prescription, CHIMS should recognize if an exercise is adapted or not. If the results are not in line with the expected ones, CHIMS should automatically adapt a new prescription to adjust the exercise in the following days. • The crew should be able to report alongside their exercise session, whether they felt fatigued or had muscle soreness (modifying factors)
Medical Emergencies	• The proposed scenarios have been agreed by the experts (Urosepsis, Pulmonary embolism, Chest Trauma & ACS and Cardiac Arrest) • If a value/data is missing, CHIMS shall indicate the % of confidence of the recommendation

Safety aspects

For the regulatory aspects it seems that the Medical Device Regulation (EU) 2017/745 and the General Data Protection Regulation (EU) 2016/679 are the two main regulations applicable to the CHIMS project at EU level at the moment. When in force, the applicability of the AI Act, the European Health Data Space (EHDS) and the EU space law must be demonstrated but remain potentially impactful.

For the safety aspects, as the application is integrated in an iPad (already approved for flight) and it is using only fictional characters, there is major issue with the validation and the use of the CHIMS SW1 prototype.

Preliminary design

During this the preliminary design phase, led by NewClin, two IA-based concepts were proposed: machine learning and system expert.

Machine learning requires an important amount of data for working. After a short investigation with the experts, this volume of data would be difficult to access.

Therefore, the consortium determined that the system expert that doesn't require data but only knowledge, would be the most suitable to the CHIMS' goals.

Based on the Expert System, a preliminary design has been conceptualized. It includes high-level architecture and functional views as well as some specifications for the development of the software.

Detailed design

Finally, the CHIMS' functional architecture planned is described in the following diagram which represents the different functions and the related flows. Functions are segregated (nutrition, exercise and emergency) for no reason.
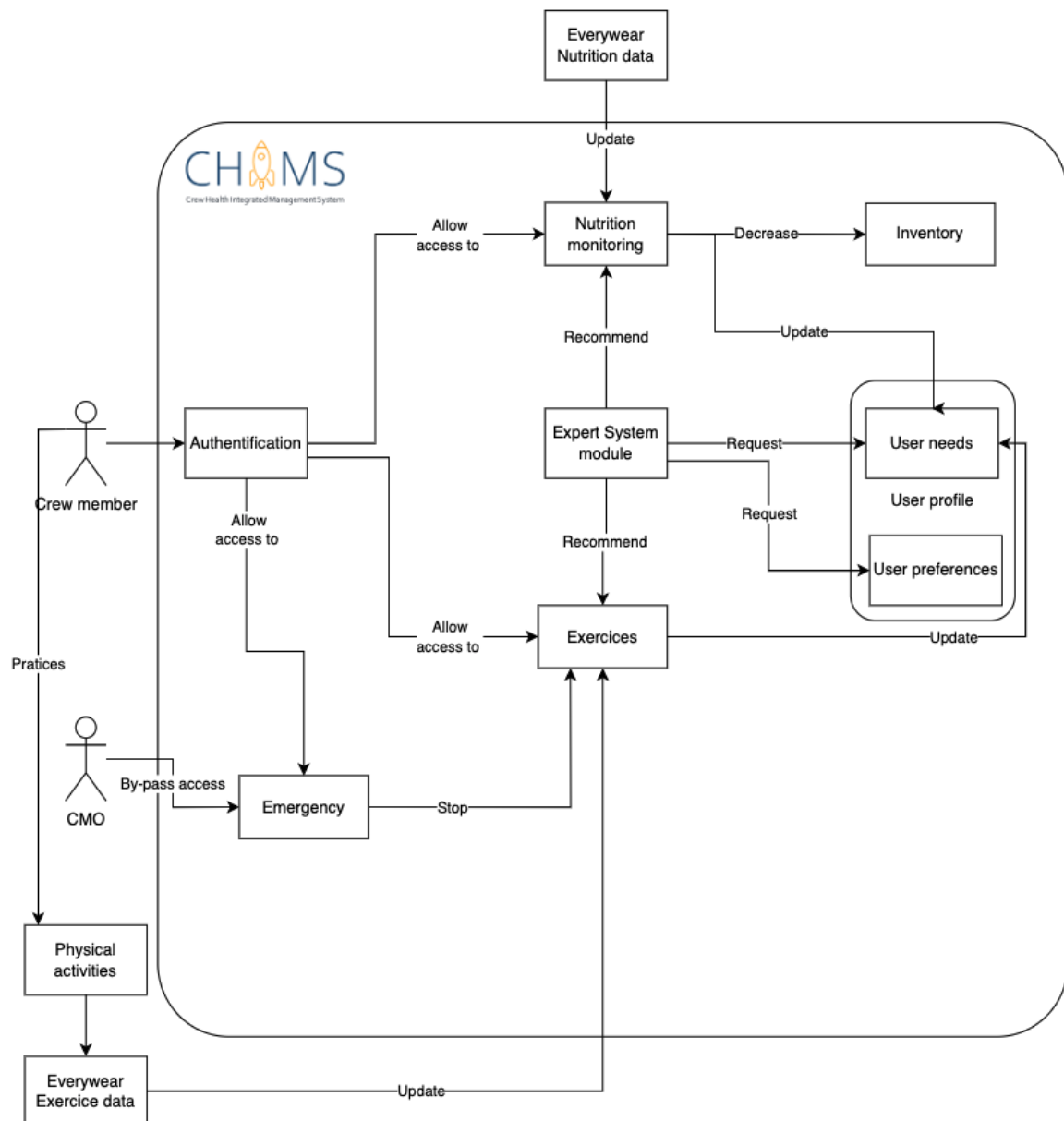
Implementation

Many changes occurred during the implementation. Several options have been investigated, and finally the prototype developed follows the approach of a digital decision tree.

The application described is a thick client application, specifically designed for native iOS platforms. It has been developed using React Native, a popular framework that enables the creation of high-performance, cross-platform applications utilizing a single codebase. By employing React Native, the development process is streamlined, allowing for efficient updates and maintenance. This approach not only leverages the robust capabilities of native iOS features but also ensures a seamless user experience that is consistent with other iOS applications. The use of React Native is particularly beneficial in enhancing the app's responsiveness and overall performance, making it a robust choice for complex client-side functionalities.

The high-level architecture is based on the MVC pattern, standing for Model-View-Controller, which is a widely used software architectural design pattern that efficiently separates an application's concerns into three interconnected components. The Model represents the application's dynamic data structure, independent of the user interface. It directly manages the data, logic, and rules of the application. The View effectively displays the data from the Model to the user and can send user commands (like mouse clicks and keyboard inputs) to the Controller. The Controller serves as an intermediary that handles input, converting it to commands for the Model or View. This separation helps in managing complex applications, as it allows for individual components to be built, tested, and modified independently.

The CHIMS App version SW1 is a stand-alone software with fictional user profiles and fictional inventories. So, it doesn't involve major integration process.

CHIMS SW1 has been implemented for the iPad 6th generation and IOS 12.4. The backwards compatibility has not been studied but it has been proven that it is compatible with the iPad pro 10"5.

The following figures are screenshots from the application.
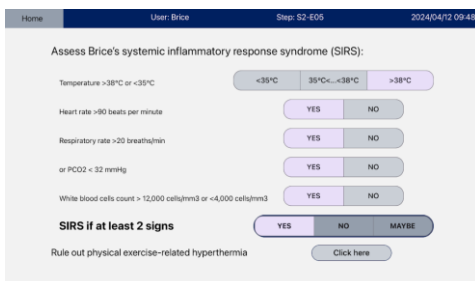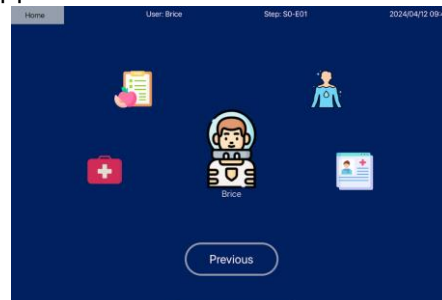
Technical verification

The verification of the CHIMS software took place after the implementation of the application. The test demonstrated that the CHIMS App is operational does not address the technical requirements has described in the SoW.

Functional validation

The validation has been performed internally within MEDES. Different type of profiles (with and without medical expertise) were selected and no experience with the CHIMS software. This validation took place in Jully 2024 and involved 4 volunteers.

The functional validation demonstrated the interest for a tool with such capabilities for Space and Earth uses but a proper user adoption would require more advanced features than the one implemented in the SW1.

Communication

The CHIMS project has been presented in the session Introduction to human spaceflight and robotic exploration within the event entitled "GSTP 30th anniversary" that took place from September 26-27th 2023 at Gdansk in Poland.

Conclusion and recommendations

Main recommendations for future development of a CHIMS-kind application that could be used for future crewed space mission are more focused on the scope and the needs exposed in the SoW and in the state of the art. The consortium recommends focussing on the initial and actual needs and advanced technologies. Therefore, the future work should consider:

- Design a software architecture:
  - Prepare the interfacing and the integration of CHIMS within the existing tools
  - Prepare a ground-based simulation tools for the data collection platform
  - For the recommendation and prescription analytical modules:
    - Investigating the capabilities of a weighted graph and dependency graph before investigating the reactive machine and semantic search
    - Investing the capabilities of synthetic data before investigating capabilities of machine learning.
- App user experience (UX):
  - Re-asses the latest applicable documentation for display and graphics on-board the ISS
  - Assessing the standards to be used for the user experience which focus on a "user centred design"
  - Investigating the capabilities of conventional AI and chatbots (rule-based or AI powered).
- Validate the software during a ground-based space mission analogue.