AREVA TN Universal Centralized Storage System – 15581

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ABSTRACT

AREVA TN has developed a new used nuclear fuel storage product concept: NUHOMS® Universal Storage Facility (USF) to meet the needs and capabilities of centralized storage. This NUHOMS® USF is a horizontal system retaining the superior seismic stability, shielding performance, and ease of canister retrieval of the existing NUHOMS® system, while creating a single, simplified storage module that can store canisters of any sizes, including horizontal NUHOMS® canisters as well canisters from vertical storage systems or canisters developed for future direct geologic storage. The NUHOMS® USF has a reduced footprint and uses less material compared to existing NUHOMS® system. The canister handling process has been renovated to simplify the canister loading process.

INTRODUCTION

Due to the suspension of the Yucca Mountain project, the Blue Ribbon Commission (BRC) on America's Nuclear Future recommended to the U.S. Department of Energy (DOE) in 2012 Consolidated Interim Storage (CIS) facilities for used nuclear fuel [1]. Subsequently, the DOE announced a plan to start by 2021 the operation of a pilot interim storage facility for the storage of used nuclear fuel from shutdown reactor sites and a larger scale interim storage facility by 2025 to provide the needed flexibility before a geologic repository is available (estimated in 2048). Although the recommendation of CIS is on hold at this moment, the need for such an interim used nuclear fuel management has not gone away. In addition, as more plants decommission, the need becomes even greater. States may take the initiative where the federal government does not, as the interest in a storage facility in West Texas demonstrates [2]. Furthermore, even in those countries planning recycling or geologic storage, interim storage may be needed as a buffer considering start delays or insufficient capacity of those plants. In response to this need, AREVA TN has developed a concept for used nuclear fuel centralized dry storage: NUHOMS® Universal Storage Facility (USF), to complement AREVA's capabilities of centralized storage of used nuclear fuels.

ASSUMPTIONS

The Product Design Specification (PDS) was developed based on NRC's current requirements for used nuclear fuel storage, to which additional requirements from potential customers where added, with the following assumptions:

- The conceptual design includes the storage module and transfer equipment based on modular dry storage only.[1]
- The centralized storage assumes the use of existing canister types. The project scope does not

1. While there is a strong case for other storage modes, for example pool storage [3], AREVA's spectrum of products already includes pool storage as well as a vault system for centralized storage.

include new canister design.

- The conceptual design should be flexible enough to accommodate horizontal, vertical and potential future DOE canisters.
- Only commercial reactor fuels are considered for this conceptual design.[2]
- The storage capacity is up to 70,000 MTU [1], based on current used nuclear fuel inventory and discharge rate of 2,000 metric tons of uranium per year.
- The system must meet the requirements of 10 CFR 72 [4].
- Used nuclear fuel transportation design is out of the project scope, but retrieval flexibility is required.

CONCEPT GENERATION PROCESS

To generate the best possible design, AREVA TN initiated a competition to encourage the generation of multiple CIS concepts. Multiple concepts were submitted by AREVA TN's staff including vertical, horizontal, indoor, sunken, and stacked concepts. A systematic decision making process was followed to select the best concept for further development. The process flow is illustrated in Fig. 1, including brainstorming for initial idea generation, one-by-one pairwise evaluation, hybridization for idea regeneration and re-evaluation until the final concept convergence.

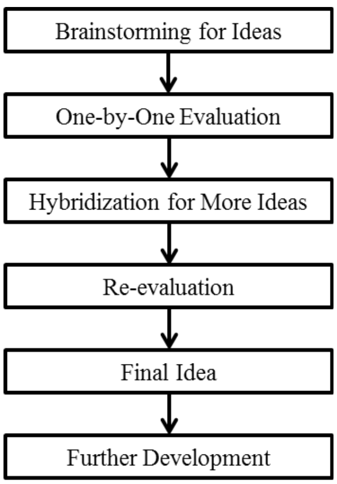

Fig. 1. Decision making process.

Evaluation Criteria

Specific criteria and sub-criteria were developed to evaluate the design concepts based on considerations important to the stakeholders. The major criteria and sub-criteria are listed here:

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2. DOE intends to include high level radioactive waste in the CIS facility, but that is not included in the scope of this project.

1. Cost, including upfront cost, operating cost and D&D cost.
2. Technical feasibility, including constructability, ease of licensing and technical maturity.
3. Functional performance, including
    a. Expandability
    b. Retrievability
    c. Multiple system adaptability
    d. Durability and aging management
    e. Normal operation
    f. Accident conditions
    g. Off-normal conditions
    h. Thermal and dose
4. Ability to achieve public consent
5. Security
6. Schedule
7. Adaptability to future evolutions: new canister types, foreign market needs, future technology improvements integration

Each of the criteria and sub-criteria were further weighted relative to their importance using ExpertChoice® [5] based on one-by-one pairwise comparison. The ability to achieve public consent was ranked as the most important criterion for this project.

Ideas Evaluation

Engineers and experts from Design, Manufacturing, Fabrication and Field Services groups participated in the evaluation process. The initial evaluation used ExpertChoice® to rank the concepts along with existing modular dry storage concepts based on the developed criteria and its weight. Then hybridization was conducted to summarize the strengths and eliminate weaknesses of the various ideas, three new hybrid concepts were regenerated which emphasized the strengths and diminished the weaknesses of the original ideas. The horizontal concept, NUHOMS® USF, was in the end selected based on its seismic stability, shielding performance, retrievability, ease of operation and desired adaptability features to adjust to future customer evolving needs.

NUHOMS® UNIVERSAL STORAGE FACILITY (USF)

As shown in Fig. 2, the NUHOMS® USF system consists of a distribution center, an array of above ground horizontal storage modules, and a surrounding berm.

The distribution center has the capability to receive and transfer, horizontally or vertically, canisters of various sizes into a transporter which is shielded and self-propelled. The automated transfer process minimizes operational dose rate. The transporter moves the canister to the storage location and loads the canister and its support skid, which are treated as one unit, into the horizontal module. The berm is installed around the facility to reduce the external visibility.

Fig. 2. NUHOMS® USF overview.

Distribution Center

Inside the distribution center are two transfer stations for handling incoming canisters:

(1) The horizontal to horizontal transfer station.

(2) The vertical to horizontal transfer station.

Both stations transfer the canister into a shielded, self-propelled transporter in a final horizontal orientation. The canister inside the transporter is then ready to be moved to the storage modules.

Horizontal to horizontal transfer station

As shown in Fig. 3 and Fig. 4, the arriving horizontal transport cask, resting on the hydraulic skid, is aligned to the transfer station and the canister is loaded horizontally onto the roller stand inside the shielded structure. A sling lifting system moves the canister from the roller stand onto a support skid inside the shielded transporter. The shielded roof is then lowered onto the transporter. The transporter is ready to leave the shielded structure and move to the storage modules.

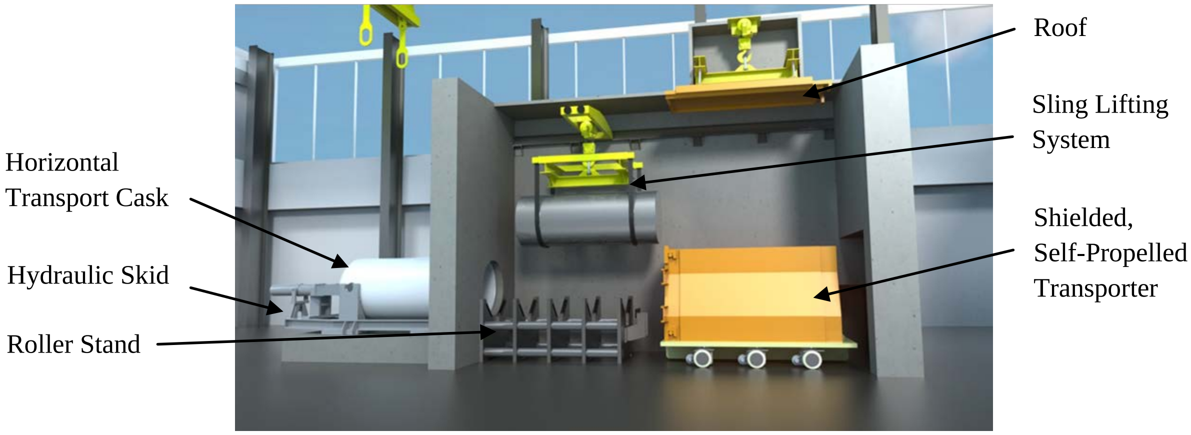

Fig. 3. Horizontal to horizontal transfer station.

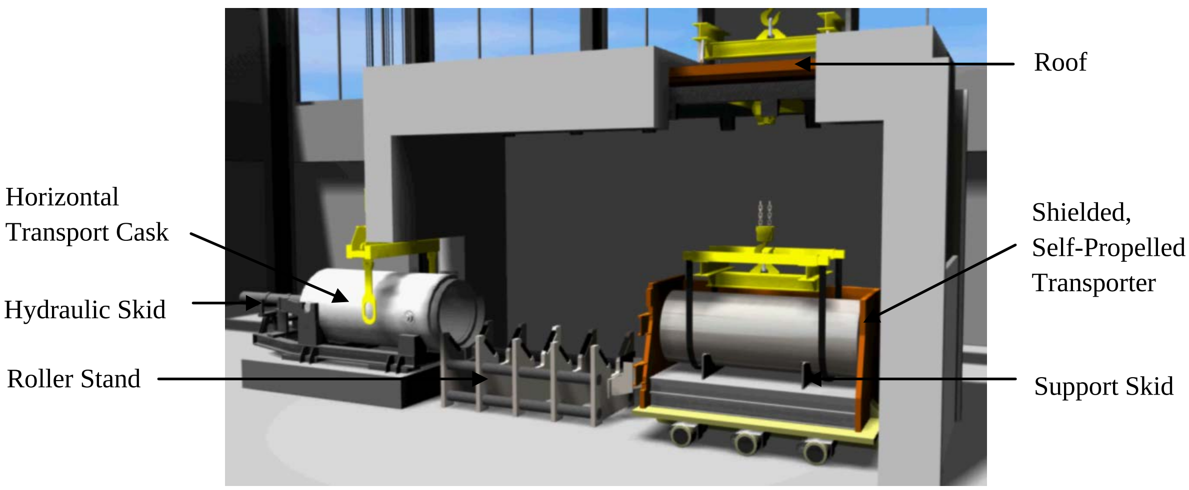

Fig. 4. Horizontal to horizontal transfer station.

<u>Vertical to horizontal transfer station</u>

As shown in Fig. 5, the arriving vertical transport cask, standing on the gantry transfer platform, is aligned to the transfer station and the canister is loaded vertically into the support skid inside the transporter which is up-ended by a hydraulic up-ender platform. A shielded door is moved to close the transporter. The hydraulic up-ender platform rotates the transporter from the vertical back to the horizontal position, as shown in Fig.6. The transporter is then ready to move to the horizontal storage modules.

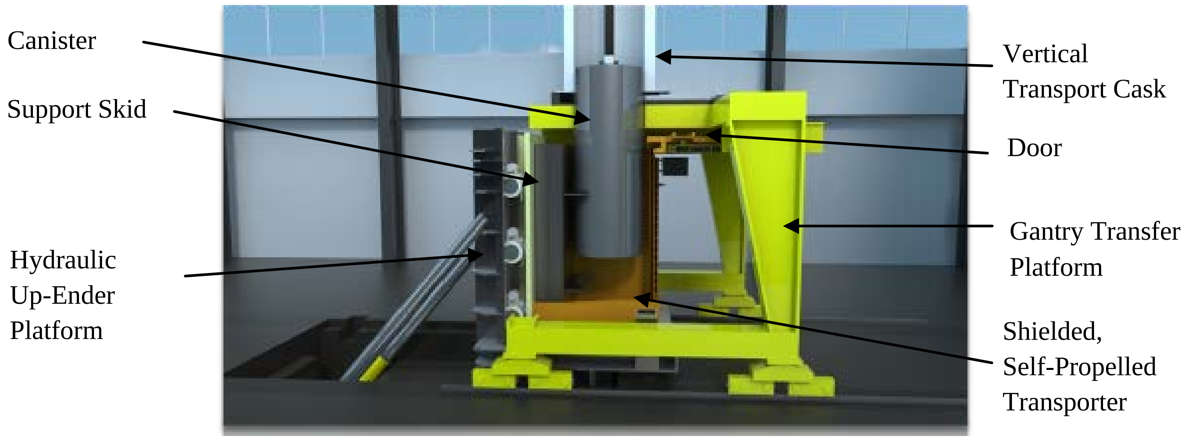

Fig. 5. Vertical to vertical transfer station.

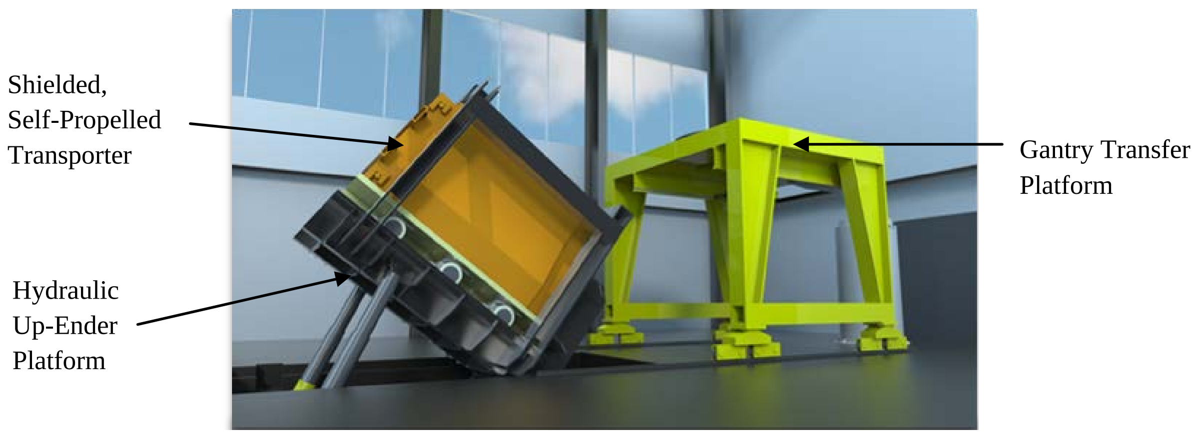

Fig.6. Vertical to vertical transfer station.

Optimized Horizontal Storage Module and Storage Pad

The storage module and storage pad are based on existing NUHOMS® HSM with many optimized features.

This module is a horizontal, low profile, modular, reinforced concrete structure with primary functions of used nuclear fuel decay heat removal, structural support, physical protection of the canister, and radiation shielding. The module can use fiber reinforced concrete to enhance heat resistance, durability, and impact resistance. The concrete overpack is arranged in arrays on the load-bearing pad, as shown in Fig. 7. The optimized features of the concrete overpack and storage pad include:

- The haul path is about 0.75 meter (2.5 feet) below the basemat of the horizontal storage module, with a width of 6.7 meter (22 feet), which is substantially less than the space required for a towed trailer.
- The concrete storage overpack is approximately 4.3 meter (14 feet) high, which is about 1.5 meter (5 feet) lower than the existing NUHOMS® HSM-H.
- One side concrete wall is removed to reduce overpack space and material.

- There are no rails installed inside the horizontal storage module, simplified loading/unloading process.
- Smaller storage area footprint with reduction of 30% comparing to existing NUHOMS®.

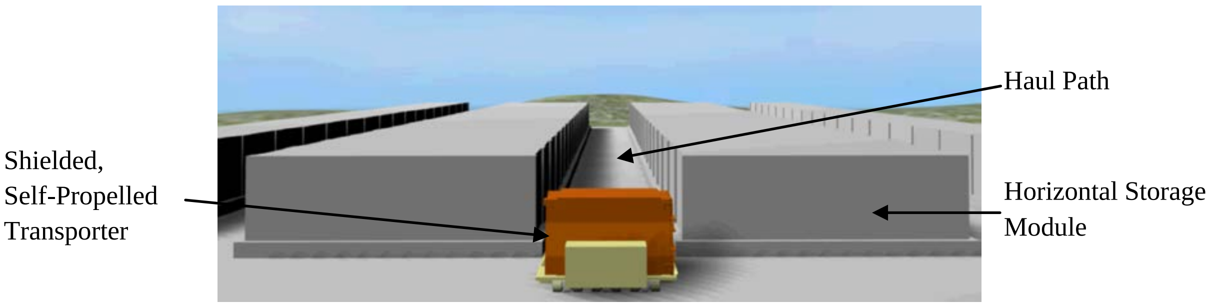

Fig. 7. Horizontal storage modules.

Loading/Unloading Process

The canister loading process is shown in Fig. 8, Fig. 9 and Fig. 10. The shielded, self-propelled transporter loaded with a canister is positioned in front of the designated horizontal storage module (Fig. 8). The storage module door is removed by an auxiliary lifting device and the shielding adaptor is placed between the transporter and the horizontal storage module. The shielded door of the transporter is removed and the transporter is positioned against the shielded adaptor. The hydraulically operated steel roller pallet lifts the support skid and canister as a unit and moves them horizontally into the storage module (Fig. 10). The skid and canister are lowered by the pallet and the pallet returns to the transporter. The canister and support skid remain inside the storage module. The shielding adaptor is removed and the transporter and storage module doors are replaced. The loading operation is performed by a minimal amount of personnel and requires only rough alignment.

Retrieving the canister to the transport cask is performed using the reverse of the loading sequence. All handling outside the distribution center occurs on the horizontal support skid. Therefore, the design does not rely on the ability of the canister welds to lift the fuel after a long period of storage, as with vertically handled canisters. At the distribution center, the canisters can be safely examined to verify their integrity prior to transportation to geologic storage or recycling.

Ease of Operations

The storage module can be fabricated entirely on site in a concrete pre-casting facility. It does not require steel shells to be fabricated and delivered to site, nor does it require extensive excavation and engineered fill. The storage site can be readily expanded as needed. Preliminary scoping calculation of horizontal storage module shows this design has improved thermal performance compared to existing NUHOMS® HSM-H.

The transporter is designed to provide flexibility of transfer rate. Its off-the-shelf components make maintenance and replacement of parts easy; there are no expensive and heavy parts to order or need long lead time for fabrication; if the whole transporter needs to be replaced or if additional ones are needed, the turnaround is fast.

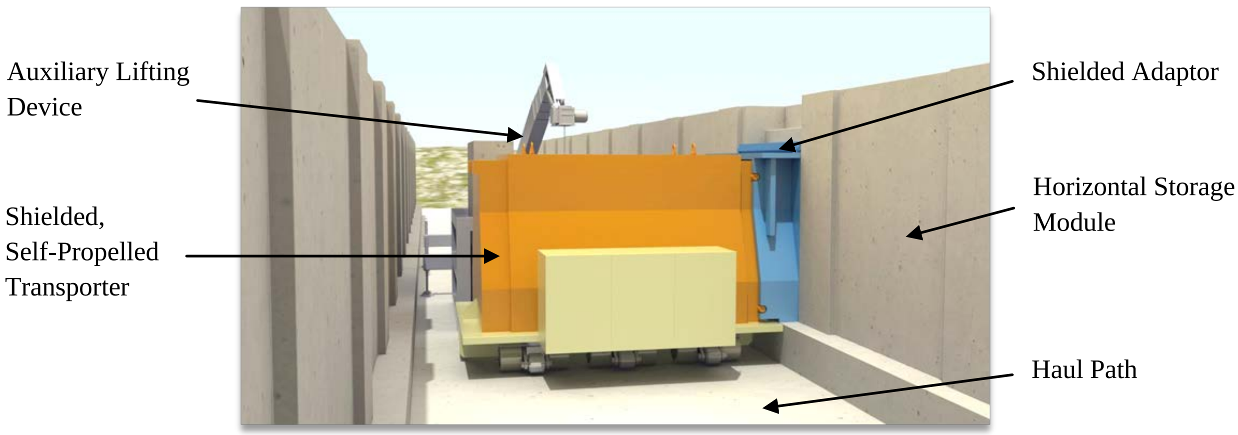

Fig. 8. Loading canister to horizontal storage module.

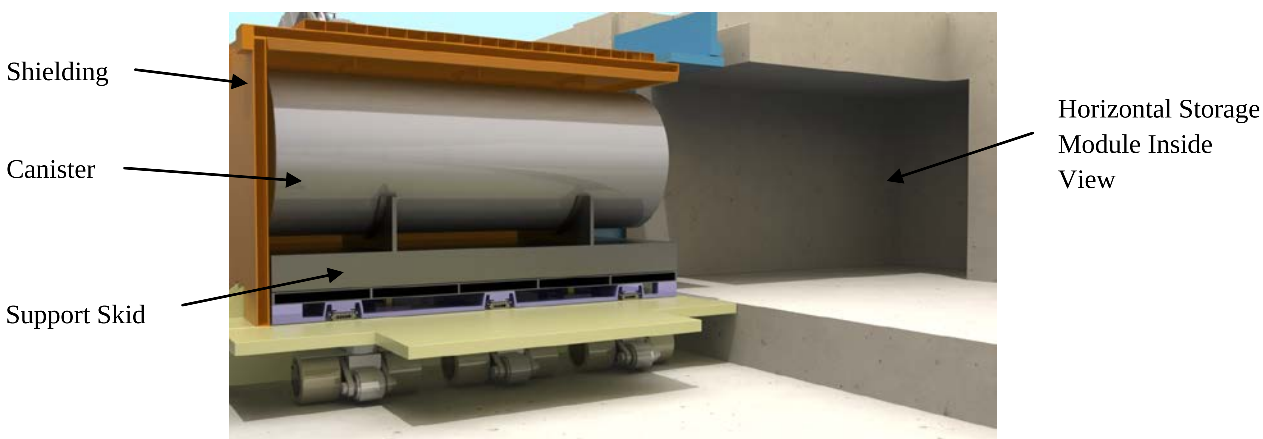

Fig. 9. Loading canister to horizontal storage module.

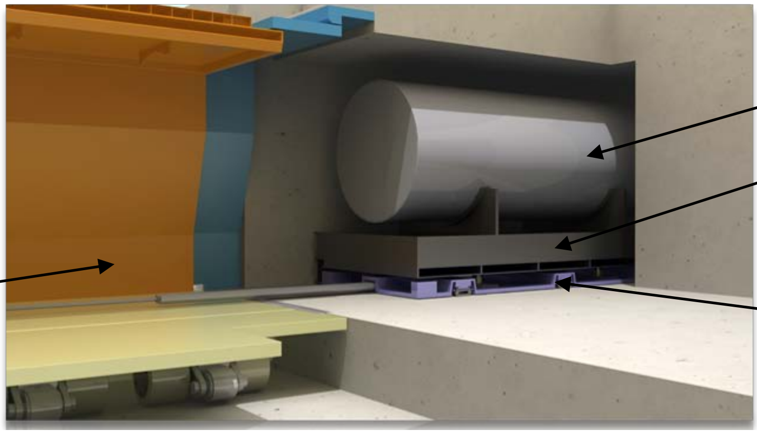

Fig. 10. Loading canister to horizontal storage module.

CONCLUSIONS

NUHOMS® USF has been developed to be an optimized, reliable, and adaptable solution for Consolidated Interim Storage (CIS) in the US and internationally. This horizontal design brings to the customer the worldwide field-proven operational experience of the NUHOMS® system, which provides high seismic capacity, superior self-shielding performance, and safe retrieval for future used nuclear fuel transportation. While preserving the benefits of horizontal storage, the system is universal, that is, it provides for the handling and storage of canisters originally designed for vertical storage.

The concept addresses operational concerns like dose exposure, ease of inspection and maintenance, security, and canister retrieval. Blockage of air cooling paths by water- or wind-driven debris is minimized by raising the basemat above the surface of the adjoining haul paths. The concrete module design presents a secure monolith with no obvious door or lid for access, and the security of the system can be further enhanced by the use of impact-resistant steel fiber reinforced concrete. Retrieval requires no outdoor critical lifts.

Reduced construction and operational cost are achieved through above ground construction which permits true modularity, eliminates the costs of excavation, and makes site expansion easy. The on-site concrete batch plant serves to provide the basemats, the haul paths, and the storage modules. Because there are no steel shells, the storage modules are precast with minimal delivery of components fabricated off-site and the attendant costs and logistics management. The reduced height of the storage module reduces the amount of rebar and concrete required, and the use of the traveling support skid eliminates the need for a canister support structure accurately fixed inside the module.

Thus, the NUHOMS® USF concept represents an evolution of the existing NUHOMS® system providing an economically and technically sound platform to adapt to the used nuclear fuel centralized interim storage needs in a variety of environments and countries.

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