ADVANCED ARMOR

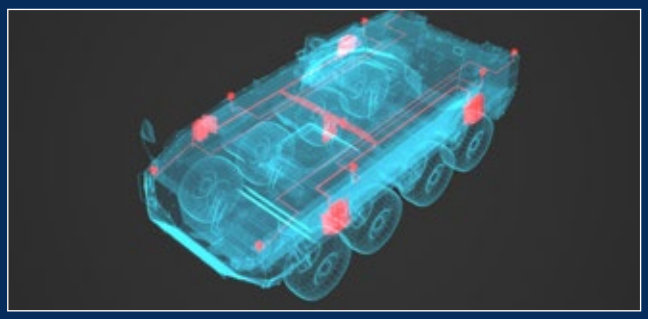
PROTECTING WARFIGHTERS

Protective Fabrics
Outdoor Fabrics
Advanced Composites
Advanced Armor
Geosynthetics
Grass

TenCate
materials that make a difference

TENCATE ABDS™ SENTINEL X
IED & blast protection

TenCate ABDS™ Sentinel X



TenCate ABDS™ Sentinel X is an active autonomous underbody blast threat protection system designed to significantly mitigate the injurious and deadly effects of imparted mine blast impulse energy on a ground vehicle and its occupants. The system has proven effective on a range of platforms in full scale live fire tests and this TRL6 technology is validated by TARDEC and endorsed by MCoE. TenCate ABDS™ is platform agnostic and has the potential to enhance survivability on any blast resistant platform; wheeled, tracked, combat, tactical or amphibious.

ABDS employs common physics to counter dangerous mine blast effects by instantly generating "recoil" to create carefully timed and strategically placed "synthetic weight" on the stricken platform. As a result, a platform will temporarily appear much heavier than it really is ("Synthetic Mass") and act accordingly against the upward impulse forces. Recoil is produced by externally mounted countermeasures that are only deployed if the processor algorithm concludes that a threat is authentic.

The countermeasures are compact, lightweight, modular (bolt-on / off & plug-n-play) Line Replaceable Units (LRUs) designed to permit a vehicle platform to easily regain valuable SWaP (payload) when the perceived underbody threat is reduced. The electronics package is also comprised of modular LRUs and can remain in situ, sans countermeasures, without any penalty. In addition, the electronics portion of the system can be utilized to independently activate various other lifesaving survivability equipment such as airbags, emergency egress lighting, active flooring and seats or harness pre-tensioners, etc.

System Performance

Specific system performance depends upon several factors including vehicle characteristics, integration complexities and desired level of threat protection. Countermeasures possess a standard configuration but can be tuned in a number of ways. The same is true of the algorithms residing within the processor. The processor also has additional capabilities including multiple independent command and control channels with numerous input/ output options. In terms of "Mass Efficiency", the ABDS system can yield enhanced performance with orders of magnitude exceeding the equivalent of adding 10-12 times the ABDS system mass in traditional passive armor materials. In the contemporary requirements environment, threshold protection will most likely be addressed with traditional passive means. However, ABDS Sentinel X can deliver objective, and greater, levels of threat protection at a fraction of the weight of today's typical armor, belly plate and flooring materials.
ABDS, in conjunction with threshold protection level vehicle designs, has demonstrated significantly improved threat protection levels for occupants and these can often meet or exceed objective threat protection targets. A large contributor to this attractive result is due to the ability of ABDS to aggressively mitigate deadly launch acceleration, reduce jump height and violent flight, eliminate end rotation and flip and to soften brutal slam down.

Reduced compression, head and neck injuries, flailing, punctures, blunt traumas and especially compound injuries as well as faster recovery and enhanced mission readiness are the obvious and intuitive yield. Therefore, it is safe to assume that ABDS can deliver enhanced blast threat protection at a fraction of the weight of alternative means and do so without compromising payload and mobility. Modelling and simulation will predict these metrics (Platform Evaluation) and a full scale live fire blast test series on a representative platform will confirm (Validation). In typical use, Sentinel X will be activated at the start of a mission and a self-diagnostic protocol will confirm operational status. The operator does nothing else until the mission concludes. Once activated, ABDS sensors continuously gather data as the processor reviews. If the data suggests a blast event has occurred and is significant enough to endanger occupants, the processor will then calculate a response and direct the countermeasures to react.

The ABDS system will not respond to "smaller" events such as anti-personnel mines, grenades, pot-holes and tall curbs, etc. Relative to a false trigger event, the ARMY Fuze Safety Review Board (AFSRB) approval includes statistical metrics with which the system complies and testing has been performed to confirm that false trigger represents no significant threat to a crew.

Armor Requirements
TenCate recommends that externally mounted hardware should be armored to the level of the vehicle. As such, TenCate has developed a generic passive armor cover to provide protection for the countermeasure and interface electronics. Once vehicle integration and requirements are identified an optimized cover can be designed. TenCate maintains a library of qualified passive armor solutions to service most contemporary passive armor requirements.

System Safety
TenCate employs a rigorous safety program: IAW Mil-Std-882E. System and software safety are major considerations for ABDS, which is designated as Hand Emplaced Ordnance and thus meets Mil-Std-1911 requirements. System & Software Safety tasks are documented in the System Safety Program Plan, which identifies system safety processes to ensure proper management of all hazards encountered throughout ABDS life-cycle. Hazard analyses, such as PHA, SSHA, FMECA, FTA, FHA and documents, such as SSPP, SwSPP, SAR are just a few of the elements developed to support our safety program. The TenCate ABDS Sentinel X system has been reviewed by the Army Fuze Safety Review Board (AFSRB) and the ARMY Insensitive Munitions Board (AIMB).

System Maturity
TenCate ABDS Sentinel X technology is TARDEC validated as TRL 6. The current system has been under evaluation by TARDEC within a joint RDECOM CRADA since 2012. The system has undergone system and subsystem tests to confirm and validate the technology at US government labs, OEMs and foreign agencies and has recieved a formal letter of endorsement from MCoE. The hardware configuration utilized in this testing has been consistent since 2012 and unit production is well in excess of 100 countermeasures.

In addition to performance testing, the system has undergone durability testing while mounted in situ on a vehicle negotiating the Nevada Automotive Test Center (NATC) Marine Corps course and the ABDS Sentinel X system and components have undergone a wide spectrum of durability and environmental tests to meet Active Protection, Vehicle and Safety standards.

TenCate System Advantages over Other Blast Protection Solutions:
Lightweight – ABDS provides a weight efficient solution that does not challenge mobility or payload when compared to equivalent traditional passive armor blast threat protection.
Easy Integration – ABDS is supplied as a bolt-on kit which does not require large, time consuming and expensive structural changes. Ideally, ABDS will be integrated in initial design phases.
Reduction of Secondary Events – Reducing overall impulse into the vehicle reduces initial accelerative loading as well as subsequent injurious events such as flailing in flight, compounded injury during slam down and reduced propensity for rollover. Injuries associated with launch, flight and slam down are mitigated. Crew and vehicle mission readiness and recovery time is improved while enemy ambush exposure is minimized.
Fast – The ABDS system has proven itself fast enough to reduce a range of injuries from head, neck, spine and lumber too the extremities (including lower tibia on some systems).
Modular / Non-Permanent – Unlike traditional passive solutions, ABDS countermeasures are designed for quick, easy, installation and removal as field circumstances demand allowing a vehicle to retain full mobility and payload capabilities during periods of low threat.
Additional Capabilities – Once integrated, the electronics package can be independently utilized for additional functionality to include managing active survivability systems such as air-bags, autonomous automatic fire suppression, emergency egress lighting, active floors, active seats and harness pre-tensioning devices.
Future Vehicle Enabling – With ABDS, future vehicles could be made lighter and with lower standoff and side walls enabling vehicles to maintain greater payload, mobility and off-road capabilities and a lower propensity to roll.

VEHICLE ARMOR

ADD-ON ARMOR

TenCate add-on armor systems are lightweight and modular composite solutions designed to protect the vehicle crew against aggressive threats from armor piercing ammunition and fragments and projectiles from IEDs. The TenCate Liba® and TenCate Ceratego™ ceramic based armor systems are engineered for maximum protection/weight performance. TenCate Liba® can be repaired in the mission area and the system outperforms every other ceremic armor system in multi-hit resistance.

SPALL LINERS

TenCate lightweight and durable spall liners are designed to protect vehicle crews against projectiles and secondary fragments from overmatching threats as well as ensuring RPG cone reduction. The TenCate Armourtex™ spall liner systems are fiber based solutions designed to fulfill a long range of requirements for ballistic performance as well as secondary properties.

RPG PROTECTION

TenCate works with numerous protection solution companies and can provide tailored protection systems for military vehicles by including industry-leading protection solutions in the survivability system supplied by TenCate.

MODULAR ARMOR

Weapons stations and turrets are protected by precision-made modular armor kits maintaining system performance and operability. The protection systems can be customized to different threat levels specified by the customer.

3D COMPOSITE STRUCTURAL ARMOR

TenCate 3D Composite Structural Armor technology replaces existing steel components with one-piece composite solutions. The technology combines structural and protection properties offering significant weight reductions and increased vehicle operability. It can replace doors, hatches, ramps, hoods and other components.

3D COMPOSITE SOLUTIONS

Optronics, periscopes and sensors are protected by lightweight 3D composite solutions that offer protection from a wide range of threats, while maintaining system performance and operability. The systems can be supplied as ready-to-install kits for new-build programs or fleet upgrade retrofit programs.

MINE AND BLAST PROTECTION

TenCate mine and blast protection systems are designed in close cooperation with vehicle manufacturers and strengthen the vehicle structure to withstand mines and IEDs under the wheels and vehicle center. The systems may be combined with the TenCate ABDS™ active blast countermeasure system to ensure the best possible protection for the vehicle crew.

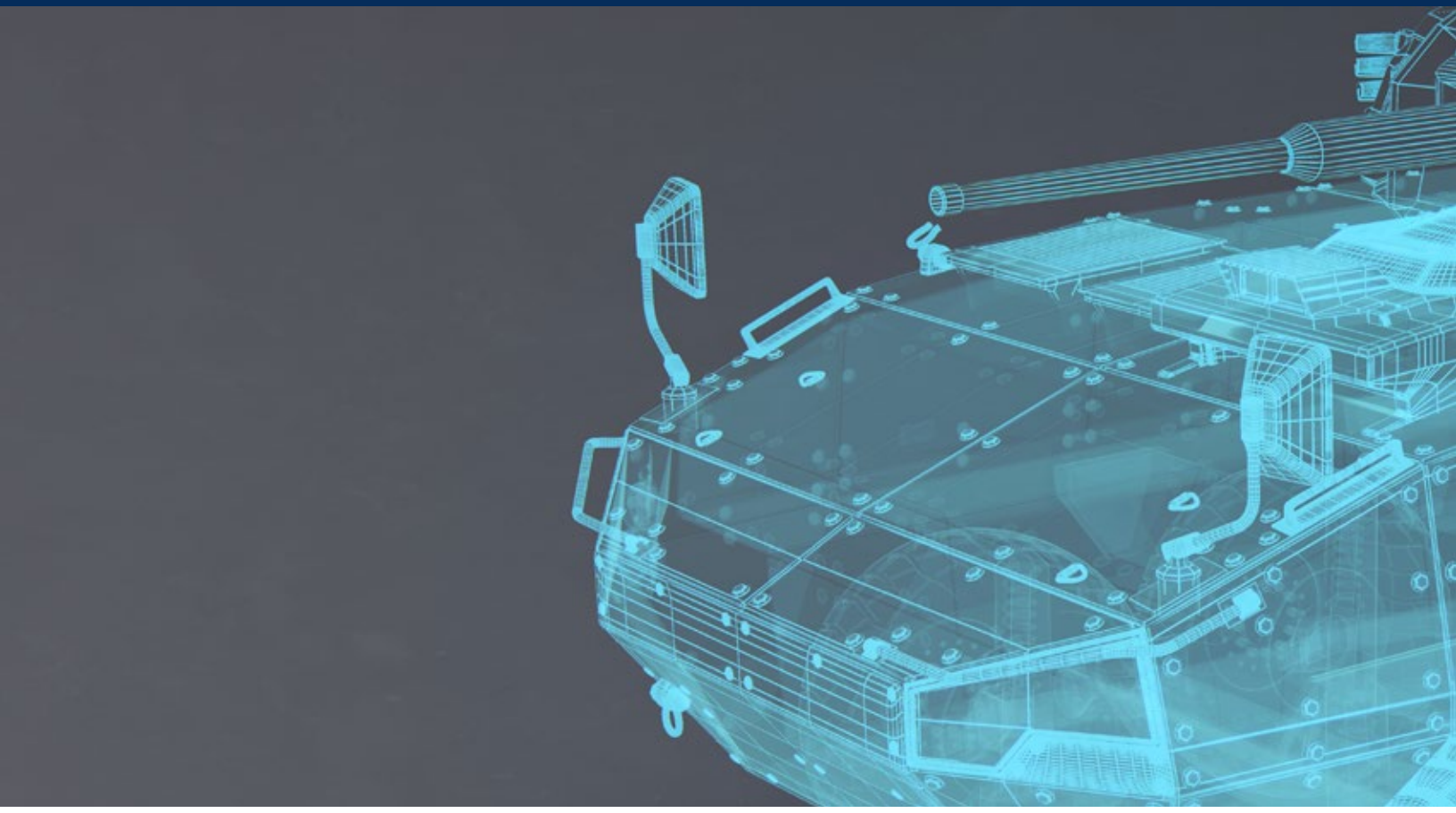
Survivability Engineering Services

TenCate Advanced Armor Design features a staff of highly experienced engineers and program managers to support ABDS and Survivability Solutions Design. Typical tasks to support ABDS evaluations and integration include:

Vehicle Integration with Requirements and Trades Consideration
TenCate has a staff of engineers familiar with integrating equipment such as up-armor packages, turret systems and active protection systems onto military vehicles. TenCate understands the importance and difficulty of designing and implementing with vehicle requirements in mind. With nearly a dozen ABDS platform integrations successfully executed no one is better equipped to integrate an active blast system onto a ground vehicle.

Prediction of System Performance
TenCate uses a variety of FEA tools to predict system performance, performance improvements and to guide system integration. LS Dyna is employed to model vehicle structure and simulate the threat event. With this methodology TenCate yields accurate and consistent predictions that match live fire test results and ATD performance expectations.

Definition and Coordination of System Testing
TenCate employs a seasoned staff that is intimately familiar with programming and executing live fire blast test events. This Team can define and assemble safe, thorough and efficient test plans, identify and recommend test labs and facilities, and arrange and execute full scale testing.

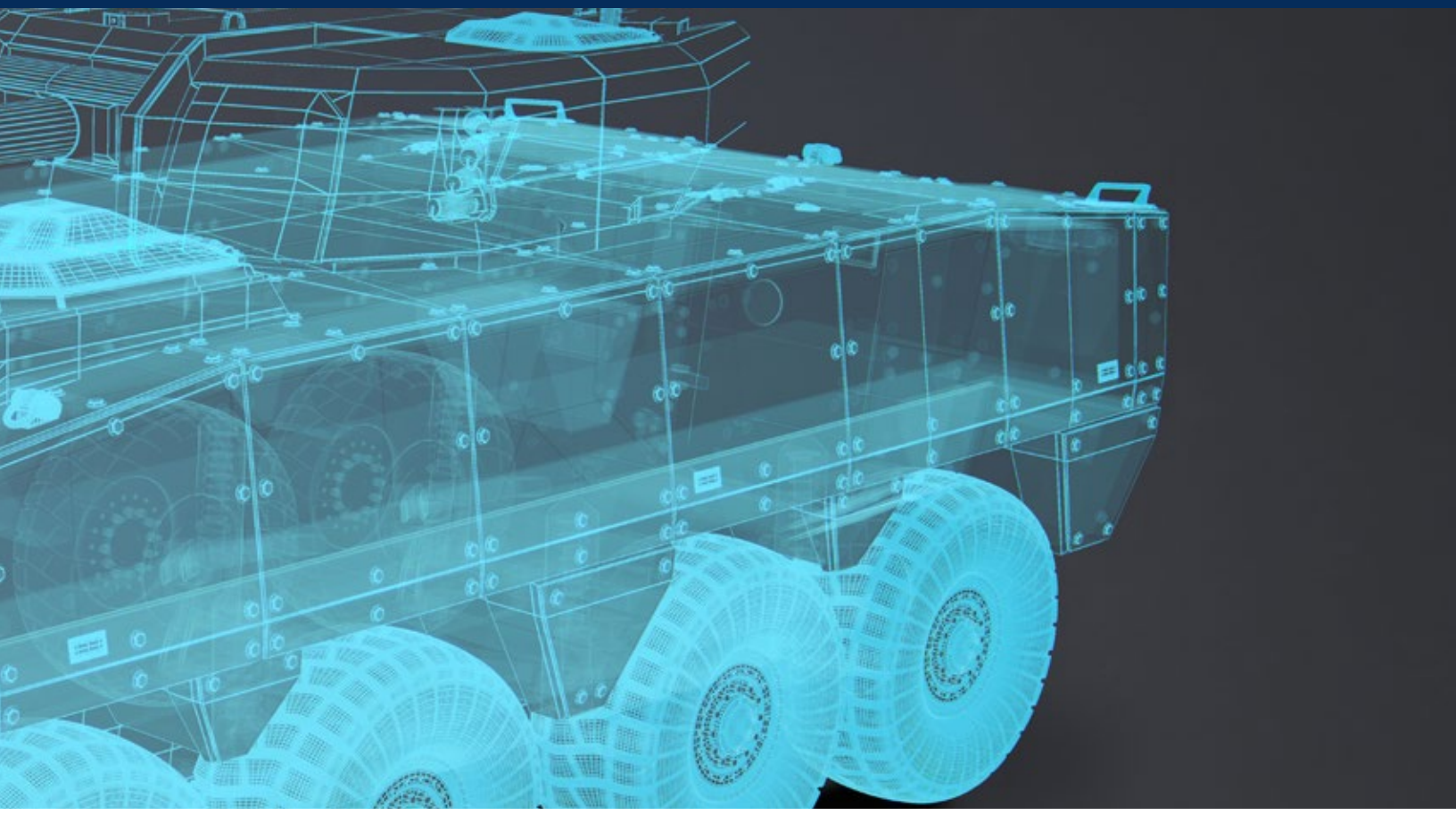


Data Analysis and Reporting
TenCate offers a variety of services relating to data acquisition, collection, evaluation, comparison, interpretation and reporting.

Additional Safety System Inclusion
While ABDS Sentinel X focuses on improving survivability by reducing imparted blast impulse energy into capsule, cargo and crew, we recognize that the introduction of additional survivability safety systems may further improve occupant survivability.

TenCate can identify and investigate potential structural modifications to limit deflection or increase performance by, for example, reinforcement or reconfiguration of an area or isolating the occupant. In addition, other active systems (which can be controlled by the ABDS processor) can be investigated such as seatbelt pre-tensioners, airbags and specialized emergency event communications.

If it involves underbody blast, TenCate is an excellent partner and resource. TenCate's unique and intimate knowledge and experience with active blast is complimented by extensive skill sets to include design, modelling and simulation, clearances and secure facilities, interpreting and achieving vehicle requirements, prototyping, testing and familiarity with a variety of platforms. Think of TenCate Advanced Armor Design as a flexible and convenient extension of your own internal ballistic and blast protection engineering resources.



AIRCRAFT ARMOR

TRANSPARENT ARMOR

TenCate can integrate and provide solutions for transparent armor for the cockpit in order to further enhance the survivability of the flight crew as well as enhancing the overall operability of the aircraft.

SEAT ARMOR

The armor kits for pilot and co-pilot are designed as modular systems, integrated in the aircraft design for optimum protection without limiting the operability of the equipment.

3D COMPOSITE SOLUTIONS

Complex 3D shaped, one-piece composite parts are designed to provide protection for special areas of the aircraft with a minimum of weight added.

RADAR-TRANSPARENT PROTECTION

TenCate can precision-engineer radar-transparent protection solutions for radar and sensors, based on the latest material technology. These solutions have special functionalities ensuring full protection and system performance.

3D COMPOSITE SOLUTIONS FOR PROTECTION OF THE ENGINE

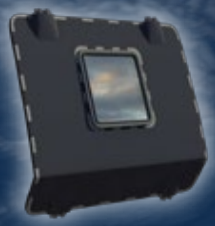
Protection for the engine is designed for extreme temperature performance and durability and consist of precision-engineered 3D composites.

DURABLE PROTECTION SYSTEMS

The TenCate protection systems are easy to install and dismantle and are tested for durability and stress resistance in order for the systems to withstand the everyday use in mission areas.

3D COMPOSITE STRUCTURAL ARMOR

For doors and other structural components, TenCate can design one-piece 3D structural parts, offering protection and structural properties in a lightweight solution, using the 3D Composite Structural Armor technology.



MODULAR ARMOR SYSTEMS FOR ALL AIRCRAFT TYPES

Protection systems for the cabin and cargo area of the aircraft are designed to be modular, easy to install and dismantle and to be able to withstand ballistic impacts, vibration, shock, UV radiation, chemicals and fire. Furthermore, anchor points and interfaces are duplicated so that the installation of armor panels does not impair the installation and functioning of auxiliary equipment.

NAVAL ARMOR

TACTICAL NAVAL SHIELD

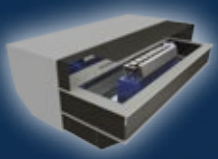
TenCate Tactical Naval Shield offers protection to personnel operating small-caliber guns. It is a rapidly deployable system that can be installed and dismantled by two crewmembers in 5 minutes without the use of tools. The shield can be customized to a wide range of threat levels depending on customer requirements.

LIGHTWEIGHT ARMOR

RHIBs, fast patrol boats and interceptor crafts can be protected from small-arms fire by super lightweight panels with special functionalities and properties, designed to fit the customer requirements and vessel specifications.

MODULAR ARMOR SYSTEMS

The TenCate armor system comprises interchangeable panels and protects against the effects of blasts, fragments and projectiles. The armor panels are integrated into the ship design and are resistant to fire, chemicals, vibration and shock, protecting both the crew and vital equipment.



MODULAR ARMOR

TenCate armor panels for protection of radar towers are modular and lightweight and are designed with system performance and vessel center of gravity in mind. These lightweight armor systems are designed in close cooperation with the ship builders to protect vital equipment against the effects from a wide range of weapons.

RADAR-TRANSPARENT PROTECTION

TenCate can precision-engineer radar-transparent protection solutions for radomes, based on the latest material technology. These solutions have special functionalities ensuring both full protection and system performance.

MODULAR ARMOR SYSTEMS

Mission-critical areas of the ship such as bridge, control rooms, ammunition storage etc. are protected by lightweight and durable modular armor systems that ensure survivability for the crew and important equipment.

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Global capability in lightweight armor solutions

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