SCaN TRANSPORTABLE COMMUNICATION PLATFORM, STCP

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Abstract

NASA Glenn Research Center required a satellite communication trailer that served dual purposes; 24/7 Emergency Communication Services (ECS) in the event of a natural or manmade disaster that disrupted conventional communications, and a Ka Band NASA TDRS capability providing a research capability for over the air evaluations/characterizations. The trailer was to be field deployable, environmentally controlled and self-contained providing local area networks (LANs) and Wide Area Networks (WAN's) with user access both wired (Ethernet) and wireless (802.11) supporting VoIP, Internet Web access and Email. The TDRSS terminal included a 200W TWT amplifier mounted on the feed boom, individual up and down converters, and custom integrated waveguide and a supporting feed system. Other features such as a mast, generator, electrical, lighting, surveillance, and storage capabilities were also required. The Trailer was developed and demonstrated these original requested capabilities. New Requirements are defined and the trailer is now being evolved and upgraded to be a backup for the Near-Earth Network (NEN) Stations at KSC that will support the launch phase of EM-1. This paper presents the current and future capabilities of the trailer and additional options that will make it a valuable deployable asset to support remote operations from any launch from location.

STCP Trailer

The Emergency Communications Project Study was conducted at NASA Glenn Research Center (GRC) for NASA Headquarters (HQ) in 2014 that provided recommendations to create a specification and to procure a prototype Emergency Communication Trailer (ECT) for Center Emergency Communication Services. Specifications were generated for a prototype ECT satisfying the communications requirements of Field Center Continuity of Operations (COOP). These specifications were based on the ECS Study proposed solutions. The procurement process was competitive with multiple vendor bids enabling NASA to contain cost and have an expanded view of the SatCom trailer market.

This action was completed by issuance of a request for proposal (RFP) that concluded with a contract award in late September, 2014, to Pathfinder Digital for the ECT. The ECT was delivered in September, 2015, with a first deployment in support of a COOP exercise in December, 2015. Following this deployment GRC's Office of Protective Services requested trailer deployments in support for both the GRC and Plum Brook Open Houses, held in 2016. A final deployment of the ECT was providing backup communications for protective services during the Republican National Convention.

A rebuild of the trailer is planned that addresses structural and other issues experienced during these past deployments providing an improved/expanded trailer structure when complete. This is not to produce a completely new design of the trailer but to improve upon the existing design with an extension to the trailer allowing for a 2.4 meter dish platform in the aft location. The current 1.2 meter dish and positioner can still be utilized by swapping the 2.4 meter dish and positioner for the 1.2 meter dish providing an alternate configuration as needed.

This rebuild while maximizing the reuse of existing equipment/cabling provides the NASA Space Communications and Navigation (SCaN) office a mobile satellite platform that will be both robust and reliable. This mobile satellite earth station will provide redeployment options as well as a cost benefit that a fixed satellite earth station cannot offer. Deployment and utilization of the trailer not only has the ability to support missions but also support various other NASA needs. Being self-contained removes limitations on where it can be deployed and operated with dual satellite dishes providing simultaneous operation allowing for not only remote operations, but the ability to back-feed data when one of the dishes is used as a test article under evaluation or is in use tracking a user vehicle.

This self-contained communication trailer utilizes a flexible, modular approach that allows it to be reconfigured and updated, and thus remain relevant and viable as the needs and missions of NASA evolve. Standard network protocols and interfaces provide both wired and wireless connectivity. An environmentally controlled equipment bay, provides temperature and humidity control for equipment in the three 19 inch racks. These racks employ shock and vibration isolation mounts permitting non-ruggedized systems and sub-systems to be utilized.

The trailer has a dry weight of approximately 8000 lbs. (fuel adds 682.5 lbs.) with a tongue weight of approximately 1000 lbs. The maximum gross vehicle weight of 10,000 lbs allows non-CDL drivers and non-commercial vehicles to tow it on deployments. The trailer is equipped with electric brakes and a safety break-away switch.

When parked, the trailer is leveled by four (4) hydraulic jacks. A 30-foot locking extendable mast contains the high intensity led lighting, security camera and Wi-Fi access points. This platform can be rotated 180 degrees to accommodate desired orientation. The mast mounted lights are controlled by a computer controlled IP switch within the trailer. The camera is web-based supporting remote monitoring and control.

Figure 1. Communication Trailer Configuration

Shore power is the primary source of power for the trailer with an onboard 12.5 Kw diesel generator with a 91-gallon fuel tank providing a secondary power source. An external fuel source can also be used. An automated transfer switch manages the trailer AC power with dedicated uninterruptable power systems (UPS), one for each of the three (3) 19-inch rack assemblies and TDRS RF equipment providing seamless switches between shore and generator power. The UPS units are capable of continuing operations for approximately 20 minutes after loss of AC Power. This provides ample time for the diesel generator to start and the automated transfer switch to switch from shore power to generator power. If both AC power sources are lost, 20 minutes provides ample time for a graceful shutdown of on-board systems. Upon restoration of shore power, the transfer switch will transfer power back to shore power.

An internal IT infrastructure provides services and connectivity for the on-board systems, operators and users of the trailer. A combination of wireless and wired network devices constitutes the trailers LAN/WAN providing these services and connectivity.

The technology deployed for wireless services must support a majority of the users' wireless devices that may include a combination of cellphones, tablets and laptops. The technology adopted, 802.11 B/G/N at 2.4 GHz and 802.11 A/N at 5.8 GHz has a broad existing user base and available devices that employ one or both of the 802.11 standards. A 30-foot mast contains both wireless access points, the security camera and the proximity high intensity LED lights. A weather proof access panel in the front of the trailer contains ports providing the Ethernet, power and Power-over-Ethernet (POE) connections required for the mast mounted access points, camera and lights. Mast deployment is optional and is not required for operation of the wireless access points.

User devices such as cell phones that implement 802.11 can load an application enabling additional services. The application allows a secondary phone number to be assigned enabling inward and outward calling and messaging (SMS, MMS) when cellular service is unavailable utilizing the trailers Internet access provided over the commercial satellite link. (This does not preclude other wireless users from using a personal service like SKYPE to make VoIP based phone calls.) For STCP local services, hosting software on the STCP server provides the call management when the external satellite link is unavailable.

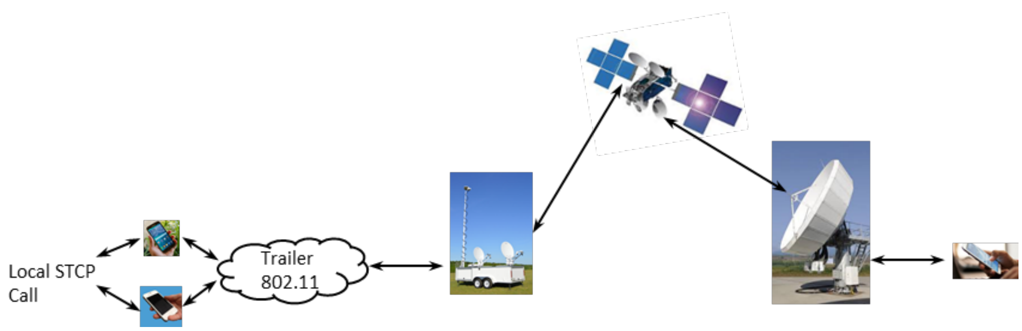

Figure 2. Cellular and Wi-Fi Connections

A number of different interfaces are required to provide the wired services. The wired data services provide the physical interface/connectivity (network) to not only the local users but also to the on-board systems, satellite equipment and wireless access points. For wired data and internet access 1 and 10 gigabit Ethernet over copper and fiber interfaces are supported. Digital and analog phone service is supported with analog supported over 2-wire FXS/FXO interface cards in the CISCO router.

Telephone services requires that VOIP be configured and setup for the FXS/FXO ports. An allocation of phone numbers are assigned and required for the FXS/FXO router ports enabling inward and outward calls over the public telephone network as well as local calling between users within the STCP private network. Local calling is supported utilizing software on the STCP server for call management enabling local calling that remains available when the external satellite links is down.

Data services, such as E-Mail, messaging, internet, streaming, file and image transfers, are provided wirelessly over the Wi-Fi access points and wired through the Ethernet ports. Multiple VLANs are possible and can be configured allowing prioritization levels for user and other traffic on the network. Users access the network utilizing their own devices that may include cell phones, tablets and laptops. The server within the trailer provides local storage of data and files, hosting of applications and centralized control and management of the on-board systems and devices.

IT and network administration ensures adequate levels of security are implemented and that regular maintenance is performed, protecting the trailer-based systems and networks, users and data files. Logs within the server provide a record of user access as well as user and system activities for identification of suspicious activities requiring further investigation and analysis.

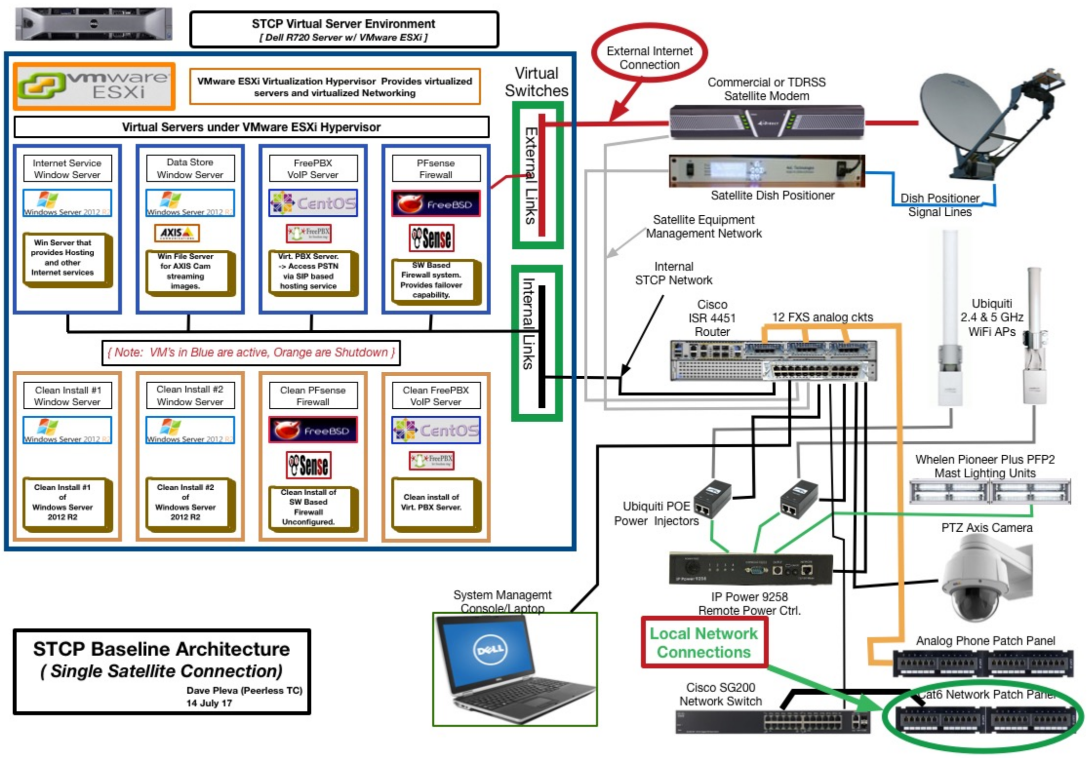

Figure 3. IT and Network Diagram

Satellite systems onboard the trailer provide remote communication services by providing connectivity for voice over the public switched telephone network, data and E-Mail over the internet or dedicated point to point services. The trailer currently contains two commercial systems including an Iridium and ViaSat modem as well as a government system which uses the Tracking and Data Relay Satellite (TDRS) system Ka-Band channels. Two 1.2 meter Ka/Ku Band satellite dishes are mounted on top of the trailer in a non-interference configuration allowing for simultaneous operation. Both dishes have positioner/trackers utilizing the patented AVL zero backlash cable drive system and AVL-AAQ Controller.

The commercial SatCom system provides 24/7 connectivity charging for data usage versus the more traditional time. Simultaneous users are supported over these satellites through use of narrow spot beams utilizing frequency reuse similar to the cellular community's approach. As satellite service providers shift from scheduling connection time to data usage billing, they must consider data prioritization/preemption ensuring more critical services are given access. These changes have increased the concurrent user base and capacity resulting in cost reductions and improved service to users.

The Ka-band TDRS augmentation addresses a limitation of the commercial system in providing limited uplink (outbound) throughput capabilities. TDRS resolves this limitation by providing a high throughput Space User Ka Band uplink, but has limited availability due to scheduled service competing with space users. Due to the limited number of TDRS satellites providing Continental US (CONUS) coverage, all NASA centers cannot be covered simultaneously. These limitations are why TDRS serves as an augmentation versus a replacement to the commercial SatCom system.

TDRS Ka-Band Link

While the VIASAT commercial link was a simple turn-key product, the TDRS link required characterization and testing before reaching full functionality. To accommodate interfacing with TDRS, the system on board the STCP Trailer uses a 1.2 meter offset dish antenna and polarizer to transmit and receive at the NASA Space Network government Ka-band: 22.55-23.55 GHz forward (FWD) command and control to the user and 25.25-27.5 GHz data return (RTN) link from the user. After passing through the polarizer, the signals travel to the diplexer where the transmitted and received signals are split. On the FWD link, the signal is amplified by a Low Noise Amplifier (LNA) and down converted before interfacing the zodiac modem set to interface at 1.2 GHz. The return signal is initiated in the modem, up converted, then passed through a Traveling Wave Tube Amplifier (TWTA) before reaching the diplexer, polarizer, and antenna feed. Figure 4 shows the described links in implemented and theoretical form.

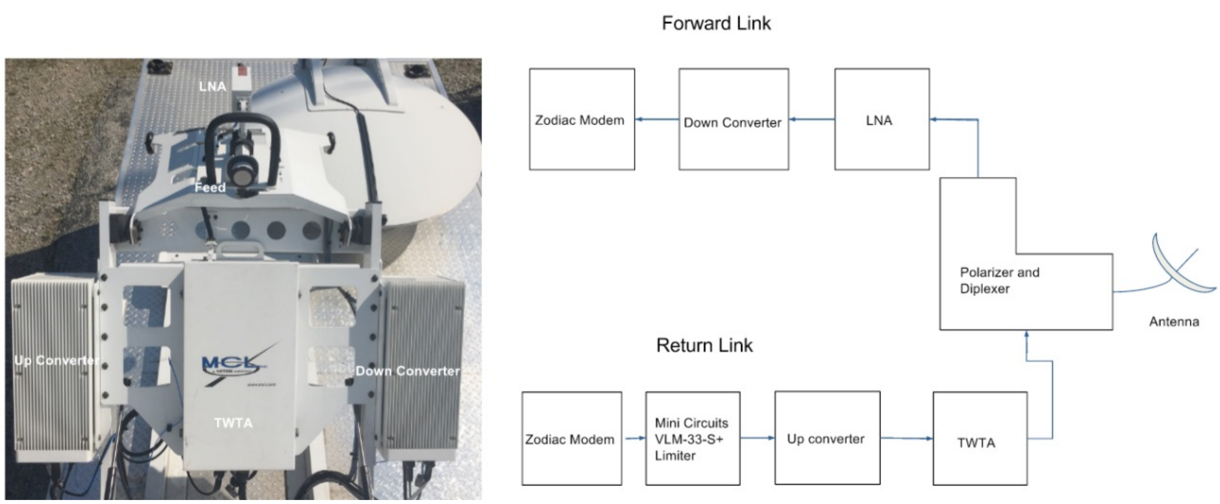

Figure 4. TDRSS RF System Diagrams.

Left: Photo of RF components. Right: Block diagram of Forward and Return Links

Before testing the behavior of the system, a link budget was created to analyze and track the expected power through the system given typical interface conditions with TDRS-12. Performance parameters used in the link budgets were first found using manufacturing specifications. These values were then verified with identical component testing in the lab, including the up converter, down converter, and LNA. The results from investigating the forward and return links by link budget are pictured below in Figure 5.

Forward Link from TDRS-12 to STCP		
Parameter	Value	Units
Power Transmitted from TDRS 12:		
TDRS EIRP	60	dBW
TDRS EIRP in dBm	90	dBm
Free Space Path Loss Between TDRS-12 and STCP:		
Frequency	22.7E+9	f (Hz)
Path Range	38.9E+6	r (m)
Wave length	13.2E-3	λ (m)
Free Space Loss	-211.36	dB
Power Through STCP System:		
Power incident on STCP	-121.36	dBm
STCP Antenna Gain	46	dB
Feed, Polarizer, and Diplexer Loss	-1.05	dB
LNA	60	dB
Coaxial Cable Loss	-7.88	dB
Down Converter	28	dB
Coaxial Cable Loss	-2.7404	dB
Mini Circuits VLM-33-S+Limiter	-0.19	dB
Power at Modem	0.78	dBm

Return Link from STCP to TDRS		
Parameter	Value	Units
Power Transmitted Through STCP System:		
Modem Power Output	-20	dBm
Cable (Microwave LMR)	-1.7918	dB
Up Converter	10	dB
Cable (Pasternack)	-1.8912	dB
TWTA	50	dB
Waveguide	0	dB
Polarizer and Diplexer	-1.05	dB
Antenna Gain	46	dB
STCP EIRP	81.267	dBm
STCP EIRP in dBm	51.267	dBw
Free Space Path Loss Between STC and TDRS-12:		
Frequency	26.5E+9	f (Hz)
Path Range	39.4E+6	r (m)
Wave length	11.3E-3	λ (m)
Free Space Loss	-212.83	dB
Power Received at TDRS-12:		
Power at TDRS in dBm	-131.56	dBm
Power at TDRS in dBW	-161.56	dBw

Figure 5. SCTP Link Budget

After these initial steps were completed, system level testing was performed on the forward link of the trailer. Applying a frequency sweeping signal generator directly to the LNA, the forward was characterized at various receive frequency settings, specifically 22480 MHz, 22930 MHz, and 23480 MHz. The maximum amplitude variation over a 50 MHz window for each of the system settings was 2.3 dB, 0.309 dB, and 0.607 dB, respectively. The graph below in Figure 6 illustrates the results from this testing.

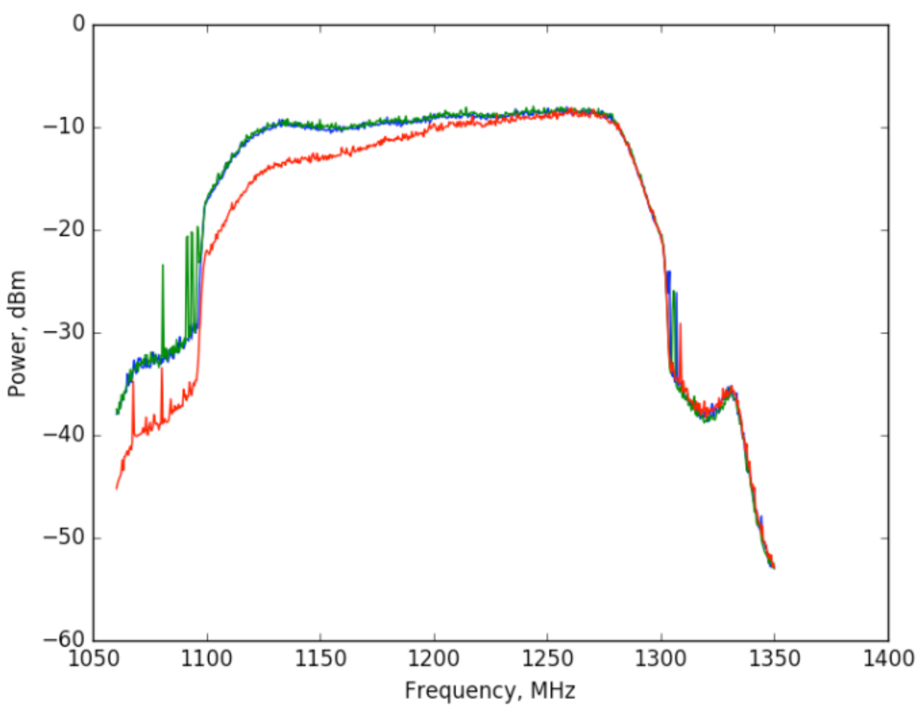

Figure 6. STCP Receive System Level Testing

Following the system level forward link characterization, a test with TDRS was arranged to provide an opportunity to peak the antenna on board the STCP trailer and to completely characterize the losses/gains through the system. The objectives of the tests were to verify the utilization of the antenna pointing software controls and confirm the forward link budget created to describe the performance of the link. After successfully peaking the antenna, the signal was measured at -0.70 dBm with a noise level of -100.41 dBm/Hz. This fell within 2 dB of the link budget's prediction, which placed the signal at 0.78 dBm. The image below Figure 7 shows the signal analyzer reading of the TDRS signal after passing through the components in the forward link. With a tested SNR (signal to noise ratio) of nearly 100 dB (C/No: carrier to noise density) we have proved the system is capable of interfacing to the TDRS constellation and will have sufficient SNR to fully utilize the TDRS FWD link capabilities.

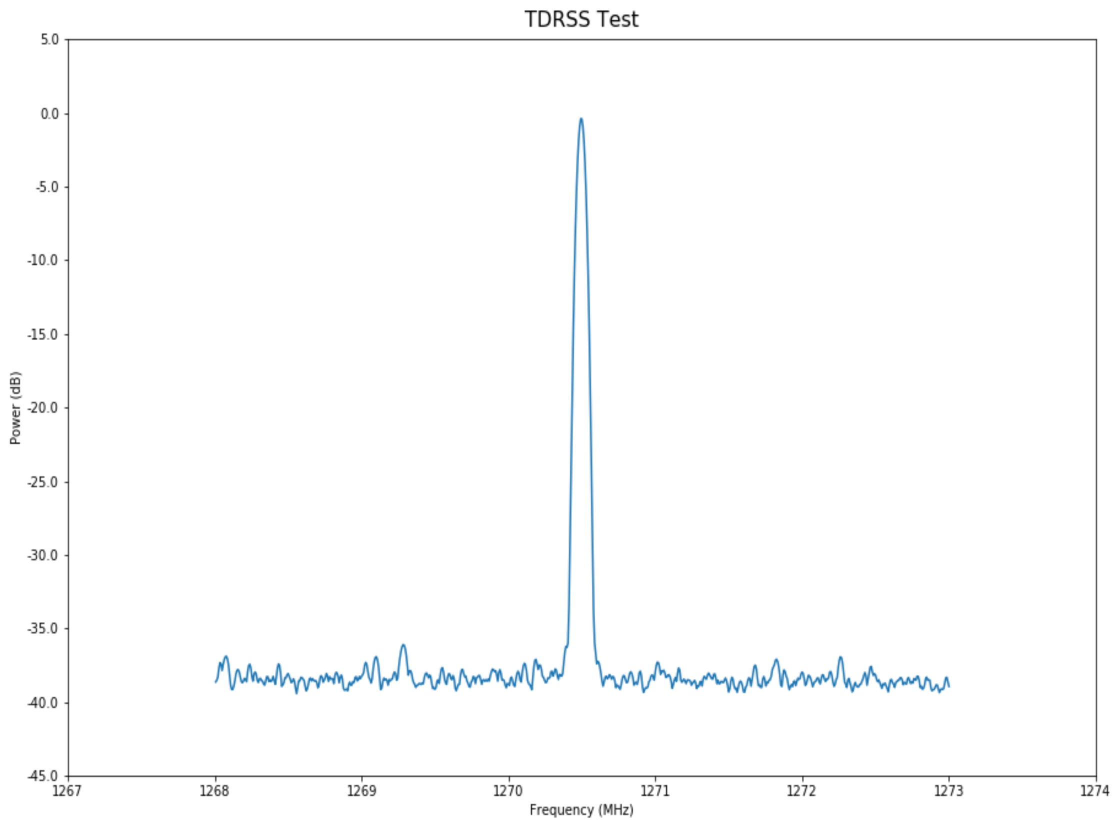

Figure 7. TDRS Signal Received by STCP

Signal peaked at -0.70 dBm with a noise level of -100.41 dBm/Hz

Summary/Conclusion

The emergency capabilities of the trailer were demonstrated during several security exercises. While the VIASAT commercial link was a simple turn-key product, the TDRS link required characterization and testing before reaching full functionality. A test with TDRS was arranged to provide an opportunity to peak the antenna on board the STCP trailer and to completely characterize the losses/gains through the system. After successfully peaking the antenna, the signal was measured and fell within 2 dB of the link budget's prediction. Testing showed that the system is capable of interfacing to the TDRS constellation and will have sufficient SNR (Signal to Noise Ratio) to fully utilize the TDRS FWD link capabilities.

Presently new requirements are being defined to evolve and upgrade the trailer to be a backup for the Near-Earth Network (NEN) Stations for the launch of EM-1.