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# The Jeep at 70: *A Defense Acquisition Success Story*

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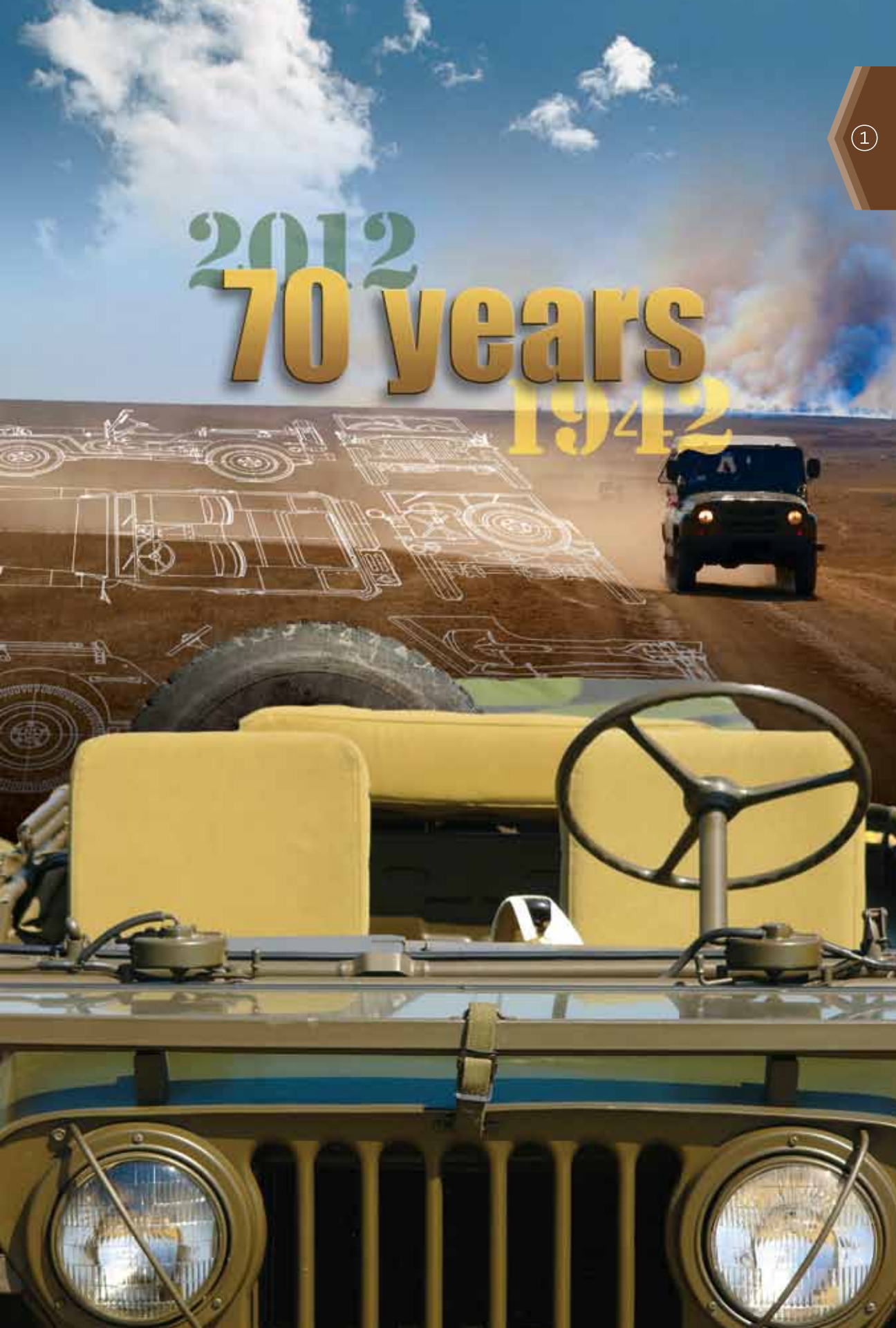
The successful development of the jeep during World War II (WWII) was a long process of requirements development, testing, and experimentation of small reconnaissance cars, and incorporation of lessons learned from WWI transport vehicles. The jeep prototype was initially developed by American Bantam Company, but later designs by Willys-Overland and Ford were also evaluated during the acquisition process. Changes in laws and procurement procedures also impacted execution of the jeep development program. Eventually, a single vehicle design was standardized and produced during the war, primarily by Willys-Overland, but also by Ford. The design of the jeep has endured as an acquisition success story. Lessons learned from the jeep development can still be applied to systems acquisition programs today.



*image designed by Diane Fleischer »*


2012
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The enormously successful vehicle we know today as the "jeep" was born out of requirements developed by the U.S. Army prior to World War II (WWII). From a small company and simple beginnings came one of the iconic symbols of WWII and arguably one of the most enduring automotive designs of all time. The successful development of the jeep demonstrates the need for requirements harmonization, and the mass production and longevity of the design demonstrates the application of thoughtful, long-range manufacturing planning. In this follow-up case study to the P-51 *Mustang* (Haggerty & Wood, 2010), we look at how the jeep design was created and what set it on the course to become the vehicle with the longest production run in U.S. history.

The overall requirement for the vehicle that became the jeep followed the demise of the horse as a method of military transport and reconnaissance. Following WWI, the world's armies focused their energies on the development of petrol-powered vehicles of all types. In the United States, the Army was interested in a vehicle that could replace both the horse and the motorcycle in the scout, reconnaissance, communication, and liaison roles as well as a vehicle large enough to carry the heavy weapons and ammunition required by infantry companies.

## Army Requirements Develop

The lean interwar years 1919–1939 were a time of experimentation in the new concepts of mechanized warfare. The Army was searching for a solution to its vehicle requirements during a time of dynamic change. Wars of the future would likely be more mobile than the trench warfare of WWI, and armies would require a wide range of mechanized forces. Initially, the Army's need was for a vehicle that would have a low silhouette, be able to carry a one- or two-man crew and a machine gun with ample ammunition. It had to have speed, toughness, and a useful payload. The vehicle also needed to have good ground clearance and cross-country mobility as it was envisioned that it would travel off-road more often than not. The Army sponsored limited evaluations of a number of existing light vehicles to find a suitable solution to its requirements. Several tracked vehicles were tried at Aberdeen Proving Ground, but they proved to be unsuitable. The Army even evaluated a radical two-man powered cart developed by Army personnel. The low-slung vehicle was equipped with a machine gun and nicknamed "The Belly Flopper." Although this

extensive experimentation and testing did not ultimately produce a vehicle for the Army, it served to refine the requirements for the light reconnaissance car.

In 1938 and again in 1939, the Pennsylvania National Guard used a few small open-topped sedans built by the American Bantam Car Company as utility vehicles during training exercises. Bantam specialized in small, inexpensive cars and they performed reasonably well in these evaluations. Based on the results of these exercises and using the Bantam design as a departure point, the Army solidified its need for a reconnaissance car. It took many of the ideas and design concepts that emerged from the various trials and demonstrations and merged them into a single set of general requirements (Denfeld & Fry, 1973).

At this point there was some internal disagreement within the Army regarding the management of the vehicle program. In the pre-WWII era, acquisition of transport vehicles was the responsibility of the Quartermaster Corps. Acquisition of tactical and combat vehicles was the responsibility of the Ordnance Corps; the new vehicle had the potential to fill several different roles, both tactical and nontactical (Rifkind, 1943). Although the vehicle was initially conceived as a general purpose commercial vehicle without armor, it had the potential to evolve into a vehicle that could serve in several roles in the combat forces. The Army resolved the situation by appointing an Ordnance Technical Committee to lead the program—headed by the Ordnance Corps, but with representatives from the Infantry, Cavalry, and Quartermaster branches (Denfeld & Fry, 1973).

The Ordnance Technical Committee was charged with developing a specification for the vehicle that would satisfy the needs of all the using branches. This required difficult compromises on specific vehicle features and characteristics desired by each branch. Committee members had to balance such needs as durability and cross-country capability with the desire for a vehicle that had a low profile, good fuel economy, and adequate carrying capacity. It was a challenge to synthesize all these needs into a vehicle design that was also affordable and producible. With much effort, eventually a single specification resulted in May 1940 and was forwarded to the Assistant Secretary of War for approval. The Quartermaster General directed the Motor Transport Procurement Branch to initiate purchase of the vehicle that would fulfill this specification (Rifkind, 1943).

## Detailed Specifications for the New Vehicle

The details of the reconnaissance car specification drawn up by the Technical Committee were as follows: The ¼-ton vehicle had to have 4-wheel drive, a maximum weight of 1,200 pounds, a useful load of 600 pounds, a maximum height of 36 inches, and a wheelbase of 75 inches. The body style was to be rectangular with bucket seats and a fold-down windshield. Performance requirements included a minimum top speed of 50 mph and a minimum sustained speed of 3 mph.

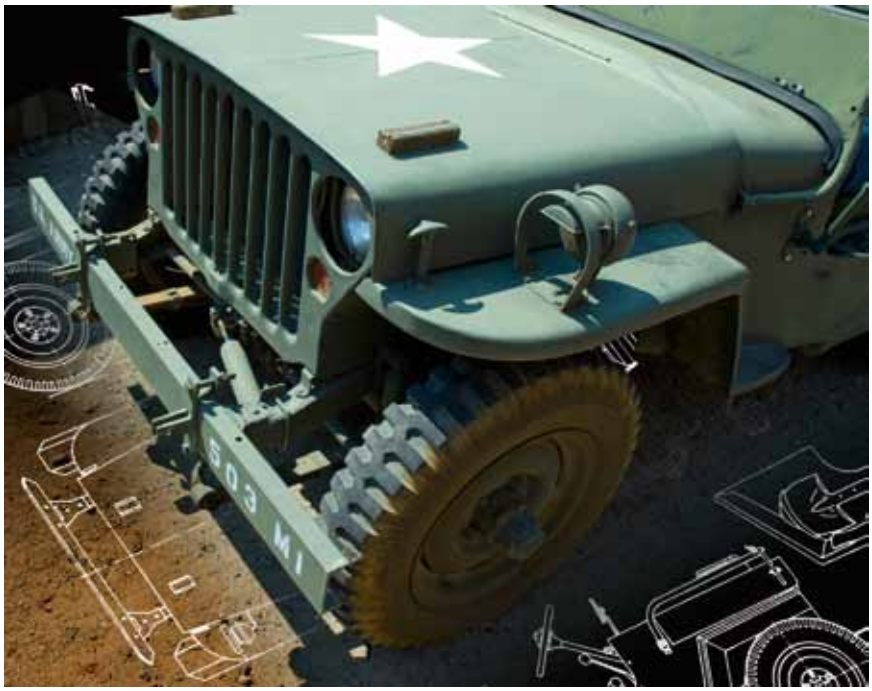
As soon as the requirements were formalized, a small group of Army officers and civilians visited the Bantam factory in Butler, Pennsylvania, to further test Bantam vehicles and discuss the concept of the new military car with the Bantam development group (Denfeld & Fry, 1973; Rifkind, 1943). The results of this meeting allowed the Army to continue to refine the specifications and even sketch a rough outline of what the new vehicle should look like. Thus, by working with industry the Army had arrived at a set of requirements that was simple, functional—and most importantly—achievable (Denfeld & Fry, 1973).

On June 27, 1940, the Ordnance Technical Committee issued its final recommendations for a ¼-ton, 4x4 truck. (The term 4x4 meant the vehicle had four wheels, all of which were powered.) The vehicle maximum weight was now raised to 1,300 pounds with a 600-pound payload, and the wheel base was increased to 80 inches (Probst, 1976; Wells, 1946; Vanderveen, 1971; Denfeld & Fry, 1973). To keep the design simple, the Army intended for manufacturers to use several common pieces of military vehicle equipment already available such as tail lights and towing pintles. The Army sent invitations to bid on 70 "pilot" trucks or sample models to 135 manufacturers. Bidding instructions mandated that the first pilot model should be delivered to Camp Holabird in Baltimore in 49 days. It was one of the first examples of "try-before-buy" ever used by the Army, which prior to WWII had been directed to purchase commercial off-the-shelf trucks almost exclusively (Thomson & Mayo, 1960).

As the vehicle development evolved, changes were also occurring in the way the Army acquired equipment. These changes were intended to help speed the process for procuring large amounts of materiel in the event of a crisis. Many in the U.S. Government feared war was near and such process changes would be required to get equipment to the field as fast as possible versus waiting for firms to submit bids. One of the most significant changes occurred in July 1940 when Congress passed Public

Law 703, which allowed the Services to negotiate contracts directly with firms of their own choosing rather than compete programs and award contracts to the lowest bidder (Thomson & Mayo, 1960).

Out of 135 companies invited to bid on the vehicle contract, only two submitted proposals: American Bantam and Willys-Overland Motors. However, only Bantam affirmed it could deliver a vehicle in the tight timeframe specified by the Army. Willys underbid Bantam on per-vehicle cost, but responded that they could not have a prototype ready for 75 days. On July 25, 1940, under the new negotiated procurement law, the Army and Bantam signed the contract for delivery of the pilot vehicles within the 49-day window (Denfeld & Fry, 1973).




## The First Jeep is Delivered

Like the NA-73X/P-51 story, the prototype machine that would eventually mature into the jeep was completed in record time. As Bantam engineers started work on August 1, 1940, they knew that meeting both the delivery date and the specifications would be extremely difficult. As the design solidified, it emerged that one requirement in particular—vehicle weight of only 1,300 pounds—would not be achievable in the short

term. But the Bantam team was experienced enough in the design of small automobiles to know that none of the other competitors could likely build a vehicle that size and that robust, which still fit into the weight envelope. Undaunted, they pressed on with their design. Working around the clock, Bantam completed the prototype and company executives drove the vehicle directly from the factory in Butler to Camp Holabird, its first long-distance trip. On September 23, they made it through the gate at Holabird with only 30 minutes to spare on their 49-day deadline.

The Bantam vehicle, as delivered, weighed in at 1,840 pounds and was powered by a 45hp Continental engine. Since the vehicle was able to successfully complete a series of strenuous tests at Holabird, the Army representatives believed that the maximum weight target could be reconsidered. Both the Bantam and Army engineers knew that as the design matured, strengthening the chassis and body for rough service would result in an increase in the vehicle empty weight. The addition of extra required equipment would also render the 1,300-pound target unrealistic. In lieu of a strict numerical weight objective, the Army performance objective was still for a few soldiers to be able to manhandle the vehicle should it get stuck in the mud, sand, or snow. Eventually, the Army accepted weight growth as inevitable as long as that performance requirement could be met (Wells, 1946). The focus then shifted to the automotive performance of the vehicle as more critical to its success than its weight. In some ways, the jeep development employed the modern concepts of evolutionary acquisition, incremental development, and systems engineering.

Since it was extremely satisfied with the prototype, the Army gave the go-ahead to Bantam to initiate production of the other 70 pilot vehicles based on that design, but incorporating some design changes and improvements that resulted from the early testing of the prototype. These changes were to improve both performance and reliability. The testing at Holabird was an early example of what we would call today Test, Analyze, and Fix or Reliability Development/Growth Testing. The first series of the improved vehicles were delivered to the Army in December 1940 and were known as "Bantam Reconnaissance Cars" (BRC).

While Bantam was moving ahead with the production of its truck, Willys was still in the competition for Army contracts. Both Willys' personnel and engineers from Ford Motor Company had been present when the Bantam pilot was delivered to Camp Holabird, so the company

had advanced knowledge of what the competing vehicle looked like. It even had the opportunity to make sketches of the Bantam vehicle. The Army later responded to charges that this represented unfair competition by saying that the pilot model was government property and that they wanted to make it available in order to develop multiple sources for production of the cars (Denfeld & Fry, 1973; Jeudy & Tararine, 1981).

Like the Bantam team, Willys' engineers also knew achieving or beating the maximum weight requirement specified by the Army would be difficult using existing technology. Using the Bantam pilot design as a starting point, Willys' designers set out to develop a car roughly fitting the other Army specifications, but incorporating an engine of their own design that they considered more suitable for the mission the Army had in mind for the vehicle (Denfeld & Fry, 1973). The Willys prototype arrived at Camp Holabird on November 11, 1940—also overweight at 2,400 pounds, but with a powerful 65hp engine. With the two prototypes in place, the Army decided its earlier weight goal should be revised upward, but it still kept a goal in place to force the industry to consider weight and weight savings as its designs matured.

A third bidder was also now in the race—Ford. The Ford Company had decided to enter the competition with its own small vehicle design incorporating an existing 46hp tractor engine. The lure of commercial business was too strong for Ford to stay out of the vehicle competition, and it was also encouraged by the Army to consider participation (Denfeld & Fry, 1973). All three companies now sensed that this rugged off-road vehicle concept had the potential to grow beyond a military application. No vehicle like it existed in the civilian world—"sport-utility vehicles" were decades away—and the promise of extensive commercial, particularly agricultural, sales awaited the company that could successfully secure the Army contracts. The Ford prototype, called the "GP," was delivered to the Army on November 23, 1940. The Army now had three competing designs to evaluate. This presented both a technical and a manufacturing challenge: how to select the best vehicle design for the mission ***and*** ensure that it could be produced in quantities sufficient for the needs of a world-wide conflict.

## Mass Production Dilemma

The key concern in getting the jeep design to the field was the issue of mass production capacity. Although Bantam had produced and refined the original design, the Army believed the small company was in no posi-

tion to produce the rate and number of vehicles the Quartermaster Corps believed they would need for wartime requirements (Thomson & Mayo, 1960; Jeudy & Tararine, 1986; Zaloga, 2005). During WWI, the Army had to employ a dizzying array of vehicles to meet urgent wartime needs and they wanted to avoid that in the future; thus, the goal of standardization underpinned the strategy for the Army vehicle fleet in the 1940s (Thomson & Mayo, 1960). Logistics planners did not want to repeat the problem of provisioning spare parts and support equipment for multiple vehicle types and multiple manufacturers.


One encouraging fact was that the designs of all three prototype reconnaissance cars were similar—a steel frame and sheet metal body. It was within the capability of each of the three manufacturers to produce them since they were in some ways simpler than the civilian passenger cars they were already building. The central issue was more one of production capacity than complexity, and there were a significant number of subcontractor components in each vehicle, particularly the drive train.

Bantam, even by its own admission, was on the ropes. Sales of its civilian vehicles were very modest—1,225 in 1939 and only 800 in 1940. By the time of the jeep design and competition, it had no operating capital and only 15 people in its engineering department (Domer, 1976). As a result, the Army looked on Bantam as high risk regarding its capacity

for producing the thousands of vehicles that would be needed for a global war. Army planners initially estimated they would need 11,800 reconnaissance cars by mid-1941 (Zaloga, 2005).

Consequently, Army acquisition personnel faced a significant dilemma—do they stay with the company that had successfully pioneered and built the vehicle they wanted, or abandon it in favor of a company or companies that could produce the quantity they would need (Thomson & Mayo, 1960)? Willys was a larger company than Bantam, but still not as large and well-resourced as Ford. The situation was further complicated by the fact that by the end of 1940, three viable yet clearly different design/prototypes existed from Bantam, Willys, and Ford. If only one was to be selected for high-rate production to meet the goal of standardization, which design would it be? All three vehicles had their own peculiar strengths and weaknesses, and no single design was clearly superior, but at least they all met the minimum Army requirements.

The Army decided to solve each problem in turn. First to be settled was the design issue, although the plan that resulted also had the secondary goal of surfacing potential production shortfalls. To move the design forward, a contract would go to all three manufacturers for 500 vehicles each. This quantity was thought to be sufficient for each interested Army branch to test the vehicles thoroughly in an operational environment and provide feedback on the competing designs. After some internal disagreements within the Army, this plan was revised to procure all 1,500 vehicles from Bantam on the grounds that only its prototype had met the first delivery requirement and had successfully completed all the initial testing, which the Willys and Ford models had yet to do. This plan was revised a second time in November 1940 to acquiring 1,500 cars with contracts to all three manufacturers, subject to approval of each company's prototype model. In consideration of the new procurement law now on the books, these were negotiated contracts not competitive bids (Thomson & Mayo, 1960).

All three manufacturers then set out to produce what in today's acquisition lexicon would be "low rate initial production" quantities. In the end, all three companies had trouble meeting delivery schedules because of a production problem at the Spicer Company, which was the source for the axles for all three vehicle designs. Indeed, the availability of axles and related equipment was a major production bottleneck for a number of military truck designs during WWII, since all-wheel

drive was not a feature offered on civilian vehicles and the only users of specialized gear components and constant velocity joints were military trucks. Shortfalls in these components bedeviled the Army for many months in the early part of WWII (Thomson & Mayo, 1960). The availability of these components is an example of a critical technology crucial to the supply chain that drove both the system performance and the total production capacity of more than one Army truck system.

## Operational Testing Results—A Further Dilemma

When these initial production vehicles reached the field, they were extensively tested by the Army with the objective of selecting the best design that would move to the next phase of high-volume production. The operational testing focused mainly on performance since the bodies of all three vehicles were similar—the Willys and Ford models having been copied from the original Bantam design. The weight of each vehicle had steadily grown, reinforcing what certain Bantam and Army engineers knew was the case in practice—vehicles tend to get heavier, not lighter. That is still true today as all the prototypes for the JLTV exceeded the desired transport weight of 15,629 pounds by several hundred to a thousand pounds (Beidel, 2011). Thus, the jeep vehicle weight limit increase over time is very similar to today's use of the threshold and goal/objective values in Performance Based Acquisition.

In the performance area, the Willys "MA" models with their 4-cylinder, "Go Devil" engine were clearly superior (Jeudy & Tararine, 1986; Denfeld & Fry, 1973). The Willys vehicles also had the best acceleration and cross-country performance. The Bantam models were notable for their superior fuel economy, steering, and braking, which was attributed to Bantam's focus on keeping the weight of the vehicle as low as possible. The Ford vehicle came in third in the competition, but it did have some features that the Army liked over the other two such as the front-end design, gear lever, handbrake, and passenger comfort. So the testing, while useful, did not resolve the dilemma of how to arrive at a single, standardized design.

The Army leadership saw only two alternatives to resolve this dilemma: (a) design a new vehicle combining all the desirable features of all three existing designs, or (b) take the best design of the three existing and graft on to it, as far as possible, the most desirable features of the other two (Cowdery, 1986; Denfeld & Fry, 1973). The first approach was rejected because of the time required to literally "go back to the drawing

board" and design a new vehicle. At that time—mid-1944—the urgency of getting vehicles into the field fast was becoming the driving requirement. So the Army, through the Quartermaster Corps (QMC), would have to award a single contract for a "combined" design.

The contract award decision itself then became controversial. Initially, the QMC wanted to award the production contract to Ford. Although its vehicle came in last in the competition, it was seen as being the lowest risk to produce the required number of vehicles on time. This acquisition approach was vetoed by the government's Office of Production Management (OPM), which argued that, at a minimum, the contract should go to either Willys or Bantam as the vehicle designs submitted by the two companies were superior and both had met their earlier contract requirements (Thomson & Mayo, 1960; Denfeld & Fry, 1973). The Willys vehicle also had the lowest unit price. The OPM also argued all along that having more than one source qualified to produce the cars would be advantageous in the long run, particularly if war loomed on the horizon. The positions of all three companies, the Roosevelt administration, and the Army resulted in a messy dispute, which even played out in the contemporary press. As a result of this controversy, the Army was forced to relent on the Ford contract plan, and on July 23, 1941, the QMC awarded a full-rate production contract to Willys for 16,000 identical jeeps at a unit price of $739.00, with an initial delivery date of January 1942. This contract award reflects what we would consider today as "Best Value" for the government.

## A Legend is Born

The task that remained was to synthesize the advantageous characteristics of the three competing vehicles into a single vehicle configuration that the Willys team was to use as the production design. After the contract award to Willys, the Army convened its own team to finalize the features of the vehicle using the Willys MA as the new baseline configuration. The Army engineers also had to ensure inclusion of other standardized military vehicle equipment into the final configuration. The design that resulted, the Willys MB "¼-ton, 4x4 utility," was broadly the Willys body, chassis, engine, and drive train with a Ford front end and grille. This configuration would become the standard for more than 640,000 WWII jeeps—an iconic design that would last 70 plus years and spawn an entire new class of civilian vehicle. The jeeps that were provided to U.S. and Allied forces during the war were an instant success. A vehicle

originally designed for use by the Combat Arms branch was adopted and used by all the Services. In fact, the vehicle was so versatile in a number of roles and in all theaters of the war that its reputation grew well beyond anything the original designers could have imagined. Although its programmatic beginnings were rocky, the little car quickly became an overnight operational success story and an instant hit with G.I.'s.

What became of the original three companies? As forecast by the OPM, as soon as the United States became involved in WWII, a second source was needed to produce the jeep in addition to those being produced by Willys, which eventually produced 362,000 MB models. That second-source contract went to Ford, which by the end of 1945, co-produced 277,000 of its own version of the Willys MB. The Ford version, the GPW, differed in only the smallest details from the Willys and allowed the Army to achieve the standardization and production volume it desired. Bantam, however, lost out completely on subsequent Army jeep contracts, producing a total of only 2,600 vehicles, many of which went to Allied nations. Congressional hearings were eventually held on the controversy of who had "invented" the jeep, and Bantam was vindicated by the judgment of the U.S. Government that the wartime design was based on its initial prototype and intellectual property (Rifkind, 1943). This victory did not help the company financially. Although Bantam did produce trailers for the jeep during the war, the company did not survive much past 1945. In truth, the jeep design was a product of a massive team effort, including all three manufacturers as well as Army engineers, both military and civilian (Vanderveen, 1971; Wells, 1946; Hogan, 1941).

Newer models of the Willys jeeps "soldiered on" in the U.S. military until the Vietnam War when they were gradually replaced with a new vehicle design—the Ford M151 MUTT. Production of civilian jeeps began immediately after WWII. Although based on newer technology, the M151 owed much of its design to its predecessors, the Bantam BRC and the Willys MB. The jeep was a design for the ages and one that will seemingly never go out of style. Today's contemporary civilian model, the Jeep Wrangler, still maintains many of the design features of the ¼-ton 4x4 reconnaissance car of WWII. Its design longevity has made it a true defense acquisition success story.

## Lessons Learned

The lessons learned from the development and production of the jeep are many. Surely the first and most significant is the importance of government and industry partnerships to work together to satisfy operational requirements. As the Army, Bantam, and Willys evaluated the maturity of the reconnaissance car design, they grew to understand the "art of the possible." The Army involvement in the jeep development functioned in ways similar to the Department of Defense (DoD)'s current Integrated Product and Process Development/Integrated Product Team environment and the Joint Capabilities Integration and Development System process. Developing requirements that are simple, functional, and achievable is a good model for the JLTV program.

A second key lesson is impact of sound production planning on the eventual deployment and sustainment of the system. The Army knew that multiple sources would be required to supply the jeeps for wartime needs. Although the methods it used to ensure multiple sources were criticized, in the end its strategy was validated as the production from both Willys and Ford provided sufficient quantities of a standardized vehicle for not only the United States, but many Allied nations. The operational testing at Camp Holabird and other locations surfaced reliability problems on the early vehicles, which would later be corrected in full-rate production versions.

A third enduring lesson is keeping designs realistic and having the courage to prioritize or revise requirements in light of common sense and the results of operational testing. The weight limit on the jeep imposed by the Army was revised based on technological and operational realities, but was maintained to avoid too many "ornaments" being added to the design. The development and production of the jeep followed an approach similar to DoD's current Performance Based Acquisition process.

Dilemmas in defense acquisition will always arise, but by taking some lessons from history, those dilemmas can be successfully resolved.

## Author Biography

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