

TORNADO's and Further Planning



TORNADO IDS (Interdiction Strike).

Photo: Authors

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In 1967 several NATO user nations joined together to plan in concurrence a multipurpose combat aircraft as a successor for the F-104 STARFIGHTER. The objective of the remaining nations to the agreement at the beginning of the project definition phase in 1969 – Italy, Great Britain, and Germany – was the development and production of a two-seater Multi-Role Combat Aircraft (MRCA) capable of performing the roles of conventional and nuclear air attacks, reconnaissance, and antisurface warfare.

To be able to effectively counter the threats posed by the Warsaw Pact at that time by means of forceful air defence and an enormous offensive potential, the main attention was focused on a high robustness and survivability of the aircraft. The operational requirements were realized with the capability to conduct extreme low level flights with automatic terrain contour flight control techniques (nap-on-the-earth flights) to minimize the exposure time vis-à-vis the enemy air defence combined with effective self-protection equipment and the capability for precise weapon delivery in all weather and visibility conditions. The result produced by the tri-national European development was the TORNADO aircraft which had made its maiden flight in 1974 and which was delivered to the armed forces of the contract nations and Saudi Arabia from 1980 onwards and which has been in service since then in various roles and variants.

The delivery of the TORNADO's to the Bundeswehr began in 1981 and was completed in 1992. The number of aircraft delivered totaled 357. The Bundeswehr has meanwhile conducted more than one million flying hours with these aircraft. The German TORNADO fleet is composed of the basic version fighter bomber TORNADO IDS (interdiction strike) and the TORNADO ECR (electronic combat and reconnaissance) which was subsequently developed based on the requirement of the Luftwaffe (German Air Force) and which is specialized for suppressing enemy ground-based air defence. The TORNADO IDS was also taken as a basis for the reconnaissance version of this aircraft. The sensor systems for imaging reconnaissance are carried in a container, the so-called recce-pod, under the fuselage. The multi-role design and the way of the execution of the task in previous and present missions have turned the weapon system into an essential and

indispensable capability platform of the German Air Force.

TORNADO – Mainstay of the Employment of the Luftwaffe

The TORNADO's of the Luftwaffe were employed in the mission roles of reconnaissance (RECCE) and suppression of enemy air defence (SEAD) for the first time in the Balkans as from 1995. In the course of the mission, which lasted until 2001, the 1st Tactical Air Wing of the Luftwaffe activated and stationed at Piacenza/Italy conducted more than 7,000 sorties with the TORNADO aircraft. The results of the tactical air reconnaissance have decisively improved the target selection and have thus clearly contributed to the success of the campaign.



TORNADO ECR (Electronic Combat and Reconnaissance).



TORNADO RECCE (Reconnaissance) in Mazar-i-Sharif.

After the failure of a political solution to the Kosovo conflict, the Bundeswehr participated with the 1st Tactical Air Wing of the Luftwaffe in 1999 for the first time since its inception actively in combat missions within the scope of the Operation “Allied Force“. Here, primarily the ECR TORNADO’s with their unique sensor systems in combination with the guided missile HARM (High-Speed-Anti-Radiation-Missile) contributed with 438 sorties considerably to the protection of the allied forces.

The positive experiences gained in the missions in the Balkans were, among other things, a base motive for the ISAF commanders in Afghanistan to also request the provision of the capabilities of the RECCE TORNADO’s for ISAF operations. Based on the resolution of the German Bundestag (Lower House of Parliament) of 9 March 2007, six TORNADO RECCE aircraft have been stationed at the operating air base at Mazar-i-Sharif in northern Afghanistan since 5 April 2007 with the task of conducting imaging reconnaissance and air surveillance. Since then the RECCE TORNADO’s were able to successfully reconnoiter far more than 10,000 objects in the whole of Afghanistan with almost 4,000 sorties flown. On the basis of an all-round and up-to-date picture of the situation it was thus possible to make a valuable contribution to the protection of the military personnel from Germany, Afghanistan, and the partner nations and of the civilian aid workers employed in the country as well as of the Afghan population.

In addition to periodic assignments of air attack and/or SEAD modules to the rapidly established NATO Response Force (NRF), the Luftwaffe permanently provides with the IDS TORNADO aircraft as a continuous mission task the platform for nuclear role share as a sign of alliance solidarity and for ensuring its say in NATO’s nuclear planning.

Integration into the “Reconnaissance-Command-Effect” Pool

In the course of the transformation of the Bundeswehr the operability of the armed forces

needs to be consistently advanced and geared to the newly weighed task spectrum. Future missions are neither possible to be restricted with regard to their intensity nor in geographical respects so that it was necessary to cover a large mission spectrum ranging from evacuation operations via the projection of the political intent up to peace-enforcing missions. The consistent orientation towards the most likely missions requires a quantitative improvement of the effectiveness in missions with higher operational flexibility, effect-scalable armament, and increased sustainability. Mission experiences of the past years give proof that air forces without precision-fire, stand-off, all-weather, and night-vision capabilities, respectively, as well as networking capabilities play an only secondary role in multinational operations. Equipping with interoperable command and control means is mandatory to be able to effectively contribute to a joint and combined operation.

Mission modules based on the TORNADO weapon system provide comprehensive capabilities for tailored-to-mission effects from the air against targets in the overall system of the enemy on the ground and at sea. Here, the support by electronic warfare means as well as the suppression and destruction, respectively, of modern enemy air defences are necessary to ensure adequate robustness. For joint and combined reconnaissance and intelligence collection the Luftwaffe makes with its airborne platforms a decisive and indispensable contribution to the operability of the Bundeswehr. A comprehensive assessment of the situation re-

quires up-to-date, detailed, and meaningful reconnaissance images. Supply of information through the “intelligence pool” allows precise target planning and target allocation and thus contributes to information superiority. On the one hand, the almost instant and secured data exchange with the flying platform allows an in-flight change and/or prioritization of the selected targets and, on the other hand, it is an essential prerequisite for engaging time-critical and mobile targets. Moreover, this link allows feedback transmissions of engagement results and consequently contributes to effective and efficient follow-up planning.

The capability for Network Enabled Operations (NEO) is required cross-sectionally, comprising all capability categories. Especially by a goal-oriented transformation from information superiority to command control and effect superiority it is possible to bring the characteristics of air warfare means like swiftness, range, flexibility better to bear. This requires a (near) real-time integration of the platforms into a communication pool.

Supplementary to this it is necessary that the flying platforms be equipped with precise, high-resolution and long-range sensor systems for navigation, target acquisition, and identification to allow them to optimally use the respective armament by taking account of the effective Rules of Engagement (ROE). In addition, the sensor systems are also to support the engagement of targets, which are time-critical, not preplanned, and mobile.

Thus, an enhancement of the operability conceived for a medium to long-term use of the TORNADO weapon system requires, among other things, armament-technical measures that serve the further integration into the “reconnaissance-command-effect” pool. Only in this way will it be possible in a dynamic and complex operational environment to transform information superiority into effect superiority.

Measures to Improve the Operational Capability of the TORNADO Aircraft

With the adoption of Air Force Structure 6 the TORNADO fleet is going to be reduced to



TORNADO with Laser Designator Pod.



TORNADO as Test Platform for GBU-54/BLJDAM.

85 aircraft in the coming years, and part of the capability spectrum will be transferred to the multirole-capable EUROFIGHTER. This numerical downsizing allows a reduction of the number of necessary measures to extend the in-service period and consequently substantial cost savings. The remaining aircraft will be adapted to the current and future challenges by extensive programs for adjusting and maintaining the combat efficiency.

Outphasing, Removal/Re-Use of High-Quality Parts, and Extension of Service Life

A large portion of the TORNADO fleet has reached the end of the service life, which was originally conceived for 4,000 flying hours. The aircraft that are not going to be disposed of will get an extension of their service life by appropriate technical measures within the scope of a "Service Life Extension (SLE) of Functional Equipment" program. It essentially comprises the exchange of service life-limiting components for the purpose of extending the qualification and type certification to 8,000 flying hours. With the so-called SLE engine it is possible to reach an extension of the qualification and type certification from 3,000 to 7,500 engine life hours through the replacement of so-called "hot parts" within the scope of the conventional engine maintenance.

An outphasing plan was devised on the basis of the state of construction and configuration, the maintenance costs to be expected, and the extent of the damage to the airframe. High-quality parts are removed from each aircraft to be decommissioned to save money and to stabilize the spare part supply with high-quality parts. This measure ensures the long-term supply with spare parts through stockpiling and a reduction in the procurement of exchange items.

Modernization Programs

Up until the full establishment of the multirole capability of the EUROFIGHTER the TORNADO continues to be the only combat aircraft of the Bundeswehr for air attack operations. By manned airborne tactical reconnaissance, suppression of enemy ground-based air defences, maritime warfare from the air with guided missiles, and the share in the nuclear role the TORNADO is to cover a broad capability spectrum until at least 2025. Against this background it is important to adapt the efficiency and coalition capabilities of the TORNADO to the current mission environment.

For the implementation of new capabilities the TORNADO's of the Luftwaffe are subjected to several retrofitting programs, which are linked to the cyclic adaptation of the avionics system software (Avionics System Software Tornado in Ada/ASSTA). The first modernization package comprised, inter alia, the integration of the TAURUS modular stand-off weapon, the laser-guided precision weapon GBU-24 (Guided Bomb Unit-24), and the LITENING TOR III

laser designator pod. The accuracy of the aircraft's position sensing was significantly increased by the installation of a laser inertial navigation system (LINS) combined with a GPS. At present, the 85 TORNADO's are being modernized in a second package with comprehensive measures to adapt the combat efficiency "display concept" and to maintain the combat efficiency "electronic warfare".

Improvement of the Air Attack Capabilities

The experiences and knowledge gained from the past missions have revealed that all-weather capability and hit accuracy are of great significance for the success of a mission. The use

of precision ammunition reduces the risk of endangering friendly forces and decreases the probability of an unintended damaging or destroying of civilian objects or even the damaging of uninvolved persons. The technological prerequisites for the integration of modern armament into the TORNADO's were created by standardized data bus connections to the weapon stations and by a modern GPS-LINS system.

Laser Designator Pod: The marking of a target with a respectively configured laser designator is a precondition for the employment of laser-guided ammunition. It is affected by either ground-based equipment or by airborne target designators. The laser designator pods of the Luftwaffe are presently being furnished with advanced hardware and additionally prepared for a future, cross-sectional use on the EUROFIGHTER. The most important innovations are the integration of an improved thermal imaging detection system (Forward Looking Infra Red/FLIR) and a new electro-optical camera system. An extension to full motion video capability, the transmission of the video image to a ground station in real time has already been realized.

GBU-24/GBU-54/B: With the laser-guided 1,000 kg bomb GBU-24 the Luftwaffe has for the Tornado's a precision weapon to engage high value and partly hardened targets. Because of the laser designation seeker head the employment of these weapons is not possible in all weather conditions. In these regards it became obvious that there is a need for an all-weather-capable precision armament with smaller explosive charges to reduce the endangerment of friendly forces and to avoid as far as possible any collateral damages. The integration of the Laser Joint Direct Attack Munition GBU-54/B with 250 kg active charge is presently under way. This munition allows engaging stationary targets in all weather conditions and, in combination with the laser target designator, to also combat mobile targets at short ranges. This armament will considerably improve the capability to provide close air support for ground forces as of 2012/2013.

TAURUS Modular Stand-off Weapon (MSW): With the introduction of the TAURUS MSW the Luftwaffe was enabled to precisely engage in cases of threat a broad spectrum of



TORNADO with RecceLite Reconnaissance



TORNADO with Navigator Head Down Display (NHDD) and Central Display Unit (CDU).

stationary targets at long distances (approximately 350 km). The target categories range from strategically important, heavily defended command posts up to tactical infrastructure of ground, air or naval forces.

Tactical Air Reconnaissance

Through an accelerated procurement procedure it was possible to introduce for employment in Afghanistan the RecceLite reconnaissance system within a period of just nine months. It was successfully employed for ISAF for the first time on 21 October 2009. With that, the Luftwaffe has at its disposal a reconnaissance system with highly sophisticated digital technology. The system consists of a reconnaissance pod which can be mounted under the aircraft as external load, a data link and evaluation station. The RecceLite can generate digital high-resolution imagery by day and night with the aid of infrared and electro-optical sensors and it improves especially the quality of the reconnaissance results at night in the infrared range. With RecceLite it is possible to automatically track both stationary and mobile targets. The high turn rates of the optics and the automatic target tracking of the sensors additionally allow the use of the system in the high velocity field as well as the full maneuverability of the TORNADO without any limitations in data collection. This contributes to an even better self-protection of the aircraft crew.

The encrypted tactical data link, the link between reconnaissance pod and ground station, allows transmitting images and quick image sequences to the evaluation stations in near real time. This allows much more up-to-date reconnaissance results and reduces the time needed for the processing and distribution of the information. The so-called "Change Detection" software is capable of comparing two pictures taken at different times with all the unchanged image information being filtered out.

This capability allows identifying e.g. earth movements or changes of the pavement, which can deliver decisive hints of possible improvised explosive devices (IEDs). This capability in particular contributes considerably to the protection of ISAF ground forces.

Enhancement of Robustness and Survivability

Combat aircraft must possess high robustness and survivability especially in complex mission scenarios. Robustness is a prerequisite for the transformation of information superiority into effect superiority. Here, high situational awareness of the aircraft crew is just as important as the availability of flexible, effective, active and passive self-protection equipment for use against a large range of possible threats by enemy forces.

Improved Display of Information in the Cockpit: The exploitation of the full efficiency of new sensors and effectors of the TORNADO requires an optimal processing of the information in the cockpit. The Luftwaffe must meet the increased demand made on the information management and the resultant requirements to display relevant information in prior-

itized ways. By a considerably improved display and distribution of the contents of the information and an optimized display/control concept the crew of the TORNADO will be enabled to comprehend, acquire and analyze the tactical situation both quicker and better. With the new displays for the front and rear cockpit it is possible to present digitally generated maps, sensor videos or system information. The central display and control unit for all relevant information needed for electronic warfare and self-protection completes the modern display concept. The situational awareness has thus been improved and the workload of the crew clearly reduced.

Modernization of Self-Protection Equipment: The measure "Maintenance of Combat Efficiency – Electronic Warfare" comprises the renewal of the sensor systems of the TORNADO aircraft as well as the computer-based processing and interpretation of the passively gained data of the electromagnetic environment. In addition to improved computer, control, and display elements it is intended to also install a new radar-warning receiver (RWR) as a component of the TORNADO Defensive Aid Sub System (TDASS). The development and procurement of a new dispenser for radar and infrared decoys (chaff and flares) as a successor system for the BOZ 101 is in the planning. A future dispenser system will have an integrated missile approach warning system, several dispensers as well as a clearly higher capacity of specialized deception means. A fully integrated TDASS will ensure the concurrent and mostly automated operation of all sensor systems and means of electronic warfare and thus relieve the crew on mission.

Improvement of the Coalition Capability

Since air campaigns are regularly conducted by multinational coalitions, the interoperability within the meaning of the capability for an unrestricted co-acting of the armed forces has been attached a central significance. Aside from standardized procedures, training and doctrine, the equipping of the aircraft with adequate technical communication means is an important contributing factor. Moreover, the unrestricted capability to conduct nighttime



MIDS Low Volume Terminal and the Link 16 Data Pool.



EUROFIGHTER

missions in present and future multinational air operations is an indispensable prerequisite.

Night Vision Capability: Meanwhile the night vision capability has become a standard in the equipment of combat aircraft not only in NATO. This fact has been coped with by the Luftwaffe through the establishment of the night vision capability for the TORNADO weapon system. It allows increasing the density of flight movements in a very confined space, to minimize the risk of collisions, and to better identify emerging threats. In addition, it serves to improve the picture and update of the situation as well as the situational awareness of the aircraft crew at nighttime.

An essential element for establishing the night vision capability is the flight helmet-mounted image intensifier goggles with acceleration-sensitive disengage in case of a bailout (emergency escape). To minimize the interference caused by light sources, the aircraft's exterior lighting as well as all illuminated control elements in the cockpit will be modified in a way to allow their luminous intensity to be dimmed down or to be switched off completely.

Tactical Radio Data Transmission: In the future for joint and combined operations, the data exchange for the picture compilation and update on the situation of friendly and enemy forces and the transmission of tactical command and control instructions will be predominantly effected by means of standardized data transmission interfaces. The access to primarily the Link 16 communication pool is thus an indispensable prerequisite for the integration of airborne weapon systems into multinational missions and command structures within the meaning of network enabled operations (NEO). For this reason the TORNADO's will also – aside from various other weapon systems of the Bundeswehr – be equipped with the MIDS (Multifunctional Information Distribution System) Low Volume Terminal (LVT), a jam-resistant digital message device (DMD) for the transmission of situation pictures and tactical messages in accordance with the Link 16 standard.

Voice Radio of the Future: The primary radio of the TORNADO aircraft will be re-

placed by a Second Generation Anti-Jam Tactical UHF/VHF Radio (SATURN). The integration of SATURN into TORNADO's is based on a NATO agreement and will ensure the jam- and interruption-free voice transmission in future. The new radio communication set is in conformity with the newer International Civil Aviation Organization (ICAO) standard for air traffic with a frequency channel selection of 8.33 kHz. In a second development stage there will be the possibility for an encrypted, secure voice communication and data transmission.

Future Importance of the TORNADO's in the Combine of Combat Aircraft

The TORNADO has proven well as a platform of the mission and as the German contribution to the NATO and EU air forces. The intention to employ the TORNADO weapon system as the only manned means for the tasks of airborne reconnaissance in the area of operations including over sea, the combating of surface forces with guided missiles, the suppression of enemy air defences and for performing its share in the nuclear role remains unchanged.

With the introduction of the multirole-capable EUROFIGHTER, the air attack capabilities will be gradually transferred to that weapon system. In doing so, already existing capabilities will be made available for the mission in a new quality and with partly new armament. A delayed or lower numbers delivery of EUROFIGHTER's than scheduled or the delayed availability of required functionalities would entail a longer use of the Tornado's to ensure the conceptually required capabilities. Potential deficits of the EUROFIGHTER weapon system would thus be possible to be compensated in part and over a limited period of time. This,

however, would necessitate the acceptance of additional costs.

Until the time the Luftwaffe is able to provide the planned sustainable mission modules with the EUROFIGHTER, the TORNADO will continue to be employed in the entire air attack spectrum. To that end, the modernized TORNADO's of the target structure will dispose of a broad spectrum of weapon and sensor systems which can also be flexibly incorporated into new scenarios and planning of the other Services. The ongoing modernization measures are equivalent to a substantial boost of capabilities. This turns the weapon system into a future-oriented capability in the hands of the joint, inter-service military planner, possibly up to the year 2025.

With the introduction of unmanned aerial systems (UAS) the Luftwaffe will dispose of completely new capabilities in the field of imaging reconnaissance in the depth of the theater of operations which will be beneficial for the armed forces as a whole. The special features of the UAS are their long endurance in the area of operations and the possibility of their making long-range transmissions of reconnaissance results in near real time. The mission experiences gained by NATO partners – particularly from stabilization operations – underscore that manned and unmanned systems can, primarily in the area of airborne reconnaissance, project respective capabilities in complementary missions. With the recently started fielding of the UAS HERON 1 the Luftwaffe expects synergistic effects to be produced in mainly the collection of reconnaissance data, evaluation, and surveillance of security-relevant areas.

Whereas the unmanned systems are capable to normally stay on task over a long period of time over a regionally confined area, jet-propelled aircraft like the RECCE TORNADO are capable of getting quickly from one area of operations to another and to reconnoiter even distant objects in shortest time. This will continue to be a strength of manned combat aircraft, which will, even in future, not be possible to be realized by UAS. To find a balanced mix of manned and unmanned aircraft is one of the conceptual challenges for the air forces of today and tomorrow. ■

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Unmanned Aerial System (UAS) HERON 1.