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The Process of Developing a New Passive Seal for Safeguards Use

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***Abstract* - The metal CAPS safeguards seal has been in use, in various forms, by the IAEA for over 50 years. The IAEA wanted to explore if advances in technology and material science have potentially enabled new features to improve security, improve the timeliness of inspectors' work, and potentially reduce costs for the IAEA. Still, replacing a seal that has become so ingrained in the culture of safeguards represents significant challenges. The IAEA must balance cost, security and usability vectors in order to ensure longevity and acceptability in joint-usage. While the development is still ongoing, this paper will provide an overview of some technical developments and activities undertaken by the IAEA to pursue the optimum design for an improved passive seal.**

Keywords: International Safeguards, seals, procurement

I. BACKGROUND

In May 2020, the IAEA Department of Safeguards, Division of Technical Services (SGTS) decided to reach out to as broad an audience as possible, to see if advances in materials and technology could enable a secure passive seal that would result in a lower total cost of ownership for the IAEA. For programmatic reasons, a solution needed to be implemented by the end of 2021, which eliminated most typical research and development program approaches.

This paper describes the innovative procurement and development process that the IAEA engaged in to procure a new passive seal design, with the intent of better informing future procurement plans within the relatively narrow ecosystems of nuclear security and safeguards. Since the competitive bidding process is still ongoing, this paper cannot describe technical approaches to the sealing problem itself.

II. PART ONE: DEFINE THE PROBLEM

The project team had previously identified the user requirements for any design of a passive seal. These user requirements had guided the IAEA's previous seal development efforts, but for various reasons those efforts had not yet resulted in a satisfactory product. The project team worked closely with the IAEA procurement team to develop those user requirements into technical requirements, along with scoring criteria that could be used to evaluate the bidder responses throughout all phases of the project. As an innovative way to address the developing nature of the project, the relative weights of the requirements would change as the designs matured. Additionally, the technical requirements were weighted more heavily in the early phases of the project, while cost became a more significant weight during the later phases.

As will be described later, the multiple-phase project resulted in an internal procurement plan that was more complex than normally used within the IAEA. This placed additional importance on getting the requirements and phases correct at the outset of the project, because any significant changes to the technical

requirements could derail the 'procurement train' and require a new procurement effort and a re-bid of contracts.

LESSONS LEARNED: Handing the draft specification and scoring criteria to sample evaluators was a critical exercise to refine both the technical requirements and the scoring criteria. The existing CAPS seal and a previously rejected prototype design were used as sample designs to be evaluated, which quickly revealed deficiencies in requirements that were missing, and requirements that were incorrectly weighted.

III. PART TWO: MARKETING

An industry-wide Expression of Interest was posted on the traditional United Nations Global Marketplace (UNGM) – the normal vehicle for announcing business opportunities. However, the reach of the UNGM website was limited; this forced the project team to explore ways to engage non-traditional companies in raising awareness of the Expression of Interest.

The team pursued multiple avenues to reach out to as many potential suppliers as possible. One innovative approach for the IAEA was to purchase Google Ads, briefly mentioning the IAEA's interest in novel passive sealing approaches and pointing to the UNGM Expression of Interest. Over the course of seven weeks, Google displayed the IAEA's ads over 50,000 times, based on safeguards and security keywords defined by the IAEA.

An announcement was posted on the IAEA's news webpage (https://www.iaea.org/news). Other posts to the IAEA's Twitter feed and LinkedIn page were made as well.

Fig 1. An example of the marketing used on various media for the new passive seal campaign.

Lastly, many companies were directly contacted, based on a list of seals-related companies maintained by the SGTS Seals team. This list, comprising about fifty companies, was augmented by approximately thirty additional companies because of their expertise in technologies that the IAEA thought *may* be relevant to a sealing solution: i.e., RFID tag manufacturers, glass manufacturers, ceramic manufacturers, and traditional security tag manufacturers. Member State Support Programmes were also notified about the UNGM posting.

The schedule constraints of the project prevented the team from establishing a project-specific, outward-facing website that could advertise the requirements of the project (as was done for some previous IAEA "Challenge" projects, such as robotics and tomography reconstruction). This would have allowed a more detailed outreach, with possible engagement of universities or other more research-based organizations.

The IAEA received twelve submissions in response to the Expression of Interest. Of the six organizations which responded to a follow-up enquiry as to where they learned about the effort, none

reported having learned about it from the Google Ads, one reported learning about it from the IAEA news post, and all six reported having been contacted by the IAEA directly.

LESSONS LEARNED: The market for IAEA safeguards interests is small. Large manufacturing and security companies (>10,000 employees), representing significant knowledge and development resources, told the IAEA that the scope of the passive seal project did not make an attractive business case for their involvement. Some members of the project team were concerned that the outreach efforts would result in the IAEA being deluged with proposals (more than twenty-five); however, twelve proposals were received. On relatively short-term development projects (less than two years), it is a more efficient use of time and money to target and reach out directly to companies that may be interested in the effort, rather than spending resources on broad industry-wide announcements.

IV. PART THREE: DEVELOPMENT

Based partly on previous seal development experience, IAEA management recognized that a solution was not readily available; there would need to be an iterative design – build – test – improve cycle required instead. From the outset, the project plan included a series of conceptual prototypes to be built and tested, then a second round of test-and-evaluation prototypes to be built and tested, and finally production ready units. The number of viable candidates during each phase was expected to decrease as the associated weights for the technical requirements became more stringent.

Ludwig Boltzmann in 1875 first linked the number of microstates of a system to the entropy of that system in the Boltzmann equation[1]; in other words, systems drift towards a disordered state because there are more disordered states than ordered states. The design process of any system similarly follows such entropy: the number of ways a system (or seal, in this case) can fail greatly exceeds the number of designs that form a successful seal. The only way to arrive at a successful design is to iterate, hopefully intelligently, through successive designs that do not work.

In parallel to the commercial process, an internal design process was initiated, drawing upon the expertise of IAEA seals team staff and the manufacturing expertise of the IAEA's Seibersdorf Laboratories mechanical workshop. The internal design was pursued as a risk mitigation approach, since the competitive award process narrowed the field of technically acceptable designs more quickly than anticipated. A similar in-house design process was pursued, to good effect, for the Asymmetric Universal Active Seal (AUAS), which is nearing authorization for Safeguards use.

For the passive seal design, the IAEA has successfully iterated through the conceptual prototype development phase, the evaluation phase, the test and evaluation prototype development phase, and is now in the evaluation phase of those test and evaluation prototypes. The IAEA will begin deploying the new design seal in 2022.

LESSONS LEARNED:

- The IAEA procurement process takes time. The IAEA needs to perform detailed technical and procurement related reviews prior to releasing any funding. A one-month turnaround from submission of proposal to releasing a purchase order appeared to be the minimum with two months being a more realistic estimate and three months being conservative. Project plans that include some portion of "receive proposal – evaluate – award" (and IAEA contractors responding to IAEA requests for proposal) should therefore plan for such a cycle.
- An iterative design - build - test is critical to developing anything useful, even in a well-characterized area like seals. If there are expensive or lengthy components to a build cycle, a substitute component should be utilized which enables affordable design iterations before moving on to the actual product

[1] $S=k_B * \ln(W)$, where S is the entropy, k_B is the Boltzmann constant of 1.38E-23 J/K, and W is the number of real microstates corresponding to the ideal gas's microstate.

V. CONCLUSIONS

The IAEA plans to begin deploying a newly designed passive seal in early 2022, to replace a seal that has been in use for over fifty years. Bringing this to fruition required some key attributes, which can apply to almost any technology development project:

- Support from the top. The consistent check-ins received from multiple levels of management during the early and middle stages of this project helped to clear some of the hurdles and drive a solution earlier. Without such support, it is easy for projects to become stalled at various points along the way as stakeholders may get involved in other matters.
- Iteration. Even on something as well characterized as the passive seal, developing a new product requires iteration as previously hidden requirements and performance attributes come to the surface as new designs are tested.