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THE NATO SOF AIR WING: A BASING DECISION

by

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There is a critical shortfall in special operations aviation support for the North Atlantic Treaty Organization's (NATO) special operations forces (SOF). One way this shortfall can be addressed is through the procurement and sustainment of the NATO SOF Air Wing (NSAW) under NATO Special Operations Headquarters (NSHQ). NSHQ coordinates, trains, and employs NATO's special operation forces. With the addition of organic SOF aviation forces, NATO's ground forces capabilities and mission success will be enhanced. This thesis focuses on the basing recommendations for the NATO SOF Air Wing.

The basing location for the NATO SOF Air Wing has centered on proximity to NATO SOF HQ in Mons, Belgium and minimized other important considerations, such as runway requirements, tarmac space, supporting infrastructure, weather, and proximity to training. A location decision is a complex endeavor; one that has long-term impact and therefore requires systematic analysis to find an effective and efficient solution. This thesis follows previous military efforts utilizing business sector applications to improve the decision making. Specifically, it applies the Analytical Hierarchy Process (AHP) to the NATO SOF Air Wing basing decision to provide an effective and efficient recommendation.

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THE NATO SOF AIR WING: A BASING DECISION

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LIST OF ACRONYMS AND ABBREVIATIONS

Acft – aircraft
AHP – Analytical Hierarchy Process
AMC – Air Mobility Command
AWACS – Airborne Warning and Control System
CI – Consistency Index
CR – Consistency Ratio
DA – Direct Action
DoD – Department of Defense
EDA – European Defense Agency
FT - feet
ICAO – International Civil Aviation Organization
ISTAR – Intelligence, Surveillance, Target Acquisition, and Reconnaissance
JSOU – Joint Special Operations University
JWC – Joint Warfare Center
MA – Military Assistance
NATO – North Atlantic Treaty Organization
NSAW – NATO SOF Air Wing
NSHQ – NATO SOF Headquarters
NSTEP – NATO SOF Training and Evaluation Program
PV – Point Value
RI – Random Inconsistency Index
SHAPE – Supreme Headquarters Allied Powers Europe
SOALI – Special Operations Air Land Integration
SOATU – Special Operations Air Tasking Unit
SOF – Special Operation Forces
SOUTHCOM – Southern Command
SQ - Square
SR&S – Special Reconnaissance and Surveillance
TSOC – Theater Special Operations Command
WSM – Weighted Sum Model

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I. INTRODUCTION

A. PURPOSE

This thesis explores basing locations for a future NATO SOF AIR WING (NSAW) to help alleviate the shortfall in NATO SOF Aviation. Currently, NATO SOF Headquarters (NSHQ) is standing up an initial SOF aviation unit with rotary-wing lift capability. The long-range vision for NATO is a robust SOF aviation capability including: a training center; fixed and rotary wing airlift; intelligence, surveillance, target acquisition, and reconnaissance (ISTAR) platforms; appropriate support units; facilities; logistics; and C2 operations.

The NSAW is initially a training unit with the goal of creating deployable SOF aviation teams. The unit emphasizes training NATO alliance members and key partners to enhance security operations capabilities. The majority of the unit's focus will be on training alliance SOF aviation personnel on common aviation platforms and interoperability with alliance SOF ground forces. Once the initial corps of NATO SOF aviators completes training, the NSAW will create the first NATO Special Operations Air Task Units (SOATU). These units will conduct counter terror strikes, ISTAR missions in support of SOF ground forces, and resupply missions for SOF forces in remote areas of operations when called upon by NATO.

Finding the best long-range basing location for the NSAW is of critical importance. Every defense dollar and euro is precious to the NATO taxpayer; thus every effort must be made to maximize the resources allocated to the NSAW. Given the nature of this unit's mission, the basing location could have tremendous impact on the success of the NSAW and NATO operations in general.

To determine an optimal location for the NSAW, this thesis presents a multi-criteria decision making process, known as Analytical Hierarchy Process (AHP), in which comparisons—quantitatively and qualitatively—are made at several candidate installations. In the end, the author provides supportable recommendations for locating the NSAW based on data available.

B. IMPORTANCE

During 2008 and 2009 in Afghanistan, NATO SOF missions were often unable to be executed due to a lack of aviation support. In some instances promised and planned lift assets shifted to other NATO or conventional units based on command priorities. In other situations, the supporting aviation unit was unable to provide anticipated lift due to unforeseen late-emerging requirements of their own, which took precedence. Regardless of the reason, *the effect was NATO SOF being unable to execute a mission when they were otherwise capable and ready to do so.*[1]

To the extent that NATO SOF has to rely on non-organic lift to support them, they are limited and are unable to fully utilize inherent capabilities. Relying on borrowed lift frequently means that the lift is available at a time of convenience to the providing unit, and it is only by chance when that time happens to be advantageous to the requesting unit. Similarly, missions are cancelled due to rehearsal time requirements imposed by the aviation unit based on mission profile risk, which the SOF unit was unable to meet.[2] Fielded NATO SOF cannot consistently count on non-organic aviation to fill air requirements. This arrangement becomes exasperated as Alliance members are counting on NATO SOF to execute no-fail missions. *This undermines the fundamental existence of NATO SOF.*

To remedy this, the Joint Special Operations University (JSOU) has addressed and quantified their goal for NATO SOF Aviation. According to JSOU Report 06–9, *Special Operations Aviation in NATO*, “to qualify as NATO SOF aviation, the recommendation is to require the ability to fly fixed- and rotary-wing aircraft, low level, in formation, to a precise location, meeting strict time on-target criteria, using night

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[1] North Atlantic Treaty Organization Special Operations Headquarters, *Special Operations Air Group: Concept for Development & Organization,* April 22, 2010, 8.

[2] NSHQ, *Special Operations Air Group*, 8.

vision devices. In addition, fixed-wing special operations aircraft must be capable of landing and taking off from austere airfields with minimum runway lighting using night vision devices."[3]

"The likely future operating environment, characterized by a distributed, non-contiguous battlespace, will not require every special operations aircraft to possess the full suite of defensive systems and airspace penetration aids."[4] If NATO SOF does find itself in need of such an aircraft, at that time NATO can call on the United States to support via the Theater Special Operations Command (TSOC). Until then, NATO SOF would be able to support itself with its own organic air, freeing U.S. assets for other missions. Put another way, NATO SOF Aviation does not need the full complement of SOF Aviation capabilities; rather they should focus on troop ingress/egress, resupply, and intelligence activities. Any additional support needed can be requested through the TSOC.

While the principal need of NATO SOF forces in Afghanistan is mobility, a SOF air capability must support the full spectrum of NATO SOF operations: Direct Action (DA), Special Reconnaissance and Surveillance (SR&S), and Military Assistance (MA). Due to mission complexity, aviation enabler integration into the Special Operations Task Group is essential.[5] The fundamental requirement for SOF Aviation to be organic to NATO provides the level of integrated planning and training essential for successful special operations. For SOF units that trained together habitually with the aviation unit supporting them, the rehearsal time for similar mission profiles was cut to several hours because both the crews and the operators had trained and executed that mission profile.[6]

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[3] Richard D. Newton, JSOU Report 06–8: Special Operations Aviation in NATO (Hurlbut Field, FL: The JSOU Press, 2006), accessed March 21, 2012, http://usacac.army.mil/cac2/cgsc/carl/docrepository/JSOU_Report_06_8.pdf, 8.

[4] Newton, 9.

[5] Newton, 7.

[6] NSHQ, *Special Operations Air Group*, 9.

In order to support NATO SOF, the NSAW's location must maximize many contrasting criteria. The optimal base for the NSAW must provide a balance between location requirements, airfield requirements, and support requirements.

C. LITERATURE REVIEW

This thesis argues that the NSAW's best location is determined by considering multiple criteria that support strategic requirements for the command to support NATO SOF objectives. Currently, the NATO SOF Air Wing's basing discussion centers on closeness to NATO SOF HQ in Belgium and minimizes other important considerations, such as access to training areas, availability of flight line (runway and apron space), supporting infrastructure, and the stability of where it will operate. A location decision is a complex decision; one that has long term impact and therefore requires systematic analysis to make the process effective, efficient, and apolitical. The decision concerning NSAW's location is similar to the 1997 Southern Command (SOUTHCOM) relocation. What location best maximized SOUTHCOM's ability to execute its command mission? For the SOUTHCOM assessment, a balance of cultural, geographical, and access matters was fashioned. SOUTHCOM's location decision was based on a contemplation of the benefits and costs associated with each location, including available infrastructure, access, operating costs, and political issues.[7] The process took approximately seven years to complete. Over one hundred sites were evaluated, and after the possible locations were narrowed to five, a team engaged with the finalist cities to determine an outcome.[8] The result was relocation to the most well-rounded locale, Miami. This was not a foregone conclusion and the command could have been located in a city that did not offer the optimum balance of access and infrastructure to meet its operating requirements.

Since that time, the Department of Defense (DoD) has expanded doctrine to include business type models in making complicated decisions. These include the Navy's

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[7] Charles D. Sykora, "Has the Time Come to Merge Southcom with Another Unified Command?" (Naval War College Paper, May 2004), 10.

[8] Otto F Sieber III, "AFRICOM: Does Location Matter" (Master's thesis, Naval Postgraduate School, March 2009), 8.

adaptation of Total Quality Leadership, the business world's Total Quality Management, and Secretary Donald Rumsfeld's privatization initiative, contracting out services (base security, cleaning, landscaping) to save money and focus services on operational missions. Consequently, the use of business models to assess locations for mission efficiency and effectiveness is consistent with previous DoD approaches. Several authors identify a holistic approach in determining the location of a headquarters or other vital units. They argue that the decision making process must include both quantitative and qualitative analysis in order to ensure consideration of all applicable factors surrounding a specific location.[9] This thesis employs the Analytical Hierarchy Process (AHP), which selects the best business location, to the question of strategic location for NSAW basing.[10] Ultimately, "decision makers must select sites that will not simply perform well according to the current system state, but that will continue to be profitable for the facility's lifetime."[11] In other words, NSAW must be positioned in the most advantageous position possible, for its lifetime, at its inception.

D. METHODOLOGY AND SOURCES

To provide a base recommendation for the NSAW, the author addresses three items. First, decide on a multi-criteria decision model for base selection. A weak decision model provides inconclusive outputs and recommendations. Using a poor model would be a tremendous waste of time and energy. Second, categorize and list basing requirements for NSAW's future aviation assets. A large proportion of the basing requirement results in the support needed for the selected aircraft. Since the NSAW is not operational and does not currently own airframes, the author uses airframes that provide

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[9] Linda G.Tresslar, "Putting the Location Decision into a Business Context," *Area Development Online: Site and Facility Planning*, (November 2006). http://www.areadevelopment.com/siteSelection/nov06/locationDecision. Shtml.

[10] Jiaqin Yang and Huel Lee, "An AHP Decision Model for Facility Location Selection," *Facilities 15*, No 9/10 (September/October 1997), 241–254.

[11] Susan Hesse Owen & Mark S. Daskin, "Strategic Facility Location: A Review," *European Journal of Operational Research* 111, (1998), 423.

the greatest constraints on a location. Finally, using the selected model, judge designated alternative bases on the requirements established from NSAW’s aviation assets.

II. DECISION THEORY

A. MULTI-CRITERIA DECISION MAKING

Multi-criterion decision making is challenging. Businesses and militaries have many factors to judge when they decide to position new facilities: nearest to their market; proximity to resources; local labor expenses; or a compromise between all the above. It is extremely important to select the best possible location, one that minimizes costs while maximizing benefits to achieve set goals. In this thesis, the goal is maximizing the location benefits of the NATO SOF Air Wing for NATO. Choosing a strategic location for the new NSAW involves many of the same opportunities and risk. In both sectors, "unless the strategic context for why a company or military chooses to be there in the first place is incorporated into the site selection process, the final decision cannot effectively satisfy the location attributes that will lead to success."[12]

All multi-criteria decision making involves a similar process: take a complex problem needing an assessment, list decision supporting criteria for analysis, rank or weigh criteria, judge alternatives based on criteria, analyze alternatives, obtain final ranking, and provide recommendation. The U.S. military has customarily used a point comparison tool to analyze complicated decisions.[13] This process is similar to the Weighted Sum Model (WSM) in multiple-criteria decision theory. Another avenue of analysis is the Analytical Hierarchy Process (AHP) model for multiple-criteria decision making. The next sections will explain both processes and justify why this thesis uses the AHP.

It is important to understand that during the decomposition of the problem, some criteria will contrast with others. The best option does not optimize each individual criterion, but accomplishes the most suitable balance among the different criteria based upon criterion weights.

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[12] Sieber, "AFRICOM," 29

[13] Doug Michna, *AC-130J Basing Criteria*, HQ AFSOC/A8PB, 19 April 2011

B. THE POINT VALUE COMPARISON FOR MAKING DECISIONS

1. Introduction

The point value comparison is a traditional analysis tool of the military. It is very similar to the WSM in that both use the sum of simple weighted comparisons to provide the decision maker easily explainable logic for each alternative.[14] These comparisons are both subjective—typically, the weighing of each criterion—and objective—each alternative comparison against the criterion. The decision maker views the analysis in a ‘stop light’ chart, highlighting each alternative’s best and worst attributes. The difference between the two models is that the WSM’s criterion weights are in percentages that add up to 1, whereas the point value comparison’s weights are initially whole numbers and the alternatives are percentages of those numbers.

2. The Process

The beginning point for a multi-criteria decision making conundrum is always a complex problem with multiple solutions. The decision maker lists the main objective and then breaks down the objective into distinct criteria. During the point value (pv) comparison process, a number, or weight, is given to each criterion. This weight essentially provides the relative importance of one criterion to another. This point value is referred to at the criteria weight—the larger the value, the greater significance to the decision. The points are then distributed between the potential grades for each criterion, “green” signifies that the alternative meets or exceeds the maximum criterion, “yellow” means the alternative meets the minimum criterion but does not reach the maximum criterion, or “red” the alternative does not meet the minimum criterion. This allows the decision maker to determine the relative importance of criteria before analyzing alternatives.[15] Table 1 illustrates a rudimentary point value comparison table.

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[14] Evangelos Triantaphyllou, *Multi-Criteria Decision Making: A Comparative Study* (Doredrecht, The Netherlands: Klewer Academic Publishers), 320.

[15] Michna, *AC-130J Basing Criteria,* 6.

Criteria	**Green (pv*1.00)**	**Yellow (pv*0.5)**	**Red (pv*0.0)**
Criterion 1 (pv = 5)	Meets Max Criteria	Meets Min Criteria	Does not meet Min
Criterion 2 (pv = 10)	Meets Max Criteria	Meets Min Criteria	Does not meet Min
Criterion 3 (pv = 20)	Meets Max Criteria	Meets Min Criteria	Does not meet Min
Criterion 4 (pv = 10)	Meets Max Criteria	Meets Min Criteria	Does not meet Min

Table 1. Point Value Comparison Table[16]

After determining weights and point distribution, each alternative is graded against the criterion. The alternative receives a point value and color rank under each criterion. Once scoring for each alternative is complete, the point totals are tallied along with number of criterion each alternative falls within the three color categories. Finally, the leadership views the total points for each alternative. This analysis tool provides an efficient and consistent strategy to ensure all candidate bases meet minimum established standards.[17] Table 2 provides a sample alternative analysis.

Alternative A	**Criterion Met**	**Color**		**Points**
Criterion 1 (pv =5)	Meets Max	Green	pv*1.0	5
Criteria 2 (pv = 10)	Does not meet Min	Red	pv*0.0	0
Criteria 3 (pv = 20)	Meets Min	Yellow	pv*0.5	10
Criteria 4 (pv = 10)	Meets Max	Green	pv*1.0	10
TOTAL	2 Green, 1 Yellow, 1 Red			25 of 45

Table 2. Point Value Comparison Sample Alternative Analysis[18]

3. Benefit

The benefit of the point value comparison is that there are two different styles of analysis performed at the same time. Each alternative receives a total point score and a

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[16] Michna, *AC-130J Basing Criteria*, 6.

[17] Ibid 7.

[18] Ibid 7.

color score. Adaptability is another benefit with the point value comparison. Its color ranking system and initial criterion weight are both very subjective and adaptable to the decision maker's need. The criterion weight is significant when summing up the total score for each alternative. The color ranking thresholds provide a simple way to view the number of criterion that fail to meet the minimum expectations.

4. Shortfalls

The deficiency in the point value comparison is that it fails to directly measure (or estimate) the relative quality of one alternative versus another. For example, if two alternatives receive "yellow" grades under a single criterion, this process considers them equal. However, they may not be equal and one installation may provide a clear advantage. For example, alternative A might meet the minimum criterion while alternative B falls incrementally short for the maximum criterion. The difference between alternative A and B is not distinguishable through this system of evaluation and might mistakenly omit an important difference between alternatives.

C. THE AHP FOR MAKING DECISIONS

1. Introduction

The Analytic Hierarchy Process (AHP), introduced by Thomas Saaty,[19] is another tool for decision makers. AHP supports the decision maker by simplifying complex decisions through determining priorities in order to make the best conclusion. By reducing complex decisions to a multi-level hierarchy of pairwise comparisons--then fusing the results into a singular score for each alternative--the AHP encompasses both objective and subjective characteristics of a decision. In addition, the AHP incorporates a bias-reducing technique for checking the consistency of the decision maker's evaluations, thus assuring unprejudiced results during the decision making process.

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[19] Thomas L. Saaty, *The Analytic Hierarchy Process,* McGraw-Hill, New York, 1980.

2. The Process

As with the point value comparison, AHP begins with a complex problem having multiple solutions. The first step for the decision maker is to state the problem or goal and decompose it into a criteria hierarchy. In most cases, individual criterions are parsed into sub-criterions. It is important that the decision maker addresses all critical components with the hierarchical structure. Afterwards, the criterions are pairwise compared against each other to develop criterion weights.[20] If a criterion has sub-criterion, this process is repeated on the sub-criterion. The pairwise comparisons determine relative importance of each criterion to the higher level in the hierarchy and use a 9-point grading scale shown in Table 3.

Intensity of Importance	**Definition**	**Explanation**
1	Equal Importance	Two items are of equal value
3	Moderate Importance	Experience and judgment slightly favor one item over another
5	Strong Importance	Experience and judgment strongly favor one item over another
7	Very Strong Importance	An item is favored very strongly over another; its dominance demonstrated in practice
9	Extreme Importance	The evidence favoring one item over another is of the highest order of affirmation

Table 3. AHP Ratings Scale[21]

The criterion weight matrix incorporates reciprocals, such that when criterion A is judged a 3 in comparison to criterion B, criterion B is judged a 1/3 in comparison in criterion A. Table 4 visualizes a properly set up criterion weight table. The criterion weights are determined through Saaty’s eigenvector computations, involving

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[20] Ching-Fu Chen, Applying the Analytical Hierarchy Process Approach to Convention Site Selection, *Journal of Travel Research 2006, 45*, 168.

[21] Chen, 169.

normalization and vector weight calculations. Descriptions of the calculations are in the Appendix.

	A	**B**	**C**	**D**	**Criterion Weight**
A	1	3	5	1/3	0.2556
B	1/3	1	3	1/5	0.1172
C	1/5	1/3	1	1/9	0.0507
D	3	5	9	1	0.5764
Note: Consistency Ratio (CR) = 0.02					

Table 4. Example of a Criterion Weight Matrix

To ensure correct weighting, the AHP incorporates the ability to measure Criterion Weight consistency. First, the consistency index (CI) is determined. The math for CI calculations is in the Appendix. Once the CI is found, the consistency ratio (CR) is obtained by dividing the CI by the Random Inconsistency Index, known as RI. RI is based on the order of magnitude, N, of a matrix; the RIs are shown in Table 5. The weightings are consistent if CR < 0.1.

N	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.46	1.49

Table 5. Random Inconsistency Indices (RI) for N ≤ 10[22]

After the criterion weights and sub-criterion weights are determined and verified for consistency, the sub-criterion and criterion weights merge into one spreadsheet to determine the overall factor weight. The overall factor weight is acquired after multiplying the sub-criterion weight with the criterion weight. Table 6 shows what an

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[22] Chen, 169.

example of an overall weighting spreadsheet with three criterions and three sub-criterions in each criterion.

Criterion	Criterion Weight	Sub-Criterion	Sub-criterion Weight	Factor Weight
A	0.3			
		A1	0.4	0.3*0.4 = 0.12
		A2	0.5	0.3*0.5 = 0.15
		A3	0.1	0.3*0.1 = 0.03
B	0.5			
		B1	0.3	0.5*0.3 = 0.15
		B2	0.2	0.5*0.2 = 0.1
		B3	0.5	0.5*0.5 = 0.25
C	0.2			
		C1	0.6	0.2*0.6 = 0.12
		C2	0.1	0.2*0.1 = 0.02
		C3	0.3	0.2*0.3 = 0.06

Table 6. Sample Overall Factor Weight Spreadsheet

Once the overall factor weighting is complete, the alternatives are compared for each sub-criterion. This comparison is identical to the criterion and sub-criterion evaluations. For each sub-criterion, the AHP assigns a score to every alternative. Again, the alternative’s score is determined from the decision maker’s pairwise comparisons of the alternatives based on that sub-criterion; the higher the number given, the increased value of that alternative with respect to the other. Table 7 shows an example pairwise analysis of alternatives. To verify the pairwise comparisons are unbiased and consistent, the CR is determined using the same steps shown during the criterion and sub-criterion pairwise comparisons.

Sub-Criterion A1 (Weight 0.12)	Alternative 1	Alternative 2	Alternative 3	Alternative Weights
Alternative 1	1	5	3	0.6333
Alternative 2	1/5	1	1/3	0.1061
Alternative 3	1/3	3	1	0.2606
Note: CR = 0.0477				

Table 7. Pairwise comparison of Alternatives on Sub-Criterion A1

This Analysis of Alternatives computation repeats for each sub-criterion. Finally, the AHP fuses each alternative's scores with each sub-criterion's factor weight, determining an ultimate score and ranking for each alternative.[23]

3. Benefit

The benefit of the AHP is in its flexibility because the scores, and final ranking, are obtained by the pairwise comparisons of both the criteria and the alternatives. The calculations made by the AHP are dictated by both the decision maker's experience and factual evidence, thus the AHP is a tool that is capable to translate both qualitative and quantitative evaluations into a multi-criteria ranking.[24] Another benefit of the AHP is the ability to verify the pairwise comparisons are indeed unbiased and consistent through the CR computations.

4. Shortfalls

The AHP requires significantly more evaluations by the decision maker than the point value comparison. This is especially true for challenges with multiple criteria and options. Although every single evaluation is a simple pairwise comparison, the evaluation task load may become unreasonable. The number of pairwise comparisons increases quadratically with the number of criteria and options.[25] For instance, when comparing 10

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[23] Chiara Mocinni, "The Analytic Hierarchy Process," accessed March 5, 2012, http://www.dii.unisi.it/~mocenni/Note_AHP.pdf.

[24] Ibid.

[25] Ibid

alternatives on 5 criteria, 10 pairwise comparisons are required to build the weight vector, and 225 comparisons are needed to build the final scoring matrix.

D. CONCLUSION: THE AHP

To determine the best location for the NSAW, the author chose to use the AHP model instead of the point value comparison because of two key features, adaptability and rigor.

1. Adaptability

Both the AHP and point value comparison can adjust values; however, adjustments to the AHP must go through the bias checker to determine suitability. The capability for a decision maker to adjust weights of criteria and sub-criteria through the pairwise comparisons is a great advantage that the point value comparison cannot equal.

2. Rigor

The Analytical Hierarchy Process takes more time to complete than the point value comparison, but in a decision such as basing the new NATO SOF Air Wing, a mathematically rigorous decision process is a safer path. In addition to the rigor, the AHP can verify that the pairwise decisions are truly unbiased through the computation of CR. This assures the decision maker that the results are trustworthy.

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III. NATO SOF AIR WING

A. AIR POWER IN NATO SOF

Since its inception, the NATO coalition has secured a stable environment throughout most of Europe and provided a means for international security as preferred by its member nations. While NATO's military capabilities are quite robust, the alliance strategizes to maintain a posture and ability set congruent with current and emerging threats. One identified absence during operations in Afghanistan is Special Operations Forces (SOF) aviation. Few member nations possess the SOF ground-supporting capabilities of air mobility or airborne Intelligence, Surveillance, Target Acquisition and Reconnaissance (ISTAR). Dependence on these few member nations has shown to be insufficient because not all nations are interoperable—in either equipment, training, or both. Likewise, reliance on conventional forces air support to achieve these missions has failed due to resource scarceness, lack of training, and unfamiliarity with SOF mission sets.[26]

1. NATO SOF Air Wing's Purpose

The purpose of the NSAW is twofold. First, maximize the benefit of NATO's current SOF investment and second, enable emerging SOF member nations to participate in NATO operations with a similar level of augmenting capabilities as those with full spectrum SOF aviation organizations.[27] This dual purpose is a win-win situation for NATO and the supporting nation. NATO can support their SOF forces with organic aviation capabilities and the supporting nation receives a fully trained SOF airman upon his or her NATO SOF Aviation tour completion.

To support these goals, the NSAW assists SOF forces in "three principal missions: Direct Action (DA), Special Reconnaissance and Surveillance (SR&S), and

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[26] NSHQ, "NATO Special Operations Air Group" 9.

[27] Erik Jansen, "Introduction to Organizations," (lecture, Naval Postgraduate School, Monterey, CA, January 10, 2012).

Military Assistance (MA)."[28] These capabilities include: Special Operations Air-Land Integration (SOALI), forward air controllers, combat control, personnel recovery, rotary and fixed wing insertion and extraction, and ISTAR. These mission sets require dedicated aircraft and SOF airmen habitually training and forging operational relationships with SOF ground forces.[29] This is paramount for the operational units in the NSAW, in that the NATO SOF ground personnel are confident in the ability of NATO SOF Air to support their mission requirements. Historically, NATO SOF is involved in four minor contingency operations and one major contingency operation. A major contingency requires the same support as the four minor operations. Optimally, the NATO SOF Air Wing would consist of eight Special Operations Air Task Units (SOATUs) to support the mission needs of NATO SOF.[30] With the addition of the training SOATU, the NSAW oversees nine units.

2. Suggested Air Wing Airframes

If the NSAW is to effectively support NATO SOF operations, it will require an array of airframes to perform the multitude of operational missions. Additionally, the training function of the NSAW should incorporate the same platforms required by operational SOATUs. The suggested platforms needed to carry out SOF missions include medium and heavy rotary lift, medium fixed-wing lift, and ISTAR—manned and unmanned.[31]

For each SOATU to operate independently, four medium-lift rotary, two heavy-lift rotary, two medium fixed-wing, three ISTAR unmanned, and two ISTAR manned airframes are necessary.[32] In total, the NSAW would require 117 aircraft, 90 manned

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[28] NATO Special Operations Headquarters, "NATO Special Operations Forces: Key to Mission Success at Strategic Level," (2009), 12.

[29] NSHQ, "Special Operations Air Group," 5.

[30] Andrew Jett, "Out of the Blue NATO SOF Air Wing," (Master's Thesis, Naval Postgraduate School, March 2012), 39.

[31] Jett, "Out of the Blue," 44.

[32] Ibid.

and 27 unmanned, to support missions and training. The specific airframes for each platform to be used by the NATO SOF Air Wing are unknown at this time; however, suggestions published in, "The NATO Special Operations Headquarters Air Warfare Center: A Defense Approach" provide some insight. The explicit aircraft are not necessary to the success of this study because a generalized requirement provides significant basis to compare basing options.

Applying Major Jett's calculations, 36 medium rotary lift, 18 heavy rotary lift, 18 medium fixed wing, 18 ISTAR fixed wing, and 27 unmanned platforms fulfill the obligation of a complete NATO SOF Air Wing. The aircraft selected for establishing criterion for each platform are the UH-60 (medium rotary-lift), UH-47 (heavy rotary-lift), C-27J (medium fixed-wing), MC-12 (manned ISTAR), and MQ-9 (unmanned ISTAR).[33] These platforms are used as a reference since NATO SOF has not determined the type of aircraft and level of ambition for the NSAW.

3. Current NATO Bases

The place to begin searching for candidate bases is with NATO. NATO specifically does not own or run many airfields which strictly support NATO operations. Much of NATO's aviation forces are requested when contingencies arise. Only the bases at Geilenkirchen, Germany, home of NATO's E-3A Sentry fleet, and Pápa, Hungary, basing three C-17s for the Heavy Airlift Wing, support dedicated NATO airmen at a NATO-run airbase.[34]

If not a committed NATO base, airfields managed by NATO members near NATO operations or headquarters is another good place to find a suitable location. Izmir, Turkey is the home of NATO's Allied Air Command Headquarters-Izmir and Çiğli Air Base is located a few miles away. The U.S. Air Force and NATO operated Çiğli Air Base

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[33] Jett, "Out of the Blue," 44.

[34] "NATO Aviation Forces," Jane's World Air Forces, Febuary 20, 2012, (accessed March 5, 2012), jwaf.janes.com/subscribe/jwaf/doc_view_print.jsp?/K2DocKey.

until 1970 when it was returned to Turkish control.[35] NATO SOF HQ is located in Mons, Belgium, and is very close to Chièvres Air Base. Chièvres houses the NATO executive transportation squadron currently administered by the USAF.[36]

In addition to locations near NATO HQ units, additional airbases that already support NATO operations are of interest to the future NSAW. Aviano Air Base in Italy houses the USAF's 31st Wing supporting NATO contingency operations such as Operation Odyssey Dawn and Operation Unified Protector.[37] Rota Naval Station, owned by Spain and operated by the United States, is an ideal location on the southern portion of the Iberian Peninsula and proclaimed as the "Gateway to the Mediterranean."[38] Finally, Morón Air Base, near Rota NS, is a semi-dormant airfield that opens and closes based on contingency needs.[39]

B. BASING CRITERIA FOR NSAW

Three major basing criterions were determined for this thesis; base location, air field capacity, and mission support. The base location criterion is separated into three sub-criterions: proximity to training, proximity to logistics, and weather. The airfield capacity criterion was also divided into three sub-criterion; runway length and apron space; single port refueling capability; and current petroleum, oil, and liquids on base. The final criterion, mission support, incorporated three sub-criterions; indigenous base security, medical facilities, and other supporting functions.

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[35] "Izmir Turkey," GlobalSecurity.org, accessed March 7, 2012, http://www.globalsecurity.org/military/facility/izmir.htm.

[36] "Chièvres," GlobalSecurity.org, accessed March 7, 2012, http://www.globalsecurity.org/military/facility/chievres.htm.

[37] "Aviano Air Base," GlobalSecurity.org, accessed March 7, 2012. http://www.globalsecurity.org/military/facility/aviano.htm.

[38] "Naval Station Rota," GlobalSecurity.org, accessed March 7, 2012, http://www.globalsecurity.org/military/facility/rota.htm.

[39] "Moron Air Base," GlobalSecurity.org, accessed March 7, 2012, http://www.globalsecurity.org/military/facility/moron.htm.

Shown in Table 8 is a pairwise comparison for the three top-level criterions. The most important criterion for this is the air base's airfield capability to support NSAW, with the location being second most important and mission support capacity being least. This is reflective of the inherent desire to house all of NSAW's aircraft at one location. The sections following further define each criterion and sub-criterion used to create the overall weighting for the final decision matrix.

	Location	**Airfield**	**Support**	**Factor Weight**
Location	1	1/3	5	0.2828
Airfield	3	1	7	0.6434
Support	1/5	1/7	1	0.0738
Note: CR = 0.0834				

Table 8. Pairwise Comparison of Top-Level Criterion

1. Air Base Location

The air base location factor is broken down into three distinct areas: proximity to training, proximity to logistics, and weather. Proximity to training is imperative to the success of the NSAW because of the costs associated with traveling to exercises throughout Europe. There are training events in a multitude of locations throughout Europe that include: NATO's Joint Warfare Center at Stavanger, Norway; NATO'S SOF Training & Education Program (NSTEP) at Chièvres, Belgium;[40] the Joint Multinational Training Center at Grafenwöhr, Germany;[41] European Defense Agency's (EDA) Exercise Green Blade in Kliene-Brogel, Belgium; and EDA's Exercise Hot Blade in Ovar, Portugal.[42] Proximity to Logistics is of important interest, especially since the

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[40] "NSTEP Overview," NSHQ, accessed September 3, 2012, http://www.nshq.nato.int/NSTEP/overiew

[41] "Installation History - Grafenwöhr Training Area," Grafenwöhr History Office, accessed September 3, 2012, http://www.grafenwoehr.army.mil/sites/about/history.asp.

[42] "Helicopter Initiatives," European Defense Agency, accessed 25 September 2012, http://www.eda.europa.eu/projects/projects-search/helicopter-initiatives.

NSAW recommendations call for contracted maintenance; thus, the need for civilian shipping lines. In addition to maintenance support, most non-flying personnel will arrive from a civilian airport and having commercial aviation close by is optimal for the NSAW. Finally, weather conditions can make or break airbase operations. Rain, snow, and limited visibility conditions can delay or even cancel sorties.

Table 9 is the pairwise comparison for the importance of these three sub-criterions with respect to the location criterion. The average distance between training locations was deemed slightly more important than the location's weather and significantly more important than distance from logistics centers. To round out the table, the location's weather criterion was determined to be more important than the distance to logistical centers.

	Prox to Training	**Prox to Logistics**	**Weather**	**Sub-Criterion Weight**
Training	1	7	3	0.6434
Logistics	1/7	1	1/5	0.0738
Weather	1/3	5	1	0.2828
Note: CR= 0.0834				

Table 9. Pairwise comparison of the Location's sub-criteria

In the Proximity to Training sub-criterion, each alternative's score will be based on the average distance between the five selected training sites. Proximity to Logistics is the average distance from a medium-sized seaport[43] and an airport that services over five million passengers per year.[44] Weather is determined by how many days have no visual hindrances: rain, snow, fog, dust, or haze.

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[43] Medium-sized Seaports handle between 1 and 20 million tons of goods per year.

[44] Five million passengers was set as a minimum for this thesis.

2. Airfield Requirements

The airfield criterion is also composed of three sub-criteria: runway length and apron space availability, single point refueling capability, and petroleum, oil, and liquids currently on hand. The closer the airfield is to accept the NSAW without additional modifications, the easier and cheaper it will be for the NSAW to stand up. Meeting minimum runway length is a necessity for an alternative to be viable. Another critical element is the required apron space availability for the 117 aircraft that will call the new air base home. The next vital requirement is the capabilities to single point refuel aircraft. A single point refueling station allows for hot pitting; refueling while an engine is operating. This optimizes training schedules where quick turnaround time is paramount. Lastly, POL is essential to permit aircraft operations. The lack of proper petroleum or oil hinders maintenance and sortie generation.

Table 10 is the pairwise comparison for the importance of these three sub-criterions with respect to the Airfield criterion. The runway length and available apron space was deemed slightly more important than if the location has single point refueling capability and more important than current POL capacity on base. To round out the table, the location’s single point refueling criterion was determined to be slightly more important than the alternative base’s current POL capacity.

	Runway and Apron	**Single Point Refueling**	**POL**	**Sub-Criterion Weight**
Runway	1	3	5	0.6333
Refueling	1/3	1	3	0.2605
POL	1/5	1/3	1	0.1062
Note: CR = 0.0477				

Table 10. Pairwise Comparison of the Airfield sub-criteria

The Single Point Refueling requirement is a simple yes or no proposition, the base either currently has it available or does not. POL is distilled down to type of jet fuel currently available since the maintenance contractor will be providing the oils and lubricants. The U.S. military as a standard uses jet propellant 8 (JP8) instead of the more hazardous JP4.[45] The runway and apron requirements are constructed from Maj. Jett's analysis for aircraft type and quantity required for the NSAW. From those airframes, apron size is determined from the Department of Defense's Unified Facilities Criteria for Airfield and Heliport Planning and Design. The aircraft requiring the longest runway determines minimum runway length. Table 11 provides information on the five airframes' runway and apron requirements.

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[45] Department of Defense, *Turbine Fuel, Aviation, Kerosene Type, JP8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37)*, (October 2011), http://www.wbdg.org/ccb/FEDMIL/dtl83133h.pdf, 2.

Airframe	**Take-off Dist. (ft.)**	**Landing Dist. (ft.)**	**Runway Length**	**Apron Space per acft (sqft)**	**Total Apron Space (sqft)**
UH-60 (36)	N/A	N/A	N/A	8000	288,000
CH-47 (18)	N/A	N/A	N/A	15000	270,000
C-27J (18)	2100	2300	2300	12000	216,000
MC-12 (18)	3300	2700	3300	6000	108,000
MQ-9 (27)	3600	6500	6500	5400	145,800
Totals			6500		1,027,800

Table 11. Runway Length and Apron Space Requirements

Beginning with runway length, the focus for this requirement is on fixed-wing aircraft; C-27J, MC-12, and MQ-9. The C-27J at max load requires 2100 feet to take off and 2264 to land.[46] The MC-12 maximum takeoff distance is 3300 feet and 2692 for landing.[47] A 6500-foot runway is necessary for the MQ-9.[48] Using the greatest limiting factor, a minimum 6500-foot runway is required for the airfield.

Apron space is determined using the Department of Defense's United Facilities Criteria: Airport and Heliport planning and design. Medium rotary airlift frames such as

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[46] "Alenia Aermacchi C-27J Spartan," Jane's All the World's Aircraft, https://janes.ihs.com.libproxy.nps.edu/CustomPages/Janes/DisplayPage.aspx?DocType=Reference&ItemId=+++1342662&Pubabbrev=JAWA.

[47] "King Air 350i Specifications," Beechcraft, www.hawkerbeechcraft.com/beachcraft/king_air_350i/specifications.aspx

[48] Air Force Civil Engineering Support Agency, *Engineering Technical Letter (ETL) 09–1: Airfield Planning and Design Criteria for Unmanned Aircraft Systems (UAS)*, (September 2009), www.wbdg.org/ccb/AF/AFETL/etl_09_1.pdf.

the UH-60 require a space 80 feet by 100 feet—8000 square feet—and 36 necessitate 288,000 square feet.[49]

The heavy rotary airlift CH-47 needs an individual space of 100 feet by 150 feet, or 15,000 square feet. The 18 CH-47s use 270,000 square feet.[50] As for the fixed wing aircraft, the C-27J requires 12,000 square feet each, and a total of 216,000 square feet for 18.[51] The manned ISTAR platform, MC-12 or militarized variant of the King Air 350, mandates an individual parking space 75 feet by 80 feet. Eighteen require 108,000 square feet.[52] The MQ-9 unmanned ISTAR platform uses a space 60 feet by 90 feet, and 27 MQ-9s require 145,800 feet to support operations.[53] In total, the ramp space is over one million square feet. This does not factor in room to maneuver.

3. Mission Support

The Mission Support criterion is composed of three sub-criteria; indigenous base security, base medical and dental, and other base support. Optimally, the alternatives have all the necessary support functions. Base Security is simply having a standing security force for the base, provided either by the host nation or current base operator. Base Medical and Dental is the ability to handle emergency care for personnel on base. Other Base Support is providing dining, communications, and other base upkeep functions. NATO and U.S. bases easily support these requirements, but since NATO or the U.S. does not own some alternatives, these support functions might not be available and the NATO SOF service member must find the support in the hosting town. This becomes particularly difficult coupled with the medical requirements for aviation forces.

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49 Department of Defense, *United Facilities Criteria: Airport and Heliport Planning and Design*, (November 2008), www.wbdg.org/ccb/DoD/UFC/ufc_3_260_01.pdf, 141.

50 DoD, *Airport and Heliport Planning and Design*, 142.

[51] "Alenia Aermacchi C-27J Spartan," Jane's All the World's Aircraft.

[52] "King Air 350i Specifications," Beechcraft.

Headquarters Air Force Civil Engineer Support Agency, *Engineering Technical Letter (ETL) 09–1: Airfield Planning and Design Criteria for Unmanned Aircraft Systems (UAS)*, 28.

Table 12 is the pairwise comparison for the importance of these three sub-criterions with respect to the Support criterion. Base Security was deemed slightly more important than on base medical and dental capability and strongly more important than remaining base support functions. To round out the table, the location's medical and dental criterion was determined to be more important than the remaining base support capacity.

	Security	**Medical**	**Misc. Support**	**Sub-criterion Weight**
Security	1	3	7	0.6434
Medical	1/3	1	5	0.2828
Misc. Sprt	1/7	1/5	1	0.0738
Note: CR = 0.0834				

Table 12. Pairwise Comparison of the Support sub-criteria

4. Synthesis of Criterion and Sub-criterion Weights

The synthesis of criterion and sub-criterion weights provides individual factor weights that each alternative is judged against in the upcoming chapter. Factor weights are calculated by multiplying the criterion weight and the sub-criterion weights together.

Criterion	**Location**			**Airfield**			**Support**		
Criterion Weight	0.2828			0.6434			0.0738		
Sub-Criterion	**Prox to Training**	**Prox to Logistics**	**Weather**	**Runway & Apron**	**Refueling**	**POL**	**Security**	**Medical Dental**	**Misc. Support**
Sub-Criterion Weight	0.6434	0.0738	0.2828	0.6333	0.2605	0.1062	0.6434	0.2828	0.0738
Factor Weight	0.1820	0.0209	0.0800	0.4075	0.1676	0.0683	0.0475	0.0209	0.0054

Table 13. Factor Weight Synthesis

From Table 13, the sub-criterion rank order of importance are: Runway and Apron space, weighted at 0.4075 or 40.75%, Distance from Training at 18.2%, Single Point Refueling (16.76%), Weather (8%), POL (6.83%), Security (4.75%), Proximity to Logistics and Medical (2.09% each), and Miscellaneous Support (0.54%).

5. Comparing NSAW Alternatives against Sub-criterion

Beginning with the three sub-criteria of the location criterion, Proximity to Training is determined by averaging the distance between five training locations. The interval is determined through direct aerial flight computations from Daft Logic's Distance Calculator using each location's global positioning system coordinates. The five training locations selected for this thesis are: NATO's SOF Training and Evaluation Program (NSTEP) at Chièvres, Belgium; the Grafenwöhr Training Area in Grafenwöhr, Germany; the Joint Warfare Center (JWC) in Stavanger, Norway; and European Defense Agency (EDA) training Exercise Green Blade in Kleine-Brogel, Belgium and Exercise Hot Blade in Ovar, Portugal.[54] A short travel distance between all three locations is optimal. The Proximity to Logistics criterion is determined by the average driving distance from the nearest major airport and seaport using Google Maps. The closest seaports and airports were determined from the website Findaport.net. Again, less distance is better for this criterion. The weather criterion is based on the number of days without visual hindrances. This can be due to rain, snow, haze, fog, or sand. The least days impacted by weather, the better. Historical weather information for the base or the nearest town was provided by weatherbase.com.

Next is determining the grading factors for the Airfield criterion's three sub-criteria. The runway and apron was determined by worldaerodata.com's database and visual apron measurements from Google Earth. As described above, the runway must be a minimum of 6500 feet long and the apron space should exceed one million square feet or have the capacity to expand. A longer runway and open apron space is optimal for the

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[54] "Helicopter Initiatives," European Defense Agency http://www.eda.europa.eu/projects/projects-search/helicopter-initiatives.

NSAW. For the single port refueling criterion, either an alternative base has single point refueling or it does not. On the petroleum, oil and liquids criterion, the major determinant is fuel type since the aircraft will be provided with contracted maintenance. The best scenario is a base with JP8. Worldaerodata.com provided the information on each the alternative's single point refueling and fuel capability.

Finally, the three Support sub-criteria consist of base security, medical capability and other miscellaneous support activities available at the location. Base security is a simple binary operation, the base uses a security force or it is an open field. The determining factor for medical and dental is the level of treatment provided on base. The best situation is a hospital and full dental clinic. Finally, the miscellaneous criterion accounts for finance, education, physical fitness, and any other supporting activities provided. Alternative location sites provide the information needed in the support criterion.

IV. NSAW LOCATION ALTERNATIVE OVERVIEW

This chapter provides a general overview and insight into the seven alternative bases for this thesis and specifically addresses the nine individual sub-criterions listed from the previous chapter. From this information, the bases are compared against each other in the following chapter.

A. CHIÈVRES AIR BASE, BELGIUM

Figure 1. Aerial view of Chièvres AB[55]

Chièvres Air Base (AB), International Civil Aviation Organization (ICAO) code EBCV, in Chièvres, Belgium, houses the 309th Airlift squadron which flies the C-37A, better known as the Gulfstream V (see Figure 1). In addition to the airlift squadron, the

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[55] "Chièvres Air Base," Google Earth, accessed 10 August 2012.

NATO SOF Training and Education Program (NSTEP) is located at the Chièvres Garrison. The base provides logistic support and executive airlift for senior NATO and Supreme Headquarters Allied Powers Europe (SHAPE) leaders.[56]

Chièvres location in Belgium is central to the five training areas selected for this thesis (NSTEP at Chièvres, Belgium; the Grafenwöhr Training Area in Grafenwöhr, Germany; NATO's Joint Warfare Center in Stavanger, Norway; and European Defense Agency (EDA) training exercise locations in Kliene-Brogel, Belgium and Ovar, Portugal), with an approximate average distance of 335 nautical miles.[57] Non-military logistical hubs nearby include Brussels International Airport, 82km away, and Brussels Seaport, 71 km away.[58] Chièvres' historical weather trends were not robust, so Hornu, a nearby town was used for weather data. Hornu tends to be cool and rainy or foggy. During the winter months, 63 days are below 32F, and only 66 days are above 70F in the summer. On average, it rains 219 days per year, snows 22 days and is foggy for 246 days.[59]

The 309th Airlift Squadron currently uses Chièvres' airfield. The functional runway is 5386 feet long and aircraft parking space is very limited as shown in Figure 1.[60] The closed runway is available, but it is less than 150 feet wide. The hangers used by the 309th occupy most of the apron space. There is some capability to expand the apron if the Chièvres became home to the NSAW. Being a NATO operation, Chièvres is well equipped to provide for the NSAW. JP8 jet fuel is available, and base security,

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[56] "Chièvres," GlobalSecurity.org, accessed March 7, 2012, http://www.globalsecurity.org/military/facility/chievres.htm.

[57] Distance calculations used Daft Logic's Google Maps Distance Calculator. http://www.daftlogic.com/projects-google-maps-distance-calculator.htm.

[58] Distance calculations used Google maps to determine the shortest driving length.

[59] "Hornu, Belgium," weatherbase.com, accessed October 15, 2012, http://www.weatherbase.com/weather/weather.php3?s=23460&refer=&cityname=Hornu-Hainaut-Belgium.

[60] "Chièvres Air Base," worldaerodata.com, accessed August 18, 2012, http://worldaerodata.com/wad.cgi?id=BE46743&sch=Chievres.

medical and other supporting functions are provided;[61] however there is no single point fueling capability currently.[62]

B. GEILENKIRCHEN AB, GERMANY

Figure 2. Aerial View of Geilenkirchen AB[63]

Geilenkirchen Air Base, ICAO code ETNG, in Teveren, Germany houses NATO's Airborne Early Warning Force which flies the E-3A Sentry (see Figure 2). In addition, the E-3B Airborne Warning and Control System (AWACS) flown by the U.S. Air Reserves operate from Geilenkirchen. The base supports over 3000 military members and civilians from 13 nations.[64]

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[61] "Chièvres," GlobalSecurity.org.

[62] "Chièvres Air Base," worldaerodata.com.

[63] "Geilenkirchen Air Base," Google Earth, accessed August 10, 2012.

[64] "Geilenkirchen Air Base," GlobalSecurity.org, accessed March 7, 2012, http://www.globalsecurity.org/military/facility/geilenkirchen.htm.

Geilenkirchen's location in northern Germany, near the Netherlands, is also central to the five training areas selected for this thesis with an approximate average distance of 340 nautical miles.[65] Non-military logistical hubs nearby include Dusseldorf International Airport, 88 km away, and Duisburg Seaport, 105 km away.[66] Geilenkirchen's weather tends to be rainy or foggy. On average, it rains 238 days per year, snows 35 days and is foggy for 279 days. Again, this limitation on visibility can impact training capabilities.[67]

NATO's E-3As and the U.S.'s E-3Bs currently occupy Geilenkirchen's airfield. The functional runway is 10,009 ft. long and apron space, though nearly a mile long, is limited due to the space required by the Sentries and AWACSs as shown in Figure 2. There is little capability to expand the apron beyond its current dimensions if Geilenkirchen became home to the NSAW. Being a NATO operation, Geilenkirchen is well prepared to house the NSAW bases on the other criterion. JP8 jet fuel is available and, base security, medical and other supporting functions are provided; however, there is no single port fueling capability currently.[68]

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[65] Distance calculations used Daft Logic's Google Maps Distance Calculator.

[66] Distance calculations used Google maps to determine the shortest driving length.

[67] "Geilenkirchen, Germany," weatherbase.com, accessed October 15, 2012, http://www.weatherbase.com/weather/weather.php3?s=501&refer=&cityname=Geilenkirchen-North-Rhine-Westphalia-Germany

[68] "Geilenkirchen Air Base," worldaerodata.com, accessed August 18, 2012, http://worldaerodata.com/wad.cgi?id=GM29555&sch=Geilenkirchen.

C. PÁPA AB, HUNGARY

Figure 3. Aerial View of Pápa AB[69]

Pápa Air Base, ICAO code LHPA, just outside Pápa, Hungary, houses NATO's Heavy Airlift Wing (HAW) which flies the C-17 Globemaster III (see Figure 3). The HAW is the first and only multinational C-17 squadron, with aviators from 12 nations.[70]

Pápa's location in northwestern Hungary provides travel complications to the five training areas selected for this thesis with an approximate average distance of 670 nautical miles.[71] Non-military logistical hubs nearby include Budapest International Airport, 117 km away, and Budapest Seaport, 105 km away.[72] Pápa's weather history is

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[69] "Pápa Air Base," Google Earth, accessed August 10, 2012.

[70] "Heavy Airlift Wing," Heavy Airlift Wing, accessed August 10, 2012, www.heavyairliftwing.org/background/the-heavy-airlift-squadron-has.

[71] Distance calculations used Daft Logic's Google Maps Distance Calculator.

[72] Distance calculations used Google maps to determine the shortest driving length.

not extensive, so this thesis used the information from Pápa’s closest city with data, Gyor, Hungary. Gyor tends to be cold in the winter with 85 days below 32F and mild in the summer with 13 days above 86F. On average, it rains 17 days per year, the number of snow days is unreported and is foggy or hazy for 155 days.[73]

NATO’s three C-17 Globemaster III’s from the HAW currently occupy Pápa’s airfield. The functional runway is 7869 ft. long and apron space is limited due to the taxiing space required by the C-17s as shown in Figure 3. There is ability to expand the apron if Pápa became home to the NSAW. Being a new NATO operation, Pápa is not as well prepared to house the NSAW based on the other criteria. While JP8 jet fuel is available and base security is provided, medical and other supporting functions are limited and there is no single point fueling capability currently.[74]

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[73] “Gyor, Hungary,” weatherbase.com, accessed October 15, 2012, http://www.weatherbase.com/weather/weather.php3?s=22821&refer=&cityname=Gyor-Hungary.

[74] “Heavy Airlift Wing: Newcomer’s Guide,” Heavy Airlift Wing Public Affairs http://www.heavyairliftwing.org/library/nations/THE%20Newcomers%20Guide%202011.pdf.

D. ÇIĞLI AB, TURKEY

Figure 4. Aerial View of Çiğli AB[75]

Çiğli Air Base, ICAO code LTBL, just north of Izmir on Turkey's western coast, houses Turkey's jet training program and is used as a standby base for NATO ((see Figure 4).[76] NATO's Allied Air Command Headquarters Izmir and the USAF's Izmir Air Station are located nearby providing support to NATO forces in the area.[77]

Çiğli's location in western Hungary provides tremendous travel complications to the five training areas selected for this thesis with an approximate average distance of

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[75] "Çiğli Air Base," Google Earth, accessed August 10, 2012

[76] "Turkey – Air Force," Jane's World Air Forces, accessed September 23, 2012, https://janes.ihs.com.libproxy.nps.edu/Grid.aspx.

[77] "Brief History of Allied Air Command Izmir," NATO, accessed September 23, 2012, http://www.aiiz.nato.int/history/.

1320 nautical miles.[78] Non-military logistical hubs nearby include Izmir International Airport, 27 km away, and Izmir Seaport, 32 km away.[79] Çiğli's weather history is not extensive, so this thesis used the information from Izmir. Izmir tends to mild in the winter with 23 days below 32F and hot in the summer with 60 days above 90F. On average, it rains 89 days per year, with 4 snow days and is foggy or hazy 315 days out of the year.[80]

Turkey's jet training program occupies Çiğli's airfield. The runway is 9821 ft. long and apron space is limited due to the space occupied by the various training aircraft. There is ability to expand the apron if Çiğli became home to the NSAW. Being a non-NATO operation now, Çiğli is not as well prepared to house the NSAW based on the other criteria. While base security is provided, medical and other supporting functions are limited, there is no single point fueling capability currently and only JP4 fuel is available.[81]

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[78] Distance calculations used Daft Logic's Google Maps Distance Calculator.

[79] Distance calculations used Google maps to determine the shortest driving length.

[80] "Izmir, Turkey," weatherbase.com, accessed September 23, 2012, http://www.weatherbase.com/weather/weather.php3?s=81271&refer=&cityname=Izmir-Turkey

[81] "Çiğli Air Base," worldaerodata.com, accessed September 24, 2012, http://worldaerodata.com/wad.cgi?id=TU43803.

E. AVIANO AB, ITALY

Figure 5. Aerial View of Aviano AB[82]

Aviano Air Base, ICAO code LIPA, in Northeastern Italy roughly 10 miles north of Pordenone is home to the USAF's 31^{ST} Fighter Wing consisting of the 555th and 510th Fighter Squadrons (see Figure 5). In addition, military transport aircraft frequent the base. During crisis and contingency operations, the air base becomes part of NATO's 5th Allied Tactical Air Force.[83]

Aviano's location in northern Italy provides a central location to most of the five training areas selected for this thesis with an approximate average distance of 575 nautical miles.[84] Non-military logistical hubs nearby are in Venice. The civilian

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[82] "Aviano Air Base," Google Earth, accessed August 10, 2012.

[83] "Wing's Mission Provides NATO Cornerstone," 31st Fighter Wing History Office, September 24, 2007, accessed September 2, 2012, http://www.af.mil/news/story.asp?id=12306931.

[84] Distance calculations used Daft Logic's Google Maps Distance Calculator.

airport is 58 km away, and the seaport is a 64 km drive.[85] Aviano's weather history is not comprehensive, so this thesis used the information from neighboring Pordenone. Pordenone has long winters with 71 days below 32F and mild summers with 57 days above 80F. On average, it rains 128 days per year, with 4 snow days and is foggy or hazy 130 days out of the year.[86]

The 31ST Fighter Wing is the main aviation unit at Aviano, but the base also supports logistical operations. Its runway is 8551 feet long and apron space is limited due to the space required by the two fighter squadrons and transport aircraft. There is minimal ability to expand the apron if Aviano became home to the NSAW due to the current layout. Being a NATO operation, Aviano is well prepared to house the NSAW based on the other criteria: base security, full medical, dental, and other miscellaneous support is provided. Additionally, Aviano has single-point fueling capability and uses JP8 fuel.[87]

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[85] Distance calculations used Google maps to determine the shortest driving length.

[86] "Pordenone, Italy," weatherbase.com, accessed September 23, 2012, http://www.weatherbase.com/weather/weather.php3?s=160361&refer=&cityname=Pordenone-Friuli-Venezia-Giulia-Italy.

[87] "Aviano Air Base," worldaerodata.com, accessed September 24, 2012, http://worldaerodata.com/wad.cgi?id=IT49911&sch=Aviano

F. MORÓN AB, SPAIN

Figure 6. Aerial View of Morón AB[88]

Morón Air Base, ICAO code LEMO, in southern Spain roughly 35 miles southeast of Seville and 75 miles from Rota Naval Station, is a semi-dormant base that’s mission flexes with the needs of NATO and the U.S. (see Figure 6). During large scale operations, military transport and refueling aircraft occupy the base since its massive apron can sustain 20 C-5 Galaxy aircraft.[89]

Morón’s location in southern Spain provides significant travel issues to most of the five training areas selected for this thesis with an approximate average distance of 910 nautical miles.[90] Morón’s nearby non-military logistical hubs are the Seville

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[88] “Morón Air Base,” Google Earth, accessed August 10, 2012)

[89] “Morón Air Base,” Globalsecurity.org, accessed March 7, 2012, http://www.globalsecurity.org/military/facility/moron.htm.

[90] Distance calculations used Daft Logic’s Google Maps Distance Calculator.

International Airport and Cadiz seaport, 56 and 93 kilometers away respectively.[91] Morón's weather history is not comprehensive, so this thesis used the information from neighboring Morón de la Frontera. Morón de la Frontera has virtually no winter with zero days below 32F and hot summers with 88 days above 90F. On average, it rains 78 days per year, with no snow days and is foggy or hazy 52 days out of the year.[92]

Morón Air Base is home to no specific aviation units, but the airfield has a variety of functions including one of NASA's Space Shuttle Transoceanic Abort Landing sites.[93] Its 11,801 ft. runway is quite long and apron space is immense when contingency operations are not occurring. The potential for apron expansion is not available if Morón became home to the NSAW. Being a semi-dormant base supported by the U.S., Morón is not as well prepared to house the NSAW based on the other criteria. Base security is provided and Morón has single point refueling with JP8; [94] however, for full medical and dental, service members must travel 75 miles to Rota Naval Station.[95]

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[91] Distance calculations used Google maps to determine the shortest driving length.

[92] "Moron de la Frontera, Spain," weatherbase.com, accessed September 23, 2012, http://www.weatherbase.com/weather/weather.php3?s=79380&refer=&cityname=Mor%F3n-de-la-Frontera-Andaluc%EDa-Spain.

[93] "Morón Air Base," Globalsecurity.org.

[94] "Morón Air Base," worldaerodata.com, accessed September 25, 2012, http://worldaerodata.com/wad.cgi?id=SP04438.

[95] "Morón Air Base," Globalsecurity.org.

G. ROTA NAVAL STATION, SPAIN

Figure 7. Aerial View of Rota NS[96]

Rota Naval Station (NS), ICAO code LERT, in southern Spain near the Straits of Gibraltar, is the central transportation hub between the United States and forward locations (see Figure 7). Rota is the largest U.S. military community in Spain, housing the U.S. Navy's Sixth Fleet, and the airfield supports an USAF Air Mobility Command (AMC) squadron.[97]

Rota's location near the Straits of Gibraltar raises significant travel concerns to most of the five training areas selected for this thesis, with an approximate average distance of 950 nautical miles.[98] Rota shares the same nearby non-military logistical

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[96] "Rota Naval Station," Google Earth, accessed August 10, 2012.

[97] "Naval Station Rota," Globalsecurity.org, accessed March 7, 2012, http://www.globalsecurity.org/military/facility/rota.htm.

[98] Distance calculations used Daft Logic's Google Maps Distance Calculator.

hubs as Moró n; the Seville International Airport and Cadiz seaport, 133 and 40 kilometers away respectively.[99] Rota has virtually no winter with one day below 32F and hot summers with 29 days above 90F. On average, it rains 16 days per year, with no snow days and is foggy or hazy 106 days out of the year.[100]

Cargo and transport aircraft from the USAF's AMC along with Sixth Fleet aviation assets use Rota Naval Station's airfield.[101] Its 12,104 ft. runway is quite long but apron space is limited due to the quantity of aircraft that already use the airfield. The potential for a limited apron expansion is available if Rota became home to the NSAW. Being a key logistical hub for the Sixth Fleet, Rota is best prepared to house the NSAW based on the other criteria: single point refueling with JP8 is available, [102] as is base security, full medical and dental, along with all other supporting activities.[103]

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[99] Distance calculations used Google maps to determine the shortest driving length.

[100] "Rota, Spain," weatherbase.com, accessed September 23, 2012, http://www.weatherbase.com/weather/weather.php3?s=94480&refer=&cityname=Rota-Andaluc%EDa-Spain.

[101] "Naval Station Rota, globalsecurity.org.

[102] "Rota NS," worldaerodata.com, accessed September 23, 2012, http://worldaerodata.com/wad.cgi?id=SP05584.

[103] "Naval Station Rota, globalsecurity.org.

V. ANALYSIS OF ALTERNATIVES

This chapter compares each alternative against the other over the nine sub-criteria. Each section is dedicated to one of the main three criteria. Afterwards, the results are synthesized together to form one spreadsheet listing the alternative's overall score and rank.

A. LOCATION

The air base location factor is broken down into three distinct areas: proximity to training, proximity to logistics, and weather. Proximity to Training is imperative to the success of the NSAW because of the costs associated with traveling to exercises throughout Europe. Proximity to Logistics is of important interest, especially since the NSAW recommendations call for contracted maintenance; thus, the need for civilian shipping lines. In addition to maintenance support, most personnel will arrive from a civilian airport and having commercial aviation close by is optimal for the NSAW. Finally, weather conditions can make or break airbase operations. Rain, snow, and limited visibility conditions can delay or even cancel sorties.

Table 14 is the pairwise comparison for the importance of these three sub-criterions with respect to the location criterion that was accomplished in Chapter 3.

	Prox to Training	**Prox to Logistics**	**Weather**	**Sub-criterion Weight**
Training	1	7	3	0.6434
Logistics	1/7	1	1/5	0.0738
Weather	1/3	5	1	0.2828
Note: CR= 0.0834				

Table 14. Pairwise Comparison of the Location Sub-criteria

In the Proximity to Training sub-criterion, each alternative's score will be based on the average distance between the five selected training sites. Proximity to Logistics is the average distance from a medium-sized seaport and an airport that services over five million passengers per year.[104] Weather is determined by how many days have no visual hindrances: rain, snow, fog, dust, or haze.

1. Proximity to Training Analysis

In the Proximity to Training sub-criterion, each alternative's score is based on the average distance between the five selected training sites: NATO's Joint Warfare Center at Stavanger, Norway; NSTEP at Chièvres, Belgium;[105] the Joint Multinational Training Center at Grafenwöhr, Germany;[106] EDA's Exercise Green Blade in Kliene-Brogel, Belgium, and EDA's Exercise Hot Blade in Ovar, Portugal.[107] Table 15 provides direct aerial distances between alternatives and each training location, the average distance, and comparative rank.

Distance in NM	**Chièvres**	**Grafenwöhr**	**Stavanger**	**Kliene-Brogel**	**Ovar**	**Average**	**Rank**
Chièvres	0	318	508	71	781	**336**	**1**
Geilenkirchen	87	239	482	27	860	**339**	**1**
Pápa	573	261	814	525	1187	**672**	**2**
Çiğli	1250	958	1500	1213	1672	**1319**	**4**
Aviano	445	220	816	420	974	**575**	**2**
Morón	894	1062	1375	957	260	**910**	**3**
Rota	945	1115	1421	1008	276	**953**	**3**

Table 15. Distance between Alternatives and Training Locations in Nautical Miles

From the rankings, the pairwise comparison table is created and alternative weight for the sub-criterion established. Chièvres and Geilenkirchen are the best; Aviano and Pápa are next with Aviano having a slight advantage. Morón and Rota are grouped third choice in this criterion, and the worst is Çiğli.

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[104] 5 Million passengers was set as a minimum for this thesis

[105] "NSTEP Overview," NATO

[106] "Installation History - Grafenwöhr Training Area," Grafenwöhr History Office.

[107] "Helicopter Initiatives," European Defense Agency.

Creating the pairwise comparison table, Chièvres' proximity to training is equal to Geilenkirchen, slightly favorable to Pápa, very favorable to Çiğli, slightly favorable to Aviano, and favorable to Morón and Rota. Geilenkirchen is slightly favorable to Pápa, very favorable to Çiğli, slightly favorable to Aviano, and favorable to Morón and Rota. Pápa is favorable to Çiğli, barely unfavorable to Aviano to provide the slight distinction between the two, and slightly favorable to Morón and Rota. Çiğli is unfavorable to Aviano and slightly unfavorable to Morón and Rota. Aviano is slightly favorable to Morón and Rota. Morón is barely favorable to Rota. Table 16 represents all the pairwise comparisons and subsequent weight for the alternatives in regard to the Proximity to Training sub-criterion.

Proximity to Training	**Chièvres**	**Geilenkirchen**	**Pápa**	**Çiğli**	**Aviano**	**Morón**	**Rota**	**Weight**
Chièvres	1	1	3	7	3	5	5	**0.293**
Geilenkirchen	1	1	3	7	3	5	5	**0.293**
Pápa	1/3	1/3	1	5	1/2	3	3	**0.122**
Çiğli	1/7	1/7	1/5	1	1/5	1/3	1/3	**0.029**
Aviano	1/3	1/3	2	5	1	3	3	**0.145**
Morón	1/5	1/5	1/3	3	1/3	1	2	**0.065**
Rota	1/5	1/5	1/3	3	1/3	1/2	1	**0.054**

Note: CR= 0.0481

Table 16. Pairwise Comparison of Alternatives on the Proximity to Training Sub-criterion

2. Proximity to Logistics Analysis

Proximity to Logistics is the average distance from a medium sized seaport and an airport that services over five million passengers per year based on 2010 statistics. Table 17 provides distances, based on driving, between each alternative and their closest civilian airport and seaport, the average, and comparative rank.

Dist. in km (driving)	**Airport**	**Distance**	**Seaport**	**Distance**	**Average**	**Ranks**
Chièvres	Brussels	82	Brussels	71	**76.5**	**3**
Geilenkirchen	Dusseldorf	88	Duisburg	105	**96.5**	**4**
Pápa	Budapest	117	Budapest	105	**111**	**5**
Çiğli	Izmir	27	Izmir	32	**29.5**	**1**
Aviano	Venice	58	Venice	64	**61**	**2**
Morón	Seville	56	Cadiz	93	**74.5**	**3**
Rota	Seville	133	Cadiz	40	**86.5**	**4**

Table 17. Distance Between Alternatives and Logistical Centers in Kilometers

From the rankings, the pairwise comparison table is created and alternative weight for the sub-criterion established. Çiğli is the best with Aviano second. Morón and Chièvres are ranked third, while Geilenkirchen and Rota follow with Rota having a slight edge over Geilenkirchen. Last is Pápa.

Creating the pairwise comparison table, Chièvres' proximity to logistics is slightly favorable to Geilenkirchen, favorable to Pápa, unfavorable to Çiğli, slightly unfavorable to Aviano, equal to Morón, and slightly favorable to Rota. Geilenkirchen is slightly favorable to Pápa, very unfavorable to Çiğli, unfavorable to Aviano, and slightly unfavorable to Morón. To cast a distinction between Geilenkirchen and Morón, Geilenkirchen received a barely unfavorable rank. Pápa is extremely unfavorable to Çiğli, very unfavorable to Aviano, unfavorable to Morón and slightly unfavorable to Rota. Çiğli is slightly favorable to Aviano, favorable to Morón, and very favorable to Rota. Aviano is slightly favorable to Morón and favorable to Rota. Finally, Morón is slightly favorable to Rota. Table 18 represents all the pairwise comparisons and subsequent weight for the alternatives in regard to the Proximity to Logistics sub-criterion.

Proximity to Logistics	**Chièvres**	**Geilenkirchen**	**Pápa**	**Çiğli**	**Aviano**	**Morón**	**Rota**	**Weight**
Chièvres	1	3	5	1/5	1/3	1	3	**0.112**
Geilenkirch.	1/3	1	3	1/7	1/5	1/3	1/2	**0.047**
Pápa	1/5	1/3	1	1/9	1/7	1/5	1/3	**0.026**
Çiğli	5	7	9	1	3	5	7	**0.417**
Aviano	3	5	7	1/3	1	3	5	**0.228**
Morón	1	3	5	1/5	1/3	1	3	**0.112**
Rota	1/3	2	3	1/7	1/5	1/3	1	**0.057**
Note: CR= 0.0638								

Table 18. Pairwise Comparison of Alternatives on the Proximity to Logistics Sub-criterion

3. Weather Analysis

The weather sub-criterion weight is determined by how many days have no visual hindrances. The number of days is calculated by summing rain and snow days, and averaging the total with the number of days with fog, haze, or dust because in many cases the sum of day totaled more than 365. Weather information for this thesis came from weatherbase.com. If an alternative did not have the necessary information, a nearby city is used. Table 19 provides the number of days with weather-related obstructions for each alternative along with average and ranking.

Weather # Days per Year	**Rain**	**Snow**	**Fog/Haze/ Dust**	**Average**	**Rank**
Chièvres	225	22	246	**246.5**	**5**
Geilenkirchen	238	35	279	**276**	**5**
Pápa	17	Unk	155	**86**	**2**
Çiğli	89	4	315	**204**	**4**
Aviano	128	4	130	**131**	**3**
Morón	78	0	52	**65**	**1**
Rota	16	0	106	**61**	**1**

Table 19. Days of Weather Hindrances for Alternatives

From the rankings, the pairwise comparison table is created and alternative weight for the sub-criterion established. Morón and Rota are the best with Pápa second and Aviano third. Çiğli is fourth while Chièvres and Geilenkirchen tie for last.

Creating the pairwise comparison table, Chièvres' weather is barely favorable to Geilenkirchen, very unfavorable to Pápa, slightly unfavorable to Çiğli, unfavorable to Aviano, extremely unfavorable to Morón and Rota. Geilenkirchen is very unfavorable to Pápa, slightly unfavorable to Çiğli, unfavorable to Aviano, and extremely unfavorable to Morón and Rota. Pápa is favorable to Çiğli, slightly favorable to Aviano, and slightly unfavorable to Morón and Rota. Çiğli is slightly unfavorable to Aviano, and very unfavorable to Morón and Rota. Aviano is slightly unfavorable to Morón and Rota. Finally, Morón and Rota are equal. Table 20 represents all the pairwise comparisons and subsequent weight for the alternatives in regard to the weather sub-criterion.

Weather	Chièvres	Geilenkirchen	Pápa	Çiğli	Aviano	Moró	Rota	Weight
Chièvres	1	2	1/7	1/3	1/5	1/9	1/9	**0.030**
Geilenkirchen	1/2	1	1/7	1/3	1/5	1/9	1/9	**0.024**
Pápa	7	7	1	5	3	1/3	1/3	**0.177**
Çiğli	3	3	1/5	1	1/3	1/7	1/7	**0.052**
Aviano	5	5	1/3	3	1	1/3	1/3	**0.109**
Morón	9	9	3	7	3	1	1	**0.304**
Rota	9	9	3	7	3	1.	1	**0.304**
Note: CR= 0.0650								

Table 20. Pairwise Comparison of Alternatives on the Weather Sub-criterion

4. Overall Analysis of Alternatives on the Location Criterion

The Location criterion accounts for a little more than 28% of the total score in this study. Totaling the three sub-criterion's scores provide a ranking of the alternatives based solely on their location. Table 21 provides a summary of the scores and rankings for each alternative with respect to the location criterion.

Criterion	**Location**				
Weight	0.2828				
Sub-Criterion	Training	Logistics	Weather		
Weight	0.6434	0.0738	0.2828		
Factor Weight	**0.1820**	**0.0209**	**0.0800**		
				TOTALS	**RANK**
Chièvres	0.0533	0.0023	0.0024	**0.0580**	**1**
Geilenkirchen	0.0533	0.0010	0.0019	**0.0562**	**2**
Pápa	0.0222	0.0005	0.0141	**0.0368**	**5**
Çiğli	0.0052	0.0087	0.0042	**0.0181**	**7**
Aviano	0.0264	0.0048	0.0088	**0.0399**	**3**
.Morón	0.0118	0.0023	0.0243	**0.0385**	**4**
Rota	0.0097	0.0012	0.0243	**0.0353**	**6**

Table 21. Alternative’s Location Criteria Scores and Rankings

Based solely on the location, the best alternative Chièvres, at 0.0580, holds a slight edge over Geilenkirchen, 0.0562. Aviano, Morón, Pápa, and Rota are all bunched together around 0.0370 with a difference less than 0.005. Last is Çiğli; however, the spread between Çiğli at 0.0181 and Chièvres is quite small at 0.0399.

B. AIRFIELD

The airfield criterion is also composed of three sub-criteria: runway length and apron space availability, single-point refueling capability, and petroleum, oil, and liquids currently at the installation. The closer the airfield is to accept the NSAW without additional modifications, the easier and cheaper it will be for the NSAW to stand up. Meeting the minimum runway length of 6500 feet is a necessity for any alternative to be viable. The other critical element is the 1 million plus square feet of apron space mandated for the 117 aircraft. Single-point refueling capabilities is the second sub-criterion for the Airfield. A single-point refueling station allows for hot pitting; the ability to refuel while an engine is operating. This optimizes training schedules where quick turnaround time is paramount. Lastly, POL is essential to permit aircraft operations. The lack of proper petroleum capacity hinders sortie generation.

Table 22 restates the pairwise comparison from Chapter 3 for the three sub-criterions with respect to the overall airfield criterion. The runway length and available apron space was deemed slightly more important than if the location has single-point refueling capability and more important than current POL capacity on base. To round out the table, the location's single point refueling criterion was determined to be slightly more important than the alternative base's current POL capacity.

	Runway and Apron	**Single Point Refueling**	**POL**	**Sub-Criterion Weight**
Runway	1	3	5	0.6333
Refueling	1/3	1	3	0.2605
POL	1/5	1/3	1	0.1062
Note: CR = 0.0477				

Table 22. Pairwise Comparison of the Airfield Sub-criteria

In the Runway and Apron sub-criterion, each alternative's score will be based on each base's runway length and available apron space. The Single Point Refueling sub-criterion is a simple yes or no proposition; the base either currently has the capability or it does not. The POL sub-criterion is distilled down to type of jet fuel currently available since the maintenance contractor will be providing the oils and lubricants. The U.S. military as a standard uses JP8 instead of the more hazardous JP4.[108]

1. Runway and Apron Analysis

The runway and apron sub-criterion weight is determined by the length of the alternative's runway and available apron space. The runway length is provided through worldaerodata.com and apron space is estimated using flight line images from Google

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[108] Department of Defense, *Turbine Fuel, Aviation, Kerosene Type, JP8 (NATO F-34), NATO F-35, and JP-8+100 (NATO F-37).*

Earth. Descriptive terms are used for apron space instead of detailed numbers due to lack of data available. Table 23 provides the runway length and apron description for each alternative along with ranking.

	Runway	**Apron space**	**Rank**
Chièvres	5386 x 164	Limited apron space on closed runway; Very little room to expand	**5**
Geilenkirchen	10009 x 147	Not Available due to AWACS; No room to expand	**4**
Pápa	7869 x 197	Not Available due to C-17 operations; Room to expand	**3**
Çiğli	9821 x 147	Limited apron space available due to training; Room to expand	**2**
Aviano	8551 x 144	Limited apron space due to 31FW; Limited room to expand	**3**
Morón	11801 x 200	Significant space available when not in contingency; Limited room to expand	**1**
Rota	12104 x 200	Limited Apron space available due to operations; Room to expand	**2**

Table 23. Runway and Apron Description for Alternatives

From the rankings, the pairwise comparison table is created and alternative weight for the sub-criterion established. Morón is the best with the largest available apron and very long runway. Rota and Çiğli are second, with Rota slightly ahead due to runway length. Aviano and Pápa are ranked third while Geilenkirchen is fourth. Last is Chièvres because its short runway cannot support the projected NSAW aircraft.

Creating the pairwise comparison table, Chièvres' Runway and Apron Space is slightly unfavorable to Geilenkirchen, unfavorable to Pápa, very unfavorable to Çiğli, unfavorable to Aviano, extremely unfavorable to Morón, and very unfavorable to Rota. Geilenkirchen is slightly unfavorable to Pápa, unfavorable to Çiğli, slightly unfavorable to Aviano, very unfavorable to Morón and unfavorable to Rota. Pápa is slightly unfavorable to Çiğli, equal to Aviano, unfavorable to Morón and slightly unfavorable to Rota. Çiğli is slightly favorable to Aviano, slightly unfavorable to Morón, and barely unfavorable to Rota. Aviano is unfavorable to Morón and slightly unfavorable to Rota. Finally, Morón is slightly favorable to Rota. Table 24 represents all the pairwise comparisons and subsequent weight for the alternatives in regard to the runway and apron description sub-criterion.

	Chièvres	**Geilenkirchen**	**Pápa**	**Çiğli**	**Aviano**	**Morón**	**Rota**	**Weight**
Chièvres	1	1/3	1/5	1/7	1/5	1/9	1/7	**0.023**
Geilenkirchen	3	1	1/3	1/5	1/3	1/7	1/5	**0.043**
Pápa	5	3	1	1/3	1	1/5	1/3	**0.086**
Çiğli	7	5	3	1	3	1/3	1/2	**0.174**
Aviano	5	3	1	1/3	1	1/5	1/3	**0.086**
Morón	9	7	5	3	5	1	3	**0.382**
Rota	7	5	3	2	3	1/3	1	**0.207**
Note: CR=	0.0593							

Table 24. Pairwise Comparison of Alternatives on the Runway and Apron Sub-criterion

2. Single-Point Refueling Analysis

The Single Point Refueling sub-criterion is a binary operation; the base either currently has the capability or it does not. The advantage of single point refueling is the ability to refuel and swap crew members without shutting down the aircraft and wasting precious training time. Worldaerodata.com supplied the information on each alternative's refueling capability. Table 25 charts each alternative's capabilities.

	Single Point	**Rank**
Chièvres	no	**2**
Geilenkirchen	no	**2**
Pápa	no	**2**
Çiğli	no	**2**
Aviano	yes	**1**
Morón	yes	**1**
Rota	yes	**1**

Table 25. Single Point Refueling Capability for Alternatives

From the rankings, the pairwise comparison table is created and alternative weight for the sub-criterion established. Aviano, Morón, and Rota are the best with single point refueling capacity. Chièvres, Geilenkirchen, Pápa, and Çiğli are without the capability, so they are last.

Creating the pairwise comparison table, Chièvres, Geilenkirchen, Pápa, and Çiğli are all equal to each other and are extremely unfavorable to Aviano, Morón, and Rota. Aviano, Morón, and Rota are all equal to each other. Table 26 represents all the pairwise comparisons and subsequent weight for the alternatives concerning the single point refueling sub-criterion.

	Chièvres	**Geilenkirchen**	**Pápa**	**Çiğli**	**Aviano**	**Morón**	**Rota**	**Weight**
Chièvres	1	1	1	1	1/9	1/9	1/9	**0.032**
Geilenkirchen	1	1	1	1	1/9	1/9	1/9	**0.032**
Pápa	1	1	1	1	1/9	1/9	1/9	**0.032**
Çiğli	1	1	1	1	1/9	1/9	1/9	**0.032**
Aviano	9	9	9	9	1	1	1	**0.290**
Morón	9	9	9	9	1	1	1	**0.290**
Rota	9	9	9	9	1	1	1	**0.290**
Note: CR=	0.0000							

Table 26. Pairwise Comparison of Alternatives on the Single Point Refueling Sub-criterion

3. Petroleum, Oil, and Liquids Analysis

The Petroleum, Oil, and Liquids sub-criterion is reduced to the type of fuel currently on the alternative base, with JP8 preferred. Only jet fuel was analyzed and not oils or other liquids because the NSAW is expected to use contracted maintenance for the aircraft. It is expected for the contractors to provide the oils and liquids. Worldaerodata.com supplied the information on each alternative's fuel capability. Table 27 lists each alternative's fuel on base.

	JP8	**JP4**	**Rank**
Chièvres	yes		**1**
Geilenkirchen	yes		**1**
Pápa	yes		**1**
Çiğli	no	yes	**2**
Aviano	yes		**1**
Morón	yes		**1**
Rota	yes		**1**

Table 27. Alternative's Current Jet Fuel

From the rankings, the pairwise comparison table is created and alternative weight for the sub-criterion established. Every base other than Çiğli offers JP8, thus they are all first and Çiğli is last.

Creating the pairwise comparison table, Chièvres, Geilenkirchen, Pápa, Aviano, Morón, and Rota are all equal to each other and are slightly favorable to Çiğli. The ranking of slightly favorable was given due to the ease of transitioning from JP4 to JP8. Table 28 represents all the pairwise comparisons and subsequent weight for the alternatives concerning the petroleum, oil and liquids sub-criterion.

	Chièvres	**Geilenkirchen**	**Pápa**	**Çiğli**	**Aviano**	**Morón**	**Rota**	**Weight**
Chièvres	1	1	1	3	1	1	1	**0.158**
Geilenkirchen	1	1	1	3	1	1	1	**0.158**
Pápa	1	1	1	3	1	1	1	**0.158**
Çiğli	1/3	1/3	1/3	1	1/3	1/3	1/3	**0.053**
Aviano	1	1	1	3	1	1	1	**0.158**
Morón	1	1	1	3	1	1	1	**0.158**
Rota	1	1	1	3	1	1	1	**0.158**
Note: CR=	0.0000							

Table 28. Pairwise Comparison of Alternatives on the POL Sub-criterion

4. Overall Analysis of Alternatives on the Airfield Criterion

The Airfield criterion accounts for a little more than 64% of the total score in this study. Totaling the three sub-criterion's scores provide a ranking of the alternatives based solely on their airfield's capability to support the NSAW. Table 29 provides a summary of the scores and rankings for each alternative with respect to the airfield criterion.

Criterion	**Airfield**				
Weight	0.6434				
Sub-Criterion	Flight line	Refueling	POL		
Weight	0.6333	0.2605	0.1062		
Factor Weight	**0.4075**	**0.1676**	**0.0683**		
				TOTALS	**RANK**
Chièvres	0.0096	0.0054	0.0108	**0.0258**	**7**
Geilenkirchen	0.0173	0.0054	0.0108	**0.0335**	**6**
Pápa	0.0350	0.0054	0.0108	**0.0511**	**5**
Çiğli	0.0707	0.0054	0.0036	**0.0797**	**4**
Aviano	0.0350	0.0487	0.0108	**0.0944**	**3**
Morón	0.1556	0.0487	0.0108	**0.2151**	**1**
Rota	0.0843	0.0487	0.0108	**0.1438**	**2**

Table 29. Alternative's Airfield Criterion Score and Ranking

Based solely on the airfield, Morón at 0.2151 holds a tremendous edge over second best Rota at 0.1438 and the other alternatives. Aviano is third with 0.0944, Çiğli is fourth, Pápa fifth, Geilenkirchen sixth, and finally Chièvres at 0.0258 is last. Considering that the airfield criterion encapsulated two of the three most significant sub-criterions to this thesis, it is not surprising that there is an extreme difference between first at and last, 0.1893, unlike the location criterion.

C. SUPPORT

The support factor is broken down into three distinct areas: base security, base medical and dental, and other miscellaneous supporting activities (finance, education, dining, morale, and wellness). Base security is important for the success of training and operations. Medical and dental is of interest in the rare situation of a medical emergency occurring. Finally, other supporting agencies help make life easier for the future NSAW personnel and their families.

Table 30 is the pairwise comparison for the importance of these three sub-criterions with respect to the support criterion that was accomplished in Chapter 3.

	Base Security	**Medical/ Dental**	**Misc. Support**	**Sub-criterion Weight**
Security	1	3	7	0.6434
Medical	1/3	1	5	0.2828
Misc. Sprt	1/7	1/5	1	0.0738
Note: CR = 0.0432				

Table 30. Pairwise Comparison of the Support Sub-criteria

The Base Security sub-criterion is a binary operation, either the location has security or it does not. This thesis does not dive deep into advanced security measures due to the inherent classified nature of security protocols. The Medical and Dental sub-criterion factor is the clinic size at the locality. Miscellaneous support sub-criterion is all the other supporting functions provided by the base or station. Typical functions include finance, education, visiting quarters, dining, and housing.

1. Security Analysis

The Base Security sub-criterion is a simple yes or no proposition, either the location has security or it does not. This thesis does not dive deep into advanced security measures due to the inherent classified nature of security protocols. Information on security came from base websites and globalsecurity.org. Table 31 provides each alternative's security capability.

	Security	**Rank**
Chièvres	yes	**1**
Geilenkirchen	yes	**1**
Pápa	yes	**1**
Çiğli	yes	**1**
Aviano	yes	**1**
Morón	yes	**1**
Rota	yes	**1**

Table 31. Alternative's Current Base Security Capacity

From the rankings, the pairwise comparison table is created and alternative weight for the sub-criterion established. Every base incorporates basic base security, thus they are all first.

Creating the pairwise comparison table, Chièvres, Geilenkirchen, Pápa, Çiğli, Aviano, Morón, and Rota are all equal to each other because they all have dedicated security forces. Table 32 represents all the pairwise comparisons and subsequent weight for the alternatives concerning the base security sub-criterion.

	Chièvres	**Geilenkirchen**	**Pápa**	**Çiğli**	**Aviano**	**Morón**	**Rota**	**Weight**
Chièvres	1	1	1	1	1	1	1	**0.143**
Geilenkirchen	1	1	1	1	1	1	1	**0.143**
Pápa	1	1	1	1	1	1	1	**0.143**
Çiğli	1	1	1	1	1	1	1	**0.143**
Aviano	1	1	1	1	1	1	1	**0.143**
Morón	1	1	1	1	1	1	1	**0.143**
Rota	1	1	1	1	1	1	1	**0.143**
Note: CR=	0.0000							

Table 32. Pairwise Comparison of Alternatives on the Base Security Sub-criterion

2. Medical and Dental Analysis

The medical and dental sub-criterion weight is determined by the level of medical and dental support provided at the location. If emergencies cannot be handled at the alternative, either the closest NATO location must support or the member must rely on local medical facilities. Medical and dental information for this thesis came from location websites and globalsecurity.org. Table 33 provides the medical and dental capacities for the seven alternatives.

	Medical and Dental	**Rank**
Chièvres	Full Support on base	**1**
Geilenkirchen	Full Support on base	**1**
Pápa	Very Limited Support on base	**4**
Çiğli	Limited Support on base	**3**
Aviano	Full Support on base	**1**
Morón	Limited Support on base Full support at Rota	**2**
Rota	Full support on base	**1**

Table 33. Alternative's Current Base Medical and Dental Capacity

From the rankings, the pairwise comparison table is created and alternative weight for the sub-criterion established. Chièvres, Geilenkirchen, Aviano and Rota all offer full medical and dental support, thus they are all first. Morón has limited support on base;

however, Rota is only 75 miles away if an emergency arises. Çiğli has limited support with Izmir Air Station, so it is judged third. Lastly, Pápa AB has very limited support and depends greatly on the surrounding area for emergency procedures.

Creating the pairwise comparison table, Chièvres was equal to Geilenkirchen, very favorable to Pápa, favorable to Çiğli, equal to Aviano, slightly favorable to Morón and equal to Rota. Geilenkirchen is very favorable to Pápa, favorable to Çiğli, equal to Aviano, slightly favorable to Morón and equal to Rota. Pápa is slightly unfavorable to Çiğli, very unfavorable to Aviano, unfavorable to Morón and very unfavorable to Rota. Çiğli is unfavorable to Aviano, slightly unfavorable to Morón and unfavorable to Rota. Aviano is slightly favorable to Morón and equal to Rota. Finally, Morón is slightly unfavorable to Rota. Table 34 represents all the pairwise comparisons and subsequent weight for the alternatives concerning the medical and dental sub-criterion.

	Chièvres	**Geilenkirchen**	**Pápa**	**Çiğli**	**Aviano**	**Morón**	**Rota**	**Weight**
Chièvres	1	1	7	5	1	3	1	**0.210**
Geilenkirchen	1	1	7	5	1	3	1	**0.210**
Pápa	1/7	1/7	1	1/3	1/7	1/5	1/7	**0.025**
Çiğli	1/5	1/5	3	1	1/5	1/3	1/5	**0.045**
Aviano	1	1	7	5	1	3	1	**0.210**
Morón	1/3	1/3	5	3	1/3	1	1/3	**0.088**
Rota	1	1	7	5	1	3	1	**0.210**
Note: CR= 0.0216								

Table 34. Pairwise Comparison of Alternatives on the Medical and Dental Sub-criterion

3. Miscellaneous Support Analysis

The miscellaneous support sub-criterion weight is determined by the level of supporting functions offered at each alternative. Support information came from the base’s website or globalsecurity.org. Table 35 provides the support levels for the seven alternatives along with rankings.

	Miscellaneous Support Level	Rank
Chièvres	High	**1**
Geilenkirchen	High	**1**
Pápa	Minimal	**3**
Çiğli	Minimal	**3**
Aviano	High	**1**
Morón	Varies by operations; High level at Rota	**2**
Rota	High	**1**

Table 35. Alternative's Miscellaneous Support Level

From the rankings, the pairwise comparison table is created and alternative weight for the sub-criterion established. Chièvres, Geilenkirchen, Aviano and Rota all offer a high support, thus they are all first. Morón's support varies depending on the level of operations; however, Rota is only 75 miles away if needed. Çiğli and Pápa have minimal support, so they are tied for third.

Creating the pairwise comparison table, Chièvres was equal to Geilenkirchen, very favorable to Pápa and Çiğli, equal to Aviano, slightly favorable to Morón and equal to Rota. Geilenkirchen is very favorable to Pápa and Çiğli, equal to Aviano, slightly favorable to Morón and equal to Rota. Pápa is equal to Çiğli, very unfavorable to Aviano, unfavorable to Morón and very unfavorable to Rota. Çiğli is very unfavorable to Aviano, unfavorable to Morón and very unfavorable to Rota. Aviano is slightly favorable to Morón and equal to Rota. Finally, Morón is slightly unfavorable to Rota. Table 36 represents all the pairwise comparisons and subsequent weight for the alternatives concerning the miscellaneous support sub-criterion.

	Chièvres	**Geilenkirchen**	**Pápa**	**Çiğli**	**Aviano**	**Morón**	**Rota**	**Weight**
Chièvres	1	1	7	7	1	3	1	**0.213**
Geilenkirchen	1	1	7	7	1	3	1	**0.213**
Pápa	1/7	1/7	1	1	1/7	1/5	1/7	**0.028**
Çiğli	1/7	1/7	1	1	1/7	1/5	1/7	**0.028**
Aviano	1	1	7	7	1	3	1	**0.213**
Morón	1/3	1/3	5	5	1/3	1	1/3	**0.093**
Rota	1	1	7	7	1	3	1	**0.213**
Note: CR= 0.0167								

Table 36. Pairwise Comparison of Alternatives on the Miscellaneous Support Sub-criterion

4. Overall Analysis of Alternatives on the Support Criterion

The Support criterion accounts for a little more than 7% of the total score in this study. In other words, the support factors are not as significant as the other two main criterions. Totaling the three sub-criterion's scores provide a ranking of the alternatives based solely on their support capacity. Table 37 provides a summary of the scores and rankings for each alternative with respect to the support criterion.

Criterion	**Support**				
Weight	0.0738				
Sub-Criterion	Security	Medical	Misc. Support		
Weight	0.6434	0.2828	0.0738		
Factor Weight	**0.0475**	**0.0209**	**0.0054**		
				TOTALS	**RANK**
Chièvres	0.0068	0.0044	0.0044	**0.0156**	**1**
Geilenkirchen	0.0068	0.0044	0.0044	**0.0156**	**1**
Pápa	0.0068	0.0005	0.0006	**0.0079**	**4**
Çiğli	0.0068	0.0009	0.0006	**0.0083**	**3**
Aviano	0.0068	0.0044	0.0044	**0.0156**	**1**
Morón	0.0068	0.0018	0.0019	**0.0106**	**2**
Rota	0.0068	0.0044	0.0044	**0.0156**	**1**

Table 37. Alternative's Support Criterion Score and Ranking

Based solely on the support sub-criterions, Chièvres, Geilenkirchen, Aviano, and Rota are very strong and tied for first. This should be expected because they are locations that have been established for quite some time. Morón is second due to its proximity to Rota. Çiğli is third because of the NATO support provided at Izmir Air Base. Finally, Pápa is last with very limited support structure. Considering that difference between first and last is 0.0077, this criterion has limited impact on the overall ranking for this thesis.

D. SYNTHESIS OF CRITERIA

To see the complete picture for this study, all the criterions and sub-criterions are pictured in Table 38. Main criteria with their pairwise comparison weights are shown first, with their total score and overall rank listed to the side.

Main Criterion	**Location**	**Airfield**	**Support**
Weight	0.2828	0.6434	0.0738

				TOTALS	**RANK**
Chièvres	0.0580	0.0258	0.0156	**0.0994**	**4**
Geilenkirchen	0.0562	0.0335	0.0156	**0.1053**	**4**
Pápa	0.0368	0.0511	0.0079	**0.0959**	**4**
Çiğli	0.0181	0.0797	0.0083	**0.1061**	**4**
Aviano	0.0399	0.0944	0.0156	**0.1499**	**3**
Morón	0.0385	0.2151	0.0106	**0.2641**	**1**
Rota	0.0353	0.1438	0.0156	**0.1946**	**2**

Table 38. Alternative's Criterion Scores, Overall Score and Rank

From Table 38, Morón Air Base is the overall best location for the NSAW, even though Chièvres was the best in Location and Support criteria. The closest alternative to Morón is Rota, followed by Aviano. The other four alternatives, Chièvres, Geilenkirchen, Pápa, and Çiğli, are all equally unacceptable to house the NSAW based on the criteria set by this study.

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VI. CONCLUSIONS

A. REVIEW

There is a critical shortfall in special operations aviation support for NATO SOF. One way this shortfall can be addressed is through the procurement and sustainment of the NATO SOF Air Wing (NSAW). The basing decision for the NSAW has centered on proximity to NATO SOF HQ in Mons, Belgium, and minimized other important considerations, such as runway requirements, tarmac space, supporting infrastructure, weather, and proximity to training. A location decision is a complex endeavor with multiple criteria that can conflict with one another. Due to the long-term impact of basing the NSAW, a decision requires systematic analysis to find an effective and efficient recommendation.

This thesis reviews two multiple-criterion decision making tools, the point value comparison and the analytical hierarchy process, and used the AHP to address the NATO SOF Air Wing basing decision. The AHP was selected as the preferred method due to the ability to adapt qualitative and quantitative measures into the process and ensure the comparisons are consistent.

To answer the basing question, three main criteria were established and pairwise compared against each other to determine main criteria weights. Within each criterion, three sub-criterions were created and also pairwise compared for determining sub-criterion weights. Each sub-criterion weight was multiplied by the main criteria weight for the factor weight. The seven selected alternative bases were pairwise compared against each other along the nine sub-criterions. The results were summed and the best alternative was determined.

B. CONCLUSION

Table 39 shows the seven alternatives' main criterion scores and overall score. Overall, the best location based on this study is Morón Air Base. This is mainly due to its massive runway and tarmac space. It is worth noting that Chièvres Air Base came in first in both the Location and Support criterions; however, it had the worst score in the Airfield criterion. The lack of runway and apron capability at Chièvres Air Base dropped it to a tie for the worst alternative with Geilenkirchen, Pápa, and Çiğli.

Main Criterion	**Location**	**Airfield**	**Support**	**TOTALS**	**RANK**
Weight	0.2828	0.6434	0.0738		
Chièvres	0.0580	0.0258	0.0156	**0.0994**	**4**
Geilenkirchen	0.0562	0.0335	0.0156	**0.1053**	**4**
Pápa	0.0368	0.0511	0.0079	**0.0959**	**4**
Çiğli	0.0181	0.0797	0.0083	**0.1061**	**4**
Aviano	0.0399	0.0944	0.0156	**0.1499**	**3**
Morón	0.0385	0.2151	0.0106	**0.2641**	**1**
Rota	0.0353	0.1438	0.0156	**0.1946**	**2**

Table 39. Alternative’s Criterion Scores, Overall Score and Rank

C. FURTHER RESEARCH

This thesis focused on the NSAW location being at one base. Since the best result was Morón Air Base, a semi-dormant air base, another study should attempt to grade other bases that are in a semi-dormant status throughout Europe. Other possibilities include having the training base at a separate location, splitting up the NSAW into two or three groups commanding a couple SOATUs each, or having the individual platforms located at separate bases.

The weights for this thesis were developed by the author. If NSHQ applies the AHP to determine the NSAW location, weighting adjustments are expected. The AHP is designed to build weights through consensus; however, sensitivity analysis is possible by adjusting the main criterion and sub-criterion weights while maintaining the same alternative pairwise comparisons for each sub-criterion.

Many other factors were not addressed by this thesis or assumed to be a true A NATO country might not want the NSAW stationed within its borders for political reasons. Being that the country is a member of NATO, it was assumed that the country would accept the new air wing. In addition, some countries may have laws restricting flight hours and flight profiles. These restrictions can hinder training opportunities and result in an suboptimal alternative being chosen. Finally, NATO might want to base the NSAW closer to possible contingency areas instead or change the selected training locations. All these items have the opportunity to significantly impact the NSAW location and must be addressed by NATO before the final location is decided.

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APPENDIX

Determining criterion weights using the AHP involves three steps.

Step 1. Create the pairwise comparison matrix. The example shown is the matrix for the top level criterions in this thesis.

	Location	**Airfield**	**Support**
Location	1	3	5
Airfield	1/3	1	7
Support	1/5	1/7	1

Step 2. Create an approximate normalized matrix. To generate a true normalized matrix involves finding the determinant of the matrix; a process that can be very long. The approximate matrix is much faster, but minor rounding errors must be accepted. The approximate matrix is created by dividing each element by the sum of its column. For the first element, 1 is divided by 4.2 (1+3+0.2). Shown below is the top level criterion's normalized matrix.

Norm	**Location**	**Airfield**	**Support**
Location	0.238	0.226	0.385
Airfield	0.714	0.677	0.538
Support	0.048	0.097	0.077

Step 3. Determine the normalized factor weight by summing the rows and divide the sum by the matrix's order of magnitude, otherwise known as the number of factors. Using the Location factor and an example… (0.238+0.226+0.385)/3=0.283.

Norm	**Location**	**Airfield**	**Support**	WEIGHT
Location	0.238	0.226	0.385	0.283
Airfield	0.714	0.677	0.538	0.643
Support	0.048	0.097	0.077	0.074

Determining the consistency ratio involves three steps.

Step 1. Obtain the Principle Eigen Value, λmax, by taking the inverse of each identity element and multiplying each with its weight, then summing them all together. The main criterion matrix's $\lambda max = (1/0.238)*0.283 + (1/0.677)*0.643 + (1/0.077)*0.074 = 3.097$

Step 2. Determine the consistency index (CI). The formula for CI is: (λmax-n)/(n-1), where n is the matrix's order of magnitude, otherwise known as the number of factors. The main criterion encompasses three factors, thus its CI = (3.097–3)/2 = 0.0484

Step 3. Obtain the consistency ratio (CR) using the equation CI/RI, where RI is determined from Saaty's random inconsistency index below. RI is 0.58 because n = 3. Thus, CR = 0.0484/0.58 = 0.0834. Since CR < 0.1, the matrix pairwise comparisons are consistent.

N	1	2	3	4	5	6	7	8	9	10
RI	0.00	0.00	0.58	0.9	1.12	1.24	1.32	1.41	1.46	1.49

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