Creative Adaptation of Interconnect Technology Across Industry Boundaries

Dave Jenkins, Richard Miller and Greg Desjardin
Ametek SCP,
Westerly Rhode Island
david.jenkins@ametek.com, richard.miller@ametek.com, gregory.desjardins@ametek.com

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Abstract - This paper will address the creative adaptation of a series of unique interconnect technologies across distinctly different industries, and markets. These technologies were adapted from the subsea and aerospace industries, and applied to a NASA application and environment, specifically for the Low Density Supersonic Decelerator (LDSD) program [1].

Subsea technologies are understandably among the most difficult to conceptualize, design and then implement. Designers unfamiliar with the subsea environment frequently underestimate the difficulty of this design environment (How hard can it be…), and quickly find out that connectors and cable systems that live in the ocean must contend with a wide variety of harsh environment demands. Very often, the failure of subsea components can be traced to a lack of appreciation for the very harsh environment that equipment must live in for example for extended periods of time in the ocean. As system designers discover, the functionality of multi-million dollar equipment can be at risk unless the interconnect systems that serve that equipment are given the equivalent level of design focus.

These harsh environment conditions include seawater corrosion, high direct and differential pressures, low oxygen in low flow areas, high vibration and in many cases unique dynamic structural demands. These conditions require the designer to include all these concerns in the design, and failing to do so can result in very rapid failure, in some cases days or weeks. The subsequent RCCA (Root Cause and Corrective Action) for subsea failures frequently points back to a failure to anticipate the full range of conditions to be seen, and a failure to flow down a specification that fully anticipates the in situ conditions.

Many of these harsh environment conditions or operations requirements can and frequently do find their way to other industries, usually in the form of one or two of the harsh environment requirements. For example, a terrestrial environment would not have the high pressure demands of a deep ocean or aerospace project, but might very well operate in an area subject to high corrosion.

In this paper, we will use as a study template the requirement for a Quick Disconnect, Hybrid fiber optic product needed for a NASA application, specifically for the Low Density Supersonic Decelerator (LDSD) program. The specific technologies needed did not exist as a package, and therefore had to be borrowed from other industries. A needed quick disconnect feature was borrowed from ROV design principles, and the high performing hybrid (2 optic, 2 electric) connectivity was borrowed from typical subsea designs that require transmit and receive optics, as well as electrical power.

We will cover how these technologies were borrowed from the subsea and aerospace industries, brought together and then packaged creatively in an interconnect application that would successfully meet the demands of a terrestrial launch system. This interconnect design adaptation was accomplished by creatively leveraging the unique features of successful ocean technologies into a new application and industry in need of these specific features. The paper will explain the features, characterize their performance, and explain how they were brought together in the design process, and then deployed in a highly successful terrestrial project.

I. Introduction and Background

In humanity's never ending quest to understand our world and how it works, mankind has pushed both up and down, i.e. into new frontiers in space, as well as into the deep ocean environments. Engineers who are in the business of designing interconnect hardware and systems for the deep ocean will quickly realize the meaning of "harsh environment", and the need for highly robust, high performing interconnect solutions. Similarly, with terrestrial and space projects, many of the same challenges exist. There simply is little room for error on a system that lives in the inhospitable environment of either space, or the deep ocean. At a minimum, the designers of both environments must live in temperature and pressure extremes, aggressive corrosion, and often times highly unusual and dynamic scenarios.

For the engineer who lives in and designs for these environments, the focus is on survivability in what we commonly call a "harsh environment". This is normally interpreted to mean an environment with much greater than atmospheric pressure, temperature and a difficult corrosion environment. ASCP routinely designs for this environment, which can and often does cross industry barriers wherever such a “harsh environment” is encountered. Further, there is nothing that would prevent the features, innovation or capabilities seen in one industry from being shared with another. This cross utilization can be seen to leverage what are often very unique design attributes into a new market space.

The genesis for this project was a connectivity requirement for a NASA application,that would test the functions of a vehicle that would carry larger payloads than presently capable, and then be able to decelerate safely from orbit to the Martian surface. The initial demand for functionality could not be accommodated with off the shelf technology, and could only be satisfied by a set of features from a variety of subsea projects. This paper will review how the features commonly seen within the ocean design environment were adapted successfully for the LDSD space program.

II. History of Project and Requirement

A. History

As NASA planned ever more ambitious robotic missions to Mars and beyond, it needed to develop technology to decelerate increasingly larger payloads traveling at supersonic speeds in thin atmospheres to new levels of performance. Maintaining the integrity of the specifications was essential, particularly for the monitoring signals.

Current NASA technology dates to the Mars Viking missions of the 1970s. New technology now under development would allow larger, heavier objects to slow from supersonic entry speeds to the subsonic ground-approach speeds necessary for a safe surface landing on Mars. Among the technologies included in design testing is a specially designed quick disconnect connector from AMETEK SCP, a world leader in connector solutions for military and commercial applications.

NASA first approached AMETEK in early 2013 to develop an interconnect solution for its Low Density Supersonic Decelerator. NASA required a connector with both electrical and fiber optic capabilities that also was designed for quick and reliable disconnection under load. NASA turned to AMETEK SCP to handle the engineering challenge because of its unique connector engineering capabilities. The connector that AMETEK designed allows the system to collect data, maintain communications and upload video until the payload is ready to be deployed, and then quickly and reliably disconnect.

AMETEK’s novel connector solution was successfully tested as a part of the launch of a high-altitude instrumentation balloon, that carried the test vehicle to an altitude of 120,000 feet. At that altitude, the vehicle was released and a solid rocket engine carried the vehicle to a height of 180,000 feet, to allow the test vehicle to be tested at adequate altitude. One of NASA’s goals is to reduce risks to potential future missions by eliminating the need to fly unproven hardware by flight testing designs that meet the higher mass payloads needs of future Mars missions with full-scale demonstrations tests in the Earth’s stratosphere. Figure 1 shows the testing platform.

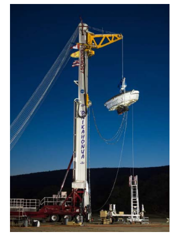

Figure 1. LDSD Testing Platform

III. Technical Parameters and Working Solution

A. Technical Overview

Early in 2013, ASCP and the NASA point of contact began the collaborative effort to develop the connector set that would accomplish the requirements for the launch scenario. The technical parameters necessary for this project, to ensure proper communications to and from the test vehicle, included electrical power and fiber optics, which by themselves are not unusual requirements. But in this case, the additional requirement needed was an ability of the connector to reliably and consistently “break away” or delatch at a specific force level. The precise force level was iterated during the design phase to arrive at the working force. In this case the delatch force needed was in the range of 60-80 lbf.

The specific attributes for the connector set included 2 electrical contacts, 2 fiber optic contacts and a delatching mechanism, with a latch profile that was iterated to achieve the required delatch force. The bulkhead receptacle side connector was configured as the deployment connection, and the plug side connector was configured as the land based connector, which included a lanyard, which is used to reliably and repeatably pull the connector set apart as the launch balloon lifts off the launchpad.

An additional capability that was discovered necessary, and then added during development was a protective bumper, so that when the connectors were delatched, and fell to the launchpad, they would be reasonably protected from damage. In Figure 2 following is shown an image of the plug, showing the protective custom bumper, and the delatching lanyard.

Figure 2. Plug Side Connector, Land Based Cable Assembly

In Table 1 below is shown the attributes of this unique connector set that were needed for full performance.

Table 1. Connector Set Attributes

	Attribute	Function
1	Electrical contacts	Power
2	Optical contacts	High bandwidth (GB) launch communications
3	Delatch	Disconnect reliably and repeatably at 60-80 lbf
4	Lanyard pull	Delatch via lanyard pull, structural connection
5	Bumper	Protection from fall post delatch

B. Connector Development and Testing Timeline

NASA approached ASCP with this requirement in March 2013. The initial discussions surrounded the requirements of the launch scenario, and if ASCP had the capability ti design, manufacture and test the connector set needed. Once NASA was convinced that ASCP had the desired capability, what resulted was a contract to design, develop and manufacture several connector sets for use at the LDSD testing prototype at Wallops Flight Facility, in Virginia. The hardware, including several land based and deployment connectors and cable assemblies, was provided in September 2013, with initial testing accomplished successfully in November 2013 in Wallops Flight Facility, and then again successfully tested in Hawaii, at the U.S. Navy Pacific Missile Range Facility (PMRF) in Kauai, HI during June 2015.

C. System Components

Shown here in Figure 3 is the land based cable assembly with reel (plug) and in Figure 4, the deployment cable assembly (receptacle).

Figure 3. Land Based Cable Assembly with Reel (Plug)

Figure 4. Deployment Cable Assembly (Receptacle)

D. Technical Decisions

At the outset of the project, it was necessary to choose an insert pattern that would be adequate for the number of conductors and fiber optic contacts, but also structurally strong enough to handle sudden repeated demate forces. At the same time, it was necessary to stay within the intended cost and schedule budgets. Because of the availability of certain insert patters, which would prevent a complete custom insert job, with the attendant tooling, we chose to utilize a 19 way insert, which was more than enough to accommodate the required circuitry.

The advantage of choosing a more dense insert configuration was that the shells would be slightly larger, and more robust. In this case, the additional size was not a problem, and in fact the additional structural integrity was a welcome addition.

Here is shown in Figures 5 and 6 the Plug face view and the Receptacle face views. While the base configuration for the insert was a 19 way configuration, only the required electrical and fiber optic contacts were populated.

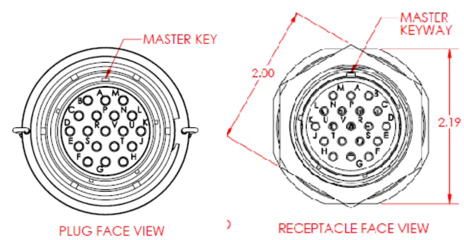

Figure 5. Plug and Receptacle Face Patterns: 19 way Base

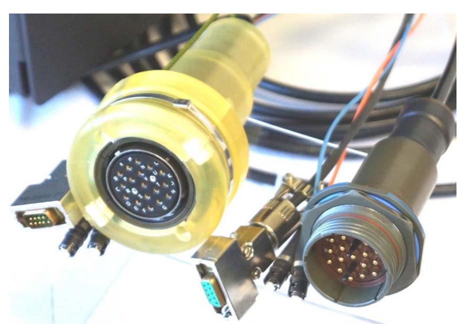

Figure 6. Plug and Receptacle Shown Together

IV. SUMMARY

ASCP is an engineering solution company, and not just a company who provides connectors. In this case it was necessary to listen carefully to a customer with a unique requirement, and develop a successful solution for a Space Program application. The innovative plug and receptacle solution was obtained by applying several technology attributes not normally combined, leveraging from both the ocean engineering, and aerospace arenas [2]. This application required electrical contacts, fiber optic contacts, reliable delatch capability, and in the end a protective bumper to ensure that the connector set would not be damaged after each launch event. The result has been a successful communications and data monitoring circuitry, which could be reliably and repeatably delatched, as a part of a critical LDSD Launch test capability.

By adapting from these adjacent but similar harsh environment areas, ASCP was able to engineer this solution with the right attributes for a successful test flights.

ACKNOWLEDGMENT

The authors would like to acknowledge our NASA point of contact, Alexander Coleman, who provided SCP the initial launch scenario detail as a part of initial coordination, to ensure the desired functionality. We acknowledge Mr Coleman's diligent efforts in ensuring that SCP had the technical detail needed to be able to design, manufacture and test the interconnect hardware, to ensure proper functioning. A key reason for the success on this, and any other kind of unique, harsh environment engineering effort is the up front technical coordination, to ensure that the final design is indeed what is needed in the application. In this case, the coordination was prompt, accurate, and the successful testing is testimony to this coordination.

REFERENCES

[1] NASA Website on Low Density Supersonice Decelerator (LDSD), https://www.nasa.gov/mission_pages/tdm/ldsd/index.html

[2] D. Jenkins, S. Thumbeck, M. Christiansen: Essential Design and Risk Management For A Next Generation Ocean Dry Mate Connector MTS/IEEE Oceans, San Diego, California, September 2013